The Department of Defense

DoD Departments:

Department of the Navy

Department of the Air Force

Defense Advanced Research Projects Agency

Ballistic Missile Defense Organization

Defense Threat Reduction Agency

Special Operations Command

National Imagery and Mapping Agency

CBD

Chemical Biological Defense

PROGRAM SOLICITATION 00.1
CLOSING DATE: 12 JANUARY 2000

FY 2000 SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

PROGRAM SOLICITATION

Number 00.1

Small Business Innovation Research Program

IMPORTANT

The DoD updates its SBIR mailing list annually. To remain on the mailing list or to be added to the list, send in the Mailing List form (Reference H) found at the back of this solicitation or complete the electronic form at http://www.teltech.com/sbir/form.html. Failure to send the form annually will result in removal of your name from the mailing list.

If you have questions about the Defense Department's SBIR program, please call the SBIR/STTR Help Desk at (800) 382-4634, or see the DoD SBIR/STTR Web Site, at http://www.acq.osd.mil/sadbu/sbir.

U.S. Department of Defense
SBIR Program Office
Washington, DC 20301

October 1, 1999:	Solicitation issued for public release
December 1, 1999:	DoD begins accepting proposals
January 12, 2000:	Deadline for receipt of proposals at the DoD Components by 3:00 p.m. local time

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON DC 20301-3000

ACQUISITION AND TECHNOLOGY

IMPORTANT NEW INFORMATION ABOUT THE DOD SBIR PROGRAM

1. **The DoD SBIR/STTR Help Desk** can address your questions about this solicitation, the proposal preparation process, contract negotiation, getting paid, government accounting requirements, intellectual property protection, commercialization reporting, the Fast Track, and other program-related areas. You may contact the Help Desk by:
   - Phone: 800-382-4634 (8AM to 8PM EST)
   - Fax: 800-462-4128
   - Email: SBIRHELP@teltech.com

2. **The DoD SBIR/STTR Web Site (http:// www.acq.osd.mil/sadbu/sbir)** offers electronic access to many important resources for SBIR participants, such as the initial public release of each SBIR solicitation, sample SBIR proposals, model SBIR contracts, links to the Component SBIR programs within DoD, answers to commonly-asked questions about SBIR contracting, descriptive data on the SBIR program, and the latest program updates.

3. **Starting with this solicitation, your SBIR Proposal Cover Sheet (formerly, "Appendix A and B") and Company Commercialization Report must be submitted electronically through www.dodsbir.net/submission,** as described in Sections 3.4b and n.

4. **DoD has adopted commercialization of SBIR technology (in military and/or private sector markets) as a critical measure of performance** for both the DoD SBIR program and the companies that participate in the program. This new policy is reflected in Sections 3.4h and 3.6 of this solicitation (Commercialization Strategy); Section 3.4n (Company Commercialization Report on Prior SBIR Awards); Section 4.4 (Assessing Commercial Potential of Proposals); and Section 5.4 (Commercialization Updates in Phase II).

5. **Under DoD's "Fast Track" policy (section 4.5), SBIR projects that attract some matching cash from an outside investor for the Phase II effort have a much higher chance of Phase II award** -- see www.acq.osd.mil/sadbu/sbir/fsttrack.html#results. Fast Track projects also receive expedited processing and interim funding between Phases I and II.

6. **Each DoD Component (Army, Navy, Air Force, etc.) has developed its own Phase II Enhancement policy.** Under this policy, the Component will provide a Phase II company with additional Phase II SBIR funding if the company can match the additional SBIR funds with non-SBIR funds from DoD acquisition programs or the private sector. See each Component's section of the solicitation for details.

7. **You may contact the DoD authors of solicitation topics to ask questions about the topics** before you submit a proposal. Procedures for doing so are discussed in Section 1.5(c) of this solicitation. Please note that you may talk by telephone with a topic author to ask such questions only between October 1, when this solicitation was publicly released, and December 1, when DoD begins accepting proposals. At other times, you may submit written questions as described in Section 1.5c.

8. **Starting with this solicitation, a number of the Navy, Air Force, and Army (including Chemical Biological Defense) topics are supported by a DoD acquisition program (e.g., New Attack Submarine, Abrams Tank),** as noted in the text of the topic. These acquisition programs are potentially important end customers for innovative new products resulting from SBIR projects. Information on how to contact these programs will be posted on the DoD SBIR/STTR Web Site (http://www.acq.osd.mil/sadbu/sbir).

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DoD PROGRAM SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH

1.0 PROGRAM DESCRIPTION

1.1 Introduction

The Navy, Air Force, Chemical and Biological Defense (CBD), Ballistic Missile Defense Organization (BMDO), Defense Threat Reduction Agency (DTRA), Defense Advanced Research Projects Agency (DARPA), National Imagery and Mapping Agency (NIMA), and U.S. Special Operations Command (SOCOM), hereafter referred to as DoD Components, invite small business firms to submit proposals under this solicitation for the Small Business Innovation Research (SBIR) program. Firms with the capability to conduct research and development (R&D) in any of the defense-related topic areas described in Section 8.0, and to commercialize the results of that R&D, are encouraged to participate.

Objectives of the DoD SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research or research and development results.

The Federal SBIR Program is mandated by Public Laws PL 97-219, PL 99-443, and PL 102-564. The basic design of the DoD SBIR Program is in accordance with the Small Business Administration (SBA) SBIR Policy Directive, January 1993. The DoD Program presented in this solicitation strives to encourage scientific and technical innovation in areas specifically identified by DoD Components. The guidelines presented in this solicitation incorporate and exploit the flexibility of the SBA Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to the DoD and the private sector.

1.2 Three Phase Program

This program solicitation is issued pursuant to the Small Business Innovation Development Act of 1982, PL 97-219, PL 99-443, and PL 102-564. Phase I is to determine, insofar as possible, the scientific, technical, and commercial merit and feasibility of ideas submitted under the SBIR Program. Phase I awards are typically \$60,000 to \$100,000 in size over a period not to exceed six months (nine months for the Air Force). Proposals should concentrate on that research or research and development which will significantly contribute to proving the scientific, technical, and commercial feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector. Proposers are encouraged to consider whether the research or research and development they are proposing to DoD Components also has private sector potential, either for the proposed application or as a base for other applications.

Subsequent Phase II awards will be made to firms on the basis of results of their Phase I effort and the scientific, technical, and commercial merit of the Phase II proposal. Phase II awards are typically \$500,000 to \$750,000 in size over a period generally not to exceed 24 months (subject to negotiation). Phase II is the principal research or research and development effort and is expected to produce a well-defined deliverable prototype. A more comprehensive proposal will be required for Phase II.

Under Phase III, the small business is expected to obtain funding from the private sector and/or non-SBIR Government sources to develop the prototype into a viable product or non-R&D service for sale in military and/or private sector markets.

Under a policy approved by the Under Secretary of Defense for Acquisition and Technology in October 1998, DoD now tracks the extent to which technologies developed under Phase II are successfully commercialized in Phase III (in military and/or private sector markets), as discussed in Section 5.4 of this solicitation. Furthermore, DoD has adopted such commercialization success as a critical measure of performance for both the DoD SBIR program and the firms that participate in the program.

This solicitation is for Phase I proposals only. Only proposals submitted in response to this solicitation will be considered for Phase I award. Proposers who were not awarded a contract in response to a prior SBIR solicitation are free to update or modify and re-submit the same or modified proposal if it is responsive to any of the topics listed in Section 8.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts will be considered (Section 4.3 and 5.2).

DoD is not obligated to make any awards under either Phase I, II, or III, and all awards are subject to the availability of funds. DoD is not responsible for any monies expended by the proposer before award of any contract.

1.3 Proposer Eligibility and Limitations

Each proposer must qualify as a small business for research or research and development purposes as defined in Section 2.0 and certify to this on the Cover Sheet of the proposal. In addition, a minimum of two-thirds of the research and/or analytical work in Phase I must be carried out by the proposing firm. For Phase II, a minimum of one-half of the research and/or analytical work must be performed by the proposing firm. The percent of work is usually measured by both direct and indirect costs, although proposers planning to subcontract a significant fraction of their work should verify how it will be measured with their DoD contracting officer during contract negotiations. For both Phase I and II, the primary employment of the principal investigator must be with the small business firm at the time of the award and during the conduct of the proposed effort. Primary employment means that more than one-half of the principal investigator's time is spent with the small business. Primary employment with a small business concern precludes full-time employment at another organization. Deviations from the requirements in this paragraph must be approved in writing by the contracting officer (during contract negotiations).

For both Phase I and Phase II, all research or research and development work must be performed by the small business concern in the United States. "United States" means the fifty states, the Territories and possessions of the United States, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, the Trust Territory of the Pacific Islands, and the District of Columbia.

Joint ventures and limited partnerships are permitted, provided that the entity created qualifies as a small business in accordance with the Small Business Act, 15 USC 631, and the definition included in Section 2.2.

1.4 Conflicts of Interest

Awards made to firms owned by or employing current or previous Federal Government employees could create conflicts of interest for those employees in violation of 18 USC and 10 USC 2397. Such proposers should contact the cognizant Ethics Counselor from the employees' Government agency for further guidance.

1.5 Questions about SBIR and Solicitation Topics

a. General Questions/Information. The DoD SBIR/STTR Help Desk is prepared to address general questions about this solicitation, the proposal preparation process, contract negotiation, payment vouchers, Government accounting requirements, intellectual property protection, the Fast Track, financing strategies, and other program-related areas. The Help Desk may be contacted by:

Phone: 800-382-4634 (8AM to 8PM EST)
Fax: 800-462-4128
Email: SBIRHELP@teltech.com

The DoD SBIR/STTR Web Site offers electronic access to SBIR solicitations, answers to commonly asked questions, sample SBIR proposals, model SBIR contracts, abstracts of ongoing SBIR projects, the latest updates on the SBIR program, hyperlinks to sources of business assistance and financing, and other useful information.

DOD SBIR/STTR WEB SITE:
http://www.acq.osd.mil/sadbu/sbir

b. General Questions about a DoD Component. General questions pertaining to a particular DoD Component (Army, Navy, Air Force, etc) should be submitted in accordance with the instructions given at the beginning of that Component's topics, in Section 8.0 of this solicitation.

c. Technical Questions about Solicitation Topics. On October 1, 1999, this solicitation was issued for public release on the DoD SBIR/STTR Web Site (**http://www.acq.osd.mil/sadbu/sbir**), along with the names of the topic authors and their phone numbers. The names of topic authors and their phone numbers will remain posted on the Web Site until December 1, 1999, giving proposers an opportunity to ask technical questions about specific solicitation topics by telephone.

Once DoD begins accepting proposals on December 1, 1999, telephone questions will no longer be accepted, but proposers may submit written questions through the SBIR Interactive Topic Information System (SITIS), in which the questioner and respondent remain anonymous and all questions and answers are posted electronically for general viewing. Proposers may submit written questions to SITIS via the Internet (see "Solicitations" on the DoD SBIR/STTR Web Site), e-mail, fax, mail, or telephone as follows:

Defense Technical Information Center
MATRIS Office, DTIC-AM
ATTN: SITIS Coordinator
NAS North Island, Box 367011
San Diego, CA 92135-7011
Phone: (619) 545-7529
Fax: (619) 545-0019
E-mail: sbir@dticam.dtic.mil
www: http://dticam.dtic.mil/sbir/

The SITIS service for this solicitation opens on or around October 4, 1999 and closes to new questions on December 29, 1999. SITIS will post all questions and answers on the Internet (see Solicitations on the DoD SBIR/STTR Web Site) from October 4, 1999 through January 12, 2000. (Answers will also be emailed or faxed directly to the inquirer if the inquirer provides an e-mail address or fax number.) Answers are generally posted within seven working days of question submission.

All proposers are advised to monitor SITIS during the solicitation period for questions and answers, and other information, relevant to the topic under which they are proposing.

1.6 Requests for Copies of DoD SBIR Solicitations

To remain on the DoD Mailing list for the SBIR and STTR solicitations, send in the Mailing List form (Reference H). You may also order additional copies of this solicitation from:

DoD SBIR Support Services
2850 Metro Drive, Suite 600
Minneapolis, MN 55425-1566
(800) 382-4634

The DoD SBIR and STTR solicitations can also be accessed via internet through the DoD SBIR/STTR Web Site at **http://www.acq.osd.mil/sadbu/sbir**.

1.7 SBIR Conferences and Outreach

The DoD holds two National SBIR Conferences a year and participates in many state-organized conferences for small business. For information on these events, see our Web Site **(http://www.acq.osd.mil/sadbu/sbir)**. We have a special outreach effort to socially and economically disadvantaged firms.

2.0 DEFINITIONS

The following definitions apply for the purposes of this solicitation:

2.1 Research or Research and Development

Basic Research - Scientific study and experimentation to provide fundamental knowledge required for the solution of problems.

Exploratory Development - A study, investigation or minor development effort directed toward specific problem areas with a view toward developing and evaluating the feasibility and practicability of proposed solutions.

Advanced Development - Proof of design efforts directed toward projects that have moved into the development of hardware for test.

Engineering Development - Full-scale engineering development projects for DoD use but which have not yet received approval for production.

2.2 Small Business

A small business concern is one that, at the time of award of a Phase I or Phase II contract:

a. Is independently owned and operated and organized for profit, is not dominant in the field of operation in which it is proposing, and has its principal place of business located in the United States;

b. Is at least 51% owned, or in the case of a publicly owned business, at least 51% of its voting stock is owned by United States citizens or lawfully admitted permanent resident aliens;

c. Has, including its affiliates, a number of employees not exceeding 500, and meets the other regulatory requirements found in 13 CFR Part 121.

Business concerns, other than investment companies licensed, or state development companies qualifying under the Small Business Investment Act of 1958, 15 USC 661, et seq., are affiliates of one another when either directly or indirectly (1) one concern controls or has the power to control the other; or (2) a third party or parties controls or has the power to control both. Control can be exercised through common ownership, common management, and contractual relationships. The term "affiliates" is defined in greater detail in 13 CFR Sec. 121.103. The term "number of employees" is defined in 13 CFR Sec. 121.106. Business concerns include, but are not limited to, any individual, partnership, corporation, joint venture, association or cooperative.

2.3 Socially and Economically Disadvantaged Small Business

A small business that is at the time of award of a Phase I or Phase II contract:

a. At least 51% owned by an Indian tribe or a native Hawaiian organization, or one or more socially and economically disadvantaged individuals, and

b. Whose management and daily business operations are controlled by one or more socially and economically disadvantaged individuals.

A socially and economically disadvantaged individual is defined as a member of any of the following groups: Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, Subcontinent-Asian Americans, or other groups designated by SBA to be socially and economically disadvantaged.

2.4 Women-Owned Small Business

A women-owned small business is one that is at least 51% owned by a woman or women who also control and operate it. "Control" in this context means exercising the power to make policy decisions. "Operate" in this context means being actively involved in the day-to-day management of the business.

2.5 Funding Agreement

Any contract, grant, or cooperative agreement entered into between any Federal Agency and any small business concern for the performance of experimental, developmental, or research work funded in whole or in part by the federal Government. *Only the contract method will be used by DoD components for all SBIR awards.*

2.6 Subcontract

A subcontract is any agreement, other than one involving an employer-employee relationship, entered into by a Federal Government contract awardee calling for supplies or services required solely for the performance of the original contract. This includes consultants.

2.7 Commercialization

The process of developing a product or non-R&D service for sale (whether by the originating party or by others), in Government and/or private sector markets.

3.0 PROPOSAL PREPARATION INSTRUCTIONS AND REQUIREMENTS

3.1 Proposal Requirements

A proposal to any DoD Component under the SBIR Program is to provide sufficient information to persuade the DoD Component that the proposed work represents an innovative approach to the investigation of an important scientific or engineering problem and is worthy of support under the stated criteria.

The quality of the scientific or technical content of the proposal will be the principal basis upon which proposals will be evaluated. The proposed research or research and development must be responsive to the chosen topic, although need not use the exact approach specified in the topic (see Section 4.1). Any small business contemplating a bid for work on any specific topic should determine that (a) the technical approach has a reasonable chance of meeting the topic objective, (b) this approach is innovative, not routine, and (c) the firm has the capability to implement the technical approach, i.e. has or can obtain people and equipment suitable to the task.

Those responding to this solicitation should note the proposal preparation tips listed below:

- Read and follow all instructions contained in this solicitation, including the instructions in Section 8.0 of the DoD component to which you are applying.
- Use the free technical information services from DTIC and other information assistance organizations (Section 7.1 - 7.4).
- Mark proprietary information as instructed in Sec. 5.6.
- Limit your proposal to 25 pages (excluding Company Commercialization Report).
- Use a type size no smaller than 12 pitch or 11 point.
- Register your firm on the DoD Electronic Submission Web Site (http://www.dodsbir.net/submission) and, as instructed on the Web Site, prepare a Proposal Cover Sheet and Company Commercialization Report to be included in your proposal.

3.2 Proprietary Information

If information is provided which constitutes a trade secret, proprietary commercial or financial information, confidential personal information, or data affecting the national security, it will be treated in confidence to the extent permitted by law, provided it is clearly marked in accordance with Section 5.6.

3.3 Limitations on Length of Proposal

This solicitation is designed to reduce the investment of time and cost to small firms in preparing a formal proposal. Those who wish to respond must submit a direct, concise, and informative research or research and development proposal of no more than 25 pages, excluding Company Commercialization Report, (no type smaller than 11 point or 12 pitch on standard 8½" X 11" paper with one (1) inch margins, and a maximum of 6 lines per inch), *including Proposal Cover Sheet, Cost Proposal, and any enclosures or attachments.* Promotional and non-project related discussion is discouraged. Cover all items listed below in Section 3.4 in the order given. The space allocated to each will depend on the problem chosen and the principal investigator's approach. In the interest of equity, proposals in excess of the 25-page limitation (including attachments, appendices, or references, but excluding Company Commercialization Report will not be considered for review or award.

3.4 Phase I Proposal Format

a. Page Numbering. Number all pages of your proposal consecutively.

b. Proposal Cover Sheet. Register you firm on the password-protected DoD Electronic Submission Web Site (http://www.dodsbir.net/submission). As instructed on the Web Site, prepare a Proposal Cover Sheet, including a brief technical abstract of the proposed R&D project and a discussion of anticipated benefits and potential commercial applications. If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released on the Internet; therefore, do not include proprietary or classified information in these sections. Print out a hard copy of the Proposal Cover Sheet from the Web Site and include it, with the appropriate signatures, as the first two pages of your proposal. Also include a photocopy of the signed Proposal Cover Sheet in the additional copies of the proposal that you submit per Section 6.0 of this solicitation. If your firm does not yet have access to the Internet, contact the DoD SBIR/STTR Help Desk (800/382-4634) for assistance.

c. Identification and Significance of the Problem or Opportunity. Define the specific technical problem or opportunity addressed and its importance. (Begin on Page 3 of your proposal.)

d. Phase I Technical Objectives. Enumerate the specific objectives of the Phase I work, including the questions it will try to answer to determine the feasibility of the proposed approach.

e. Phase I Work Plan. Provide an explicit, detailed description of the Phase I approach. The plan should indicate what is planned, how and where the work will be carried out, a schedule of major events, and the final product to be delivered. The Phase I effort should attempt to determine the technical feasibility of the proposed concept. The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the total proposal.

f. Related Work. Describe significant activities directly related to the proposed effort, including any conducted by the principal investigator, the proposing firm, consultants, or others. Describe how these activities interface with the proposed project and discuss any planned coordination with outside sources. The proposal must persuade reviewers of the proposer's awareness of the state-of-the-art in the specific topic.

Describe previous work not directly related to the proposed effort but similar. Provide the following: (1) short description, (2) client for which work was performed (including individual to be contacted and phone number), and (3) date of completion.

g. Relationship with Future Research or Research and Development.

(1) State the anticipated results of the proposed approach if the project is successful.
(2) Discuss the significance of the Phase I effort in providing a foundation for Phase II research or research and development effort.

h. Commercialization Strategy. Describe in approximately one page your company's strategy for commercializing this technology in DoD and/or private sector markets. Provide specific information on the market need the technology will address and the size of the market. Also include a schedule showing the quantitative commercialization results from this SBIR project that your company expects to achieve and when (i.e., amount of additional investment, sales revenue, etc. - see items a through g in Section 5.4).

i. Key Personnel. Identify key personnel who will be involved in the Phase I effort including information on directly related education and experience. A concise resume of the principal investigator, including a list of relevant publications (if any), must be included.

j. Facilities/Equipment. Describe available instrumentation and physical facilities necessary to carry out the Phase I effort. Items of equipment to be purchased (as detailed in Reference A) shall be justified under this section. Also state whether or not the facilities where the proposed work will be performed meet environmental laws and regulations of federal, state (name), and local Governments for, but not limited to, the following groupings: airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices, and handling and storage of toxic and hazardous materials.

k. Consultants. Involvement of a university or other consultants in the project may be appropriate. If such involvement is intended, it should be described in detail and identified in Reference A. A minimum of two-thirds of the research and/or analytical work in Phase I, as measured by direct and indirect costs, must be carried out by the proposing firm, unless otherwise approved in writing by the contracting officer.

l. Prior, Current, or Pending Support of Similar Proposals or Awards. *Warning* -- While it is permissible, with proposal notification, to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous federal program solicitations, it is unlawful to enter into contracts or grants requiring essentially equivalent effort. If there is any question concerning this, it must be disclosed to the soliciting agency or agencies before award.

If a proposal submitted in response to this solicitation is substantially the same as another proposal that has been funded, is now being funded, or is pending with another Federal Agency or DoD Component or the same DoD Component, the proposer must so indicate on the Proposal Cover Sheet and provide the following information:

(1) Name and address of the Federal Agency(s) or DoD Component to which a proposal was submitted, will be submitted, or from which an award is expected or has been received.
(2) Date of proposal submission or date of award.
(3) Title of proposal.
(4) Name and title of principal investigator for each proposal submitted or award received.
(5) Title, number, and date of solicitation(s) under which the proposal was submitted, will be submitted, or under which award is expected or has been received.
(6) If award was received, state contract number.
(7) Specify the applicable topics for each SBIR proposal submitted or award received.

Note: If Section 3.4.1 does not apply, state in the proposal "No prior, current, or pending support for proposed work."

m. Cost Proposal. Complete the cost proposal in the format shown in Reference A of this solicitation for the Phase I effort only. Some items in Reference A may not apply to the proposed project. If such is the case, there is no need to provide information on each and every item. What matters is that enough information be provided to allow the DoD Component to understand how the proposer plans to use the requested funds if the contract is awarded.

(1) List all key personnel by name as well as by number of hours dedicated to the project as direct labor.

(2) Special tooling and test equipment and material cost may be included under Phases I and II. The inclusion of equipment and material will be carefully reviewed relative to need and appropriateness for the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the Government and should be related directly to the specific topic. These may include such items as innovative instrumentation and/or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with the DoD Component, unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by the DoD Component.

(3) Cost for travel funds must be justified and related to the needs of the project.

(4) Cost sharing is permitted for proposals under this solicitation; however, cost sharing is not required nor will it be an evaluation factor in the consideration of a Phase I proposal.

When a proposer is selected for award, the proposer should be prepared to submit further documentation to its DoD contracting officer to substantiate costs (e.g., a brief explanation of cost estimates for equipment, materials, and consultants or subcontractors).

n. Company Commercialization Report on Prior SBIR Awards. If your firm is submitting a Phase I or Phase II proposal, it is required to prepare a Company Commercialization Report through the password-protected DoD Electronic Submission Web Site (http://www.dodsbir.net/submission) As instructed on the Web Site, list in the Report the quantitative commercialization results of your firm's prior Phase II projects, including the items listed in section 5.4a through g of this solicitation (sales revenue, additional investment, etc.). The Web Site will then compare these results to the historical averages for the DoD SBIR Program. Once your firm has completed the Report on the Web Site, print out a hard copy of the Report, sign and date it, and attach it to the back of your proposal.

Your firm may also, at its option, attach to the back of the Report additional, explanatory material (no more than five pages) relating to the firm's record of commercializing its prior SBIR or STTR projects, such as: commercialization successes (in government and/or private sector markets) that are not fully captured in the quantitative results (e.g. commercialization resulting from your firm's prior Phase I projects); any mitigating factors that could account for low commercialization; and recent changes in the firm's organization or personnel designed to increase the firm's commercialization success. The Company Commercialization Report and additional explanatory material (if any) will not be counted toward the 25-page limit for Phase I proposals.

A Report showing that a firm has received no prior Phase II awards will not affect the firm's ability to obtain an SBIR award. Firms that do not yet have access to the Internet should contact the DoD SBIR Help Desk (800/382-4634) for assistance.

3.5 Bindings

Do not use special bindings or covers. Staple the pages in the upper left hand corner of each proposal.

3.6 Phase II Proposal Format

This solicitation is for Phase I only. A Phase II proposal can be submitted only by a Phase I awardee and only in response to a request from the agency; that is, Phase II is not initiated by a solicitation.

Each Phase II proposal must contain a Proposal Cover Sheet and a Company Commercialization Report (see Section 3.4b and n). In addition, each Phase II proposal must contain a two-page commercialization strategy, addressing the following questions:

(1) What is the first product that this technology will go into?

(2) Who will be your customers, and what is your estimate of the market size?

(3) How much money will you need to bring the technology to market, and how will you raise that money?

(4) Does your company contain marketing expertise and, if not, how do you intend to bring that expertise into the company?

(5) Who are your competitors, and what is your price and/or quality advantage over your competitors?

The commercialization strategy must also include a schedule showing the quantitative commercialization results from the Phase II project that your company expects to report in its Company Commercialization Report Updates one year after the start of Phase II, at the completion of Phase II, and after the completion of Phase II (i.e., amount of additional investment, sales revenue, etc. - see items a through g in section 5.4).

Additional instructions regarding Phase II proposal preparation and submission will be provided or made available by the DoD Components to all Phase I winners at time of Phase I contract award.

3.7 False Statements

Knowingly and willfully making any false, fictitious, or fraudulent statements or representations may be a felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to $10,000, up to five years in prison, or both.

4.0 METHOD OF SELECTION AND EVALUATION CRITERIA

4.1 Introduction

Phase I proposals will be evaluated on a competitive basis and will be considered to be binding for six (6) months from the date of closing of this solicitation unless the offeror states otherwise. If selection has not been made prior to the proposal's expiration date, offerors will be requested as to whether or not they want to extend their proposal for an additional period of time. Proposals meeting stated solicitation requirements will be evaluated by scientists or engineers knowledgeable in the topic area. Proposals will be evaluated first on their relevance to the chosen topic. A proposal that meets the goals of a solicitation topic but does not use the exact approach specified in the topic will be considered relevant. (Prospective proposers should contact the topic author as described in Section 1.5 to determine whether submission of such a proposal would be useful.)

Proposals found to be relevant will then be evaluated using the criteria listed in Section 4.2. Final decisions will be made by the DoD Component based upon these criteria and consideration of other factors including possible duplication of other work, and program balance. A DoD Component may elect to fund several or none of the proposed approaches to the same topic. In the evaluation and handling of proposals, every effort will be made to protect the confidentiality of the proposal and any evaluations. There is no commitment by the DoD Components to make any awards on any topic, to make a specific number of awards or to be responsible for any monies expended by the proposer before award of a contract.

For proposals that have been selected for contract award, a Government Contracting Officer will draw up an appropriate contract to be signed by both parties before work begins. Any negotiations that may be necessary will be conducted between the offeror and the Government Contracting Officer. It should be noted that only a duly appointed contracting officer has the authority to enter into a contract on behalf of the U.S. Government.

Phase II proposals will be subject to a technical review process similar to Phase I. Final decisions will be made by DoD Components based upon the scientific and technical evaluations and other factors, including a commitment for Phase III follow-on funding, the possible duplication with other research or research and development, program balance, budget limitations, and the potential of a successful Phase II effort leading to a product of continuing interest to DoD. DoD is not obligated to make any awards under Phase II or the Fast Track, and all awards are subject to the availability of funds. DoD is not responsible for any monies expended by the proposer before award of a contract.

Upon written request and after final award decisions have been announced, a debriefing will be provided to unsuccessful offerors on their proposals.

4.2 Evaluation Criteria - Phase I

The DoD Components plan to select for award those proposals offering the best value to the Government and the nation considering the following factors.

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

c. The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

Where technical evaluations are essentially equal in merit, cost to the Government will be considered in determining the successful offeror.

Technical reviewers will base their conclusions only on information contained in the proposal. It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be contained or referenced in the proposal.

4.3 Evaluation Criteria - Phase II

The Phase II proposal will be reviewed for overall merit based upon the criteria below.

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

c. The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

The reasonableness of the proposed costs of the effort to be performed will be examined to determine those proposals that offer the best value to the Government. Where technical evaluations are essentially equal in merit, cost to the Government will be considered in determining the successful offeror.

Phase II proposal evaluation may include on-site evaluations of the Phase I effort by Government personnel.

Fast Track Phase II proposals. Under the regular Phase II evaluation process, the above three criteria are each given roughly equal weight (with some variation across the DoD Components). For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals under a separate, expedited process in accordance with the above criteria, and will select these proposals for Phase II award provided:

(1) they meet or exceed a threshold of "technically sufficient" for criteria (a) and (b); and
(2) the project has substantially met its Phase I technical goals

(and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). Consistent with DoD policy, this process should result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects.

4.4 Assessing Commercial Potential of Proposals

A Phase I or Phase II proposal's commercial potential will be assessed using the following criteria:

a. The proposer's commercialization strategy (see Sections 3.4h and 3.6) and, as discussed in that strategy: (1) any commitments of additional investment in the technology during Phase II from the private sector, DoD prime contractors, non-SBIR/STTR DoD programs, or other sources, and (2) any Phase III follow-on funding commitments; and
b. The proposer's record of commercializing its prior SBIR and STTR projects, as shown in its Company Commercialization Report (see Section 3.4n). If the "Commercialization Achievement Index" shown on the first page of the Report is at the 5th percentile or below, the proposer will receive no more than half of the evaluation points available under evaluation criterion c in Sections 4.2 and 4.3 ("potential for commercialization"), unless the SBIR program manager for the DoD Component receiving the proposal (Army, Navy, Air Force, etc.) recommends, in writing, that an exception be made for that proposer, and the contracting officer approves the exception.

A Company Commercialization Report showing that the proposing firm has no prior Phase II awards will not affect the firm's ability to win an award. Such a firm's proposal will be evaluated for commercial potential based on its commercialization strategy in item a, above.

4.5 SBIR Fast Track

a. In General. On a pilot basis, the DoD SBIR program has implemented a streamlined Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort (as well as for the interim effort between Phases I and II). The purpose is to focus SBIR funding on those projects that are most likely to be developed into viable new products that DoD and others will buy and that will thereby make a major contribution to U.S. military and/or economic capabilities.

Outside investors, as defined in <u>DoD's Fast Track Guidance</u> (Reference F), may include such entities as another company, a venture capital firm, an individual investor, or a non-SBIR, non-STTR government program; they do not include the owners of the small business, their family members, and/or affiliates of the small business.

As discussed in detail below, projects that obtain matching funds from outside investors and thereby qualify for the SBIR Fast Track will (subject to the qualifications described herein):

(1) Receive interim funding of $30,000 to $50,000 between Phases I and II;
(2) Be evaluated for Phase II award under a separate, expedited process; and
(3) Be selected for Phase II award provided they meet or exceed a threshold of "technically sufficient" and have substantially met their Phase I technical goals (and assuming other programmatic factors are met), as described in Section 4.3.

Consistent with DoD policy, this process should prevent any significant gaps in funding between Phases I and II for Fast Track projects, and result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects.

All DoD Components administer the Fast Track according to the procedures in this section, except for BMDO. BMDO administers slightly different procedures that have been approved by the Under Secretary of Defense for Acquisition and Technology - see the BMDO proposal instructions in Section 8 of this solicitation.

b. How To Qualify for the SBIR Fast Track. To qualify for the SBIR Fast Track, a company must submit a Fast Track application within 150 days after the effective start date of its Phase I contract, unless a different deadline for Fast Track applications is specified by the DoD Component funding the project (see the Component's introductory page in Section 8 of this solicitation - the deadlines range from 120 to 180 days). The company is encouraged to discuss the application with its Phase I technical monitor; however, it need not wait for an invitation from the technical monitor to submit either a Fast Track application or a Fast Track Phase II proposal.

A Fast Track application consists of the following items:

(1) A completed Fast Track application form, found at Reference B of this solicitation. On the application form, the company and its outside investor must:
   (a) State that the outside investor will match both interim and Phase II SBIR funding, in cash, contingent on the company's selection for Phase II award, as described on the form at Reference B.

The matching rates needed to qualify for the Fast Track are as follows:

- For companies that have never received a Phase II SBIR award from DoD or any other federal agency, the minimum matching rate is 25 cents for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $187,500.)
- For all other companies, the minimum matching rate is 1 dollar for every SBIR dollar. (For example, if such a company receives interim and Phase II SBIR funding that totals $750,000, it must obtain matching funds from the investor of $750,000.)

(b) Certify that the outside funding proposed in the application qualifies as a "Fast Track investment," and the investor qualifies as an "outside investor," as defined in DoD Fast Track Guidance (Reference F).

(2) A letter from the outside investor to the company, containing:

(a) A commitment to match both interim and Phase II SBIR funding, in cash, contingent on the company's selection for Phase II award, as discussed on the form at Reference B.

(b) A brief statement (less than one page) describing that portion of the effort that the investor will fund. The investor's funds may pay for additional research and development on the company's SBIR project or, alternatively, they may pay for other activities not included in the Phase II contract's statement of work, provided these activities further the development and/or commercialization of the technology (e.g., marketing).

(c) A brief statement (less than one page) describing (i) the investor's experience in evaluating companies' ability to successfully commercialize technology; and (ii) the investor's assessment of the market for this particular SBIR technology, and of the ability of the company to bring this technology to market.

(3) A concise statement of work for the interim SBIR effort (less than four pages) and detailed cost proposal (less than one page). Note: if the company has already negotiated an interim effort (e.g., an "option") of $30,000 to $50,000 with DoD as part of its Phase I contract, it need only cite that section of its contract, and need not submit an additional statement of work and cost proposal.

The company should send its Fast Track application to its Phase I technical monitor, with copies to the appropriate Component program manager and to the DoD SBIR program manager, as indicated on the back of the application form.

Also, in order to qualify for the Fast Track, the company:

(1) Must submit its Phase II proposal within 180 days after the effective start date of its Phase I contract, unless a different deadline for Fast Track Phase II proposals is specified by the DoD Component funding the contract (see the Component's introductory page in Section 8 of this solicitation - the deadlines range from 150 days to 210 days).

(2) Must submit its Phase I final report by the deadline specified in its Phase I contract, but not later than 210 days after the effective start date of the contract (for the Air Force, not later than 270 days).

(3) Must certify, within 45 days after being notified that it has been selected for Phase II award, that the entire amount of the matching funds from the outside investor has been transferred to the company. Certification consists of a letter, signed by both the company and its outside investor, stating that "$_____ in cash has been transferred to our company from our outside investor in accord with the SBIR Fast Track procedures." The letter must be sent to the DoD contracting office along with a copy of the company's bank statement showing the funds have been deposited. IMPORTANT: If the DoD contracting office does not receive, within the 45 days, this certification showing the transfer of funds, the company will be ineligible to compete for a Phase II award not only under the Fast Track but also under the regular Phase II competition, unless a specific written exception is granted by the Component's SBIR program manager. Before signing the certification letter, the company and investor should read the cautionary note at Section 3.7. If the outside investor is a non-SBIR/non-STTR DoD program, it must provide a line of accounting within the 45 days that can be accessed immediately.

Failure to meet these conditions in their entirety and within the time frames indicated will generally disqualify a company from participation in the SBIR Fast Track. Deviations from these conditions must be approved in writing by the contracting office.

c. Benefits of Qualifying for the Fast Track. If a project qualifies for the Fast Track:

(1) It will receive interim SBIR funding of $30,000 to $50,000, commencing approximately at the end of Phase I. Consistent with DoD policy, the vast majority of projects that qualify for the Fast Track should receive interim SBIR funding. However, the DoD contracting office has the discretion and authority, in any particular instance, to deny interim funding when doing so is in the Government's interest (e.g., when the project no longer meets a military need or the statement of work does not meet the threshold of "technically sufficient" as described in Section 4.3).

(2) DoD will evaluate the Fast Track Phase II proposal under a separate, expedited process, and will select the proposal for Phase II award provided it meets or exceeds a threshold of "technically sufficient" for evaluation criteria (a) and (b), as described in Section 4.3 (assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Consistent with DoD policy, this process should result in a significantly higher percentage of Fast Track projects obtaining Phase II award than non-Fast Track projects. However, DoD is not obligated, in any particular instance, to award a Phase II contract to a Fast Track project, and DoD is not responsible for any funds expended by the proposer before award of a contract.

(3) It will receive notification, no later than ten weeks after the completion of its Phase I project, of whether it has been selected for a Phase II award.

(4) If selected, it will receive its Phase II award within an average of five months from the completion of its Phase I project.

d. Additional Reporting Requirement. In the company's final Phase II progress report, it must include a brief accounting (in the company's own format) of how the investor's funds were expended to support the project.

5.0 CONTRACTUAL CONSIDERATIONS

Note: Eligibility and Limitation Requirements (Section 1.3) Will Be Enforced

5.1 Awards (Phase I)

a. Number of Phase I Awards. The number of Phase I awards will be consistent with the agency's RDT&E budget, the number of anticipated awards for interim Phase I modifications, and the number of anticipated Phase II contracts. No Phase I contracts will be awarded until all qualified proposals (received in accordance with Section 6.2) on a specific topic have been evaluated. All proposers will be notified of selection/non-selection status for a Phase I award no later than July 12, 2000. *The DoD Components anticipate making 500 Phase I awards from this solicitation.* On average, 1 in 8 Phase I proposals receive funding.

b. Type of Funding Agreement. All winning proposals will be funded under negotiated contracts and may include a fee or profit. The firm fixed price or cost plus fixed fee type contract will be used for all Phase I projects (see Section 5.5). *Note: The firm fixed price contract is the preferred type for Phase I.*

c. Average Dollar Value of Awards. DoD Components will make Phase I awards to small businesses typically on a one-half person-year effort over a period generally not to exceed six months (subject to negotiation). PL 102-564 allows agencies to award Phase I contracts up to $100,000 without justification. The typical size of award varies across the DoD Components; it is therefore important for a proposer to read the introductory page of the Component to which it is applying (in Section 8.0) for any specific instructions regarding award size.

d. Timing of Phase I Awards. Across DoD, the median time between the date that the SBIR solicitation closes and the award of a Phase I contract is 4 months.

5.2 Awards (Phase II)

a. Number of Phase II Awards. The number of Phase II awards will depend upon the results of the Phase I efforts and the availability of funds. *The DoD Components anticipate that approximately 40 percent of its Phase I awards will result in Phase II projects.*

b. Type of Funding Agreement. Each Phase II proposal selected for award will be funded under a negotiated contract and may include a fee or profit. The firm fixed price or cost plus fixed fee type contract will be used for all Phase I projects. *Note: The firm fixed price, level-of-effort contract is the preferred type for Phase II (see sample on our DoD SBIR/STTR Web Site at http://www.acq.osd.mil/sadbu/sbir/contract.html).*

c. Average Dollar Value of Awards. Phase II awards will be made to small businesses based on results of the Phase I efforts and the scientific, technical, and commercial merit of the Phase II proposal. Average Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation). PL 102-564 states that the Phase II awards may be up to $750,000 each without justification. See special instructions for each DoD Component in Section 8.

d. Timing of Phase II Awards. Across DoD, the median time between DoD's receipt of a Phase II proposal and the award of a Phase II contract is 6.5 months.

5.3 Phase I Report

a. Content. A final report is required for each Phase I project. The report must contain in detail the project objectives, work performed, results obtained, and estimates of technical feasibility. A completed SF 298, "Report Documentation Page", will be used as the first page of the report. (A blank SF298 is provided in Reference E of this solicitation.) In addition, monthly status and progress reports may be required by the DoD agency.

b. Preparation.

(1) If desirable, language used by the company in its

Phase II proposal to report Phase I progress may also be used in the final report.

(2) For each unclassified report, the company submitting the report should fill in block 12a (Distribution/Availability Statement) of the SF298, "Report Documentation Page" with one of the following statements:
   (a) Approved for public release; distribution unlimited.
   (b) Distribution authorized to U.S. Government Agencies only; contains proprietary information.

   Note: The sponsoring DoD activity, after reviewing the company's entry in block 12a, has final responsibility for assigning a distribution statement.

(3) Block 13 (Abstract) of the SF 298, "Report Documentation Page") must include as the first sentence, "Report developed under SBIR contract for topic [insert solicitation topic number]". The abstract must identify the purpose of the work and briefly describe the work carried out, the finding or results and the potential applications of the effort. Since the abstract will be published by the DoD, it must not contain any proprietary or classified data.

(4) Block 14 (Subject Terms) of the SF 298 must include the term "SBIR Report".

c. Submission. The company shall submit FIVE COPIES of the final report on each Phase I project to the DoD in accordance with the negotiated delivery schedule. Delivery will normally be within thirty days after completion of the Phase I technical effort. The company shall, at the same time, submit ONE ADDITIONAL COPY of each report directly to the DTIC (unless instructed otherwise by the sponsoring DoD activity in the Phase I contract):

ATTN: DTIC-OCA
Defense Technical Information Center
8725 John J Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218.

If the report is classified, the sponsoring DoD activity will provide special submission instructions. *Note: The sponsoring DoD activity has final responsibility for ensuring that the company or the DoD activity provide DTIC with all applicable Phase I and Phase II technical reports, classified and unclassified, developed under SBIR contract, per DoD Directive 3200.12 (http://web7.whs.osd.mil/dodiss/directives/direct2.htm).*

5.4 Commercialization Updates in Phase II

If, after completion of Phase I, the contractor is awarded a Phase II contract, the contractor shall be required to periodically update the following commercialization results of the Phase II project through the Web Site at www.dodsbir.net/submission:

a. Sales revenue from new products and non-R&D services resulting from the Phase II technology;
b. Additional investment from sources other than the federal SBIR/STTR program in activities that further the development and/or commercialization of the Phase II technology;
c. The portion of additional investment representing clear and verifiable investment in the future commercialization of the technology (i.e., "hard investment");
d. Whether the Phase II technology has been used in a fielded DoD system or acquisition program and, if so, which system or program;
e. The number of patents resulting from the contractor's participation in the SBIR/STTR program;
f. Growth in number of firm employees; and
g. Whether the firm has completed an initial public offering of stock (IPO) resulting, in part, from the Phase II project.

These updates on the project will be required one year after the start of Phase II, at the completion of Phase II, and subsequently when the contractor submits a new SBIR or STTR proposal to DoD. Firms that do not submit a new proposal to DoD will be asked to provide updates on an annual basis after the completion of Phase II.

5.5 Payment Schedule

The specific payment schedule (including payment amounts) for each contract will be incorporated into the contract upon completion of negotiations between the DoD and the successful Phase I or Phase II offeror. Successful offerors may be paid periodically as work progresses in accordance with the negotiated price and payment schedule. Phase I contracts are primarily fixed price contracts, under which monthly payments may be made. The contract may include a separate provision for payment of a fee or profit. Final payment will follow completion of contract performance and acceptance of all work required under the contract. Other types of financial assistance may be available under the contract.

5.6 Markings of Proprietary or Classified Proposal Information

The proposal submitted in response to this solicitation may contain technical and other data which the proposer does not want disclosed to the public or used by the Government for any purpose other than proposal evaluation.

Information contained in unsuccessful proposals will remain the property of the proposer except for the Proposal Cover Sheet. The Government may, however, retain copies of all proposals. Public release of information in any proposal submitted will be subject to existing statutory and regulatory requirements.

If proprietary information is provided by a proposer in a proposal which constitutes a trade secret, proprietary commercial or financial information, confidential personal information or data affecting the national security, it will be treated in confidence, to the extent permitted by law, provided this information is clearly marked by the proposer with the term "confidential proprietary information" and provided that the following legend which appears on the Proposal Cover Sheet (Section 3.4b) of the proposal is completed:

"For any purpose other than to evaluate the proposal, the data referenced below shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed in whole or in part, provided that if a contract is awarded to the proposer as a result of or in connection with the submission of this data, the Government shall have the right to duplicate, use or disclose the data to the extent provided in the contract. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction is contained on the pages of the proposal listed on the line below."

Any other legend may be unacceptable to the Government and may constitute grounds for removing the proposal from further consideration and without assuming any liability for inadvertent disclosure. The Government will limit dissemination of properly marked information to within official channels.

In addition, each page of the proposal containing proprietary data which the proposer wishes to restrict must be marked with the following legend:

"Use or disclosure of the proposal data on lines specifically identified by asterisk (*) are subject to the restriction on the Cover Sheet of this proposal."

If all of the information on a particular page is proprietary, the proposer should so note by including the word "PROPRIETARY" in both the header and footer on that page.

The Government assumes no liability for disclosure or use of unmarked data and may use or disclose such data for any purpose.

In the event properly marked data contained in a proposal in response to this solicitation is requested pursuant to the Freedom of Information Act, 5 USC 552, the proposer will be advised of such request and prior to such release of information will be requested to expeditiously submit to the DoD Component a detailed listing of all information in the proposal which the proposer believes to be exempt from disclosure under the Act. Such action and cooperation on the part of the proposer will ensure that any information released by the DoD Component pursuant to the Act is properly determined.

Those proposers that have a classified facility clearance may submit classified material with their proposal. Any classified material shall be marked and handled in accordance with applicable regulations. Arbitrary and unwarranted use of this restriction is discouraged. Offerors must follow the Industrial Security Manual for Safeguarding Classified Information (DoD 5220.22M) procedures for marking and handling classified material.

5.7 Copyrights

To the extent permitted by statute, the awardee may copyright (consistent with appropriate national security considerations, if any) material developed with DoD support. DoD receives a royalty-free license for the Federal Government and requires that each publication contain an appropriate acknowledgment and disclaimer statement.

5.8 Patents

Small business firms normally may retain the principal worldwide patent rights to any invention developed with Government support. The Government receives a royalty-free license for its use, reserves the right to require the patent holder to license others in certain limited circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically. To the extent authorized by 35 USC 205, the Government will not make public any information disclosing a Government-supported invention for a period of five years to allow the awardee to pursue a patent.

5.9 Technical Data Rights

Rights in technical data, including software, developed under the terms of any contract resulting from proposals submitted in response to this solicitation generally remain with the contractor, except that the Government obtains a royalty-free license to use such technical data only for Government purposes during the period commencing with contract award and ending five years after completion of the project under which the data were generated. Upon expiration of the five-year restrictive license, the Government has unlimited rights in the SBIR data. During the license period, the Government may not release or disclose SBIR data to any person other than its support services contractors except: (1) For evaluational purposes; (2) As expressly permitted by the contractor; or (3) A use, release, or disclosure that is necessary for emergency repair or overhaul of items operated by the Government. See FAR clause 52.227-20, "Rights in Data - SBIR Program" and DFARS 252.227-7018, "Rights in Noncommercial Technical Data and Computer Software -- SBIR Program."

5.10 Cost Sharing

Cost sharing is permitted for proposals under this solicitation; however, cost sharing is not required nor will it be an evaluation factor in the consideration of any Phase I proposal.

5.11 Joint Ventures or Limited Partnerships

Joint ventures and limited partnerships are eligible provided the entity created qualifies as a small business as defined in Section 2.2 of this solicitation.

5.12 Research and Analytical Work

a. For Phase I a minimum of two-thirds of the research and/or analytical work must be performed by the proposing firm unless otherwise approved in writing by the contracting officer.

b. For Phase II a minimum of one-half of the research and/or analytical work must be performed by the proposing firm, unless otherwise approved in writing by the contracting officer.

The percentage of work is usually measured by both direct and indirect costs, although proposers planning to subcontract a significant fraction of their work should verify how it will be measured with their contracting officer during contract negotiations.

5.13 Contractor Commitments

Upon award of a contract, the contractor will be required to make certain legal commitments through acceptance of Government contract clauses in the Phase I contract. The outline that follows is illustrative of the types of provisions required by the Federal Acquisition Regulations that will be included in the Phase I contract. This is not a complete list of provisions to be included in Phase I contracts, nor does it contain specific wording of these clauses. Copies of complete general provisions will be made available prior to award.

a. Standards of Work. Work performed under the contract must conform to high professional standards.

b. Inspection. Work performed under the contract is subject to Government inspection and evaluation at all reasonable times.

c. Examination of Records. The Comptroller General (or a fully authorized representative) shall have the right to examine any directly pertinent records of the contractor involving transactions related to this contract.

d. Default. The Government may terminate the contract if the contractor fails to perform the work contracted.

e. Termination for Convenience. The contract may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the contractor will be compensated for work performed and for reasonable termination costs.

f. Disputes. Any dispute concerning the contract which cannot be resolved by agreement shall be decided by the contracting officer with right of appeal.

g. Contract Work Hours. The contractor may not require an employee to work more than eight hours a day or forty hours a week unless the employee is compensated accordingly (that is, receives overtime pay).

h. Equal Opportunity. The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.

i. Affirmative Action for Veterans. The contractor will not discriminate against any employee or applicant for employment because he or she is a disabled veteran or veteran of the Vietnam era.

j. Affirmative Action for Handicapped. The contractor will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.

k. Officials Not to Benefit. No member of or delegate to Congress shall benefit from the contract.

l. Covenant Against Contingent Fees. No person or agency has been employed to solicit or secure the contract upon an understanding for compensation except bona fide employees or commercial agencies maintained by the contractor for the purpose of securing business.

m. Gratuities. The contract may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the contract.

n. Patent Infringement. The contractor shall report each notice or claim of patent infringement based on the performance of the contract.

o. Military Security Requirements. The contractor shall safeguard any classified information associated with the contracted work in accordance with applicable regulations.

p. American Made Equipment and Products. When purchasing equipment or a product under the SBIR funding agreement, purchase only American-made items whenever possible.

5.14 Contractor Registration [NEW]

Before DoD can award a contract to a successful proposer under this solicitation, the proposer must be registered in the DoD Central Contractor Registration database. To register, see http://www.ccr2000.com/ or call 1-888-227-2423.

5.15 Additional Information

a. General. This Program Solicitation is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR contract, the terms of the contract are controlling.

b. Small Business Data. Before award of an SBIR contract, the Government may request the proposer to submit certain organizational, management, personnel, and financial information to confirm responsibility of the proposer.

c. Proposal Preparation Costs. The Government is not responsible for any monies expended by the proposer before award of any contract.

d. Government Obligations. This Program Solicitation is not an offer by the Government and does not obligate the Government to make any specific number of awards. Also, awards under this program are contingent upon the availability of funds.

e. Unsolicited Proposals. The SBIR Program is not a substitute for existing unsolicited proposal mechanisms. Unsolicited proposals will not be accepted under the SBIR Program in either Phase I or Phase II.

f. Duplication of Work. If an award is made pursuant to a proposal submitted under this Program Solicitation, the contractor will be required to certify that he or she has not previously been, nor is currently being, paid for essentially equivalent work by an agency of the Federal Government.

g. Classified Proposals. If classified work is proposed or classified information is involved, the offeror to the solicitation must have, or obtain, security clearance in accordance with the Industrial Security Manual for Safeguarding Classified Information (DoD 5220.22M). The Manual is available on-line at **http://www.dis.mil** or in hard copy from:

Defense Investigative Service
1340 Braddock Place
Alexandria, VA 22314
Phone: (703) 325-5324

6.0 SUBMISSION OF PROPOSALS

An original plus (4) copies of each proposal or modification will be submitted, in a single package, as described below, unless otherwise stated by specific instructions in Section 8.0.

NOTE: EACH PROPOSAL MUST CONTAIN A COMPLETED PROPOSAL COVER SHEET AND COMPANY COMMERCIALIZATION REPORT (see Section 3.4b and n).

6.1 Address

Each proposal or modification thereof shall be submitted in sealed envelopes or packages addressed to that DoD Component address which is identified for the specific topic in that Component's subsection of Section 8.0 to this solicitation.

The name and address of the offeror, the solicitation number, the topic number for the proposal, and the time and date specified for proposal receipt must be clearly marked on the outside of the envelope or package. To protect your proposal against rough handling, damage in the mail, and the possibility of unauthorized disclosures, it is recommended that your proposal be double-wrapped and that both the inner and outer envelopes or wrappings be clearly marked.

Offerors using commercial carrier services shall ensure that the proposal is addressed and marked on the outermost envelope or wrapper as prescribed above.

Mailed or handcarried proposals must be delivered to the address indicated for each topic. Secured packaging is mandatory. The DoD Component cannot be responsible for the processing of proposals damaged in transit.

All copies of a proposal must be sent in the same package. Do not send separate information copies or several packages containing parts of the single proposal.

6.2 Deadline of Proposals

Deadline for receipt of proposals at the DoD Component is 3:00 p.m. local time, January 12, 2000. Any proposal received at the office designated in the solicitation after the exact time specified for receipt will not be considered unless it is received before an award is made, and:

(a) it was sent by registered or certified mail not later than January 5, 2000;

(b) it was sent by mail or hand-carried (including delivery by a commercial carrier) and it is determined by the Government that the late receipt was due primarily to Government mishandling after receipt at the Government installation; or

(c) it was sent by U.S. Postal Service Express Mail Next Day Service-Post Office to Addressee, not later than

5:00 p.m. at the place of mailing on January 10, 2000.

Note: There are no other provisions for late receipt of proposals under this solicitation.

The only acceptable evidence to establish the date of mailing of a late proposal sent either by registered or certified mail is the U. S. Postal Service postmark on the envelope or wrapper and on the original receipt from the U.S. Postal Service. Both postmarks must show a legible date or the proposal shall be processed as if mailed late. "Postmark" means a printed, stamped, or otherwise placed impression (exclusive of a postage meter machine impression) that is readily identifiable without further action as having been supplied and affixed by employees of the U. S. Postal Service on the date of mailing. Therefore, offerors or respondents should request the postal clerk to place a legible hand cancellation bull's-eye postmark on both the receipt and the envelope or wrapper. Acceptable evidence to establish the time of receipt at the Government installation includes the time/date stamp of the installation on the proposal wrapper, other documentary evidence of receipt maintained by the installation, or oral testimony or statements of Government personnel. The only acceptable evidence to establish the date of mailing of a late proposal sent by Express Mail Next Day Service-Post Office to Addressee is the date entered by the post office receiving clerk on the "Express Mail Next Day Service-Post Office to Addressee" label and the postmark on both the envelope or wrapper and on the original receipt from the U.S. Postal Service. Therefore, offerors should request the postal clerk to place a legible hand cancellation bull's eye postmark on both the receipt and the envelope or wrapper.

Proposals may be withdrawn by written notice or a telegram received at any time prior to award. Proposals may also be withdrawn in person by an offeror or his authorized representative, provided his identity is made known and he signs a receipt for the proposal. *(Note: the term telegram includes mailgrams.)*

Any modification or withdrawal of a proposal is subject to the same conditions outlined above. Any modification may not make the proposal longer than 25 pages (excluding Company Commercialization Report). Notwithstanding the above, a late modification of an otherwise successful proposal which makes its terms more favorable to the Government will be considered at any time it is received and may be accepted.

6.3 Notification of Proposal Receipt

Proposers desiring notification of receipt of their proposal must complete and include a self-addressed stamped envelope and a copy of the notification form (Reference C) in the back of this brochure. If multiple proposals are submitted, a separate form and envelope is required for each. Notification of receipt of a proposal by the Government does not by itself constitute a determination that the proposal was received on time or not. The determination of timeliness is solely governed by the criteria set forth in Section 6.2.

6.4 Information on Proposal Status

Evaluation of proposals and award of contracts will be expedited, but no information on proposal status will be available until the final selection is made. However, contracting officers may contact any and all qualified proposers prior to contract award.

6.5 Debriefing of Unsuccessful Offerors

An unsuccessful offeror that submits a written request for a debriefing within 30 days of being notified that its proposal was not selected for award will be provided a debriefing. The written request should be sent to the DoD organization that provided such notification to the offeror. Be advised that an offeror that fails to submit a timely request is not entitled to a debriefing, although untimely debriefing requests may be accommodated at the Government's discretion.

6.6 Correspondence Relating to Proposals

All correspondence relating to proposals should cite the SBIR solicitation number and specific topic number and should be addressed to the DoD Component whose address is associated with the specific topic number.

7.0 SCIENTIFIC AND TECHNICAL INFORMATION ASSISTANCE

7.1 DoD Technical Information Services Available

The Defense Technical Information Center (DTIC) provides background technical information services at no cost, which can assist SBIR/STTR participants in proposal preparation, product development, marketing and networking.

The DTIC SBIR/STTR web site provides the following free services at **http://www.dtic.mil/dtic/sbir**:

1. **Public STINET:** DTIC's online technical database.
2. **OLTIPS** has bibliographies for each DoD SBIR and STTR topic
3. **Technical Reports**: Up to ten hard copy technical reports are available at no cost from DTIC during an SBIR, or a combined SBIR/STTR, solicitation period. Additional reports can be charged to a credit card or deposit account.
4. **TRAIL** provides biweekly listings of new DTIC accessions matching the recipient's interests
5. **SITIS** answers specific technical questions concerning DoD topic descriptions,.

DTIC is a major component of the DoD Scientific and Technical Information Program, managing the technical information resulting from DoD-funded research and development **(http://www.dtic.mil).** DTIC also provides access to specialized information services. MATRIS is the focal point for information on manpower, training systems, human performance, and human factors **(http://dticam.dtic.mil).** The Information Analysis Centers (IACs) are the DoD centers of expertise concerned with engineering, technical and scientific documents and databases worldwide **(http://www.dtic.mil/iac/).**

Call or visit (by prearrangement) DTIC at the location most convenient to you.

ATTN: DTIC-SBIR
Defense Technical Information Center
8725 John J Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218
Ph: (800) 363-7247
Fax: (703) 767-8228
Email: sbir@dtic.mil
www: http://www.dtic.mil/dtic/sbir

ATTN: DTIC-BRNB
DTIC Northeastern Regional Office
Building 1103
5 Wright Street
Hanscom AFB, MA 01731-3012
Ph: (781) 377-2413
Fax: (781) 377-5627
Email: boston@dtic.mil

DTIC Southwestern Regional Office
ATTN: DTIC-BRNA
AFRL-PSO/TL
3550 Aberdeen Ave, SE
Kirtland AFB, NM 87117-5776
Ph: (505) 846-6797
Fax: (505) 846-6799
Email: albuq@dtic.mil

ATTN: DTIC-BRND
DTIC Midwestern Regional Office
Bldg. 196, Area B
2261 Monahan Way
Wright-Patterson AFB, OH 45433-7022
Ph: (937) 255-7905
Fax: (937) 656-7002
Email: dayton@dtic.mil

ATTN: DTIC-BRNL
DTIC Western Regional Office
Bldg. 80
2420 Vela Way, Suite 1467
El Segundo, CA 90245-4659
Ph: (310) 363-8980
Fax: (310) 363-8972
Email: losangel@dtic.mil

7.2 Other Technical Information Assistance Sources

Other sources provide technology search and/or document services and can be contacted directly for service and cost information. These include:

National Technical Information Services
5285 Port Royal Road
Springfield, VA 22161
Ph: (703) 605-6000 or (800) 553-6847
Fax: (703) 605-6900
Email: info@ntis.fedworld.gov
www: www.ntis.gov

University of Southern California
Office of Patents and Copyright Administration
3716 South Hope Street, Suite 313
Los Angeles, CA 90007-4344
Ph: (213) 743-2282
Fax: (213) 744-1832
www: www.usc.edu/dept/Patents_Copyrights

Center for Technology Commercialization
1400 Computer Drive
Westborough, MA 01581-5043
Ph: (508) 870-0042
Fax: (508) 366-0101
www: www.ctc.org

Great Lakes Technology Transfer Center/Battelle
25000 Great Northern Corporate Center, Suite 260
Cleveland, OH 44070

Ph:	(440) 734-0094
Fax:	(440) 734-0686
www:	www.battelle.org/glitec/

Midcontinent Technology Transfer Center
Texas Engineering Experiment Station
The Texas A&M University System
301 Tarrow
College Station, TX 77843-8000

Ph:	(409) 845-2907
Fax:	(409) 845-3559
www:	www.tedd.org

Mid-Atlantic Technology Applications Center
University of Pittsburgh
3200 Forbes Avenue
Pittsburgh, PA 15260

Ph:	(412) 383-2500
Fax:	(412) 383-2595
www:	www.mtac.pitt.edu

Southern Technology Application Center
University of Florida
1900 SW 34th Street, Suite 206
Gainesville, FL 32608-1260

Ph:	(352) 294-7822
Fax:	(352) 294-7802
www:	www.state.fl.us/stac/

Federal Information Exchange, Inc.
555 Quince Orchard Road, Suite 360
Gaithersburg, MD 20878

Ph:	(301) 975-0103
Ph:	(800) 875-2562
Fax:	(301) 975-0109
www:	www.rams-fie.com

7.3 DoD Counseling Assistance Available

Small business firms interested in participating in the SBIR Program may seek general administrative guidance from small and disadvantaged business utilization specialists located in various Defense Contract Management activities throughout the continental United States. These specialists are available to discuss general administrative requirements to facilitate the submission of proposals and ease the entry of the small high technology business into the Department of Defense marketplace. The small and disadvantaged business utilization specialists are expressly prohibited from taking any action which would give an offeror an unfair advantage over others, such as discussing or explaining the technical requirements of the solicitation, writing or discussing technical or cost proposals, estimating cost or any other actions which are the offerors responsibility as outlined in this solicitation. (See Reference D at the end of this solicitation for a complete listing, with telephone numbers, of Small and Disadvantaged Business Utilization Specialists assigned to these activities.)

7.4 State Assistance Available

Many states have established programs to provide services to those small firms and individuals wishing to participate in the Federal SBIR Program. These services vary from state to state, but may include:

- Information and technical assistance;
- Matching funds to SBIR recipients;
- Assistance in obtaining Phase III funding.

Contact your State Government Office of Economic Development for further information.

8.0 TECHNICAL TOPICS

Section 8 contains detailed topic descriptions outlining the technical areas in which DoD Components request proposals for innovative R&D from small businesses. Topics for each participating DoD Component are listed and numbered separately. At least 20 percent of the Navy, Air Force, and Chemical Biological Defense topics either are authored by a DoD acquisition program (e.g., New Attack Submarine, Abrams Tank) or are of significant interest to such a program, as noted in the text of the topic. These acquisition programs are potentially important end customers for innovative new products resulting from SBIR projects. Information on how to contact these programs will be posted on the DoD SBIR/STTR Web Site (http://www.acq.osd.mil/sadbu/sbir).

Each DoD Component Topic Section contains topic descriptions, addresses of organizations to which proposals are to be submitted, and special instructions for preparing and submitting proposals to organizations within the Component. Read and follow these instructions carefully to help avoid administrative rejection of your proposal.

Many of the topics in Section 8 contain references to technical literature or military standards, which may be accessed as follows:

- References with "AD" numbers are available from DTIC, by calling 800/DoD-SBIR or sending an e-mail message to sbir@dtic.mil
- References with "MIL-STD" numbers are available from the Department of Defense Single Stock Part for Military Specifications, Standards, and Related Publications at http://www.dodssp.daps.mil.
- Other references can be found in your local library or at locations mentioned in the reference.

CHEMICAL AND BIOLOGICAL DEFENSE PROGRAM

General Information

In response to Congressional interest in the readiness and effectiveness of U.S. Nuclear, Biological and Chemical (NBC) warfare defenses, Title XVII of the National Defense Authorization Act for Fiscal Year 1994 (Public Law 103-160) required the Department of Defense (DoD) to consolidate management and oversight of the Chemical and Biological Defense (CBD) program into a single office within the Office of the Secretary of Defense. The public law also directed the Secretary of Defense designate the Army as the Executive Agent for coordination and integration of the CBD program. The executive agent for the Small Business Innovation Research (SBIR) portion of the program is the Army Research Office-Washington (ARO-W).

The objective of the DoD CBD program is to enable U.S. forces to survive, fight and win in chemical and biological warfare environments. Numerous rapidly-changing factors continually influence the program and its management. These forces include declining DoD resources, planning for warfighting support to numerous regional threat contingencies, the evolving geopolitical environment resulting from the breakup of the Soviet Union, U.S. participation in the Chemical Weapons Convention, and the continuing global proliferation of chemical and biological weapons. Improved defensive capabilities are essential in order to minimize the impact of such weapons. U.S. forces require aggressive, realistic training and the finest equipment available that allows them to avoid contamination, if possible, and to protect, decontaminate and sustain operations throughout the non-linear battlespace. Further information about the DoD CBD Program (and related programs) is available at the DoD Counterproliferation and Chemical Biological Defense Homepage at Internet address http://www.acq.osd.mil/cp/.

The overall objective of the CBD SBIR program is to improve the transition or transfer of innovative CBD technologies between DoD components and the private sector for mutual benefit. The CBD program includes those technology efforts that maximize a strong defensive posture in a biological or chemical environment using passive and active means as deterrents. These technologies include chemical and biological detection; information assessment, which includes identification, modeling and intelligence; contamination avoidance; and protection of both individual warfighters and equipment.

Tri-Service Program

The U.S. Army, Navy, and Air Force have developed separate SBIR topics for research and development in various CBD areas of interest. As lead agency, the Army will coordinate Tri-Service efforts related to the receipt, evaluation, selection, and award of Phase I proposals and similarly for potential follow-on Phase II efforts under this program.

Submitting Your Phase I CBD SBIR Proposal

The CBD SBIR Program now requires that a proposing firm have Internet access via the World Wide Web, in order to submit its Phase I SBIR proposal – in its entirety – online. You must also submit an original and two copies via mail or other delivery means (See 4. Postal Submission below). Please review and follow these procedures when submitting each Phase I proposal:

1. Online Submission: The entire proposal including all forms must be submitted via the Internet. Visit the Army SBIR Website at http:/www.aro.army.mil/arowash/rt to get started. This page has a link to the DoD-wide SBIR proposal submission system (available directly at http://www.dodsbir.net/submission). The DoD system will lead you through the preparation of the following proposal sections:

   a. Proposal Cover Sheet (formerly Appendices A & B) – Pages 1 and 2 of your proposal)
   b. Company Commercialization Report (formerly Appendix E) (does not count against page limit)

Once the Proposal Cover Sheet is saved in the DoD system, you will be asked to upload your Technical Proposal and Cost Proposal (Reference A of this solicitation) via the website.

2. Acceptable Formats for Online Submission: All technical proposal files will be converted to Portable Document Format (PDF) for evaluation purposes; therefore, the Technical Proposals should be submitted in PDF format. Other acceptable formats (PC/Windows) are: Text, Rich Text Format (RTF), MS Word, WordPerfect, and Adobe Acrobat. The Technical Proposal should include all graphics and attachments, should conform to the limitations on margins and number of pages, and should exactly reflect the hardcopy version. Offerors are responsible for performing a virus check on each submitted Technical Proposal. Each submitted electronic technical proposal will be scanned for viruses. The detection of a virus on any submitted electronic Technical Proposal may cause rejection of the proposal.

3. **Note:** Firms without Internet access must request an exemption by calling 703-617-7425 no later than 7 January, 2000. Additional instructions will be provided.

4. Postal Submission: Postal submission includes an original signed proposal with all forms and required attachments, plus two copies. All proposals written in response to topics in this solicitation must be received by the date and time indicated in Section 6.2 of the introduction to this solicitation. Offerors are advised to submit proposal(s) well before the deadline. **Late proposals will not be accepted.**

All Phase I proposals - one original (clearly marked, with original signatures) and two copies - must be submitted to the CBD SBIR Program Management Office at the address below. Each copy must include Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report. All hand deliveries must be made to the Army Materiel Command (AMC) building mail room, located at the rear of the AMC building. Proposers should be aware that the AMC mail room hours are 0730-1530 hrs (local) and are subject to change without prior notice. *Offerors using non-government courier services assume the risk for late delivery of proposals.

Mail proposals to:
Dr. Kenneth A. Bannister
U.S. Army Research Office-Washington
Room 8N31, Army Materiel Command Building
5001 Eisenhower Avenue
Alexandria, VA 22333-0001
(703) 617-7425

Potential offerors must follow the proposal content rules for the agency which has proponency for topics. Topics are numbered in series, with Army topics starting at 101, Navy topics starting at 201, and Air Force topics starting at 301. Detailed instructions for proposals to be submitted against Army topics are given below. **Refer to the appropriate Navy and Air Force sections in this Solicitation for information on how to prepare proposals for submission against Navy and Air Force CBD topics.**

Army Proposal Guidelines

The Army has enhanced its Phase I-Phase II transition process by implementing the use of a Phase I Option that the Army may exercise to fund interim Phase II activities while a Phase II contract is being negotiated. The maximum dollar amount for a Phase I feasibility study is $70,000. The Phase I Option, which **must** be proposed as part of the Phase I proposal, covers activities over a period of up to four months and at a cost not to exceed $50,000. All proposed Phase I Options must be fully costed and should describe appropriate initial Phase II activities which would lead, in the event of a Phase II award, to the successful demonstration of a product or technology. **The Army will not accept Phase I proposals which exceed $70,000 for the Phase I effort and $50,000 for the Phase I Option effort**. Only those Phase I efforts selected for Phase II awards through the Army's competitive process will be eligible to exercise the Phase I Option. To maintain the total cost for SBIR Phase I and Phase II activities at a limit of $850,000, the total funding amount available for Phase II activities under a Phase II contract following an Option effort will be $730,000.

Companies submitting a Phase I proposal to the Army under this Solicitation must complete the Cost Proposal (Reference A of this solicitation) within a total cost of $70,000 (plus up to $50,000 for the Phase I Option). Phase I and Phase I Option costs must be shown separately; however, they may be presented side-by-side on a single Cost Proposal. The Phase I Option proposal must be included within the 25-page limit for the Phase I proposal. In addition, all offerors will prepare a Company Commercialization Report, for each proposal submitted. The Company Commercialization Report does not count toward the 25-page limitation.

Selection of Phase I proposals will be based upon scientific and technical merit, according to the evaluation procedures and criteria discussed in this solicitation document. Due to limited funding, the Army reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded.

Proposals not conforming to the terms of this solicitation, and unsolicited proposals, will not be considered. Awards are subject to the availability of funding and successful completion of contract negotiations.

Army Phase II Proposal Guidelines

CBD Phase II proposals are invited by the individual Service from CBD Phase I projects that have demonstrated the potential for commercialization of useful products and services. The invitation will be issued by the Service organization responsible for the Phase I effort. Invited proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing the developed technology. Fast Track participants may submit a proposal without being invited. Cost-sharing arrangements in support of Phase II projects and any future commercialization efforts are strongly encouraged, as are matching funds from independent third-party investors, per the SBIR Fast Track program (see section 4.5 of the introduction to this solicitation). Commercialization plans, cost-sharing provisions, and matching funds from investors will be considered in the evaluation and selection process, and Fast Track proposals will be evaluated under the Fast Track standard discussed in section 4.3 of the introduction to this solicitation. Phase II proposers are required to submit a budget for a base year (first 12 months) and an option year. These costs must be submitted using the Cost Proposal format in Reference A of this solicitation, and may be presented side-by-side on a single Cost Proposal Sheet. The total proposed amount should be indicated on the Proposal Cover Sheet, under "Proposed Cost". Phase II projects will be evaluated after the base year prior to extending funding for the option year.

Phase II Plus - The Army has established the ***Phase II Plus*** Initiative, effective immediately, as a three-year pilot program to facilitate the rapid transition of SBIR technologies, products, and services into Army or other DoD acquisition programs. Under ***Phase II Plus***, the Army provides matching SBIR funds to expand an existing Phase II that attracts investment funds from an acquisition program. Private sector investments will also be considered for ***Phase II Plus*** funding. ***Phase II Plus*** allows for an existing Phase II Army SBIR effort to be extended for up to one year to perform additional research and development. ***Phase II Plus*** matching funds will be provided on a dollar-for-dollar basis up to a maximum $100,000 of SBIR funds. All ***Phase II Plus*** awards are subject to acceptance, review, and selection of candidate projects, are subject to availability of funding, and successful negotiation and award of a ***Phase II Plus*** contract modification. Details and groundrules for this program may be found at the Army SBIR Website, http://www.aro.army.mil/arowash/rt/.

The Army is committed to minimizing the funding gap between Phase I and Phase II activities. With the implementation of Phase I Options, all Army Phase II proposals will receive expedited reviews and be eligible for interim funding. Accordingly, all Army Phase II proposals, including Fast Track submissions, will be evaluated within a single evaluation schedule.

Key Dates

00.1 Solicitation Open	1 December 1999 – 12 January 2000
Phase I Evaluations	January - April 2000
Phase I Selections	April 2000
Phase I Awards	May 2000

PROPOSAL CHECKLIST

This is a Checklist of Requirements for your proposal. Please review the checklist carefully to assure that your proposal meets the Army SBIR requirements. **Failure to meet these requirements will result in your proposal not being considered for review or award**. Do not include this checklist with your proposal.

______1. The proposal cost adheres to the individual Service (Army, Navy, or Air Force) criteria specified.

_____ 2. The proposal is limited to only **ONE** solicitation topic. All required documentation within the proposal references the same topic number.

______3. The proposal, including the Phase I Option Cost Proposal, is 25 pages or less in length. (Excluding the Company Commercialization Report.) Proposals in excess of this length will not be considered for review or award.

_____ 4. The entire proposal including all forms must be submitted via the Internet using the DoD's Online SBIR Proposal System which can be accessed at address: http:// www.aro.army. mil/arowash/rt/.

_____ 5. The Proposal Cover Sheet (formerly, Appendix A and B), is the first two pages of your proposal. The Proposal Cover Sheet clearly shows the proposal number assigned by the system to your proposal and is signed. The Technical Abstract contains no proprietary information, does not exceed 200 words, and is limited to the space provided. Cost Proposal (Reference A). is complete, signed, and is included as the last section of the proposal. (For Army topics the **Phase I and Phase I Option** costs must be shown separately on the Cost Proposal).

_____ 6. The Company Commercialization Report is submitted in accordance with Section 3.4.n. This report is required even if the company has not received any SBIR funding. (This report does not count towards the 25-page limit)

_____ 7. The proposal contains only pages of 8-1/2" X 11" size. No other attachments such as disks, and video tapes are included. The proposal contains no type smaller than 11-point font size (except as legend on reduced drawings, but not tables). The proposal is stapled in the upper-left-hand corner, and no special binding or covers are used.

_____ 8. An original with original signatures as required **(clearly marked)** and two copies of the proposal are submitted. The proposal must be sent registered or certified mail, postmarked by January 5, 2000, or delivered to the Army SBIR Office no later than **January 12, 2000, 3:00 p.m. local time** as required (see Section 6.2). Offerors who elect to use commercial courier services do so at their own risk. The Army **cannot** accept responsibility for proposals delivered late by commercial couriers.

_____9. Include a self-addressed, stamped envelope and a copy of the Notification Form (Reference C) located in the back of the solicitation book, if notification of proposal receipt is desired. **No responses will be provided if these are not included with your proposal.**

INDEX OF CHEMICAL BIOLOGICAL DEFENSE FY00 TOPICS

Air Force CBD Topics

CBD00-301 Discrimination of Biological Agents At Moderate Standoff Ranges

CBD00-302 In-flight Decontamination

CBD00-303 Thin, Flexible Chemical Agent Resistant Materials

CBD00-304 Open Wound Decontamination

CBD00-305 Multi-Component Adsorption Data and Modeling

CHEMICAL BIOLOGICAL DEFENSE FY00 TOPICS

Army CBD Topics

CBD00-101 TITLE: Miniaturized Sample Preparation Module

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Development of sample preparation modules to interface with Micro-electromechanics and micro-electronics (MEMS) sensors.

DESCRIPTION: MEMS technology has reduced the size and power requirements for detection of genetic material from microorganisms using Polymerase Chain Reaction (PCR). To date, however, portable detectors are suitcase size and require manual addition of a single colony culture. A remaining challenge is the miniaturization of sampling devices. Such devices could be for aerosols, water sampling or soil samples that could be interfaced with existing MEMS sensors. Much development is required in the area of automated sample cleanup since the purity of DNA in small devices is much more critical.

PHASE I: Current sample collecting or sample preparation systems will be cataloged and evaluated for miniaturization. One or more devices will be selected along with MEMS sensor(s) into which it will interface.

PHASE II: : A miniaturized device will be constructed and demonstrated. Integration with the MEMS sensor device(s) selected in Phase I will be conducted for development of a complete biosensor system ready for field tests. Initial packaging and interface standards will be presented for possible incorporation into ASME or MIL standards.

PHASE III DUAL USE APPLICATIONS: Development of miniaturized sample collection and preparation devices would greatly accelerate commercialization. Such devices could be used in medical, environmental monitoring and food preparation areas.

KEYWORDS: sample preparation, PCR, MEMS sensor

REFERENCES: Belgrader, P., et.al. "PCR Detection of Bacteria in Seven Minutes," Science, 284:449-450, 1999.

CBD00-102 TITLE: Improved Sensitivity for Chemical and Biological Standoff Detection

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM, Nuclear, Biological, & Chemical Defense Systems

OBJECTIVE: Establish technical feasibility of developing a means of obtaining greatly increased sensitivity of standoff chemical and biological (CB) detection.

DESCRIPTION: Innovative and creative approaches to this research and development effort are requested to establish the technical feasibility of producing higher-sensitivity LIght Detection And Ranging (LIDAR) standoff CB detectors. Development of such a device directly supports both short-range (Joint Service Warning and Identification LIDAR Detector, also a Defense Technology Objective - DTO) and long-range (Miniature Standoff Agent Detector) goals for Contamination Avoidance identified in the Joint Service Nuclear, Biological, and Chemical (NBC) Defense Research, Development, and Acquisition (RDA) Plan, and outlined in its Chemical Detection Roadmap. These standoff detectors also support Army as well as Joint Service goals in Wide Area Decontamination by identifying and mapping areas requiring decontamination.

Significant flexibility is allowed in formulating proposed approaches to meet these goals. Current LIDARs (e.g. Reference 1) for standoff CB detection uniquely identify CB agent spectral features by measuring the laser energy at each wavelength that has passed through the cloud. The ultimate sensitivity of the measurement depends on the signal to noise ratio. Current LIDARs are capable of detecting small fractions (1/10 to 1/100) of the dose that will produce a lethal effect in 50% of poisoning cases, (lethal dose known as "LD50"). However, even this sensitivity is not sufficient to determine completely safe boundaries for areas that have been under attack (due to long-term effects of low-level exposures). Nor is it sufficient to measure suspected areas of weapon manufacture. In order to do these tasks, the sensitivity must be raised by about a factor of ten. Current carbon dioxide (CO_2) LIDARs using Transversely Excited Atmospheric (TEA) lasers can attain 2% noise levels consistently by pulse averaging. The desired factor of ten sensitivity increase can only be accomplished by reducing the noise of the system by a factor of ten. Among the methods to be considered are: 1) signal averaging to levels consistently less than 1% noise with a goal of 0.1%, 2) further reducing instrument noise, such as with lower noise detector elements and/or preamplifiers, better energy normalization techniques, and better shielding, 3) coherent detection, including the possibility of utilizing detector arrays in order to reduce transmitter repetition rate requirements.

If the approach is successful, it could be integrated into the CO2 TEA laser-based JSWILD acquisition program to enhance its CB detection capabilities to include very low level detection. The Program Manager for NBC Defense Systems would be interested in providing non-SBIR funding during or after Phase II to integrate this capability (see attachment) into JSWILD.

PHASE I: All efforts are to be directed toward establishing the feasibility of increasing the sensitivity of the TEA CO2 LIDAR as described above. The limitations of signal averaging shall be defined theoretically and experimentally and shall include the effects of speckle, atmospheric effects and field of view of the LIDAR. Instrumentation effects shall be identified and experiments will be performed to indicate the degree of improvement over conventional devices.

PHASE II: A breadboard TEA CO2 LIDAR shall be constructed and tested utilizing a GFE CO2 laser transmitter to demonstrate technical feasibility of the approach. The device will be capable of consistently achieving noise levels of less than 0.2% with a goal of 0.1%. That is, the sensitivity of the breadboard LIDAR will be demonstrated to be greater than 10 times that of the current device. The performance will be verified by means of outdoor testing utilizing realistic topographic targets.

PHASE III DUAL-USE APPLICATIONS: Phase III military applications include full-sized and miniature standoff CB detectors for contamination avoidance and decontamination. In addition, dual-use intelligence and domestic preparedness applications could directly benefit from having a standoff detection device with greatly increased sensitivity. Phase III commercial applications include spin-off detectors for standoff environmental pollution monitoring and for drug interdiction.

KEYWORDS: chemical, biological, detection, carbon dioxide laser, LIDAR, standoff, sensitivity, system noise.

REFERENCES: Wavelength Agile CO2 Laser and Chemical Sensor, Cohn, D. B., Fox J. A., Swim, C. R., SPIE Proceedings, Vol. 2119, p. 72-82, January 1994.

CBD00-103 TITLE: <u>Detection and Identification of Buried or Concealed BW Agents and Simulants using Nuclear Quadrupole Resonance Spectroscopy</u>

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Build a sensor for detecting biological warfare agents and simulants using Nuclear Quadrupole Resonance (NQR) Spectroscopy. Such a system would be capable of detecting concealed BW agents in a closed suitcase or buried below the ground.

DESCRIPTION: Nuclear Quadrupole Resonance (NQR) has been used for detection of explosives, narcotics, and buried landmines. Commercial NQR detection systems are now beginning to appear in Airport Security systems for detection of explosives, narcotics, and other contraband. Typically in these applications, the NQR signal of a nitrogen-14 atom in an unusual molecular configuration is detected. All compounds that contain nitrogen-14 have Nuclear Quadrupole Resonance absorption bands in the region of 0.2 MHz to 5.0 MHz. Electromagnetic radiation in this region can easily see through a suitcase to look for contraband or look below the surface of the ground for buried landmines. Dipicolinic acid (2,6-pyridinedicarboxylic acid, C5H3N(COOH)2) is a major constituent of the bacterial spores that make up many BW agents. In some cases, calcium dipicolinate constitutes up to 17% of the dry weight of the spores. Dipicolinic acid, or DPA for short, is believed to be an important contributor to the resistance of spores to both heat and UV radiation. The material also appears to be important in spore stability and spore germination. The dipicolinate ion has a nitrogen atom in a benzene ring and has a distinctive Nuclear Quadrupole Resonance (NQR) signal. The NQR signatures of dipicolinate have been predicted to lie somewhere between 3.0 and 5.0 MHz. "Dipicolinate is almost unique to bacterial spores, and it may constitute as much as 15% of their weight." Page 47, Microbiology, Davis, Dulbecco, Eisen, Ginsberg, Fourth Edition, 1990, J.B. Lippincott.

PHASE I: Demonstrate laboratory scale a proof-of-concept NQR system capable of detection of bacterial spores. The proof-of-concept system shall be able to detect small (less than ten grams) quantities of the BW simulant Bacillus Subtilis using the distinctive NQR signature of the bacterial spores. Determine the resonance frequencies for Calcium Dipicolinate and also for Bacillus Subtilis.

PHASE II: Build a prototype of an NQR system for detecting BW agents in a closed container such as a suitcase. Demonstrate detection of small quantities (less than ten grams) of Bacillus Subtilis in a closed and locked suitcase.

PHASE III DUAL USE APPLICATIONS: Conduct a feasibility study of modifying existing contraband detection systems in airports based on NQR spectroscopy to provide additional protection against BW agents shipped in closed containers such as a locked suitcase.

OPERATING AND SUPPORT COST REDUCTION: NQR contraband and explosive detectors are currently in use at commercial airports. These sensors are saving a fortune by providing Airport security in a manner that is fast and non-intrusive. Such cost savings could also be extended to providing protection against BW agents.

KEY WORDS: BW Agents, Airport Security, Domestic Preparedness, NQR, Nuclear Quadrupole Resonance.

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CBD00-104 TITLE: CB Water Monitor Biological Concentration

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM, Nuclear, Biological, & Chemical Defense System

OBJECTIVE: Build a hand held system to collect, concentrate, and isolate biological agents from source, treated, stored, and distributed water supplies. The extracted agents will be presented to varying detection systems (see Topic Number CBD00-105). Analytes include bacterial cells, spores, cysts, viruses, and toxins. Novel methods to extract genetic material, including DNA and mRNA are also desired.

DESCRIPTION: The Joint Service Agent Water Monitor (see Topic Number CBD00-105) will require sample collection, concentration, and extraction of biological analytes such as bacterial cells, spores, cysts, viruses, and toxins. No detection technology has been found that can detect to the trace levels required and accommodate the widely varying background waters (source, treated, stored/distributed) that will be monitored. Target analytes may be diluted in large volumes of water (thousands of gallons), the water may be turbid (such as natural waters), it is likely the background of the water will not be favorable to a particular sensor technology. This is especially true for natural water samples. This pre-processing is seen as a separate technology "module" in the JSAWM system and is therefore solicited as a separate topic. After a sample has been collected, concentrated, and extracted, it can be passed to a number of competing and/or complementary detection technologies. The Objective of the JSAWM program is to develop a hand held sensor to detect, identify, and quantify CB agents in water supplies. The pre-concentration module should fit within this format. Size, weight, power requirements are a consideration. We have not found this capability in the commercial market. This is an R&D effort involving a degree of technical risk.

PHASE I: Contractor will demonstrate proof of principle operation based on 20 gallon challenges. The 20 gallon aliquots will have varying concentrations and composition. The system can be a laboratory set-up, but should be man-portable.

PHASE II: Contractor will build a prototype system to be field tested. This will involve tests where the new monitors are placed in-line in real and simulated water lines for testing.

PHASE III DUAL USE APPLICATIONS: The proposed pre-processing system would have immediate applications in monitoring municipal and commercial water supplies for possible contamination by biological contaminants.

OPERATING AND SUPPORT COST (OSCR) REDUCTIONS: There is currently no method to extract, concentrate, and isolate trace levels of biological agents from thousands of gallons of water.

KEYWORDS: water, source, treated, distributed, potable, pre-concentration, extraction, isolation, biological, agents, bacteria, spores, cysts, viruses, toxins, parasites.

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CBD00-105 TITLE: Chemical and Biological Water Monitor

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM, Nuclear, Biological, & Chemical Defense System

OBJECTIVE: Develop a hand held, real time sensor system that can detect, identify, and quantify chemical and biological agents in water supplies. Power, size, and weight are considerations. Both in-line and batch monitoring are desired. Time to detection sought is 10 minutes. Water supplies include point source, treated, stored and distributed waters. Sensor system will provide early warning of contamination or possible attack.

DESCRIPTION: There is an immediate need for the ability to detect, identify, and quantify chemical and biological (CB) agents in water supplies during water point selection, production, storage, and distribution to consumers (including shower points and personnel decontamination stations). Water point selection can be natural waters such as lakes, rivers, streams, reservoirs, municipal waters. Production water is field/shipboard treated water. Stored and distributed water can be treated field water, bottled water, and locally purchased water that is trucked or piped to military storage (field and ship). Chemical Detection is required to parts per trillion levels by class, such as nerve, blister, and blood.

Biological detection by class is considered to be bacteria, virus, toxin, parasite and pathogenic versus non-pathogenic. The trace levels of detection required are considered problematic. A call has been made for technologies in "CBD00-104 Water Contamination Concentration" to concentrate and extract dilute analytes from water. Detection technologies that can do the detection, identification, and/or quantification without such pre-processing are highly desirable.

PHASE I: Contractor shall propose and design a system to detect, identify, and quantify chemical and/or biological agents in water. The main goal of Phase I will be a proof of principle demonstration based on a Government furnished test matrix. The Contractor and the Government will agree on the test matrix before testing. The "proof of principle" system can be a laboratory breadboard. Emphasis is placed on technologies that are innovative and creative. The final system (not necessarily the Phase I system) is expected to be a hand held device. Deliverable is a report and test data.

PHASE II: Contractor will build a hand held developmental prototype. Developmental prototypes do not have to be field hardened. The goal of Phase II will be demonstration and delivery of the system to the Government. The Government will test the system. This will involve tests where the new monitors are placed in-line in real and simulated water lines for testing.

PHASE III DUAL USE APPLICATIONS: The current estimated requirement is 20,000 fielded units for Joint Service use. Successful candidates will be added to the JSAWM as a "technology module". The JSAWM concept is a modular system analogous to current day computers. Peripheral devices can be added and removed by the user as needed. Additional applications exist in other DoD and government agencies such as Medical, Domestic Preparedness, Demilitarization, Treaty Verification. JSAWM has been working closely with CEHR where a medical requirement for water monitoring exists. Although JSAWM and CEHR requirements have striking differences, we are working together to leverage technologies and programs where possible. In addition, the proposed water monitor would have immediate application in monitoring municipal, commercial, and recreational water supplies. The EPA has funded two non-profit organizations in the past two years to search for advanced warning and early monitoring technologies for water contamination. At the recent ILSI Risk Institute Workshop (May 1999, Reston, VA), a number of public water managers, CDC, and EPA addressed the concern and need for early warning monitoring of public water. The EPA has an immediate need for early warning monitoring of recreational water.

OPERATING AND SUPPORT COST (OSCR) REDUCTIONS: Current water monitoring systems require numerous reagents and are time and labor intensive. The JSAWM program is seeking and/or developing technologies that can detect in less than or equal to 10 minutes for chemical and biological analytes with minimal attendance, maintenance, logistics, and cost.

KEYWORDS: early warning, rapid, potable, source, stored, distributed, water, monitoring, potable, chemical, biological, in-line monitor, water treatment quality assurance.

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CBD00-106 TITLE: Development of a Miniaturized Biological Detector

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop a miniaturize Biological detector that can be either scattered on the battlefield for early warning or warn by the soldier on his / her lapel.

DESCRIPTION: The Edgewood Chemical and Biological Center (ECBC) is developing a number of biological agent's detectors. All the detectors that are currently under development are large, heavy, and require expertise in their operation. Some detectors that are in development are "brief case" size, but require a separate sampler for collecting the particles from the air and introducing them to the detector.

In recent years great progress had been made in the micro machining / nano technology area. The purpose of this effort is to apply this emerging technology for developing a miniaturized biological detector that will include a miniaturized aerosol sampler / collector and detection device, a miniaturized GPS and a miniaturized communication system. The detector can be either a general biological detector or detectors for a specific agents. In the first case multiple miniaturized detectors could be scattered on the battlefield and act as an early warning system by networking them. In the second case the detector will be worn by the individual soldier and alert him / her, and the medics, when he or she was exposed to the specific agents. This will greatly facilitate treatment. In addition, the detector will be able to detect when the soldier is being exposed to a locally endemic biological material. This is necessary as the involvement of US in various missions around the world is expected to expand and as more and more emphasis is being placed on preserving the health of the soldier, following the Gulf War Syndrome. The detector should be able to operate for a as a stand alone device for a period of at least 48 hours unattended operation, stay in constant communication with the home base and store the data (including GPS data and time/date) for that period.

PHASE I: Demonstrate the technology and design and build a prototype detector. Test the ability of the detector to sample the air, detect when biological aerosols above a preset threshold level are present, and communicate its finding. The deliverable from phase I will be the prototype detector and the various documentation required to further develop the technology and proceed to phase II.

PHASE II: Further develop the technology to the point were it can be mass-produced at a reasonable cost and demonstrate it in chamber and field trials. The demonstration should include the ability of the detector to detect generic biological aerosols and a specific biological aerosol.

PHASE III DUAL USE APPLICATIONS: In its military application the detector can be used as an early warning system when scattered on the battlefield ahead of the troops (Army and Marines) around an airfield (Airforce) or a port (Navy). Another potential military use is to fly the miniaturized detector into a suspicious cloud, or drop it by a parachute into the cloud to identify the nature of the cloud and determine if it can present a hazard to the troops. The technology developed under this SBIR can be transferred to the health industry, the environmental protection arena and to the industrial hygiene area. A miniaturizes biological agent detector can be used by health care providers to monitor the spread of infectious diseases and by individual health providers to detect when they were exposed to an infectious organism. In the environmental protection arena it will enable the EPA to quickly identify the cause of "sick building". Industrial hygienists will be able to use the device to monitor and control the exposure of workers to harmful organisms.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Miniaturization technology took off during the past few years and is expected to develop quickly. Mimicking the development of microelectronics, mass production cost can be expected to decline quickly. It is expected that once developed a mass produced detector could cost several hundreds dollars vs. tens of thousands of dollars to produce a detector based on conventional technology.

KEYWORDS: Biological detectors, Biological agents, miniaturization.

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CBD00-107 TITLE: Development of a Miniaturized Chemical Detector

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop a miniaturize Chemical detector that can be either scattered on the battlefield for early warning or warn by the soldier on his / her lapel.

DESCRIPTION: The Edgewood Chemical and Biological Center (ECBC) fielded and is developing a number of chemical agent's detectors. All the detectors that had been fielded or, are currently under development, are large, heavy, and require expertise in their operation. Several detectors are handheld. DARPA as well as the Navy are sponsoring several programs to develop miniaturized chemical detectors (Canadian Commercial Corp, University of North Texas). A "chemistry lab on a chip" is currently being reported by ORNL . The purpose of this effort is to develop a miniaturized chemical detector that will include a miniaturized sampler / collector and detection device, a miniaturized GPS and a miniaturized communication system. The detector should be able to detect all the common chemical warfare agents at a sub effect level. The detector should also be able to operate in a collection mode. In that mode it should be able to collect volatile and semi-volatile vapors for later analysis. In the first case multiple miniaturized detectors could be scattered on the battlefield and act as an early warning system by networking them. In the second case the detector will be worn by the individual soldier and alert him / her, and the medics, when he or she was exposed to the specific agents. This will greatly facilitate treatment and provide better situational awareness to the commander. In its collection mode the detector will provide information were the soldier has been and to what harmful vapors (including industrial effluents) he or she had been exposed. This is necessary as the involvement of US in various missions around the world is expected to expand and as more and more emphasis is being placed on preserving the health of the soldier, following the Gulf War Syndrome. The detector should be able to operate for a as a stand alone device for a period of at least 48 hours unattended operation, stay in constant communication with the home base and store the data (including GPS data and time/date) for that period. Other operational possibility is to mount the detector on a UAV for damage assessment following destruction of suspected of production or storage sites in hostile territory.

PHASE I: Demonstrate the technology and design and build a prototype detector. Test the ability of the detector to sample the air and detect when chemical agents are present. The deliverable from phase I will be the prototype detector and the various documentation required to further develop the technology and proceed to phase II.

PHASE II: Further develop the technology to the point were it can be mass-produced at a reasonable cost and demonstrate it in chamber and field trials. The demonstration should include the ability of the detector to detect chemical agents and collect semi volatile and volatile vapors that can later could be analyzed given standard analytical methods.

PHASE III DUAL USE APPLICATIONS: In its military application the detector can be used as an early warning system when scattered on the battlefield ahead of the troops (Army and Marines) around an airfield (Airforce) or a port (Navy. The technology developed under this SBIR can be transferred to the environmental protection arena and to the industrial hygiene area. In the environmental protection arena it will enable the EPA to quickly identify the cause of "sick building" and identify effluent from hazardous waste sites. Industrial hygienists will be able to use the device to monitor and control the exposure of workers to harmful chemicals.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Miniaturization technology took off during the past few years and is expected to develop quickly. Mimicking the development of microelectronics, mass production cost can be expected to decline quickly. It is expected that once developed a mass produced detector could cost several hundreds dollars vs. tens of thousands of dollars to produce a detector based on conventional technology.

KEYWORDS: Chemical detectors, Chemical agents, miniaturization.

REFERENCES:
1. Kenning, Vanessa M.; Call, Charles J.; Call, Patrick T.; Birmingham, Joseph G.; "Collection of airborne bacteria with micro-machined virtual impactor Arrays" Proceedings of the 1998 ASME International Mechanical Engineering Congress and Exposition, Anaheim, CA Nov 1998.
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CBD00-108 TITLE: Chemical Immobilizing Agents for Non-lethal Applications

TECHNOLOGY AREAS: Chemical/Biological Defense, Weapons

OBJECTIVE: To demonstrate the feasibility of a safe, reliable chemical immobilizing agent(s) for non-lethal (NL) applications in appropriate military missions and law enforcement situations.

DESCRIPTION: Previously developed or proposed incapacitating or immobilizing agents have been deficient in one or more technical aspects. These deficiencies include low safety ratios and inadequate performance characteristics, such as, reliability of desired response, onset time to effects and duration of effects. Recent pharmaceutical developments suggest that new approaches to safer Chemical immobilizers with improved performance characteristics may be available. The Joint Non Lethal Weapons Directorate, Quantico, VA is the executive agent for Non Lethal technologies. Discussions with the JNLWD indicate that this technology falls under their broad core mission area of "incapacitating personnel" and could be used in specific areas such as "clearing of facilities" and "area denial".

PHASE I: Assess route of entry of potential immobilizing agents through coordination with the User. The route of entry is key since it affects safety/efficacy issues, onset time to effect and delivery technique. Conduct an analysis of promising new chemical immobilizing agents or combinations of agents. The analysis of this area will include recent breakthroughs in the pharmacological classes such as Anesthetics/analgesics, tranquilizers, hypnotics and neuromuscular blockers. Select the most promising new approaches/immobilizing agents. Review existing data to identify gaps for proposed use. Design and conduct a toxicological test program with these new immobilizing agents to fill data gaps. Establish the mode of immobilization, the effective dose(age) for immobilization, onset time and duration of effects, and safety ratio in the most appropriate animal species. Correlate these new experimental results with existing data, if any, from other studies, especially in humans (clinical tests) and non-human primates to establish feasibility of use for non-lethal applications.

PHASE II: Establish desired performance/operational characteristics versus potential scenarios of use. Solicit comprehensive input from potential users, such as, Special Operations Forces; Military Police; and other service support through the Joint Non Lethal Weapons Directorate; Department of Justice (FBI and National Institute of Justice) agencies; and state and local law enforcement representatives. Determine implications of the Chemical Warfare Convention (CWC) for proposed scenarios of use. Select optimum scenario(s) of use. Design and conduct non-human primate and clinical tests to establish safety and performance characteristics. Design and conduct ancillary toxicological tests to address environmental and similar concerns. Design and demonstrate an appropriate delivery technique for example; an aerosol generator for dissemination for the inhalation route of entry, or a dart for injection in the intra-muscular route of entry.

PHASE III DUAL USE APPLICATIONS: Potential military uses include Meeting US and NATO objectives in peacekeeping missions; crowd control; embassy protection; rescue missions; and counter-terrorism. For many years the Department of Justice has been interested in alternate non-lethal (or less-than-lethal (LTL)) technology for law enforcement. For example, the 1986 Attorney General's Conference on Less-Than-Lethal Weapons included a plenary briefing and a workshop session on LTL chemical agents. The interest in developing LTL alternatives to guns and bullets and clubs remains today. Potential applications include: use by local, state and national law enforcement agencies, for example, FBI, Alcohol Tobacco Firearms (ATF) and state and local police, in hostage and barricade situations; crowd control; close proximity encounters, such as, domestic disturbances, bar fights and stopped motorists; to halt fleeing felons; and prison riots.

KEYWORDS: immobilizing agents, incapacitating agents (incaps), less-than-lethal (LTL) agents, non-lethal (NL) agents, Riot Control Agents (RCA), Advanced Riot Control Devices (ARCAD).

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CBD00-109 TITLE: Biological Warfare Agent (BWA) Deactivating Textile Systems for Chemical/Biological (CB) Protection

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM Soldier

OBJECTIVE: To develop nanofiber and/or air-permeable microporous membranes containing sub-micron BWA deactivating particles for CB protective clothing applications via coatings and semipermeable membrane loading technologies.

DESCRIPTION: Current air-permeable, activated carbon based chemical protective (CP) clothing provides good chemical agent protection against vapor and liquid challenges. However, their fabric structures are susceptible to penetration by small aerosol particulates. These aerosols can be used to carry viruses, bacteria, toxins, and health-hazardous insecticides such as organophosphates. A vaccine has been developed and shown to be effective against Anthrax. However, protective clothing has been determined as necessary in providing supplemental protection against Anthrax and other viral/bacterial percutaneous threats such as T2 Mycotoxin.1 Air-permeable microporous membranes and electrospun nanofiber webs have demonstrated 99.9% aerosol efficiency while maintaining desirable moisture vapor transmission rates. However, BWA contained in/on these aerosols could potentially be airborn again through the wearer's movements and can harm others who are not in protective clothing. The user is also susceptible during the garment doffing procedure. Furthermore, although a healthy skin has been viewed as an excellent barrier to biological agent threats, there is a high probability on the battlefield that soldiers will have skin scratches and wounds in conducting their various missions. These skin scratches and wounds represent pathways to BWA infection. This topic calls for the investigation of commercially available BWA threat deactivating materials2 (e.g., biocides with metallic oxides or halide functional end-groups) and the development of new nanofiber or microporous membranes that contain these biocidal materials. The use of these new membranes could be an effective way to supplement the capability of permeable CP clothing with minimal sacrifice in comfort via evaporative cooling.

PHASE I: Identify effective BWA deactivating materials and membrane carriers via laboratory demonstration of biocidal activity toward Bacillus subtilis and Bacillus Thuringienises. These are spore-forming bacterial surrogates to Anthrax. Specific test protocols3 and test criteria will be provided. Performance testing and evaluation of multilayer membrane/fabric samples will also be conducted in consultation and/or participation of the US Army Medical Research Command. These tests will measure the deactivation of biological aerosol surrogates (Bacillus subtilis and Bacillus Thuringienises, and/or others), aerosol and liquid resistance, (and chemical agent simulant vapor efficiency as combined with carbon-based permeable fabrics). Show the feasibility for protective clothing applications.

PHASE II: Optimize BWA deactivating material loading process onto microporous and/or nanofiber membranes. Scale up laboratory membrane production to pilot scale process. Investigate clothing fabrication processes that include loading of BWA deactivating particles. Provide material samples and prototype clothing deliverables, and participate in US Army laboratory testing and evaluation, and prototype ensemble fabrication for system testing of its effectiveness against biological agent surrogates and also chemical agent simulants (as used with other chemical protective materials.)

PHASE III DUAL-USE APPLICATIONS: Dual use applications include HAZMAT and environmental clean-up, counter-terrorism, law-enforcement, industrial applications, individual protection from blood-born pathogens, CB protective breathing/gas masks, aerosol protective filters, air stream and liquid cleaning systems.

KEYWORDS: CB warfare agents, nanofiber membranes, air-permeable microporous membrane, CB agent protective clothing, biocides, self-deactivation, and BWA protective membranes.

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CBD00-110 TITLE: Chemical Protective Gloves with Enhanced Properties

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM Soldier

OBJECTIVE: Explore nanoscale phenomena to develop novel materials and a nonpolluting process for the manufacture of tactile, durable, flame retardant, solvent resistant gloves impermeable to liquid chemical warfare (CW) agents.

DESCRIPTION: The 7-, 14-, and 25-mil-thick chemical protective gloves currently used by the military are made of butyl rubber reinforced with carbon black [1]. They are produced by an organic-solvent, dipping process. The gloves are neither resistant to petroleum-type solvents, oils and lubricants nor to flames. However, they show excellent resistance to liquid CW agents and to oxygenated-type solvents. With the incorporation of inorganic nanoparticles into select polymers, it may be possible to improve their resistance to CW agents and at the same time take advantage of their other features, such as good resistance to solvents, abrasion and aging. It has been shown that inorganic nanoparticles dispersed in a polymeric matrix have a tendency to form layers through its thickness, thus enhance barrier properties of polymers [2]. Moreover, the inorganic nature of these nanoparticles and their intumescent properties may impart flame resistance and thus eliminate the need for adding flame retardant chemicals into formulations [3]. Furthermore, these new materials should be amenable to nonpolluting processing techniques, such as injection molding, blow molding, spraying/sintering, or aqueous/emulsion dipping.

PHASE I: Select candidate polymers and fabricate glove materials in the laboratory. Determine pertinent physical and mechanical properties, and also resistance to permeation by CW agents.

PHASE II: Optimize the best candidate materials selected in Phase I. Develop a cost-effective, nonpolluting process for the manufacture of gloves. Produce gloves in 7-, 14- and 25-mil thicknesses for laboratory testing and field evaluation.

PHASE III: Butyl gloves are widely used in industrial applications. Improvements either in properties of materials, such as flame retardancy and abrasion resistance, or process, which would lower the volatile organic compounds (VOC) content, will readily find commercial acceptance. Other potential commercial applications for materials containing nanoparticles include coatings for tentage and for special purpose protective suits needed for domestic preparedness activities.

OPERATING AND SUPPORT COST REDUCTION (OSCR): Since there are vastly more companies that produce gloves by an emulsion process than by an organic-solvent dipping process, any new material which can be produced by the former would greatly facilitate procurement of these items for the military, resulting in more competitive pricing. Also, this topic offers an opportunity for a significant reduction in VOC releases by employing nonpolluting process operations.

KEYWORDS: gloves, elastomers, polymers, nanomaterials, nanoparticles, chemical protection.

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CBD00-111 TITLE: Development of Enhanced Chemical Biological (CB) Closure

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM Soldier

OBJECTIVE: To develop miniaturized CB / water-tight separating closure

DESCRIPTION: Recently developed CB uniforms incorporate state-of-the–art seam-tapeable light-weight materials offering complete protection from direct liquid, vapor and aerosol exposure. All CB suits are evaluated in final design for 'Man In Simulate Testing' (MIST). The front entry closure system has been water-tight closures from the commercial dry-suit market. However, although these closures pass evaluation of MIST, they are incompatible with the uniform since they are for heavy-duty application. Consequently, these closures possess a slider resistance that is extremely high (enough to rip the outershell fabric). The closure tape stiffness overwhelms the CP uniform outershell fabric and due the extreme thickness of the closure tape, it is difficult to seam-tape and in some cases the seam-tape fails to stick properly. Furthermore, these closures are costly at about $1. per inch.

Ongoing Trust: The primary thrust of this proposal is tied to the development of a mutiservice Army / Navy 'Waterproof CB Resistant Closure Suit' which incorporates a selected lightweight permeable membrane that does not use carbon base coating. Purpose of suit is to reduce weight, increase flexibility, provide seam tapeability and be breathable, however the suit shall be totally waterproof including closures. The suit has been using a commercially available dry-suit diving closure. However, this zipper totally overwhelms the base lightweight outershell fabric of the CB uniform since they are hard to open / close, very stiff due to there extreme thickness, difficult to vacuum package due to stiffness and uncomfortable to wear, but they do pass all CB protection requirements. Purpose of this SBIR is to develop a miniaturized version of this closure as to reduce cost, improve seam tapeability, flexibility, comfort, donning/doffing, packing size and weight without sacrifice to CB protection.

PHASE 1: Overall requirements for proposed SBIR would be to provide for a miniaturized water-tight closure in a commercial size range of 2-6 (small-medium) with a significantly reduced cost. The minimum chain crosswise strength shall be 145 lbs, offer resistance to liquid, as well as vapor chemicals, in closed state and be hydrostatic resistant at 50 cm. for 10 min. period in both a relaxed and in a 5 lb. crosspull mode of the opposite tape sides. Slider pull strength shall offer 2.0 pound (max.) slider resistance, be available in separating configuration, and use a lightweight highly flexible closure tape that offers a seam-tapeability at 5 lb. (min.) peel resistance. Design for Phase 1 shall incorporate use of single slider in conjunction with a means to separate the closure (pin & box, etc). Technical barriers include design of separating unit, lower pull resistance, selection of materials to offer CB resistance and yet be seam tapeable.

PHASE 2: Finish with addition of second slider in a mouth to mouth arrangement, other concepts and develop manufacturing equipment for large scale production of miniaturized closure. The closure shall be applied to field testing of new generation CB uniforms, rainwear, CB / general field tentage, equipage, tarps (weapon covers), underwater usage or other end-items.

POTENTIAL COMMERCIAL MARKET: Closures shall be used on array of commercial tentage, equipage, wet / dry suits, truck / boat covers, nuclear suits, tarps, bags or other protective applications.

KEYWORDS: closure, chemical biological

CBD00-112 TITLE: Development Of Two Phase Multivaccine Delivery System With Protective and Bioadhesive Properties For Oral Immunization.

TECHNOLOGY AREAS: Chemical/Biological Defense, Biomedical

OBJECTIVE: Design, produce and evaluate a two phase controlled vaccine delivery system for oral immunization, which is capable of protecting the incorporated immunogen in the stomach, and provide maximized release in the colon by bioadherence. In its final form the delivery system should accommodate up to for different immunogens, and should provide full protection for one year against aerosol-delivered the highest possible respective challenge level
in appropriate animal host. The estimated time of the preclinical development and full evaluation of the carrier system for orally administered vaccines is 3 years.

DESCRIPTION: Oral administration of peptides, proteins and vaccines requires incorporation into a biodegradable primary carrier with controlled release- rate property. The primary carrier should be enclosed in a secondary
biodegradable carrier which is capable of protecting the primary carrier/vaccine complex against the adverse conditions of the stomach. For maximized increased bioavalability of the vaccine, the primary carrier matrix should display bioadhesive properties toward mucosal membranes.

PHASE I of the development entails identification of the primary and the secondary carrier system for the release of the recombinant protective antigen of anthrax vaccine, and in vivo evaluation of the system in proper animal model. To achieve single immunization which will provide full protection for one year against anthrax challenge, the incorporated vaccine should stimulate two-three distinct antibody peaks with several weeks of intervals between the peaks. If required, a mucosal adjuvant should be incorporated separately into the primary carrier to help enhance the humoral immune response by synchronized release of the vaccine and the adjuvant. The encapsulation efficacy should not be below 80% of the vaccine input, and the core-loading should not be below 1%-2%.

PHASE II of the development entails application of the two phase delivery system to vaccines which protect against plague and Q fever and a vaccine against emerging threat identified prior to Phase II. Phase II will include development of prototype carrier system containing 3-4 vaccines which will provide full protection in their respective animal model for at least one year against aerosol-delivered highest possible challenge level. If needed, mucosal adjuvant should be included in the prototype two-phase delivery system.

Phase III will entail safety studies and production scale-up of a large batch sufficient for human trials conditioned on IND approval.

KEY WORDS: primary bioadhesive carrier, secondary protective carrier, oral immunization, single dose, mucosal adjuvant, long-term protection, multivaccine two-phase carrier system.

CBD00-113 TITLE: Development Of Human Skin Model For Sulfur Mustard Research

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Medical Research and Materiel Command

OBJECTIVE: To acquire a full thickness or partial thickness (epidermal) human skin model for in vitro cultivation that can be used in biomedical research of the sulfur mustard (HD) injury.

DESCRIPTION: Morphopathologic data of HD dermal toxicity has been gathered largely in controlled animal investigations and in cultured human monotypic cells. However animal models typically do not manifest the full formation of fluid-filled surface bullae found with human exposure and cultured monotypic cells do not provide information on the involvement of the dermal-epidermal junction. Our requirements for the development of a full thickness or partial thickness (epidermal) in vitro human skin model for HD study is based upon the need for an in vitro skin model which would relax dependence on animals for repetitive screening studies and would more closely simulate typical human dermal responses to HD.

PHASE I: The following are requirements of the skin model:

1. Morphologically must possess in vivo counterparts of interest to the research mission such as components of a true basement membrane, hemidesmosomes, basal cell adherent mechanisms, desmosomes, epithelial stratification, evidence of cellular differentiation to include the generation of a stratum corneum.
2. Immunohistochemically should express dermal proteins of interest to the research mission such as laminin, collagens (Types IV, III, VII), bullous pemphigoid antigen BPA (1 and 2), keratin, fibronectin, desmosomal, GB3 (anchoring filament protein), integrins (alpha 6 beta 4).
3. The model must be configured to accept HD vapor cup as well as liquid exposures. The typical vapor cup used for vapor exposures is 12-14 mm.

The product in this phase will be subjected to light microscopic, ultrastructural and immunohistochemical study for verifications of the above considerations.

PHASE II: The product in this phase will be subjected to exposures to HD. The consequences of the exposure will be explored by morphological and immunohistochemical study. Special attention will be given to induced processes of apoptosis-vs-oncosis as evidenced by the elaboration of specific epithelial markers such as Bcl -2, P53, and tunel staining (DNA nicks). In addition the product will used for screening of candidate HD prophylactic and therapeutic compounds.

PHASE III DUAL USE APPLICATIONS: The product in this phase may have potential for drug screening by cosmetic and pharmaceutical companies.

KEY WORDS: Skin model, human skin equivalent, basement membrane zone, adhesion molecules, sulfur mustard, HD.

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CBD00-114 TITLE: Chemical Destruction of Chemical Warfare Agents and Toxic Materials in a Mobile Solvent-free Reactor

TECHNOLOGY AREAS: Chemical/Biological Defense, Materials/Processes, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM, Non-Stockpile Chemical Material

OBJECTIVE: To develop a metal oxide solvent-free system utilizing chemical reactivity to neutralize chemical warfare agents and toxic materials. The system will be compact, mobile, and based on a reactive chemistry that includes components widely available and easily transported.

DESCRIPTION: Advances in metal oxide chemistry have shown that nanoparticulate metal oxides can be utilized for the destruction of chemical warfare agents and toxic materials of concern to the DoD and industry.1-3 For example magnesium oxide nanoparticles have enhanced reactivity due to the larger surface area of the nanoparticles and the larger number of active edge sites.4 Their reactivity arises from direct oxidation and hydrolysis of materials and thus is a solvent free chemical reaction. The potential exists to utilize these oxide nanoparticles in a solvent-free reactor for the destruction of toxic materials or chemical agents. During wartime activities or otherwise containers or shells of chemical agent may be encountered on the battlefield or training grounds. Neutralization before relocation is the preferred method of dealing with the unwanted and possibly dangerous materials. Metal oxide chemistry shows promise as a solvent-free system for neutralization of toxic agents. The reactor developed should fully neutralize the chemical agent or toxic material under a variety of conditions of humidity, temperature, and material purity. Complete neutralization of the chemical agent includes utilizing minimal amounts of metal oxide particles. The reactor should be capable of neutralizing 4-8 L batches of material and be readily transported by a small truck.

PHASE I: Phase I will include the identification of the ideal metal oxide and development of optimum reaction conditions including temperature, concentration, and reaction time of a metal oxide destruction system. Phase I will also include design of a reactor that will utilize the system developed. A method for determining if the materials have been destroyed in the reactor should be considered at this point.

PHASE II: Phase II will focus on engineering a prototype reactor and determining the key parameters for efficient operation utilizing the metal oxide system developed in Phase I. Live agent testing should be included in the Phase II testing of the metal oxide system and reactor.

PHASE III DUAL USE APPLICATIONS: Phase III includes development of a deployable reactor for chemical warfare agents or toxic materials and initiation of the process of gaining approval for use with hazardous materials. This reactor is of interest to the non-stockpile chemical demilitarization program or battlefield destruction of chemical agent confiscated from opponents. Dual use application includes the utilization of the system for the destruction of small batches of industrial compounds that might not be readily transported to another site.

KEYWORDS: decontamination, chemical warfare agents, toxic industrial chemicals, metal oxides, demilitarization, deployable

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Navy CBD Topics

CBD00-201 TITLE: Chemical/Biological Sensor for Munitions

TECHNOLOGY AREAS: Chemical/Biological Defense, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: MARCOR SYSCOM, PM: Combat Support & Logistics Equipment/Nuclear Biological Chemical

OBJECTIVE: Develop chemical/biological sensor system that is robust and small enough to be used as payload in an artillery projectile.

DESCRIPTION: There is no remote CB sensor that can be deployed from a ship prior to expeditionary forces being projected ashore. The intent of this project will be to develop the technology that will lead to a quickly deployed CB agent early warning capability to support forces participating in amphibious operations. Specifically, the intent is to develop the agent detection subsystems of a CB detector payload for a 5"/62 gun projectile, which can be delivered by Naval guns for quick and accurate placement on the beach. The system must be rugged enough to withstand the forces associated with delivery(14,000 gs/300rev/sec), miniaturized to fit within size (290 cu in) and weight (18 lb) constraints and must be able to communicate alerts back to ships 23 miles off-shore. The subsystem should be capable of performing simultaneous analyses of multiple CB agents.

PHASE I: Determine the feasibility of a chemical/biological agent sampling/handling/detection subsystem that could be integrated with other subsystems (radio transmitter, power, etc) to produce a complete CB detector payload for 5"/62 gun projectiles.

PHASE II: Construct and demonstrate the sampling/handling/detection subsystem based on the design developed in Phase I. The demonstration system can be designed to detect a selected benign agent for proof-of-principle, however, the approach for extension to specific agents of interest in Phase III and beyond must be addressed. The system can be constructed at macro-scale levels for bench-top demonstration in Phase II. However, the system must be constructed using scaleable technology components that can be miniaturized and ruggedized in Phase III.

PHASE III: Design and construct a miniaturized and ruggedized sampling/handling/detection subsystem. Manufacture prototype units that can be incorporated into a complete munition payload Engineering Development Model. Final product objective for Phase III and beyond is a system that can simultaneously perform analysis of three to six agents.

COMMERCIAL POTENTIAL: The specific sensors developed would have significant potential for airport inspection applications and for remote sensing in public areas such as subway stations. Additionally, miniature automated titration analysis systems that can be manufactured in large numbers would be of significant interest to educational institutions and commercial chemical and pharmaceutical companies.

KEY WORDS: Chemical; biological; detection; titration; miniature; projectile

CBD00-202 TITLE: Miniaturized Gas Sampling Technology for a Chemical Dosimeter/Detector

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM, Nuclear, Biological, & Chemical Defense System

OBJECTIVE: Develop a power efficient, miniature/lightweight gas sampling system for a chemical dosimeter/detector.

DESCRIPTION: A variety of detector technologies which do not require support gases (other than air) including surface acoustic wave (SAW), ion mobility spectrometry (IMS), photoionization (PI), chemiresistor (CR), quadrapole mass spectrometery (QMS) are available or are in development for the detection and monitoring of chemical agents. For hand held, dosimeter, or distributed monitoring, key development issues relate to size, weight and power consumption of detector components. For example, a miniature chemical dosimeter is highly sought after for personal monitoringdevice. The development of such a system requires a significant reduction in the form factor and power requirements of current enabling technologies. With the advance of the cellular communication technology, significant progress has been achieved in the power consumption level and real estate requirements for signal processing electronics. This is primarily achieved via novel semiconductor processes, and advanced circuit design techniques. In contrast, no concentrated effort has been applied to miniaturize the gas sampling system and reduce the associated power consumption. The gas sampling system is a generic concern to all detectors being developed. Innovative concepts are sought in the design, and implementation of a power efficient, miniature gas sampling system, which will sample ambient air for analysis and provide the ability to re-configure flow path via valve switching. The dimension of the sampling system should be no bigger than 2" wide x 3" long x 3/8" thick (not including battery), light-weight, chemically inert, and capable of providing a minimal of 500 ml/min flow rate. The system should operate under standard mil spec ambient conditions and from -5 PSI to 15

PSI pressure. The system should be powered by a light-weight battery for at least a 12-hour continuous operation. The concept, if proven successful, should be producible with an existing manufacturing technology.

PHASE I: Demonstrate the concept of a miniature gas sampling technology.

PHASE II: Implement the concept identified in Phase I and demonstrate the capability of the technology with a prototype system.

PHASE III: Identify commercial development partner(s) and provide commercialization plan and documentation for mass production.

DUAL USE: A miniature, personal chemical detector/dosimeter is highly sought after in the industry to monitor toxic industrial chemicals (TIC). The form factor and power requirements of existing personal detectors is too bulky to be used conveniently in the field. Furthermore, a power efficient, light-weight chemical dosimeter/detector allows long term medical studies to be carried out on an individual in the field.

KEYWORDS: gas sampling system, chemical dosimeter, miniaturization

CBD00-203 TITLE: Development of a Portable Aerosol Collector

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop a badge-sized aerosol collector using either electrostatic or electrodynamic precipitation to monitor personal exposure to BW agents. Apply the same technology to develop a small sampler that could be used to monitor areas within ships, aircraft cockpits and cabins, access repair panels for evidence of contamination.

DESCRIPTION: Personal detection of troops operating in the field at remote locations close to front lines or in high threat areas is lacking. In addition, viable technologies to monitor for contamination within or on aircraft, within ships and other assets is also lacking. The type of aerosol sampler required for personal/small area detection under such conditions would have to be a lightweight, reliable, quiet sampler, capable of operation without the use of battery packs or bulky pumps and little or no fluids. We propose to develop a portable sampler based on electrodynamic precipitation technology coupled with microelectronic manufacturing techniques. Electrodynamic precipitation works by establishing an electrical gradient that attracts particles. Electrodynamic sampling technologies have numerous advantages over more conventional sampling devices such as prolonged sampling, have no moving parts, and require no fluids to capture aerosol particles. When combined with microelectronic manufacturing, small samplers requiring very low power requirements can be manufactured. Such a sampler could be used as for monitoring an individual's exposure or that of a small area.

PHASE I: The first phase of this work would involve laboratory investigations focused on characterizing and optimizing sensitivity and capacity of an electrodynamic sampler. Work would also be directed towards applying micro-electronic manufacturing techniques towards development of such a sampler. Laboratory work would also include exposing the sampler to decreasing concentrations of simulant biowarfare agents to determine the senstivivity and the capacity of such as sampler.

PHASE II: The second phase of the research would be dedicated to development and testing of a prototype sampler in an aerosol chamber. Testing of the sampler would involve measuring collection of aerosolized target microorganisms will be aerosolized under various combinations of low and high humidity and temperature in the presence and absence of physical interferents such as dust, pollen, smoke and other small particulates. Known concentrations of interferent will be aerosolized during and after collection of target microorganisms. The results of interferent studies will be used to measure the effect of abiotic and biotic background particulates on sample collection and the effect of humidity and temperature on sample recovery.

PHASE III DUAL USE APPLICATIONS: Dual use of such a sampler includes measuring exposure of those working in BL3 and higher laboratories to exposure dangerous microorganisms. Such a sampler could also measure exposure of workers to dust, soot and other particulates encountered in potentially hazardous working environments such as mines, metal working shops and slaughterhouses. Such a sampler will also be useful in assessing the hazards found in compartments that need "gas-free" testing prior to entrance. The sampler could also be usful for collecting trace amounts of illicit substances.

KEYWORDS: Biological warfare, aerosol sampling, electrodynamic sampling, micro-electrical manufacturing, detection, aerobiology, biodetection.

CBD00-204 TITLE: Ultra-fast Cemical Agent Detector with Fast Gas Chromatograph (CG) Analysis

TECHNOLOGY AREAS: Chemical/Biological Defense, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM, Nuclear, Biological, & Chemical Defense System

OBJECTIVE: Innovative chemical transducers are needed with fast "equilibrated" signal kinetics and/or optimized gas sampling pneumatics that increase the performance of technologies such as the surface acoustic wave (SAW) sensor. The chemical transducer developed should provide equilibrated signal responses to chemical agent simulants in <0.1 s and preferably <0.05s, and allow similar recovery times to signal baseline. Interface the transducer or transducer and developed pneumatics system to a "fast" GC system and demonstrate detector operation is capable of monitoring narrow eluting analyte GC peaks for chemical agent simulants. The simulants should have similar retention indices to actual chemical agents.

DESCRIPTION: Novel chemical transducers and sampling pneumatics are needed to improve the signal kinetics performance over and above existing detectors based on surface acoustic wave (SAW), ion mobility spectrometry (IMS), photoionization (PI), chemiresistor (CR), and quadrapole mass spectrometery (QMS). For hand held, dosimeter, or distributed monitoring, key development issues relate to size, weight and power consumption of detector components. One area of generic concern to all detectors is the signal response characteristics. Normally a sensitive, fast and reversible response are considered desirable. The areas that govern the signal response characteristics include the chemical transducer and the associated gas sampling pneumatics. Regardless of the core chemical detector technology involved, it is possible for false alarms to occur. One way to increase the performance of a detector is to include some form of collection/concentration and chromatographic capability to separate complex mixtures of gases prior to detection. The draw back with such an approach is the increased time involved in analysis. However with the advent of "fast GC" systems that can carry out complex analysis in less than 10 seconds, there is an increased need for detectors that can functionally be integrated to these GC systems. Unfortunately many current technologies are not compatible with the "fast GC" systems because the signal kinetics of the gas sensor technology are too slow. Transducer pneumatics can be direct to ambient air or involve a gas concentrating device (preconcentrator) that can then be interfaced to a gas chromatographic (GC) column that is serially connected to the detector of interest (eg. SAW, IMS, PI, CR, QMS). Ultra fast GC analysis with high performance (all nerve, mustard, and blood agents clearly separated) is possible for a complex mixture of agents in about 10 seconds. However, The eluting GC analyte peaks from such a GC column are extremely narrow with peak widths that are of the order of 0.5 s. In order for the detector to follow the trace of such a narrow peak, the detector should be able to respond and recover to signal baseline in <0.1 seconds and preferably <0.05 s. Current designs of detector technologies for example the Joint Chemical Agent Detector currently in its EMD phase (that do not require support gases) do not allow for this level of performance, so they are not currently able to take full advantage of the GC technology available. Development of innovative transducers and gas pneumatics to allow rapid equilibrated detector signal responses is highly desirable for a variety of chemical agent detector applications and would be advantageous in accomplishing effective integration with current fast GC systems. The resulting technological innovations are expected to be enabling to the SAW JCAD, JSPGM, and JTCOPS programs which all have requirements for detection of toxic gases. Commercial interest in chemical detectors with fast signal kinetics compatible with fast GC systems would be in field monitoring of chemicals at industrial locations, and in areas where toxic industrial chemicals are released into the environment.

PHASE I: Demonstrate the concept of a chemical transducer and/or pneumatics/chemical transducer capable of fast and reversible equilibrated signal kinetics to chemical agent simulants. The developed technology should allow detector gas sampling system and/or transducer detection and recover to signal baseline in <0.1s and preferably <0.05s.

PHASE II: Integrate the technology identified in Phase 1 with a fast GC system, and demonstrate the capability of the technology with a prototype system.

PHASE III DUAL USE APPLICATIONS: Identify commercial development partner(s) and provide commercialization plan and documentation for production.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The development of a chemical transducer/pneumatics with fast signal kinetics compatible with a "fast GC" would allow a much higher level of user confidence and reduce the need for multiple technologies or systems to confirm/deny detection/identification of agents. Reducing the need for multiple technologies would lead to a direct cost reduction.

KEYWORDS: Chemical Transducer, Pneumatics, Fast GC, Gas Chromatography, Equilibrated Signal kinetics

CBD00-205 TITLE: <u>Particle Filter/Separator For Use In Biological Samplers</u>

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM, Nuclear, Biological, & Chemical Defense System

OBJECTIVES: The object is to develop reliable in-line filters and separators for use with biological sampling equipment at 800-1000 lpm flow rates. To prove feasibility and reliability of incorporating such devices into existing systems without reducing down stream function.

DESCRIPTION: There is a need to reduce the ingestion of 50 micron and larger particles from a biological wet sample. This need has arisen due to large particles causing clogging of particle counters (e.g. TSI APS and MetOne) and wet samplers in current biological agent detection systems. The base line particle sizes for biological agents are 2-10 micron with some clusters as large as 15 micron and as small as 1 micron. Background particles are found at many sites employing developed biological agent detection systems. These large particles have many sources and when the devices are constantly exposed to these sources clogging occurs. Some examples of sources are industrial waste and equipment exhaust as well as pollutants from controlled and uncontrolled burns (e.g. forest fires, controlled back-burns and the burning of old crop fields).

PHASE I: Phase I efforts should focus on experimentation to evaluate proposed filtering and/or separator technology. Filtering of particles 50 microns and above is desired. The filtering technology should not significantly reduce a flow rate of 800 - 1000 liters per minute. Initial demonstration of the technology should show that the desired particle sizes are filtered and particles below that size pass through.

PHASE II: Phase II will proceed if there is sufficient data collected to prove that this process of using a filter/separator is a reliable and efficient way to reduce large particles from entering into a biological sampler. Phase II efforts should focus on integration of the filter/separator technology into existing biological agent detection systems and full blown chamber testing to evaluate the efficacy and reliability of the developed technology.

PHASE III: The filter/separator would be placed on existing Biological sampling equipment used on Navy ships. This would include the Interim Biological Agent Detection System (IBADS). It could be used with the Joint Program Office (JPO) Portal Shield and JBREWS equipment. These devices would also have a use on future aerosol sampling equipment where applicable.

DUAL USE APPLICATIONS: These devices could be used within the civilian community where applicable, with biological detection equipment for anti-terrorism.

KEYWORDS: Filter, Separator, biological, testing

CBD00-206 TITLE: Field Rugged Man-Portable Chemical Biological(CB) Gas Chromatograph(GC) Mass Spectrometer(MS) for Environmental Assessments.

TECHNOLOGY AREAS: Chemical/Biological Defense, Weapons

OBJECTIVE: Assess Federal, State, and Local landfills, Chemical and Biological storage facilities(bunkers/ammo-dumps, etc...), Petroleum & Chemical Plant tanks(above & below ground), for surface contamination.

DESCRIPTION: The intent of this project is to quickly, and rapidly assess CB agents that permeate (filter) from stored 55-gallon drums, tanks, landfills, or pipelines in Petroleum plants. The CB GC/MS must be rugged enough to withstand forces associated with MIL-STD-810-E (environmental tests), shock & vibration, solar radiation, and be decontaminated using the current FM 3-5 (field decontamination manual), and or Federal, State, and Local laws and regulations. The CB GC/MS must be capable of ultimately performing simultaneous analysis of multiple CB agents, as well as, Toxic Industrial Chemicals (TIC's), Toxic Industrial Biologicals (TIB's). Engineering design, system development, risk identification, and the evaluation of the desired technical performance in systems specifications to achieve the systems objective must be evaluated.

PHASE I: Determine the feasibility of developing the Chem/Bio field rugged GC/MS for environmental assessments. The market survey/study must be based on the development of the Chem/Bio GC/MS that is both Man-portable, and safe to operate.

PHASE II: Build and demonstrate the proper handling, sampling, and detection capabilities of the CB GC/MS system based on Phase I design criteria's. The demonstration of the CB agent detection system can use "stimulus" to mimic the actual agent of interest (chem/bio), and "trigger" the alarm. The CB GC/MS can include the use of modeling & simulation, test beds, and prototypes of full-scale engineering development models of the system in Phase II. The objective is to test a "Pre-production" system that closely approximates the final product. Test & Evaluation's on Critical Technical Issues, and technical risks, trade-off evaluations on specifications, operational requirements, life-cycle-costs, schedule, as well as safety is determined.

PHASE III: Design and fabricate(build) a field rugged CB GC/MS that analysis the soil, and or ,vegetation for Toxic Industrial Chemicals(TIC's), and Toxic Industrial Biologicals(TIB's), and CB threat agents of interest. Production Acceptance Test & Evaluation(PAT&E) will be used to verify system compliance with the requirements and specifications of the contract. Tests that are described in the Test Evaluation Master Plan(TEMP), but not conducted during Phase II, are completed during Phase III. System elements are integrated into the final operational configuration, and development testing is completed when all system performance requirements are met.

COMMERCIAL POTENTIAL: The Field Rugged CB GC/MS could be used by Federal, State, and Local authorities to monitor landfills, wetlands, Petroleum & Chemical plant discharge(holding pit's ditches, etc..), and CB storage bunker's for CB threat agents seeping into ground water, or rising to the surface. Furthermore, the system when manufactured in large numbers, can possibly reduce the systems overall costs . This will give both DOD, and civilian authorities the capability to accurately "assess" TIC's, and TIB's, and CB agents of interest.

KEYWORDS: Chemical Biological, Toxic Industrial Chemicals (TIC's), Toxic Industrial Biologicals(TIB's, Detection, Ground Water Analysis, Soil Analysis

CBD00-207 TITLE: Mission-Oriented Protection Posture (MOPP) IV Ensemble Degradation Monitor

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop a miniature warning device that alerts the user when his/her MOPP IV suit is no longer safe to wear.

DESCRIPTION: This is a requirement to develop the technology to warn the user that his/her MOPP IV ensemble has degraded to the level of "discard", due to excessive wear, or decontamination of the ensembles composite materials. The intent is to quickly warn the operator/user that his/her MOPP IV ensemble has become hazardous to their health. The system must be small, easily attached to Load Bearing Gear(LBE), or to the MOPP IV ensemble itself. The system must survive MIL-STD-810-E(shock, vibration, solar radiation, etc...). The system will consist of a cylindrical(vial shape in nature), device, that has "2" indicator's; one is for "Clear(white bottom-half)", and the other is for "Discard(red top-half)".The system starts out in the "Clear" mode(white), and gradually increases to the level of "Discard"(red). The system once used will be considered as a consumable(throw-away), along with the MOPP IV ensemble, and properly discarded.

PHASE I: During Developmental Testing and Evaluation (DT&E), the systems components, sub-systems, and prototype development models will be tested. The Test and Evaluation functional compatibility, interoperability, and Integration with fielded and developing systems is included. During Phase I, adequate DT&E is accomplished to ensure engineering is reasonably complete, and that all significant design problems have been identified, and the solutions to these problems are in hand. This is when the system's risk identification, and system development will be scrutinized.

PHASE II: Build, and design during the Engineering and Manufacturing Development(EMD) phase to the systems actual detection capability of a degraded MOPP IV ensemble. The objective is to test a pre-production system that resembles the final product. Determine the systems performance limitations, safe operating parameters, environmental impact assessments, vulnerability, and logistical supportability. The assessment of the Critical Technical Issues, technical risks, and the evaluation of the operational requirements, life cycle costs, and schedule.

PHASE III: The final design of the system is conducted, and the tested to the Test Evaluation Master Plan(TEMP). Any test that is not conducted during Phase II, are completed during Phase III. The systems elements are integrated into the final operational configuration, and development testing is completed when all of the systems performance requirements are met. The Production Acceptance Test & Evaluation(PAT&E), are verified for system compliance with the requirements, and specifications of the contract. Deficiencies that are not corrected are recorded.

COMMERCIAL IMPACT: The commercial sector, and DOD are both candidates for this system. Once the system is "proven", and becomes available on the market, it's production potential(consumable), will be unlimited. HAZMAT teams, Fire Departments, Police(special-units) Forces, Rescue Squads, Hospitals, etc..., and the Department Of Defense will be highly interested in this particular system. The production of this system (device), will have a significant impact on the total "Life-Cycle-Cost" of the system.

KEYWORDS: HAZMAT, MOPP IV Suit, Chemical Biological Detection

Air Force CBD Topics

CBD00-301 TITLE: Discrimination of Biological Agents at Standoff Distances

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop and demonstrate a novel eyesafe, manportable, laser-based technique to discriminate biological agents from naturally occurring backgrounds at moderate standoff distances (up to 10 km).

DESCRIPTION: This topic solicits innovative and creative solutions to a research and development (R&D) problem in moderate range standoff biological agent detection and discrimination. Possible detection techniques include, but are not limited to, discrimination of the bio particles by utilizing polarization and/or multiple scattering methods. Specifically excluded are the LIght Detection And Ranging (LIDAR) techniques known as DIfferential SCattering/DIfferential Absorption LIDAR (DISC/DIAL), since they are already being pursued in separate efforts. All innovative approaches are encouraged and will be considered, provided they meet Phase I and II technical goals.

As stated in the definition of the Joint Warfighting Capability Objective (JWCO) for CB Warfare Detection, the "Capability for standoff detection of biological and chemical agents is our single most pressing need." Also, one of the 2 Counterproliferation JWCOs is stated as the "Capability to detect and evaluate the existence of a manufacturing capability for weapons of mass destruction (WMD)." The current state-of-the-art biological detection system is the M94, a helicopter-mounted 1 micron scattering detection lidar. The eyesafe upgrade to this device is the Long-Range Biological Standoff Detection System (LR-BSDS). Both detect the presence of aerosol clouds at ranges of as great as 30-50 km. However, neither device is capable of discriminating between naturally occurring aerosols and those associated with a BW release. Another lidar, the Short-Range Biological Standoff Detection System (SR-BSDS), is currently being developed for evaluation. This device will be able to detect the presence of biologically-active particles within a naturally occurring aerosol environment. However, it utilizes non-eyesafe ultraviolet light, is severely limited in range, is quite large, and must be operated in darkness for maximum sensitivity. For example, it has been calculated that detection ranges at night are less than 1 km for minimum threat clouds. In addition, both the SR-BSDS and LR-BSDS are very large and expensive systems, weighing over 1000 pounds each, and require a dedicated vehicle such as a helicopter or HMMWV to house them and provide the power they need.

Naturally occurring atmospheric particles fall into the 0.3 to 0.7 micron range. On the other hand, particles onto which BW agent have been deposited are much larger (2-10 microns). If radiation impinges in clouds of these materials, it is well-known that the larger particles will cause the radiation to be much more multiply reflected. Thus, it is possible to discriminate clouds of BW agents by measuring the relative amounts of the singly and doubly backscattered signals. This can easily be done by using a LIDAR with detectors that are viewing both on and off axis.

In addition, it known that the particles onto which the bio agents are deposited are cylindrical (or at least non-spherical) in shape. This gives rise to the possibility that they will be sensitive to polarized light. Since it has been established that naturally-occurring dust has no such polarizing qualities, there is a possibility that this fact can be used to discriminate bio particles from the atmospheric background. Preliminary calculations show that identification of the bio-aerosols could be possible at ranges up to 10 km if either of these techniques prove viable.

PHASE I: Measurements will be made to indicate the feasibility of the method proposed to discriminate bio clouds from natural backgrounds. Specifically, at least the biosimulant bacillus globigii (BG) will be considered. If possible, other materials including known binders for BW agents will also be examined as well as the effect of growth media. These data will be used to specify the design characteristics and project the performance of a moderate range (5-10 km) lidar using a novel bio-discrimination technique.

PHASE II: Construct or assemble a manportable breadboard lidar that will emit wavelengths shifted to eyesafe regions by optical parametric oscillation (OPO) or other techniques. The lidar will be used in field tests to demonstrate that the proposed novel technique can be used to identify BW simulants from naturally occurring aerosols at ranges of up to 5-10 km.

PHASE III DUAL-USE APPLICATIONS: Phase III military applications include manportable, standoff CB detectors for contamination avoidance, decontamination, and counterproliferation. Phase III commercial applications include detectors for standoff environmental pollution monitoring.

KEYWORDS: chemical, biological, detection, carbon dioxide laser, LIDAR, standoff, sensitivity, system noise.

CBD00-302 TITLE: In-flight Decontamination

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM, Nuclear, Biological, & Chemical Defense System

OBJECTIVE: Develop and demonstrate technology that can be used to decontaminate (neutralize) personnel and cargo while in-flight for both rotary and fixed-wing aircrafts.

DESCRIPTION: The capability to decontaminate (neutralize) personnel and cargo while in-flight is extremely valuable to the military. The technology needs to be lightweight, highly efficient, environmentally friendly, non-toxic to personnel, and materials compatible with the inside of an aircraft (both rotary and fixed-wing). This capability will allow personnel to lower protective levels and reduce the physiological and pyschological burden of being in protective gear in an enclosed space for a long duration. In addition, the overall system needs to be air-worthy in order for its use aboard an aircraft.

PHASE I: Develop and demonstrate feasibility of technology to decontaminate (neutralize) personal protective equipment (suits and masks) and cargo (typical materials like cardboard, tarp, plastic covers, etc) contaminated with simulants in an enclosed space. The technology must be environmental friendly and have no side effects on personnel inside the enclosed space.

PHASE II: The technology must be proven against "live agents." Develop and demonstrate an application system using the technology developed in Phase I. The system must be air-worthy, material compatible with the inside of aircrafts and usable by a single individual to decontaminate other personnel and cargo while aircraft is in-flight.

PHASE III DUAL-USE APPLICATIONS: Phase III military application will be for in-flight decontamination as required by the Joint Operation Requirements Document Joint Service Sensitive Equipment Decontamination (in final staffing). Phase III commercial applications for hazardous material clean-up for domestic preparedness and environmental pollutants.

KEYWORDS: chemical, biological, decontamination, hazardous material.

CBD00-303 TITLE: Thin, Flexible Chemical Agent Resistant Materials

TECHNOLOGY AREAS: Chemical/Biological Defense, Materials/Processes

OBJECTIVE: Develop a thin flexible 24 hr. military chemical agent resistant material for use in mask hoods, mask components and water containers.

DESCRIPTION: Current materials and their manufacturing processes for this application are very expensive and produce material that are bulky and not very flexible or can not last 24 hrs in a military chemical environment. Limitations in the current manufacturing processes do not allow the material to meet all of the requirements or allow the material to be versatile to meet all of the applications. The current specification that is used for mask hood material is MIL-C-51251. A new material shall be able to withstand military chemical agents and battlefield contaminants for a period of 24 hrs. The following is a list of the contaminants:

Contaminant	Test Method
Methyl Ethyl Ketone (MEK)	MIL-STD-810E
Isopropanol	MIL-STD-810E
Diesel Fuel	MIL-STD-810E
Gasoline	MIL-STD-810E
Toluene	MIL-STD-810E
Acetone	MIL-STD-810E
Motor Oil	MIL-STD-810E
Bleach (1 teaspoon calcium hypochlorite per gallon of water)	MIL-STD-810E
NaOH 5%	MIL-STD-810E
VX (military chemical agent)	MIL-STD-282
TGD (military chemical agent)	MIL-STD-282
HD (military chemical agent)	MIL-STD-282
GB (military chemical agent)	MIL-STD-282
Insect repellent (N,N-Diethyl-m-tolumide)	MIL-STD-810E
DS2, Decontaminating Solution (Caustic)	MIL-STD-810E
Hydraulic Fluid	MIL-STD-810E
JP4 (Jet Fuel)	MIL-STD-810E
JP8 (Jet Fuel)	MIL-STD-810E
LSA (Lubricant Small Arms)	MIL-STD-810E
AFFF (Aqueous fire Fighting Foam)	MIL-STD-810E

The material shall be able to withstand boiling water for 4 hours.
The current material manufactured under MIL-C-51251 only meets the above list of contaminants for a period of six hours. Current materials that meet all of the above contaminants for a 24 hour exposure are very thick (.060" to .125" in thickness), not flexible, and expensive. The currently available thinner (.005" to .025" in thickness) materials can not withstand the battlefield

contaminants for 24 hours. The new material shall be thin (less than .015" in thickness), flexible (can withstand cyclic flexing at –60oF to 160o, Newark Flex – ASTM#D2097-69), have a low noise signature (comparable to the butyl coated cloth of MIL-C-51251), have a 10 kgf minimum puncture resistance (ASTM#D2582-67), have a weight less than 12 ounces per sq./yd and shall be FDA approved for potable water. The material shall be able to be integrated into multiple manufacturing processes such as heat sealing, ultrasonic welding, bonding, etc... The development of a new material/manufacturing process would allow for a number of the above requirements to be successfully met. The development of the material/manufacturing process shall also be concentrated on versatility to meet additional requirements through a secondary process performed to the material or combining additives to the material before processing.

PHASE I: Research any new developments in materials technologies. Research existing and new manufacturing techniques that can be applied. The research shall be concentrated in developing three candidate materials using combinations of new and existing materials and manufacturing processes.

PHASE II: Further develop the candidate materials/manufacturing process and provide samples of the materials for evaluation. Conduct testing to evaluate their resistance to chemical agents and battlefield contaminants. Characterize the candidate materials physical properties for strength, tear resistance, durability, temperature performance and flame resistance. Develop a matrix that evaluates cost and performance of all the candidate materials. Construct mask hood and water container prototypes from all of the candidate materials.

DUAL-USE APPLICATIONS: The candidate materials will have a significant applications in the current developmental mask programs such as the Joint Service General Purpose mask, Joint Service Aircrew Mask and the Air Warrior. The candidate materials will also have application for other programs such as chemical protective clothing and gear. Industry will also have a use for the developed materials in the first responders and firefighter's chemical gear.

CBD00-304 TITLE: Open Wound Decontamination

TECHNOLOGY AREAS: Chemical/Biological Defense

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PM, Nuclear, Biological, & Chemical Defense System

OBJECTIVE: Develop and demonstrate technology that can be used to decontaminate (neutralize or remove, preference is neutralization) chemical and biological agents in open-wounds of casualties personnel.

DESCRIPTION: The capability to decontaminate (neutralize or remove, preference is neutralization) chemical and biological warfare agents in open-wounds of casualties is extremely valuable to the military. This capability will increase the safety and survivability of casualties and personnel in the course of medical treatment of casualties in a chemical and biological contaminated environment. The technology needs to be rapid but mild due to the sensitive nature of open-wounds. This capability will allow medical personnel to more readily treat casualties in a safe and effective manner.

PHASE I: Develop and demonstrate feasibility of technology to decontaminate (neutralize or remove, preference is neutralize) contamination in open-wounds. The demonstration will use simulants for the warfare agents and medically approved laboratory substitutes for open-wound conditions. The initial focus will be on chemical warfare agents using simulants for GB, VX and HD.

PHASE II: The technology must be proven against "live agents" with medically approved laboratory substitutes for open-wound conditions. The technology must have the potential to be FDA approved for human use.

PHASE III DUAL-USE APPLICATIONS: Phase III commercial and military application will be for treatment of casualties that have been contaminated with hazardous materials. This application benefits the military in chemical and biological warfare contaminated environments. The commercial use will be in treatment of personnel injured during hazardous material clean-up, domestic preparedness situations, and environmental pollutants.

KEYWORDS: chemical, biological, decontamination, hazardous material, open-wound, medical.

CBD00-305 TITLE: Multi-Component Adsorption Data and Modeling

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop and demonstrate a model to predict adsorption and desorption processes for a range of chemicals to provide a better understand of real world issues associated with air purification filtration systems in the presence of multi-contaminants.

DESCRIPTION: Military air purification filters remove heavy-vapor contamination by adsorption. Future regenerative filtration systems designs are based on understanding how vapors are adsorbed and desorbed. Complex interactions between adsorbed water and heavy vapors, e.g., nerve agents, cause this to be a poorly understood phenomenon. Fundamental studies, both experimental and modeling, are needed to more completely describe and understand the resulting multi-component adsorption process.

Vapors of prime interest are CW nerve and blister agents that boil between approximately 150 and 300 C. Studies using simulants which have similar vapor pressures and water solubility are recommended. Results should include adsorption equilibrium data on microporous adsorbents of interest to DoD at a variety of relative humidity and temperatures and an effort to correlate the data.

PHASE I: Measurements of adsorption equilibria on select microporous adsorbents will be made of simulants which have similar vapor pressure and water solubility to chemical warfare nerve and blister agents at a variety of relative humidity and temperatures. The collected data will be empirically modeled to attempt to correlate the data.

PHASE II: The empirical model developed in Phase I will be expanded to a theoretical model and the database of chemical adsorption and desorption processes will be expanded to include typical battlefield interferents and a select list of toxic industrial materials.

PHASE III DUAL-USE APPLICATIONS: Phase III commercial and military applications include filtration systems for both collective and individual respiratory protection; e.g. environmental control systems and respiratory masks. The military applications will involve warfare agents whereas the commercial applications for environmental pollutants.

KEYWORDS: chemical, biological, filtration, adsorption, desorption, regenerative, modeling.

NAVY
PROPOSAL SUBMISSION
INTRODUCTION

The responsibility for the implementation, administration and management of the Navy SBIR program is with the Office of Naval Research (ONR). The Navy SBIR Program Manager is Mr. Vincent D. Schaper ((703) 696-8528). The Deputy SBIR Program Manager is Mr. John Williams ((703) 696-0342). If you have any questions, problems following the submission directions, or inquiries of a general nature, contact one of the above persons. For technical questions about the topic contact the Topic Authors listed on the website before 1 December 1999. Mail one original and four copies of your Phase I proposal to the address below. Proposals must be received by **12 January 2000.**

Office of Naval Research
ONR 364 SBIR
800 North Quincy Street, RM 633
Arlington, VA 22217-5660

The Navy's SBIR program is a mission-oriented program, which integrates the needs and requirements of the Navy through R&D topics, which have dual-use potential. All Navy SBIR topics fall within the DOD Science and Technology areas and the Navy Science areas, listed in Table 1. Navy topics will be funded from these areas according to a priority it has established to meet its mission goals and responsibilities. Information on the Navy SBIR Program can be found at (**http://www.onr.navy.mil/sbir**). Additional information pertaining to the Department of Navy mission can be obtained by viewing various Navy World Wide Web sites at http://www.navy.mil

UNIQUE NAVY REQUIREMENTS:

1. Navy requires a " DOD Proposal Cover Sheet" (formerly Appendix A & B) to be submitted electronically through the Navy SBIR Website or DOD SBIR Submission Web Site at http://www.dodsbir.net/submission. The company must print out the forms directly from the Website, sign the forms and submit them with their proposal.
2. All Phase I award winners must electronically submit Phase I summary report through the Navy SBIR Website at the end of their Phase I.
3. Phase II award winners must also submit Phase II Summary reports through the Navy SBIR Website.
4. The Navy requires that all Phase II proposers submit a Proposal Cover Sheet & Commercialization Report through the DoD SBIR Submission Web Site. Mail a printed and signed copy of the Proposal Cover Sheet and Commercialization Report only to the Navy SBIR Program Office listed above. Mail the full Phase II proposal with Proposal Cover Sheet and Commercialization Report to the sponsoring Navy activity and technical point of contact.
5. The requirements and time frames for Navy Fast Track submission have been modified and are described below.
6. The Navy only accepts proposals with a base effort less than $70,000 with an option less than $30,000.

NEW IN FY 2000:

1. The Small Business Administration (SBA) has made a determination that will permit the Naval Academy, the Navy Post Graduate School and the other military academies to participate as subcontractors in the SBIR/STTR program, since they are institutions of higher learning.

2. The Navy will allow firms to include with their proposals, success stories that have been submitted through the Navy SBIR Website at (**http://www.onr.navy.mil/sbir**). A Navy Success Story is any follow-on funds that the firm has received from a past Phase II Navy SBIR or STTR awards. To qualify the firm must submit these success stories no later than **13 December 1999,** through the Navy SBIR Website. The success story should then be printed and included as appendices to the proposal. These pages will not be counted towards the 25-page limit. The success story information will be used as part of the evaluation of the third criteria, Commercial Potential (listed in Section 4.2 of this solicitation) which includes the Companies Commercialization Report (formerly Appendix E) and the strategy described to commercialize the technology discussed in the proposal. Commercialization is viewed as any follow-on funds, from the DOD, DOD contractors or the private sector, used to further develop the technology or

from sales of a product. The Navy is very interested in companies that transition SBIR efforts directly into Navy and DOD programs and/or weapon systems. If a firm has never received any Navy SBIR Phase II it will not count against them, and they will be evaluated on the other evaluation criteria listed in Section 4.2 Phase I Evaluation Criteria.

3. Effective with the fiscal year (FY) 2000, no Navy activity will issue a Navy SBIR Phase II award to a company where the elapsed time between the completion of the Phase I award and the actual Phase II award date is eight (8) months or greater; unless the process and the award has been formally reviewed and approved by the Navy SBIR Program Office. Also, any SBIR Phase I contract that has been extended by 'no cost extensions' beyond one (1) year will be ineligible for a Navy SBIR Phase II award using SBIR funds.

4. The Navy has adopted a New Phase II Enhancement Plan to encourage transition of Navy SBIR funded technology to the Fleet. Since the Law (PL102-564) permits Phase III awards during Phase II work, the Navy will provide a 1 to 4 match of Phase II to Phase III funds that a company obtains from an acquisition program up to $250,000 in additional SBIR funds.

5. If you did not submit under 99.2, be aware that there is a new DOD report required to be filed pertaining to commercialization of prior SBIR awards. You can access the required DOD report information through the Navy SBIR electronic submission site.

PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

1. The Navy will not accept any proposals from companies that have not submitted the DOD Proposal Cover Sheet (formerly Appendix A & B) and the DOD Commercialization Report (formerly Appendix E) electronically over the Internet. These forms must be printed out directly from this site and be included with the entire proposal that is mailed to the Navy and received by 12 January 2000.

2. Your Phase I proposed cost for the base effort can not exceed $70,000. Your Phase I Option proposed cost can not exceed $30,000. The costs for the base and option should be clearly separate, and identified on the Proposal Cover Sheet, in the cost proposal, and in the work plan section of the proposal.

4. Your proposal must be received on or before the deadline date. The Navy will not accept late proposals, or incomplete proposals. If you have any questions or problems with submission of your proposal allow yourself time to contact the Navy and get an answer to your question. Submit electronic Internet forms early, as computer traffic increases, computer speed slows down. Do not wait until the last minute.

ELECTRONIC SUBMISSION OF PROPOSAL COVER SHEET AND COMMERCIALIZATION REPORT:

Submit your DOD Proposal Cover Sheet (formerly Appendix A & B) and the DOD Commercialization Report (formerly Appendix E) to the Navy using the DOD online submission at http://www.dodsbir.net/submission and as discussed in Section 3.4b and 3.4n of this solicitation. This site allows your company to come in any time (prior to the closing of the solicitation) to edit or print out your appendices. **The Navy WILL NOT accept any forms from past solicitation books or any electronic download version except those from the DOD SBIR Website as valid proposal submission forms.** Detailed instructions can be found by selecting the Help button on this site once you have registered. If you have any questions or problems with the electronic submission contact the DOD SBIR Helpdesk at 1-800-382-4634.

ELECTRONIC SUBMISSION OF PROJECT REPORTS:

The submission of an electronic Phase I Summary Report will now be required at the end of Phase I. The Phase I Summary Report is a non-proprietary summary of Phase I results and should include potential applications and benefits and not exceed 750 words. It should require minimal work from the contractor because most of this information is required in the final report. The summary of the final report will be submitted through the Navy SBIR/STTR Website at: http://www.onr.navy.mil/sbir, click on "Submission", then click on "Submit a Phase I or II Summary Report".

NAVY FAST TRACK DATES AND REQUIREMENTS:

All Fast Track Applications and required information must be sent to the Navy SBIR Program Manager at the address listed above and to the designated Contracting Officers Technical Monitor (the Technical Point of Contact (TPOC)) for the contract and the appropriate Administrative Point of Contact listed at the end of this Introduction. A copy of the Fast Track application cover sheet (Reference B) must also be send to the DoD SBIR Program Manager, at the address listed on the back of the sheet. The dates and information required by the Navy are the same as the dates and information required under the DOD Fast Track described in the front part of this solicitation.

ARE YOU A SUPPORT CONTRACTOR FOR A NAVY ACTIVITY ?

Do you have employees occupying space in a Navy activity? Or do you have a support contract to provide services outside of an SBIR Phase I, II or III contract award? Then you must indicate so on the Proposal Cover Sheet form. The Navy is concerned with potential conflict of interest and if you reply yes to either of the above you may be precluded from participation in the Navy's SBIR Program.

YOUR SUBMISSION TO THE NAVY SBIR PROGRAM:

This solicitation contains a mix of topics. When preparing your proposal keep in mind that Phase I should address the feasibility of the solution to the topic. Be sure that you clearly identify the topic your proposal is addressing. The Phase I option should address the transition into the Phase II effort. The Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees which have been invited to submit a Phase II proposal by the Navy technical point of contact (TPOC) during or at the end of a successful Phase I effort will be eligible to participate for a Phase II award (with the exception of Fast Track Phase II proposals). If you have been invited to submit a Phase II proposal to the Navy by the TPOC, obtain a copy of the Phase II instructions from the Navy SBIR Webpage or request the instructions from the Navy Administrative POC listed at the end of this introduction. Phase III efforts should also be reported to the SBIR program office noted above.

The Navy will provide potential awardees the opportunity to reduce the gap between Phases I and Phase II if they provide a $70,000 maximum feasibility Phase I proposal and a fully costed, well defined ($30,000 maximum) Phase I Option to the Phase I. **The Navy will not accept Phase I proposals in excess of $70,000 (exclusive of the Phase I option).** The technical period of performance for the Phase I should be 6 months and for the Phase I option should be 3 months. The Phase I Option should be the initiation of the next phase of the SBIR project (i.e. initial part of Phase II). The Navy will also offer a "fast track" into Phase II to those companies that successfully obtain third party cash partnership funds ("fast track" is described in Section 4.5 of this solicitation). When you submit a Phase II proposal it should consist of three elements: 1) a $600,000 maximum base effort, which is the demonstration phase of the SBIR project; 2) a transition or marketing plan (formerly called a "commercialization plan") describing how, to whom and what stage you will market your technology to the government and private sector; 3) a Phase II Option ($150,000 maximum) which would be a fully costed and well defined section describing a test and evaluation plan or further R&D if the transition plan is evaluated as being successful. Phase II efforts are for two (2) years no more, no less, Phase II options are for an additional six (6) months, any variation requires a waiver from the NAVY SBIR Program Office. You must also submit your Phase II Proposal Cover Sheet and Commercialization Report electronically to the Navy SBIR Program Office at the address above through the Navy SBIR Website. While Phase I proposals with the option will adhere to the 25 page limit (section 3.3), Phase II proposals together with the Phase II Option will be limited to 40 pages (unless otherwise directed by the TPOC or contract). The transition plan should be in a separate document.

The Navy will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

TABLE 1. NAVY MISSION CRITICAL SCIENCE AND TECHNOLOGY AREAS

TECHNOLOGY AREAS	SCIENCE AREAS
Aerospace Propulsion and Power	Atmospheric and Space
Aerospace Vehicles	Biology and Medicine
Battlespace Environment	Chemistry
Chemical and Biological Defense	Cognitive and Neural
Clothing, Textiles and Food	Computer Sciences
Command, Control and Communications	Electronics
Computers, Software	Environmental Science
Conventional Weapons	Manufacturing Science
Electron Devices	Materials
Electronic Warfare	Mathematics
Environmental Quality and Civil Engineering	Mechanics
Human-System Interfaces	Ocean Science
Manpower, Personnel and Training Systems	Physics
Manufacturing Technology	Terrestrial Sciences
Materials, Processes and Structures	
Medical	
Sensors	
Surface/Undersurface Vehicles/Ground Vehicles	
Modeling and Simulation	

NAVY SBIR PROGRAM MANAGERS OR ADMINISTRATIVE POINTS OF CONTACT FOR TOPICS

Topic Numbers	Point of Contact	Phone
N00-001 to N00-020	Ms. Carol Van Wyk	301-342-0215
N00-021 to N00-026	Mr. Rod Manzano	703-784-4587
N00-027 to N00-034	Ms. Linda Whittington	619-537-0146
N00-035 to N00-037	Mr. Charles Marino	202-764-1553
N00-038 to N00-072	Mr. Bill Degentesh	703-602-3005
N00-073 to N00-095	Mr. Douglas Harry	703-696-4286

NAVY 00.1 SBIR TITLE INDEX

Naval Air Systems Command

N00-001 Advanced Failure Modes and Effect Criticality Analysis (FMECA) Models that Accurately and Quickly Identify Optimum Levels of Diagnostic and Prognostic Requirements

N00-002 Compressor Impeller Erosion Resistant Surface Treatment

N00-003 Auto-correlation of Elevation Data from Digital Stereo Imagery

N00-004 Signal and Cable Integrity Monitoring and Diagnostics

N00-005 Reverse Rotation Capable Brush Seal Design

N00-006 Protective Materials for Aircraft Transparencies

N00-007 Intelligent Tutoring System for Tactical Aircraft Training (ITS-AIR)

N00-008 Environmentally Insensitive Active Decluttering

N00-009 Multistatic Operation

N00-010 Tracking Multisensor Data

N00-011 Military Utility of Automatic Dependent Surveillance - Broadcast (ADS-B)

N00-012 Low-Cost Precision Missile Trackers for Directional Infrared Countermeasures (DIRCM)

N00-013 Middle Game Localization Utilizing Air Deployable Active Receiver (ADAR)

N00-014 Joint Optical Air Data System

N00-015 Development of a Novel Infrared Detector Based on Quantum Well Optical Parametric Amplification (OPA) for Light Detection And Ranging (LIDAR) Receiver Applications

N00-016 Multibeam Sonobuoy Operator Displays

N00-017 Wavelet Compressions to Increase Desktop Personal Computer (PC) Real-Time Texture and Terrain Paging

N00-018 Compact Infrared Countermeasure (IRCM) Jam Head

N00-019 Solid-State Imaging Array for Laser Radar Applications

N00-020 Obsolete Electronic Parts Automated Functional Replacement System

Marine Corps Systems Command

N00-021 Nitrogen Charging System for the Advanced Amphibious Assault Vehicle (AAAV)

N00-022 Small, portable, lightweight, multi-fuel powered electric generators

N00-023 Personnel and Material Tagging

N00-024 Position Location Tracking from Inside Building to Outside Building in an Instrumented Military Operations On Urbanized Terrain (MOUT) Environment

N00-025 Wearable Operator Control Unit

N00-026 Precision Sea-Based Logistics

Space and Naval Warfare Systems Command

N00-027 Link-16 Enhanced Positional Accuracy for Precision Guidance

N00-028 High Frequency Transmit Mast Clamp Current Probe

N00-029 Jammer Placement Artificial Intelligence Tool

N00-030 Wireless Line-of-Sight Networks for IntraBattlegroup Communications

N00-031 Sensor Tasking Segment (STS)

N00-032 Automated Network Anomaly Detection and Fault Tolerance Toolkit

N00-033 Trusted Workstation Using a Plug-in Encryption Module

N00-034 Wideband Radio Frequency (RF) Distribution System

Strategic Systems Program

N00-035 High Precision Depolarized Fiber Optic Gyro (DFOG)

N00-036 MicroElectroMechanical Systems (MEMS) for Ordnance Monitoring

N00-037 Global Positioning Satellite (GPS) Receiver Test Bed

Naval Sea Systems Command

N00-038 Robotic Manipulator for Cargo/Weapons Handling

N00-039 Advanced Fuel Filtration

N00-040 Fire Resistant, Labor Saving, Reduced Weight, Pipe Coupling (Flange)

N00-041 Remotely/Externally Adjustable Valve Actuators

N00-042 Cabling Jackets with Zero Halogen to Meet UL910 Flame Test

N00-043 Enhanced Resistance to Mine Detonation

N00-044 A Dynamic Configurable MCM Assessment Tool for Amphibious Assault Operations

N00-045 Laser Radar (Lidar) Remote Wind Sensor for LCAC

N00-046 Non-Contact Measurement of Ocean Currents

N00-047 LASER Vibration Monitoring of Unmanned Machinery

N00-048 Design and develop a real-time on-line RMA trends and analysis reporting assessment database for Towed Array Systems

N00-049 Innovative Signal Processing Concepts for Active Emissions

N00-050 Smart Tools to Support Shipboard Network Administrators

N00-051 Development a Nondestructive Evaluation (NDE) Technology for Inspecting Structural Welds under Coatings

N00-052 Application of Virtual Large Display Video Goggles to Submarine Imaging Systems

N00-053 Highly Directional Compact UHF Antenna

N00-054 Non-Metallic Bearings

N00-055 Digital Radar Receiver on a Chip

N00-056 Low-Cost Net-Form Fabrication of Hot Gas Valve Components

N00-057 Propulsion Improvement for Long Range Guns

N00-058 Direct Digital Signal Synthesizers

N00-059 Advanced Reactive Materials As Propellants

N00-060 Aerodynamic range extension of guided projectiles

N00-061 Effect of Ocean Waves on Tracking Low-E Objects in Multipath

N00-062 Force Level Automated Certification of Downward Compatible Baseline Software

N00-063 Reconfigurable Maintenance And Diagnostic Assemblies (RMDA)

N00-064 Miniature RF Filters

N00-065 High Velocity Combustion Processes in the Solid State

N00-066 Operator Assistant for Artillery-Launched Observation Round

N00-067 Upward Compatible Baseline Support Framework For Effective Force Level System Regression Testing and Certification

N00-068 Flexible Sound Source

N00-069 Multi-Static Active Sonar Processing with Unknown Transmission Type and/or Unknown Source Location

N00-070 Innovative Broadband Signal Processing Algorithms

N00-071 Advanced Automated Sonar Operator Machine Interface

N00-072 Multistatic Acoustic Source for Unmanned Underwater Vehicles (UUV)

Office of Naval Research

N00-073 Advanced Compression for Digital Terrain Elevation Data

N00-074 Modeling and Simulation of Decision-making Under Uncertainty

N00-075 Low-Distortion Microwave Active Filters

N00-076 Wide Bandgap AlGaN Based Solar Blind Ultraviolet Photodetectors

N00-077 Four dimensional (4-D) Atmospheric and Oceanographic Instrumentation

N00-078 Heavy Power Transmission for Positioning and Actuation

N00-079 Conjugated Polymers for Corrosion Inhibition

N00-080 Low Thermal Conductance Torque Tube

N00-081 Quiet Turning and/or Nonrotating Devices for Marine Propulsion

N00-082 SiC Bipolar Junction Transistor (BJT) High Power Switch for the Advanced Quite Electric Drive Motor

N00-083 Development of a Finite Element Analysis for Failure Prediction of Large Composite Structures Under Dynamic Loads

N00-084 Composite Gun Barrel

N00-085 Development of a LonTalk Drive Chip (LDC) for High Performance Custom LonTalk Nodes

N00-086 Metrics for Evaluation of Cognitive Architecture-Based Collaboration Tools

N00-087 Real-Time Operator State Assessment Technologies

N00-088 Optimum Organization of Maintenance Aiding Information

N00-089 Compact, Light Weight Color Night Vision Goggles

N00-090 Innovative Air and Surface Strike Weapons Technology

N00-091 Technology for Shipbuilding Affordability

N00-092 Combat System Automated Testing

N00-093 The Manufacture and Integration of Power Building Blocks and Cells for PEBB

N00-094 Fast-response Sensor for the Measurement of the Optical Properties and Carbon Content of Organic Aerosols

N00-095 Real-time Interactive Analysis and Visualization Interface for Environmental Research Data

NAVY 00.1 SBIR WORD/PHRASE INDEX

KEYWORD/PHRASE..TOPIC NO.

NAVY FY00.1 TOPIC DESCRIPTIONS

N00-001 TITLE: Advanced Failure Modes and Effect Criticality Analysis (FMECA) Models that Accurately and Quickly Identify Optimum Levels of Diagnostic and Prognostic Requirements

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO-A, Air, ASW, Assault & Special Mission

OBJECTIVE: Develop and demonstrate an accurate and easy to use advanced FMECA modeling capability that would allow timely analysis of various aircraft subsystems.

DESCRIPTION: There is a need to improve and streamline the diagnostic, prognostic, and health management requirement design definition process. The advanced FMECA model can be used to identify the optimum mixture of diagnostic, prognostic, and health management capabilities. This modeling analysis would be used to aid in making the necessary capability and requirements trade-offs in order to define the optimum final system design.

PHASE I: Define and report on a strategy to develop this advanced FMECA modeling capability. Quantify the benefits and boundaries of applying this capability. Develop and demonstrate a prototype modeling capability.

PHASE II: Develop a final application of this advanced FMECA modeling capability to be applied to a major aircraft subsystem, like propulsion. Apply this model to this subsystem (propulsion) and define the resulting optimized diagnostic, prognostic, and health management system requirements. Demonstrate the necessary trade-off functions and resultant benefit areas (life-cycle costs, functional capabilities, etc.). Demonstrate that this general advanced FMECA modeling capability can also be applied to a second major aircraft subsystem. Deliver a software program for evaluation and demonstration.

PHASE III: Develop and deliver a general "global" advanced FMECA modeling capability program that can be used for a complete aircraft system design requirement including all aircraft subsystems. Apply this program capability to a new aircraft diagnostic, prognostic, and health management design. Market and sell the software program.

COMMERCIAL POTENTIAL: This analytical tool could be used in the design and development of any complex system. In particular, commercial manufacturers of fixed-wing or rotor craft aircraft could utilize the FMECA model in applying diagnostic, prognostic, and health management capabilities in their design.

REFERENCES: "Reliability Tool Kit: Commercial Practice Edition" by Reliability Analysis Center, 201 Mill St., Rome, N.Y. 13440-6916, email: dnicholls@mail.iitri.com, web site: www.reliability analysis center

KEYWORDS: Diagnostics; Prognostics; FMECA; System Design; Health Management; Supportability

N00-002 TITLE: Compressor Impeller Erosion Resistant Surface Treatment

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-275, V-22 Osprey Program

OBJECTIVE: The primary objective of the work is to develop an innovative surface treatment for shaft driven compressor (SDC) impellers used in aircraft applications to prevent erosion of the impeller.

DESCRIPTION: The Armed Services presently use SDC's on certain aircraft to provide, among other things, service to on-board inert/oxygen gas separators (OBIGS/OBOGS) and environmental control systems (ECS). Air intakes for these compressors are equipped with particle separators to prevent abrasive material from contacting the impeller. The impellers can operate from 87,000 to 100,000 rpm's (nominal) and at temperatures from 125_F (degrees F) to 600_F (degrees F). Aircraft, particularly helicopters and other vertical/short take-off and landing (VTOL/STOL) aircraft such as the V-22 Osprey, when operating over sandy or dusty landing zones (LZ's) or during dust/sand storms, have experienced rapid erosion of impellers, especially when the particle separator is overtaxed. This can lead to loss of function of critical components and potentially catastrophic system failure. There is a need to provide a surface treatment for SDC impellers, currently made of titanium 6-4 alloy, which eliminates the erosion phenomena or obviates it to an acceptable level.

PHASE I: Complete a development effort that demonstrates the scientific merit and feasibility of providing an erosion resistant surface treatment for SDC impellers for use on military aircraft. The surface treatment must be compatible with current impeller alloys and not degrade other performance requirements of the compressor.

PHASE II: Develop, test, and field demonstrate the surface treatment developed under the Phase I SBIR effort.

PHASE III: Produce the system demonstrated in the Phase II effort. The treatment will be transitioned to the Fleet through specification modifications and revisions.

COMMERCIAL POTENTIAL: A successful surface treatment can be used for SDC impellers for commercial aircraft as well as DOD aircraft and can transition to any other activity needing improved erosion resistant surfaces.

REFERENCES: Picture reference available, phone 301-342-0215.

KEYWORDS: Erosion; Impeller; Surface Treatment; Titanium; Sand; Shaft Driven Compressor

N00-003 TITLE: Auto-correlation of Elevation Data from Digital Stereo Imagery

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 281 Cruise Missile Command and Control

OBJECTIVE: Develop a robust technique to automatically collect high-resolution, high-accuracy elevation data from stereo photography with a suitably low amount of manual editing.

DESCRIPTION: Precision terrain aided navigation (PTAN) shows promise as a global positioning system (GPS) independent, high-accuracy en route and terminal navigation technique for a variety of platforms, including precision guided munitions like Tomahawk. For terminal navigation, this concept requires high-accuracy, high-resolution elevation data for use as reference maps. (High-resolution here means at most 3 meter post spacing.) To be operationally flexible, this elevation data must be quickly generated from a variety of sources, i.e., automatically. One such elevation source is stereo photography. Automatic generation of elevation data from stereo photography requires an auto-correlator. Current auto-correlators are not sufficiently robust. Although they execute quickly, there are too many elevations generated that require manual editing to meet accuracy requirements.

PHASE I: Develop auto-correlator requirements including accuracy, resolution, manual collection percentage, timing, image quality, etc. consistent with PTAN requirements.

PHASE II: Prototype auto-correlator algorithm and demonstrate with digital point positioning data base (DPPDB) imagery.

PHASE III: Develop complete software package including user documentation for use of auto-correlator as a stand-alone application or as an embedded application within larger systems.

COMMERCIAL POTENTIAL: This software could be used by state and local agencies as well as the private sector for generation of elevation data for a variety of geo-spatial applications such as surveying and earth-resource management.

REFERENCES: "Three Dimensional Computer Vision - A Geometric Viewpoint", by Olivier Faugeras, The MIT Press, Cambridge, Mass,1996.
http://dgrwww.epfl.ch/PHOT/publicat/wks96/Art_3_5.html
http://dgrwww.epfl.ch/PHOT/publicat/wks96/Art_3_1.html
http://www.ncgia.ucsb.edu/conf/SANTA_FE_CD-ROM/sf_papers/miller2_david/miller_paper2.html

KEYWORDS: Precision Terrain Aided Navigation; Terrain Modeling; Stereo Imagery; Tomahawk; Elevation Data; Auto-Correlation

N00-004 TITLE: Signal and Cable Integrity Monitoring and Diagnostics

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-290, Maritime Patrol Aircraft

OBJECTIVE: Develop technology capable of checking cable integrity in engine control and health management systems. The technology would detect, identify, monitor, and isolate signal problems and causes. This capability would reside as a sub-element of an aircraft/engine health management system, and enhance system safety, reliability, and availability.

DESCRIPTION: The increasing use of electronic control and health management systems on aircraft makes the need for consistent and reliable data imperative. As the systems become more complex, and take on more critical aircraft and engine control functions, and as the volume of data increases, the integrity of the data stream must be verified. Intermittent faults, shorts and grounds can cause uncommanded and/or unsafe control inputs. The signal and cable integrity monitoring and diagnostic system would ensure that the data is uncorrupted and help troubleshoot problems when they arise by providing maintenance actions.

PHASE I: Investigate all technologies and software to determine possible applicability to determine signal and cable integrity of aircraft and engine electronic systems. The system must detect, identify, monitor, and isolate signal faults, in real time on an operational aircraft system.

PHASE II: Develop and demonstrate an integrity monitoring system for use on an operational aircraft/engine system that will detect, identify, monitor, and isolate signal faults, in real time. The system will demonstrate the ability to troubleshoot aircraft system faults.

PHASE III: Transition the signal and cable integrity system into a fleet of aircraft as an enhancement to resident electronic control and health management systems, as a sensor system that is integrated with the engine that can detect and monitor disk cracks in real time. The inspection could be done as a separate maintenance action during ground maintenance, but the goal would be to have constant monitoring.

COMMERCIAL POTENTIAL: Although commercial aircraft could utilize this capability, it could also be used to enhance the overall system safety of any electronic control or health monitoring system.

KEYWORDS: Signal; Cable; Diagnostics; On-Wing; Monitoring; Inspections

N00-005 TITLE: Reverse Rotation Capable Brush Seal Design

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-275, V-22 Osprey Program

OBJECTIVE: Develop a brush seal design which is capable of accommodating reverse engine rotation for the V-22 Osprey aircraft. The design must be compatible with the existing engine power turbine brush seal dimensions.

DESCRIPTION: Designs are needed to develop a brush seal capable of accommodating both forward and reverse engine rotation. Significant innovation is required to solve the problem of brush seal reverse rotation operation. The V-22 Osprey requires that the AE1107C (T406) engine rotate in reverse during the blade fold wing stow operation. The brush seal design must allow engine reverse rotation within the torqueing capabilities of the rotor phasing unit (RPU) utilized in the propeller rotor positioning segment of the blade fold wing stow sequence. Leakage rates must be similar to those of current brush seal designs throughout the specified minimum mean time between overhaul period of the engine. Proposed designs must fit into the existing seal locations within the V-22 AE1107C engine power turbine section. Minimum impact to the existing engine design is highly desirable.

PHASE I: Produce prototype brush seal design option(s) that can accommodate both forward and reverse engine rotation application within the V-22 AE1107C power turbine section. Emphasis should be placed on leakage rates, engine operating environment, and compatibility with the existing AE1107C design and ground maintenance equipment. Design trades for minimizing leakage rates should also be performed.

PHASE II: Fabricate prototype seal(s) based on Phase I results analyzing dynamic capability of the seal(s). Test seal(s) in a component rig for leakage and dynamic performance demonstrating both forward and reverse rotation capability. Demonstrate compatibility with existing V-22 AE1107C rotor positioning ground unit. Perform preliminary design trade studies to expand the Phase I design to include other military and commercial applications.

PHASE III: Expand the preliminary design trade studies conducted in Phase II to a finalized design which can be utilized on other military and commercial applications. Transition the reverse rotation brush seal technology to a production capable item.

COMMERCIAL POTENTIAL: Commercial applications include gas turbine, turbopump, and other gas path sealing applications that require both forward and reverse rotation operation.

REFERENCES:

1. Rolls Royce Allison AE1107C drawing no. 23051300
2. Rolls Royce Allison AE1107C drawing no. 23063231

KEYWORDS: Brush Seal; Reverse Rotation; Gas Path Leakage; Gas Turbines; Blade Fold Wing Stow; Test and Evaluation

N00-006 TITLE: Protective Materials for Aircraft Transparencies

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-265, F/A-18 Strike Fighter Program

OBJECTIVE: Develop optically transparent materials that can be applied to aircraft transparencies to increase the resistance to abrasion, scratches and chemical attack.

DESCRIPTION: The program will evaluate materials that can be applied to aircraft transparencies made from acrylic or polycarbonate to improve the resistance to impact damage, scratching and chemical attach. Materials that can be coated on or bonded to the outer surface of the transparency will be evaluated. Laboratory evaluation of test coupons will be used to demonstrate improved performance without degradation to physical, mechanical or optical properties of the base material. Successful candidates will then be scaled up to show compatibility with current manufacturing processes and actual transparency shape, size and curvature. Successful demonstration will be followed by commercialization and evaluation for use in other applications such as commercial aircraft and automotive windows.

PHASE I: Select and evaluate protective materials. Test selected materials using simple flat laminates of acrylic and polycarbonate. Develop processes to apply the material. Material selection should be based on (1) light transmission, (2) haze, (3) abrasion, (4) chemical resistance to operational solvents and wind screen cleaning materials (such as Plexus), and (5) adhesion properties of the materials as applied to acrylic and polycarbonate substrates. Assess properties before and after exposure to accelerated weathering. Acrylic test substrates should follow MIL-PRF-8184F, Types I and II, and MIL-P-25690B Class 2 specifications. Polycarbonate test substrate should follow MIL-C-83310 requirements. Evaluate both protected and unprotected samples to determine specific improvement in abrasion and chemical resistance resulting from protective material application.

PHASE II: Further evaluate the best protective materials from Phase I assessment to determine manufacturing processes and to develop data on actual transparencies and wind screens. Scale up the application/manufacturing processes to meet current requirements for fabrication of aircraft wind screens and canopies. The processes of application of a coating or film should be capable of covering the entire outer surface and be compatible with current manufacturing methods. Perform testing to determine optical, abrasion and chemical resistance of the materials on actual canopies and wind screens using standard test methods. Compare the data to standard canopies and wind screens to determine improvements in performance. Make an assessment of the impact of this protective coating on the overall operation of the transparency system.

PHASE III: Scale up the protective material and application process to meet production requirements for military aircraft transparencies. Investigate and develop secondary applications of the material in protecting windows and transparencies for commercial aircraft, automobiles and other vehicles.

COMMERCIAL POTENTIAL: The development of an optically transparent scratch and chemical resistant protective material that is compatible with acrylic and polycarbonate will have a wide range of applications in commercial products. Protection for automobile, truck, bus and subway windows is a large market. In addition, a protective coating for lights, signs and other equipment that is subject to damage from the environment or vandalism is a potentially significant market for this material.

REFERENCES:

1. MIL-PRF-8184F
2. MIL-P-25690B

KEYWORDS: Aircraft Transparencies; Acrylic; Polycarbonate; Scratch Resistant; Coating; Wind Screen

N00-007 TITLE: Intelligent Tutoring System for Tactical Aircraft Training (ITS-AIR)

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA 205, Aviation Training Systems

OBJECTIVE: Develop an instructorless and intelligent tutoring system for deployable tactical aircraft training systems. ITS-AIR is expected to be based upon human-centric design principles, usability analysis, intelligent agent technology, and advanced cognitive modeling.

DESCRIPTION: The Navy is investing in commercial off-the-shelf (COTS) aircraft simulation technology that can be deployed at sea. Simulation systems have been very expensive to develop due to the cost of hardware and software. The requirement for instructors, operators, and maintenance personnel also makes them expensive to operate in the field. New developments in COTS computer technology, self-diagnostic maintenance, on-line technical support, and on-site service contracts will dramatically reduce simulator costs in future years. Simulator instructional systems are handmade for each simulator and require an instructor to operate the system and provide performance feedback to the trainee. The absence of a COTS ITS product for flight simulators increases system development and operational costs and reduces the capability to deploy the system. A generic, intelligent, and instructorless capability may improve usability, reduce costs, and improve the training effectiveness of new simulators. Generic features will allow ITS-AIR to be easily adapted for new tactical aircraft training simulations. The use of intelligent agent technology will optimize human learning and consequently reduce the time to learn. Instructorless operation will increase field use by students and reduce personnel costs by eliminating the need for an instructor/operator.

The context of ITS-AIR will be a reconfigurable aircraft mission rehearsal simulator. While ITS-AIR will initially be applied to a single aircraft type and a restricted set of mission tasks, it must have the capability to be extended to other aircraft types and a full range of missions without major software modification. Desired ITS-AIR capabilities include student control of the training simulation, windowed user interfaces, intelligent mentoring, performance monitoring and diagnosis, adaptive training, flexible cognitive models, rapid reconfiguration for new simulations, and scalability for team/crew training.

PHASE I: Explore alternative feasibility concepts and design a prototype ITS-AIR. The design may consider tradeoffs in the desired capabilities specified in the objective to meet performance and cost objectives. The context of the tutor design will be a Navy tactical aircraft simulation, supported by a cognitive task analysis for the missions to be trained. The design should consider implementation issues on both SGI IRIX and Windows NT operating systems in an object-oriented environment. It should include a detailed description of each ITS-AIR module and user interface, and include discussion of the software interface to facilitate extension of ITS-AIR to other aircraft types and missions. The design should also include plans to incorporate cognitive models and intelligent agents.

PHASE II: Develop, test, and operationally demonstrate a prototype ITS-AIR as formulated under the Phase I effort. The contractor will interface the ITS-AIR to a deployable tactical aircraft-training simulator. The initial set of aircraft and missions to be included in the prototype will be determined at this time. The contractor will determine the value of ITS-AIR by comparing student learning in the ITS-AIR controlled simulator with the same simulator controlled by an instructor.

PHASE III: Once the prototype ITS-AIR has been designed and demonstrated, and its effectiveness has been determined, produce a technology demonstration based on the prototype system developed in Phase II. During this phase, ITS-AIR will be extended to all of the aircraft and missions envisioned for the deployable simulator.

COMMERCIAL POTENTIAL: There are many potential applications for this ITS-AIR. They include other DOD departments and aircraft companies that are developing aircraft mission simulators for training in the U.S. and overseas.

REFERENCES:
1. Anderson, J.R., Boyle, C.F., Corbett, A.T., and Lewis, M.W. (1990). Cognitive modeling and intelligent tutoring. Artificial Intelligence, 42, 7-49.
2. Tambe, M., Johnson, W. L., Jones, R.M., Koss, F., Laird, J.E., Rosenbloom, P.S., Schwamb, K. (1995). Intelligent agents for interactive simulation environments. AI Magazine 16(1).
3. Towne, D.M. (1998). Development of Scenario Tutors in a Generalized Authoring Environment: Feasibility Study. (Office of Naval Research (ONR) Final Report No. 119) Los Angeles: Behavioral Technology Laboratories, University of Southern California.
4. Towne, D.M. (1999, in press) Automated Production of Instructionally Appropriate Scenarios, Proceedings, 8th Computer Generated Forces Conference.
5. Towne, D.M. (1997). Intelligent diagnostic tutoring using qualitative symptom information. Proceedings, American Institute of Artificial Intelligence, Intelligent Tutoring Systems Authoring Tools.

KEYWORDS: Flight Simulation; Training; Intelligent Tutoring; Intelligent Agent; Adaptive Instruction; Aircraft Training

N00-008 TITLE: Environmentally Insensitive Active Decluttering

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-264, Air ASW Systems

OBJECTIVE: Develop or identify signal processing concepts that decrease the sensitivity of active decluttering algorithms to environmental conditions.

DESCRIPTION: Active sonar systems face a significant decluttering problem especially when operating in shallow water. Tactical scenarios present a further complication because response time is critical and, as a result, classification in the fewest number of pings is crucially important. Historically, the decluttering problem has often been addressed by estimating parameters (or clues) of active acoustic returns and classifying the returns based on comparison of these clues against thresholds. There are various approaches to implementing this concept using a sequence of hard decisions or a sequence of soft (i.e., reversible) decisions. Since all of these approaches suffer from the fact that the values of the clues are highly sensitive to the environment, definition of a single set of thresholds is inadequate. One response to this problem, recommended especially in developments targeting tactical applications, has been to de-emphasize the use of environmentally sensitive clues and rely more heavily on kinematic information derived from tracking the acoustic returns over multiple pings. Though this can reduce the performance sensitivity to the environment, the disadvantages are that it requires some minimal target motion and requires some minimum number of pings to build a track. Other concepts to reduce environmental sensitivity have typically attempted to adapt to the environment by adjusting the clue thresholds or the actual choice of which clues to use. These concepts primarily consider modifications to the information processing algorithms (i.e., the processing done on the data after it has been filtered, beamformed, normalized and detected).

The emphasis of this study would be to develop a unique approach to reducing the environmental sensitivity of active decluttering algorithms. The goal is to explore signal-processing techniques that reduce the variability of the processed acoustic returns presented to the information processing algorithms. More specifically, the goal is to develop signal-processing techniques that yield consistent results across all environments so that a single set of clues and thresholds can be defined to distinguish targets from clutter. The signal processing approach developed here should focus on features which are independent of target motion relative to the sensor or effects of the environment.

PHASE I: Define the signal processing to be used. Define measures of effectiveness (MOEs) and estimate the potential of the proposed processing to achieve environmental independence. Estimate potential classification performance improvement in terms of lack of sensitivity to the environment. For the purpose of this initial evaluation, reasonable assumptions about the effectiveness of the signal processing concepts can be made without extensive validation.

PHASE II: Implement the signal processing concept selected in Phase I and perform an extensive evaluation, against actual at-sea data from at least two Navy sonar systems, of the effectiveness and the impact on decluttering performance. Based on the evaluation, modify (if necessary) the signal processing concept, select a single set of clues and a single set of thresholds, and use these to measure actual classification effectiveness across a large number of diverse environments.

PHASE III: Implement the concept defined in Phase II for use with a selected Navy sonar system during at-sea testing. Design a series of at-sea tests to evaluate how robust the decluttering and classification performance of the system is across a number of diverse environments.

COMMERCIAL POTENTIAL: Methods developed in this SBIR could be used for commercial applications that utilize active probe signals and must discriminate against high levels of clutter such as seismic exploration/profiling, weather radars, and commercial search radars.

KEYWORDS: Decluttering; Classification; Sonar; Active Signal Processing; Environmental Adaptation; Shallow Water

N00-009 TITLE: Multistatic Operation

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-264, Air ASW Systems

OBJECTIVE: Develop effective bistatic/multistatic capabilities for two specific combinations of Navy sonar systems, which impact air antisubmarine warfare (ASW) operations.

DESCRIPTION: Multistatic operation of Navy sonar systems can potentially improve overall ASW effectiveness despite significant improvements in the capabilities of potential submarine adversaries. As enemy submarines become quieter and more capable, utilization of active sonar techniques becomes necessary to maintain tactically effective ASW ranges for detection, classification, and localization. Active sonar operation in shallow water environments is in turn complicated by the severe clutter that is encountered. Multistatic operation enables Navy forces to take full advantage of active sonar capabilities and to improve decluttering performance while allowing critical assets to remain acoustically covert. Multistatic capabilities for all viable combinations of U.S. Navy sonar systems eventually need to be developed. However, two specific multistatic scenarios are of particular near-term interest to the Navy. Consideration of these particular scenarios will provide general insight into multistatic operation that will apply to other sonar systems.

The first such scenario consists of multistatic operation of one or more SH-60R platforms, utilizing the AQS-22 airborne low frequency sonar (ALFS) dipping sonar, along with one or more surface ships utilizing the present SQS-53C system and (in the future) the multi-frequency towed array (MFTA) system. The only step to date that has been taken to allow these systems to operate multistatically is that their operational frequency bands overlap.

Innovative modifications to waveforms, signal processing, information processing, and display processing will need to be made. The second scenario of near-term interest to the Navy is multistatic processing of sonobuoys utilizing advanced sources like improved extended echo ranging (IEER) or low- frequency active (LFA). There are numerous ongoing efforts evaluating the effectiveness of using air deployable active receiver (ADAR) sonobuoys as the receive sensor in this scenario. However, the Navy already has a tremendous inventory of directional frequency analysis and recording (DIFAR) sonobuoys available to it. Understanding the innovative processing options using a mixture of the existing DIFAR sonobuoys along with ADAR sonobuoys will allow the Navy to make informed decisions about the most cost-effective use of its sonobuoy assets. Innovative modifications to signal processing, information processing, and display processing are sought.

PHASE I: Identify and address both scenarios to a level of detail that allows a preliminary estimate of potential improvement in ASW effectiveness. Develop candidate approaches for deployment strategies based on the environmental conditions. Identify potential modifications to signal processing, information processing, and display processing. Identify required sea-test data to support a laboratory evaluation of these concepts.

PHASE II: Implement concepts developed in Phase I and evaluate effectiveness against simulated data and sea-test data. Implementation and comparison of multiple concepts will be done wherever warranted. Identify portions of implementation that are especially sensitive to "real-world" effects and design an at-sea test plan to evaluate performance. All software should be developed in a manner that simplifies potential future integration into existing Navy systems.

PHASE III: Develop and integrate real-time implementation of processing changes into Navy-selected platforms for the purpose of supporting extensive at-sea testing. The software product should be flexible enough to support testing but robust enough to simplify conversion to "fielded" software if test results support such an action.

COMMERCIAL POTENTIAL: Methods developed in this SBIR could be used for commercial multisensor applications like seismic exploration/profiling or monitoring of off-coast drug trafficking where coordination of multiple sensors is necessary and (in the drug trafficking application) where covertness of certain platforms is highly desirable.

KEYWORDS: Multistatics; Environmental Adaptation; Sonar; Signal Processing; Classification; Decluttering

N00-010 TITLE: Tracking Multisensor Data

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO-A, Air, ASW, Assault & Special Mission

OBJECTIVE: Develop a robust multisensor tracking capability for active and passive sensors for use in scenarios that include sonobuoy fields.

DESCRIPTION: There are many Navy antisubmarine warfare (ASW) scenarios where data from multiple acoustic sensors must be combined to form target tracks. Specifically, existing trackers in the U.S. Navy inventory have difficulty combining data from sonobuoy fields (both active and passive) to effectively track targets. Similarly, existing trackers do not effectively combine sonobuoy data with data from a dipping sonar. Such scenarios pose a number of unique problems. Passive sonobuoys have limited range so the amount of time that a single target is tracked concurrently by multiple sonobuoys is limited. Many passive sonobuoys are limited to providing only bearing information, and the bearing information is typically much coarser than other sonar systems can provide. The very nature of how a helicopter dipping sonar is used means that acoustic dipper data is only available intermittently. Additionally, the existing trackers require an extensive amount of operator interaction to initiate tracks and to correlate tracks from different sensors. Historically, incorporation of the information available from passive and active sonobuoys and from the active dipping sonar has not been done as an integrated, system-level design. The goal of this effort would be to develop a single integrated tracker that combines sonobuoy and dipping sonar acoustic returns to try to maintain uninterrupted tracks with a minimal level of operator interaction. The tracker design must also address multi-static operation with the sonobuoys and dipping sonar acting as the receivers for sources that include directional command activated sonobuoy system (DICASS) sonobuoys, the dipping sonar and improved extended echo ranging (IEER) sonobuoys. Performance of the tracker will be used to evaluate present sensor deployment tactics and identify any desired modifications to those tactics.

PHASE I: Define a tracking algorithm that addresses the specific multisensor, air ASW scenario described above. Derive preliminary estimates of various thresholds and association gates based on evaluation against simulated data. Develop preliminary estimates of the maximum gaps in target track data that can be tolerated. Estimate expected gaps in target track data based on present sensor deployment tactics. Determine whether potential tracker performance and reasonable changes in deployment tactics can support uninterrupted target tracking.

PHASE II: Confirm preliminary findings from Phase I by evaluating tracker performance against actual at-sea recorded data for a large variety of noise background levels, clutter levels and signal-to-noise ratios (SNRs) of the target acoustic signals (both passive and active). If sufficient at-sea data is not available to evaluate tracker performance for multi-static operation, then insertion of artificial target returns into actual recorded background data can be used. Identify whether in situ environmental measurements can be used to improve system robustness by adapting the tracker to the environment.

PHASE III: Implement the tracker from Phase II and perform at-sea testing to validate performance of the tracker under actual operational conditions. Both monostatic and multistatic operations will be tested.

COMMERCIAL POTENTIAL: Methods developed in this SBIR could be used for commercial multisensor tracking or localization applications like seismic exploration/profiling or monitoring of off-coast drug trafficking.

KEYWORDS: Sonar; Signal Processing; Tracking; Multistatics; Dipping Sonar; Sonobuoys

N00-011 TITLE: Military Utility of Automatic Dependent Surveillance - Broadcast (ADS-B)

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-209, Air Combat Electronics

OBJECTIVE: Explore the dual use of rapidly emerging civil ADS-B technology to address military applications such as combat identification, command and control, situational awareness, military air surveillance, and range clearance.

DESCRIPTION: The advancement of ADS-B technology is moving at a rapid pace within civil aviation. During the 1996 Olympics, ADS-B Helicopter Traffic Separation very successfully provided improved situational awareness and enhanced safety. The Cargo Airline Association has already completed demonstrations of this technology and will conduct an operational evaluation of ADS-B systems in the summer of 1999. The ADS-B minimum aviation system performance standards (MASPS) were published as RTCA DO-242 and both the minimum operational performance standards (MOPS) for 1090 MHz ADS-B and cockpit display of traffic information (CDTI) have been drafted and will be published in 1999. The participation of the DoD in the development of ADS-B has been negligible. It is time to explore the promising usefulness of civil ADS-B for military applications.

PHASE I: Study the feasibility of using civil ADS-B technology for military applications. Explore the feasibility of using ADS-B functionality to address primary mission deficiencies in command and control and combat identification while improving situational awareness and safety. Analyze the potential impact of ADS-B on current tactics, techniques, and procedures (TTP).

PHASE II: Develop a development plan, perform prototype development and demonstrate the integration of prototype system into a selected military aircraft. Test and operationally demonstrate both the civil and military ADS-B functionality studied during Phase I.

PHASE III: Transition the ADS-B prototype system into a Naval Aviation program managed by PMA-209 and other applicable programs. Develop a common ADS-B integration approach on other Navy and Marine Corps aircraft.

COMMERCIAL POTENTIAL: ADS-B is based on civil technology. The hardware and software developed and demonstrated during this SBIR effort should have many applications for General and Business aviation. The cargo airlines association CAA is evaluating the potential of ADS-B for traffic awareness and deconfliction. Through 1999 and 2000, considerable work is progressing for ADS-B development. General aviation applications are yet to be determined.

REFERENCES:
10 RTCA DO-242 ADS-B MASPS
20 RTCA DO 181A, ch 1&2, ATCRBS / Mode S MOPS

KEYWORDS: Surveillance; Situational Awareness; Automatic Dependent Surveillance - Broadcast; RTCA; Dual Use; Safety

N00-012 TITLE: Low-Cost Precision Missile Trackers for Directional Infrared Countermeasures (DIRCM)

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-272, ATAPS Tactical Aircraft Electronic Warfare

OBJECTIVE: Utilize uncooled image intensified charge coupled device (I2CCD) arrays for precision missile tracking during the laser infrared (IR) jamming function. I2CCDs would replace expensive, low-reliability, cooled IR focal plane arrays (FPAs) while at the same time improving performance.

DESCRIPTION: There is a need for IRCM system counter threats that are difficult to defeat using conventional IRCM techniques. Because the new generation of threats are more capable, IRCM energy must be directed at the threat missile to obtain sufficient energy on target to cause it to miss the aircraft. In order to attain the energy on target, an IR jammer must be able to track the threat missile with enough accuracy to point a laser at the threat missile. Current IR detectors in tracking sensors are expensive and must be cooled in order to achieve the sensitivity needed to track IR missile threats in all phases of flight. The coolers used with the detectors are least reliable part of the sensor. These coolers cause a reduction in the reliability of the tracking sensor, increase maintenance requirements, and increase the cost of the sensors. developing an uncooled IR detector for the tracking sensor will reduce the design complexity, reduce the production costs and increase the reliability of the tracking sensor.

PHASE I: This phase consists of characterizing the IR radiation characteristics of threat missiles from 0.5 to 1.1 microns during day and night operation for all phases of missile flight. Determine the feasibility of using the uncooled detectors in sensors for tracking threat missiles in all phases of flight. Evaluate expected sensor resolution and estimate the costs to produce the detectors. Prepare performance requirements for the uncooled IR detectors in a tracking sensor. Prepare a report documenting the findings.

PHASE II: Integrate I2CCD prototypes and precision tracking software with existing precision gimbal systems for nondisruptive/cooperative testing on prescheduled DoD missile warning system (MWS)/IRCM/DIRCM live missile firing programs. Demonstrate precision and leading edge missile tracking during both motor burn and post-burnout flight phases. Define I2CCD engineering development model configurations suitable for potential inclusion in the DoD DIRCM, Advanced Threat Infrared Countermeasures (ATIRCM), Tactical Aircraft Directed Infrared Countermeasures (TADIRCM), and Laser IRCM Flyout Experiment (LIFE) programs/hardware. Refine potential engineering, manufacturing, and development (EMD) cost estimates and life-cycle cost savings associated with utilization of I2CCD technologies in lieu of cooled IR FPA precision cameras. Define I2CCD critical item development specifications.

PHASE III: Conduct EMD efforts focused on providing low-cost common module I2CCD precision tracking cameras for all DoD directional IRCM systems.

COMMERCIAL POTENTIAL: The integration of I2CCD cameras with the available precision missile tracking algorithms/software is ideal for affordable commercial surveillance systems such as plant intrusion security, border security/surveillance, bird detection at commercial airports for aircraft safety, helicopter tracking of suspect vehicles during high-speed police pursuits, etc.

KEYWORDS: Directional IRCM; Laser IRCM; Image Intensified Charge Coupled Devices; Uncooled Sensors; Leading Edge Track Algorithms; IR Jamming

N00-013 TITLE: Middle Game Localization Utilizing Air Deployable Active Receiver (ADAR)

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-264, Air ASW Systems, PMA-290, Maritime Patrol Aircraft

OBJECTIVE: A typical air antisubmarine warfare (ASW) mission can be divided into three parts. During the beginning of the mission, utilizing prior knowledge, an ASW aircraft will attempt to greatly reduce the area of uncertainty (AOU) using active assets (which in the future are projected to be improved extended echo ranging (IEER)). Then the aircraft will often transition to a passive attack in the hopes of obtaining a closest point of approach (CPA). Currently, this is accomplished with directional frequency analysis and recording (DIFAR) sonobuoys. The kill is then accomplished with directional command activated sonobuoy system (DICASS) sonobuoys. The ADAR sonobuoy has a passive capability, a capability at this point that is largely untapped. The purpose of this effort is to develop the capabilities of the ADAR sonobuoy for the middle phase.

DESCRIPTION: The ADAR sonobuoy passed OPEVAL (Operational Evaluation - a series of tests designed to see if the system is ready for manufacture) recently and is in production. During this evaluation most of the testing was done on the active capabilities of ADAR. The sonobuoy also has a passive capability, which as mentioned above, could be utilized during the passive phase of a localization procedure. The purpose of this SBIR would be to develop passive processing systems utilizing the ADAR sensor.

PHASE I: Phase I would first involve an evaluation of the passive capabilities of the ADAR sonobuoy. In a proposal addressing this requirement, serious thought should be given to the time constraints involved in this evaluation and to how it might reasonably be obtained. The second part of Phase I would be the area in which there would be significant technical risk: specification of algorithms and systems that could be utilized to process the ADAR sensor received data.

PHASE II: Phase II would be the development of a demo system built to the specifications developed in Phase I. The requirement would be strictly for a demo, i.e., a system to show the feasibility of the passive algorithms and processing systems. No constraints would be placed on the contractor regarding the development of this demo system. Any system giving approximately the same detection performance as a DIFAR-based system would be acceptable.

PHASE III: Develop cooperative arrangement between the SBIR contractor and the prime contractor for ADAR so as to enhance ADAR's passive capabilities. Since currently not much effort has been expended on the passive systems, there would be much potential for improvement of ADAR by a small business contractor.

COMMERCIAL POTENTIAL: Potential commercial uses of the technology developed under this topic would primarily be in two areas: seismic processing and medical monitoring technology. The digital processing improvements that would come out of this topic could greatly improve the passive sensor instrumentation and processing utilized in these two areas.

REFERENCES: 10 ADAR Performance Sonobuoy Specification (PSS) dated 10/9/98

KEYWORDS: Passive; Digital: Array; Beamforming; Detection; Classification

N00-014 TITLE: Joint Optical Air Data System

TECHNOLOGY AREAS: Air Platform, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-265, F/A-18 Strike Fighter Program and PMA-276, H-1 Program

OBJECTIVE: Design, Develop, Fabricate and Demonstrate Optical Air Data System (OADS) Optimized for a JSF Application

DESCRIPTION: The Naval Air Warfare Center and Air Force Research Laboratory have conducted research to demonstrate the viability of the OADS concept. An OADS emits laser energy into the atmosphere, out of the influence of the aircraft, and detects the return signal from backscattered light. The return light energy is Doppler shifted so that by determining the frequency shift of the return light from the outgoing energy, the line-of-sight velocity can be determined. The backscattered light is compared against the outgoing laser frequency spectrum; temperature can be determined by measuring the increased width due to molecular broadening caused by temperature; and pressure can be derived by measuring the density, which is directly related to intensity magnitude of the backscattered light. With at least three line-of-sight determinations, the aircraft velocity, angle-of-attack and angle-of-sideslip can be determined. The advantages of an OADS approach are lower calibration costs (measurement made in ambient atmosphere, common system across aircraft platforms), higher survivability (no radar cross section (RCS) penalty from forward-looking air data probes), and larger operating envelopes (no inherent speed or angle-of-attack limitations as in pneumatic systems). Significant research and development has been conducted on particle-based backscatter optical systems that rely on backscattered light from aerosols for the signal source. Unfortunately, this approach is susceptible to data dropouts in a "clean" atmosphere and still requires independent measurements of ambient pressure and temperature (which require calibration to reduce platform induced effects on the measurements). The Navy and Air Force have jointly sponsored Optical Air Data research using molecular-based backscatter which eliminates the negative consequences of aerosol based systems. This approach requires a much shorter wavelength (0.266 microns vs. 1 – 10 microns for aerosol systems). Source alternatives include lasers that emit light at this wavelength (not available at the size and power levels needed) or use of optical doublers (very inefficient and not easily integrated into flight environment) to shift IR laser output light to a higher frequency. The current program hopes to achieve a flight demonstration with limited objectives this fall. Available laser power and optical efficiencies will limit velocity update rates to 1 Hz. Temperature and pressure measurements, which can be determined from the shape of the return waveform, will be measured at 0.1 Hz. It is recognized that this program is insufficient to get the technology matured sufficiently for Engineering, Manufacturing and Development. An important aspect of future research is to increase laser power and improve photonic efficiencies at the short wavelengths.

PHASE I: Design a prototype OADS that can operate in the airborne environment within the constraints of a multi-variant JSF aircraft and has maximum flexibility for installation and testing in several classes of air vehicle platforms. Analysis shall identify system level requirements based on JSF air data requirements (velocity at 20 Hz, angle of attack at 40 – 80 Hz, pressure/temperature at 20 Hz with 1% accuracy on velocity/pressure/temperature and 0.5 deg on angle of attack with acceptable weight, volume, and power constraints). Considerable attention shall be given to the optical chain requirements including the laser to identify and execute a technology maturation path that achieves this level of performance with moderate risk. New and innovative means to generate the required laser power at the short wavelengths may be considered within these risk constraints.

PHASE II: Fabricate and test an OADS that is viable for JSF application. Identify any additional engineering/demonstration required to transition to engineering and manufacturing, development (EMD) and coordinate under the auspices of a prime aircraft contractor. The culmination of Phase II will be a flight demonstration. Identify and measure weather and aircraft environmental impacts on system performance during flight. Develop technical risks along with risk mitigation and technology maturation investment roadmaps clearly projecting technology maturation needs and required investment for technology transition to EMD.

PHASE III: Adapt the OADS system to a wind shear and gust alleviation device. Identify requirements for JSF, high-speed civil transport, and commercial airliner applications. Identify critical technology elements and required technology maturation. Develop unique technologies required for adaptation of OADS to wind shear and gust measurements. Atmospheric measurements shall be made at a sufficient distance from the aircraft-about 0.5-1 km for gust response, 5-10 km for wind shear avoidance-so that reasonable warning or inputs to the vehicle control system can be generated. Implications on laser power and optical chain requirements shall be clearly defined. Design, fabricate, test, and validate system performance as an optical air data sensor and wind shear/gust alleviation system. Evaluate performance in a flight environment and assess suitability for multi-aircraft type operation.

COMMERCIAL POTENTIAL: There are two primary advantages of the application of this technology to the commercial sector: multifunction operation and commonality. With additional engineering and development, this technology can be extrapolated to a wind shear detection and gust alleviation system. This application has seen considerable technology investment in recent years due to a rash of aircraft wind shear induced incidents. An optical sensor has a considerable advantage over pneumatic approaches because an optical system can measure considerable distances ahead of the aircraft, where pneumatic air data is limited to making measurements near the aircraft's skin. A wind shear detection and gust alleviation system can significantly impact safety and ride qualities and possibly provide weight savings for new aircraft designs. If the engineering is done for multiple function operation, it should be possible to operate an OADS simultaneously as a wind shear and gust sensor as well as an air data system. In addition, a considerable cost savings can be realized due to the fact that minimal calibration is required. The same system can be installed across aircraft types for equipment and supplier commonality. Modifications can be made to the outer mold line with no impact on air data system performance.

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KEYWORDS: Optical Air Data; Laser Velocimeter; LIDAR; Flight Control; Air Data; Laser

N00-015 TITLE: Development of a Novel Infrared Detector Based on Quantum Well Optical Parametric Amplification (OPA) for Light Detection And Ranging (LIDAR) Receiver Applications

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-201, Conventional Strike Weapons

OBJECTIVE: Develop an infrared detector based on quantum well OPA for use in LIDAR systems.

DESCRIPTION: The Navy is developing a low-cost, compact infrared detector for LIDAR systems based on OPA technology. OPA detectors provide for an optical gain of several thousand with a significantly better signal-to-noise ratio as compared to conventional photo diode detectors with electronic amplification. To obtain low manufacturing cost, compact size, and high performance, it is necessary to develop an improved OPA device that can be integrated with high-performance, high-speed detectors. The newly emerging photonic band gap technologies based on III-V quantum wells provide a unique means for greatly improving the effective nonlinear coupling coefficients needed for a large gain and robust OPA operation. The goal of this topic is to construct a quantum well photonic band gap OPA device.

Quantum Well OPA design studies must include photonic band gap structure; electronic band gap structure; materials composition; electrical and nonlinear optical properties; optical gain; and phase-matching bandwidth for temperature, angle, and frequency. Specific Navy design requirements are:

- Capable of large-scale production
- Low cost
- Allow for variability of pump, signal and idler wavelengths
- Accommodate different types of photo detectors

PHASE I: Develop a photonic band gap OPA device structure concept for detecting infrared light in LIDAR systems. Perform a feasibility study that clearly demonstrates the functionality of the concept. The study must include a thorough analysis of the gain, noise, speed, and conversion efficiency of the proposed detection concept, as well as an experimental demonstration of the essential features of the concept.

PHASE II: The primary goal of Phase II is to demonstrate a working detector which is based on the concept developed during Phase I. The work will include developing the capability to manufacture arrays of such devices for use in LIDAR systems. This phase will also include performance tests of the detectors that demonstrate the overall improvements in signal to noise ratio, speed, gain, and efficiency of the devices.

PHASE III: Integrate the detectors into a working LIDAR system and demonstrate the benefits of the performance enhancements during flight tests.

COMMERCIAL POTENTIAL: The benefits of this research will include the development of high-performance arrays for missile defense, surveillance, and countermeasure sensors for both military and commercial use. This research will also support development of noninvasive medical sensors for use in drug screening, blood testing, and other diagnostics requiring high sensitivity to infrared signals.

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KEYWORDS: Optical Parametric Amplification; Quantum Well Detector; LIDAR; Nonlinear Optics; Photonic Band Gap Structure; Quasi Phase Matching; Infrared; High-Speed Detectors

N00-016 TITLE: Multibeam Sonobuoy Operator Displays

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-264, Air ASW Systems, PMA-290, Maritime Patrol Aircraft

OBJECTIVE: Design efficient/effective methods of providing an undersea warfare (USW) operator of a multistatic active acoustic system with an on screen color display of one or more search and analysis formats that can handle multiple beam (up to 24 per sonobuoy) data from sonobuoys for the detection of underwater targets of interest.

DESCRIPTION: Presenting a vast amount of acoustic data to a USW operator on a single screen effectively so that the operator can quickly review all contacts (passive and active, monostatic and bistatic) and then rapidly review expanded areas of interest (snippets) can present a work overload situation which will eventually reduce an operator's ability to detect a target of interest. With the introduction of color displays to USW suites, color itself will be of great value, but the multibeam data must still be presented to the operator in a manner, that can be related to the search area. With the advent of multibeam sonobuoys such as the air deployable active receiver (ADAR) sonobuoy, new display formats and techniques need to be investigated to provide the most effective operator-machine interface available for data interpretation. An operator must easily and, preferably, simultaneously, view all data from a minimum of four multibeam sonobuoys on a single monitor and have it presented in a fashion that permits quick, detailed analysis of signals of interest. The display formats must handle the minimum number of four sonobuoys' data. Color should be thought of as one of many coding dimensions available for display design. The number and set of colors chosen should allow for increased search rate, signal detection(s), and reduced operator workload while in an operational USW mission environment. Investigations should include, but not be limited to, bearing versus time (BVT) and amplitude scan (A-Scan) formats.

PHASE I: Develop 24-beam display formats to display data from four ADAR sonobuoys. Present the investigated formats to a Naval Air selected group of USW operators and engineers for choice selection.

PHASE II: Design software on a commercial off-the-shelf (COTS) platform to implement the Naval Air selected display format from Phase I incorporating the use of simulated or unclassified real ADAR data.

PHASE III: Integrate the Phase II software into air or sea platforms for Fleet use.

COMMERCIAL POTENTIAL: Future development of radar displays

KEYWORDS: Undersea Warfare; Displays; ADAR; Multistatic; Sonobuoys; Multibeam

N00-017 TITLE: Wavelet Compressions to Increase Desktop Personal Computer (PC) Real-Time Texture and Terrain Paging

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO-T, Tactical Aircraft

OBJECTIVE: There is a need to develop a powerful wavelet compression and paging scheme. The scheme would be linked into current run-time application programming interface (API) simulation applications that allow textures and terrain to be compressed on the disk to save disk size and decompressed on the fly in system memory or texture memory to save memory. This would reduce the input/output (I/O) and memory requirements of the system to support extremely high-resolution terrain and textures for real-time simulation applications on desktop PCs.

DESCRIPTION: The current state of the art in high-performance scene visualization is to use joint photographic expert group (JPEG) or color space compression. This allows current I/O systems to move more megabytes (MB) of information over the same wire/bus. The more information that can be moved, the higher the potential resolution of the textures or the speed the eye-point may move through the environment without anomalies. However, JPEG and color space compression have unacceptable artifacts when used to perform very high compression and require hardware-accelerated cards to limit the impact on the desktop central processing unit (CPU). These two compression methods are also limited to the textures and cannot be applied to the terrain, which is the second largest user of space and bandwidth in high-resolution applications. The intent of this effort is develop a wavelet compression scheme that can be applied to both the textures and the terrain, and is compatible with the large number of commercial-off-the-shelf (COTS) run-time API and desktop PC systems.

This method will save on bandwidth and disk storage through the increased compression. It is also expected that only the highest resolution of the texture maps will have to be saved and that the lower level mip-map textures will be generated on the fly by decompression to the intermediate stages. This should result in a decrease in disk and bandwidth of 33 percent. Application of similar savings in the terrain area is also expected through similar methods. In addition:

_ Application of wavelets on images that are material based at each pixel, versus color based at each pixel, should be considered with the advent of sensor simulation.

_ Application of wavelet storage and decompression of textures in the on-board texture memory of PC video cards to allow for more optimal use of memory should be considered when developing the wavelet and software paging algorithms.

PHASE I: Provide a feasibility study of wavelet compression applicability to texture and terrain for use in real-time simulation applications. The study should include demonstration of the wavelet algorithms in a pager configuration, and the ability to link the pager to a current run-time API or embed it in an open graphics language (OpenGL) application. The report should include a discussion of the impact on positional and context accuracy of the wavelet algorithm on the texture images and terrain.

PHASE II: Develop a wavelet compression/decompression engine that supports off-loading the CPU processing and a peripheral component interconnect (PCI) or equivalent IEEE standard interface format. Develop the tools to automate the development of wavelet compressed disk files for use in simulation. The system should provide the functionality and critical performance aspects of a final system, but the physical package may not be the final form.

PHASE III: Develop a production prototype card and software. Demonstrate the system working in several production real-time API environments and on several PC hardware systems. This unit should be rugged and approach the final production form. It should have full operational performance and serve as a production prototype. Investigate the ability to embed the wavelet engine in several COTS PC video cards to develop a turn-key solution.

COMMERCIAL POTENTIAL: This technology will be useful in geographic information systems (GIS), medical imaging, the computer gaming industry, and other commercial imaging applications, such as increased storage of digital still photographic images.

KEYWORDS: Texture; Terrain; Compression; Wavelet; Mission Planning; Low-Cost PC

N00-018 TITLE: Compact Infrared Countermeasure (IRCM) Jam Head

TECHNOLOGY AREAS: Air Platform, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO-T, Tactical Aircraft

OBJECTIVE: Develop a compact infrared laser transceiver for use in tactical aircraft for IRCM.

DESCRIPTION: There is a need for the development of a lightweight, compact laser transceiver for use on Navy tactical (TACAIR) aircraft. The transceiver must support the functions of the TACAIR IRCM concept including and acting as a mid-wave infrared receiver/tracker and an open-loop IRCM laser transmitter/beam-director. The Navy is seeking innovative approaches to the design of hardware to perform the tracking and jam functions. Present system uses mirrors and articulated arms redirect the laser beam and IR images in desired directions. These take up a large fraction of the size and weight allocated for the system. The goal of this SBIR topic is to develop an IRCM Jam head concept that is practical and affordable to build. Proposals will be ranked on complexity, cost and practicality. The jam head must be able to transmit and receive mid-wave infrared (MWIR) signals over an angular coverage of at least 90 degrees with a 1 milli-radian degree resolution.

PHASE I: Perform a concept design and feasibility study to address the following areas: a) jam head design and layout; b) receiver/tracker and laser transmitter/beam director performance analysis; and c) jam head size, weight, power, and cost estimate.

PHASE II: Build and demonstrate a prototype IRCM jammer and deliver it to the Naval Air Warfare Center.

PHASE III: Build a production ready model of the jam head for field test and demonstration.

COMMERCIAL POTENTIAL: This technology could be used in a laser based remote sensing applications. For example, pollution monitoring sensors to detect oil pipeline leaks or other applications where there is a need to detect molecules from a distance. This system could also be used for surveillance applications, for example, non-cooperative air or ground identification for both the military and the law enforcement community.

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KEYWORDS: Infrared Countermeasures (IRCM); Midwave Infrared (MWIR); Jam Head; Laser; Receiver/Transmitter; Tracker/Beam Director.

N00-019 TITLE: Solid-State Imaging Array for Laser Radar Applications

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO-T, Tactical Aircraft and PMA-231, E-2/ATDS

OBJECTIVE: Develop a two-dimensional high-speed optical detector array for laser radar imaging operating at the eye-safe optical wavelength of 1.55 microns.

DESCRIPTION: The Navy is currently using solid-state photo diode optical detector systems for optical communications and one-dimensional laser radar systems. Low-level laser radar signal applications require detection systems exhibiting high gain and low noise. Given the ever increasing demand for low-level signal capability over a wider bandwidth, noise levels of present detector systems will impose signal processing limits on future laser radar systems. Future systems will also demand discrimination and resolution capabilities unavailable with single detector systems. The proposed effort will provide a 5 x 5 low-noise optical detector array based on 1.5 GHZ - 2 GHZ pin diode or avalanche photo diode technology with a pixel detector element diameter of 25 microns operating in the eye-safe wavelength region of 1.55 microns. It offers significant improvement of signal to noise and resolution over present systems. This effort will increase the range and overall capability of laser radar systems.

PHASE I: Define a practical and affordable 5 x 5 imaging array based on pin diode or avalanche photo diode technology. Include: (a) the technological approach used to develop the specified array; (b) the quantum efficiency and responsivity of each pixel element at 1.55 microns; (c) the gain and speed characteristics of each pixel over the DC to 2.0 GHZ bandwidth; (d) dark current and noise equivalent power (NEP) characteristics of each pixel element; and (e) signal processing and parallel processing interface issues, as well as high speed pixel clocking at one nanosecond rates. The end product will be a technical report describing the defined array and projected performance parameters.

PHASE II: Design, build and test an engineering demonstration model of the 5 x 5 array based on the concepts and parameters defined in Phase I for use in laser radar ranging and discrimination targeting systems.

PHASE III: Produce a production ready model (PRM)of the 5 x 5 detection imaging array to be integrated into Navy laser radar systems. Deliver the prototype detector array to the Navy.

COMMERCIAL POTENTIAL: Affordable and robust imaging systems for law enforcement applications and image recognition systems for automated manufacturing processes.

KEYWORDS: Detector Array; Pin Diode; Avalanche Photo diode; Laser Radar; Laser Radar Receiver; Eye-safe Target Identification

N00-020 TITLE: Obsolete Electronic Parts Automated Functional Replacement System

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PMA-280, Tomahawk All-U-Round

OBJECTIVE: An electronic component is said to be obsolete when its commercial availability becomes limited or vanishes. Because of rapid changes in technology and the length of the acquisition cycle, every weapon system will experience obsolescence during its lifetime. This costs the government millions of dollars to emulate replacement parts, redesign circuit cards, find alternative sources, or make investments in life-of-type buys. The objective of this SBIR is to identify and develop processes, techniques, and tools that will reduce the cost of replacing these obsolete parts.

DESCRIPTION: With the goal of reducing life-cycle cost, the government is interested in exploring the potential for developing an automated system for the design and manufacture of functional replacements for electronic assemblies that contain obsolete components. Such a system would characterize and model the functional performance of the electronic circuitry and automatically design a functional replacement using available parts. A complete approach will address the several levels and types of electronic assemblies including:

- General integrated circuits (ICs) and application specific integrated circuits (ASICs)
- Analog circuits
- Digital circuits: both logic and signal processing functions
- Hybrid circuits

The successful offerer will address the approach to handling all or part of the preceding circuit types. It will also provide an analysis that describes the cost advantage of this approach.

PHASE I: Provide an in-depth study characterizing the problem and proposed system solutions identifying key attributes and applicable technologies. Provide a detailed design study of potential system designs to include hardware as well as software algorithms necessary for full system integration. Provide a detailed cost analysis showing the cost advantage of this approach.

PHASE II: Demonstrate a prototype system that analyzes, models, and designs functionally equivalent circuit board sets to eliminate the need for unavailable parts.

PHASE III: Provide productized systems readily available for commercial sales.

COMMERCIAL POTENTIAL: Success through Phase III will provide a system which incorporates the tools, algorithms, and hardware required for design of functionally equivalent circuit boards to alleviate the problem of obsolete parts procurement. Applications are generic and this product could be used for sustainment and post-production support of any electronic system.

KEYWORDS: Obsolete Parts; HDL; Sustainment; Post-Production Support; Integrated Circuits; System Integration; Algorithm

N00-021 TITLE: Nitrogen Charging System for the Advanced Amphibious Assault Vehicle (AAAV)

TECHNOLOGY AREAS: Ground/Sea Vehicles

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: DRPM Advanced Amphibious Assault Vehicle

OBJECTIVE: Develop a lightweight, compact, high-pressure, nitrogen charging system that can charge the AAAV's Hydro-pneumatic Suspension Units (HSU's) in the field.

DESCRIPTION: The AAAV has 14 HSU's that use nitrogen gas to create a spring force. The current system used to charge the HSU's is heavy and difficult to transport. A new charging system is required, for field maintenance, that is small and light enough to carry on the AAAV. Ideally, the charging system would not require bottles of nitrogen. The AAAV needs a charging system that has the capability to remove nitrogen directly from the atmosphere (purity similar to commercially available bottled nitrogen). The new system must be capable of charging an 80 cubic inch volume (at 70 ^{0}F) to 7,000 psi within 30 minutes (15 minutes preferred). It is desirable that the maximum system weight be less than 87 lbs. The charging system will use on-board vehicle power. Required maintenance and repairs to the charging system must be performed without the use of special tools. Electric (28 VDC @ 500 amp maximum) and hydraulic (3500 psi @ 50 gal/minute maximum) power is available from the vehicle. Use of electric power is preferred. The charging system must also have the capability to use bottled nitrogen, when available.

PHASE I: Conduct a trade study of current technology to determine the optimum balance of performance, size, weight and cost to meet the requirements stated above. Comments from government/military personnel in the AAAV office will be provided for the trade study. Develop a charging system design and document the expected performance.

PHASE II: Manufacture and test three charging systems. This effort will include a period of redesign between prototypes to incorporate design improvements based on government test and evaluation. The contractor will provide maintenance procedures and spare/repair parts for testing. The contractor will support system maintenance and repair during operation of the prototypes.

PHASE III: Prepare a manufacturing plan to produce the nitrogen charging system in quantity. Market the product to the military and commercial sector where nitrogen systems are used.

COMMERCIAL POTENTIAL: Can be used anywhere a low to high pressure nitrogen gas charge is needed. The use of nitrogen prevents oxidation/corrosion of internal components improving the reliability of the charged system. High pressure nitrogen is used in numerous military systems. Commercial applications include the auto racing industry and heavy construction equipment.

REFERENCES:
1. Engineering Design Handbook, Automotive Series Automotive Suspensions, 14 April, 1967, published by United States Army Material Command, pg. 1-22
2. Fundamentals of Vehicle Dynamics, Gillespie, T. D., Copyright 1992, published by Society of Automotive Engineers, pg.147-189

KEYWORDS: Tools, Maintenance, Nitrogen, High Pressure, Efficiency, Nitrogen Charging

N00-022 TITLE: Small, portable, lightweight, multi-fuel powered electric generators

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Sensors/Electronics/Battlespace

OBJECTIVE: Develop small, light weight (under 50 lb.), multi-fuel (diesel, JP-5, JP-8) capable electric generators with output in the 1 kW range.

DESCRIPTION: As military operations become increasingly dependent on C4I capabilities, there is increasing need for light weight electric power generators that are highly portable to meet both AC and DC power needs for small detachments operating in the field. Often the need is in the 0.5~1 kW range but for extended duration. With the one-fuel forward policy being implemented by the military, such units must be powered by diesel type of fuels. Presently, the smallest standard diesel powered generator in the military inventory weigh in excess of 300 lb. and is not suitable for portable use. The development of innovative concepts for small, light weight, multi-fuel capable generators that can be made available in the near term, at low cost is sought. The target weight for a fully packaged 1 kW unit is under 50 lb. The project will present some element of technical risk due to the size, weight, power constraints, however tradeoffs can be explored to mitigate that risk.

PHASE I: Develop concept based on near-term available technologies.

PHASE II: Develop and demonstrate a packaged prototype, one-man portable, light weight, diesel powered, 1 kW, 120 V single phase AC-generator.

PHASE III: Carry out manufacturing engineering to convert the prototype to production units with a variety of power and voltage levels with AC and/or DC output capabilities. Provide three units as deliverable for field testing and evaluation. Produce units in commercial quantities to military needs and expand into the commercial market to achieve further cost reduction to benefit military procurement.

COMMERCIAL POTENTIAL: Demand for small, portable, diesel generators exist in the commercial sector for home emergency power, recreational use at camp sites, and auxiliary power for motor homes and boats where the safety and stability of diesel fuel over gasoline represents a significant advantage. Additional needs include use on construction sites, for illumination of temporary road signs and at special events.

REFERENCES: Mission Need Statement for Command and Control Warfare, Cryptologic, and Signals Intelligence Systems number CCC11.21, dated 13 December 1993.
Operational Requirements Document for the Team Portable Collection System;
PSQ-9A (NO. INT 255.1.3) Dated 13 December 1995

KEYWORDS: Portable power, multi-fuel, diesel engine, generators, light weight.

N00-023 TITLE: Personnel and Material Tagging

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Provide operator the option of tagging (marking) personnel or equipment for future actions.

DESCRIPTION: The ability to non-lethally tag, or mark, personnel and equipment is desired for conducting military operations in urban terrain (MOUT) and other areas where immediate action is not appropriate. Such settings are challenging from a military perspective since there are many situations where immediate action would cause inappropriate collateral damage or unacceptable risk to the operators. The proposed technology solutions should be effective, non-lethal to personnel, and produce no permanent injury. The proposed technology solution should also not be easily countered. Delivery of the tagging device must also be addressed. The stand-off range for delivery must be at least 50 meters with an extended range of 500 meters or greater desired. The tag should be active with a range of at least one kilometer. Miniaturization is of importance, since one feature of this tag is covertness. Tagging of enemy military equipment for targeting by a NLW at some later time is an example of how this technology could be used.

PHASE I: Determine candidate technology solution(s) and conduct initial testing to demonstrate potential for technology to: 1) non-lethally tag personnel and/or equipment, 2) be effective from ranges of at least one kilometer, and 3) be sufficiently small in size that it could be difficult to detect.

PHASE II: Demonstrate technology solution(s) against personnel and/or pieces of equipment. Develop conceptual delivery mechanism capable of delivering the technology solution(s) from at least 50 meters range.

PHASE III: Build prototype delivery system for technology solution(s) and demonstrate effectiveness of complete system against various personnel and/or pieces of equipment (vehicles, mobile machinery, etc.) from a range of at least 50 meters with >500 meters preferred. The tagging device delivered must be active with a range of one kilometer, and be small and covert once it is delivered to the target.

COMMERCIAL POTENTIAL: This system could be used by law enforcement agencies for marking personnel and/or equipment such as vehicles for future action. This would allow law enforcement the option of avoiding dangerous situations.

REFERENCES: Joint Non-Lethal Weapons Concept, Signed by LtGen M.R. Steele, Deputy Chief of Staff for Plans, Policy, and Operations, U.S. Marine Corps on 1/05/98, Available on World Wide Web at www.usmc.mil/nlw.

KEYWORDS: Tagging, Marking, Non-Lethal, MOUT

N00-024 TITLE: Position Location Tracking from Inside Building to Outside Building in an Instrumented Military Operations On Urbanized Terrain (MOUT) Environment

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop technology that will allow individuals to be tracked from inside a building to outside a building without losing contact in a MOUT environment. Additionally, this technology should track players located in areas in close proximity to building walls.

DESCRIPTION: In a MOUT environment there is a need to track individuals inside and outside of buildings. Tracking individuals outside buildings is normally accomplished by using GPS equipment. Tracking individuals inside a building is normally implemented by using an ultrasonic system. When an individual transitions from outside to inside the building the indoor tracking system acquires the individual instantly. Conversely, when an individual transitions from inside to outside the building the outdoor tracking system may take minutes to acquire the individual. This delay is unacceptable because the instrumented individual could have traveled over numerous meters while out of contact with the current tracking systems. Once GPS is acquired, the system can track the individual, but the history track between the time when the indoor tracking system lost contact and the outdoor tracking system (GPS) acquired the individual will be unknown.

PHASE I: Develop a design concept that can track an individual as the individual traverse from inside a building to outside a building without losing contact with the system. Additionally, the system should track individuals in areas outside of buildings where GPS cannot be acquired. The system shall have a tracking accuracy of one meter.

PHASE II: Develop a prototype system that can track an individual as the individual traverse from inside to outside a building without losing contact with the system. Extend the system to track a squad of instrumented Marines inside a MOUT environment as they traverse inside and outside buildings without losing contact the contractor shall demonstrate this capability.

PHASE III: Apply technology developed in Phase II to the Marine Corps Range Instrumentation System.

COMMERCIAL POTENTIAL: This system is applicable to any tracking system where individuals need to be tracked inside and outside of buildings. Use for SWAT training and monitoring prisoners are examples of likely commercial applications.

REFERENCES: Military Operations On Urbanized Terrain - Instrumentation System (MOUT-IS) Evaluation Report, Naval Air Warfare Center Training System Division Technical Report 98-016, November 1998

KEYWORDS: MOUT-IS, Indoor/Outdoor Tracking System, Position Location Tracking, GPS, Ultrasonic System

N00-025 TITLE: Wearable Operator Control Unit

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Initiate design of a comfortable, practical operator control unit for small Unmanned Ground Vehicle (UGV) Systems that minimizes intrusion and additional burdens placed on the system operator.

DESCRIPTION: Existing and emerging U.S.M.C. and U.S. Army Unmanned Ground Systems requirements address small robotic systems with minimal impacts on the load carried by soldiers and Marines. These requirements further desire that the operator be free to carry out other duties without undo hindrance from UGV equipment. The operator typically must remain free to perform other battle tasks while wearing and operating the control system.

PHASE I: Determine the feasibility, interfaces, architecture, and limitations presented by a wearable control system. An initial design concept would be delivered.

PHASE II: Develop and test a wearable Operator Control Unit by interfacing the system with at least one vehicle provided by the Unmanned Ground Vehicles/Systems Joint Project Office. Use of the Joint Architecture for Unmanned Ground Systems (JAUGS) will be required to enable the control unit to interface future vehicle systems as well.

PHASE III: Provide a rugged, reliable, militarily acceptable control system to address current and emerging requirements for Man-Packable and Medium UGVs for the Department of Defense.

COMMERCIAL POTENTIAL: This system could be applied to law enforcement as well as industrial inspection robot programs.

REFERENCES:
USMC Mission Need Statement for a Tactical Unmanned Ground Vehicle (TUGV); dtd 10 November 1993.

Operational Requirements Document for the Tactical Unmanned Ground Vehicle (TUGV); USATRADOC; dtd 16 August 1994;USMC dtd 7 May 1996.
Mission Need Statement for Special Operations Forces Micro Robotic Vehicle (SOMROV); USSOCOM; dtd 22 September 1997.
Operational Requirements Document for Outdoor Miniatures Robotic Ground Vehicle (OMRGV); USSOCOM; dtd 18 August 1998.

KEYWORDS: Unmanned; robotic; man-portable; wearable; control; ground.

N00-026 TITLE: Precision Sea-Based Logistics

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: DRPM Advanced Amphibious Assault Vehicle

OBJECTIVE: Develop, integrate, and test technologies for a Precision Sea-Based Logistics System that will allow automated tracking of spare parts, status of maintenance actions, cost accounting, prognostics, decision support system, and wire and wireless communication of this logistic data using universal, standard protocols.

DESCRIPTION: Precision Sea-Based Logistics is a critical aspect to Ship-To-Objective-Maneuver (STOM) and Operational Maneuver From The Sea (OMFTS). Total Asset Visibility (TAV) of spare parts; repair action notification and tracking; maintenance history; cost accounting; and prognostic evaluation is the key goal of this program.

Precision Sea-Based Logistics consists of a human-factored, computerized system located at centralized geographic locations. The system must be able to transfer and store reliability, maintainability, costs, and spare parts data. The system will allow spare part requisitions, maintenance requests, and fund transfers. TAV shall be maintained in the centralized database to include configuration management and maintenance history. These centralized systems shall be capable of wire and wireless communications with remote locations such as mobile vehicles (tank, boat, truck, etc) or maintenance facilities. The centralized systems maintain automated tracking of spare parts and status of maintenance actions performed on the mobile vehicles. The centralized systems also orders spare parts for the mobile vehicles, and schedules repair work at the maintenance facilities.

A Decision Support System (DSS) must be an integral aspect of the Precision Sea-Based Logistics. The DSS must filter vehicle data prior to the transmittal of such data either by wire or wireless.

PHASE I: Conduct a cost-benefit analysis to determine the most suitable technologies, both hardware and software, to employ. The technical feasibility and risks of existing and future technologies should be assessed. Develop a Precision Sea-Based Logistics concept with open system architecture to include the Decision Support System. Options and protocols for wire and wireless communication shall be identified. Develop a Performance Specification.

PHASE II: Fabricate and test one Advanced Technology Demonstrator to proof out the feasibility, operability, and suitability of the technology chosen from Phase 1. The contractor shall demonstrate the Advanced Technology Demonstrator in an operational environment. A test plan and test report shall be generated. The system shall be a open-architecture, low-cost design which allows incorporation into military and commercial applications.

PHASE III: Package and market the Precision Sea-Based Logistics System to the military and to commercial industry where Total Asset Visibility of its equipment is needed. Identify multiple, qualified vendors for commercial software modules used in the Precision Sea-Based Logistics system. Update the Performance Specification based on feedback from government and industry representatives. For military applications, have capability to interface with existing maintenance and supply information systems such as the USMC Asset Tracking for Logistics and Supply System (ATLASS), Small Unit Logistic Advanced Concept Technology Demonstrator (SUL ACTD), and MCWL Combat Service Support Operations System (CSSOS); US Air Force NALCOMIS; and U.S. Navy 3M and Integrated Condition Assessment System (ICAS).

COMMERCIAL POTENTIAL: The Precision Sea-Based Logistics System will have application to numerous military platforms and distributed commercial industries such as UHaul and UPS where Total Asset Visibility of its equipment is necessary.

KEYWORDS: Total Asset Visibility, Sea Based Logistics, Wireless Communication, Local Area Network, Reliability & Maintainability, Configuration Management

N00-027 TITLE: Link-16 Enhanced Positional Accuracy for Precision Guidance

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a prototype software solution for providing munitions-quality positional accuracy suitable for Government and commercial applications.

DESCRIPTION: The Joint Services and NATO are currently, and will continue well into the 21st century, deploying Link-16 as the tactical data link in a variety of surface, air and subsurface platforms due to its robust (secure, high jam resistant) real time accuracy. The inherent Relative Navigation (RELNAV) capability of the Time Division Multiple Access (TDMA) architecture and synchronization process can be further explored to provide munitions-quality accuracy, thus providing a means of seamless end-to-end connectivity across a battlespace; for example, pilot to missile. Emerging network centric architectures would include smaller platforms, which are currently envisioned as solely relying on GPS for geopositioning, and are therefore vulnerable to satellite outage, jamming and spoofing. However, this research would initiate an innovative opportunity to complement or replace those GPS-reliant military and commercial applications. The time synchronous operation and high accuracy Time of Arrival (TOA) measurement capability of Link-16 data link terminals make possible the expectation that a higher performance navigation function will be achieved by a software only solution, thus requiring no hardware retrofit. The purpose of this SBIR is to identify, design and develop prototype innovative software solutions, using but not limited to the inherent theoretical principles of Link-16 and GPS, that show the most promise to achieve the desired positional accuracy for both military and commercial applications.

PHASE I: Identify and develop algorithms that show the most promise of improving positional accuracy to three meters or less Circular Error Projection (CEP). Demonstrate the viability of the algorithm(s), computer program interfaces and links.

PHASE II: Develop, test, and demonstrate under realistic conditions the most promising navigational algorithms. Carry out further validation, including certified laboratory and field testing of the developed software. Where it can be done economically, with non-SBIR funding, comparisons of the SBIR-tested algorithms with other available algorithms will be performed.

PHASE III: Apply software solution to Navy missile/weapon to demonstrate goal accuracy. Demonstrate the developed algorithm through simulation and then flight test.

COMMERCIAL POTENTIAL: From the outset this development must be keyed to multi-use applications - this imperative is driven by the need for interoperability and navigational coherency across military battlespaces, and is comparable to wide-area and metropolitan networks, regional and national enterprises such as FAA traffic control, and surveillance by FBI Coast Guard or Customs. This is needed wherever accurate, coordinated geolocation or navigation is required. Reduced size, weight and cost Link-16 terminals are presently being studied which would further open up an innovative application to industry in commercial air, transportation or any other system which presently utilizes GPS. The global capability of GPS and the real-time tactical capability of Link-16 RELNAV are complementarily attributes for both military and commercial applications. The potential capability and flexibility of the developed solution would allow its use for other commercial applications including precision landing systems, waypoint navigation, local and wide area coordination, and free flight cross-country navigation.

REFERENCES: "JTIDS RELNAV Redefined" by James L. Farrell and C. Gary Stephens

KEYWORDS: GPS; JTIDS; Link-16; Navigational; Relative Navigation; Precision Guidance

N00-028 TITLE: High Frequency Transmit Mast Clamp Current Probe

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop one or more low cost, low maintenance current probes capable of exciting various parts of a ship superstructure to act as a transmit antenna in the 2-30 MHz frequency range.

DESCRIPTION: The existing High Frequency (HF) antennas occupy substantial volume. This makes it difficult to find suitable installation locations that don't interfere with ship's operations (such as flight operations and weapons engagement) and don't cause performance degradation for this system and others because of physical blockage and Electromagnetic Interference (EMI). In addition the size and geometry of the existing HF antennas produce significant Radar Cross Section, thereby increasing the probability of the ship being detected and attacked.

PHASE I: Determine if there are magnetic materials for probe construction that can withstand the heat generated by multiple 1 kW transmitters and that can produce an impedance match to the structure over a broad band of frequencies. Determine the number of current probes required to cover the 2-30 MHz frequency range and the number of transmitters that can operate into each current probe.

PHASE II: Develop a prototype antenna(s) and measure its performance (EIRP, antenna pattern, linearity, inter-mods, isolation, EMI, etc.). Maximize performance while minimizing weight and volume. Antenna requirements are frequency range 2-30 MHz, VSWR 3 to 1, Omni-directional Antenna Pattern, polarization vertical, and 1 kW transmit power.

PHASE III: The current probe will transition to SPAWAR PMW179 to be backfitted on existing platforms and incorporated into new ships.

COMMERCIAL POTENTIAL: The current probe development is directly marketable to commercial and private vessels to provide low volume HF communications.

REFERENCES: Law, Preston, Shipboard Antennas, Artech House, Inc., Dedham, Mass. 02026, 1983

KEYWORDS: HF; Antenna; Whips; Topside; Communications; EMI

N00-029 TITLE: Jammer Placement Artificial Intelligence Tool

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a modeling/simulation tool which would make intelligent decisions on optimal jammer resources to apply and where to apply them to a specified military scenario.

DESCRIPTION: Using digital maps including terrain propagation models as well as a data base of jammer resources, the user would specify criteria for GPS jamming levels in an area including areas where no GPS jamming would be desired. The modeling tool would select the most appropriate GPS jammer resources from a database menu and determine placement, power levels, and directivity requirements to meet the pre-selected jamming environment. An additional utility enables mission planning for jamming avoidance.

PHASE I: Develop an architecture approach identifying existing software tools, new software requirements, and software interface requirements. Demonstrate ability to model GPS in-band propagation in various terrains. Propose decision making software approach using artificial intelligence technology.

PHASE II: Develop necessary new software resources including artificial intelligence decision-making algorithms and integrate software. Refine decision making software and operator displays. Demonstrate prototype system in Fleet exercise and wargame scenarios.

PHASE III: Develop an efficient software package suitable for ruggidized PC execution. Incorporate data bases of Electronic Warfare assets as well as global terrain propagation and visualization software. Demonstrate utility in real time wargame/fleet exercise activities. Integrate tool in Navy shipboard workstations.

COMMERCIAL POTENTIAL: This tool could be used by DOT activities such as FAA as well as mobile communications systems in predicting impacts of interference on GPS and non-GPS wireless systems and communications and supporting corrective placement planning.

REFERENCES: Presidential Decision Directive 'U.S.GPS System Policy', March 1996

KEYWORDS: GPS, jammers, artificial intelligence.

N00-030 TITLE: Wireless Line-of-Sight Networks for IntraBattlegroup Communications

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a wireless line-of-sight network capable of communicating at high data rates with up to 20 mobile platforms (..i.e, ships, submarines, etc.) and shore sites.

DESCRIPTION: The U.S. Navy is in need of a means of high data rate line-of-sight (LOS) communications between its ships, submarines, and shore sites. The Radio Frequency (RF) wireless network is characterized by a dynamic topology consisting of up to 20 mobile platforms (potentially more if airborne platforms are used). The communications should be robust to node outages (due to adverse propagation effects) and not rely on a single central controller. The wireless LOS network should be self-configuring and determine the optimum relay nodes (to extend the LOS communication ranges) without user intervention. The topology is commonly referred to ?ad hoc? in that all platforms are mobile. In addition, the communications should be robust to multipath fading and interference.

The wireless LOS network is to be implemented and tested in the AN/USC-61 Digital Module Radio (..see SPAWAR PMW-179 for additional information). Thus, this development will primarily be software for use in software programmable radios being built by the DOD. In addition the software should be portable to Joint Tactical Radio Systems (JTRS) which have hardware capable of supporting this wireless LOS network. Consideration should also be given to the use of these waveforms and protocols by joint forces (these applications could involve 100s of mobile platforms requiring multiple RF channels and/or a hierarchical wireless networking approach).

PHASE I: It is anticipated that this phase will define the physical, link, and network level protocols to be implemented. All protocols and waveforms will be simulated extensively in high level software (preferably using the ?C? language) in scenarios common to the U.S. Navy. This includes defining the intended operating frequencies and bandwidth for both Military and Commercial applications. In addition, Phase I will map these protocols into the AN/USC-61 Lowest Replaceable Units (LRUs), conduct a load balance on the individual processors, determine which algorithms require implementation in Field Programmable Gate Arrays (FPGAs), and determine the software constructs required to proceed with the implementations in DMR and JTRS. Deliverables will be a report describing the protocols and waveforms and their performance and the Phase II method of implementation. The report will also highlight those modifications required (if any) between the military and commercial variants.

The design of the wireless LOS network will at a minimum address the following specifications:
Support COTS Internet Protocols (..i.e, Transmission Control Protocols (TCP), User
Data Protocol (UDP), etc.) and multicast protocols
Allow for easy connection to external COTS routers

- Support User throughputs of at least 256 Kbps with round-trip latencies of less than 300 milliseconds
- Must have flexible operating frequency capabilities for military purposes in common U.S. Navy VHF and UHF frequency bands

PHASE II: Migrate the ?C? language software developed in Phase I into the AN/USC-61 Digital Modular Radio for implementation and testing. SPAWAR PMW-179 will assist with this phase by supporting the DMR vendor designated to assist the SBIR vendor in helping with integrating this new capability into the DMR and its Human Computer Interface so that it does not disrupt the existing operational modes of DMR. Testing will be conducted to assure accurate operation. The software will be ported to at least four DMRs to allow for wireless LOS network testing (laboratory and limited over-the-air).

PHASE III: Perform operational testing in a complete Aircraft Carrier Battle Group and/or Amphibious Readiness Group including at least 6 mobile platforms. If these tests reveal any deficiencies in the waveform or protocols, they will be improved and the wireless LOS network waveform will also be tested in other radios that are JTRS compliant, possibly tested in a joint operations.

COMMERCIAL POTENTIAL: The ''Wireless Line-of-Sight Networks for IntraBattlegroup Communications'' has outstanding potential to address commercial applications in compliance with SBIR funding ''dual-technology'' attributes.Commercial applications include mobile Users operating without existing infrastructures such as warehouse operations, fire and police field work, emergency relief backup and third world countries surveying.

REFERENCES: DMR Performance Specification, SPAWAR-D-900, 5 July 1998, DMR AN/USC-61 Primer, 15 March 1999

KEYWORDS: Wireless LOS Networks, Intra-Ship Communication Networks, RF Wireless Networks, and HDR LOS

N00-031 TITLE: Sensor Tasking Segment (STS)

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

OBJECTIVE: Develop common network-centric tasking software segment for managing and controlling Information Warfare (IW) sensors and countermeasure resources across the shipboard, battle-group, theater, and national IW environments.

DESCRIPTION: Present IW sensor systems have different tasking software and displays, each designed to control front-end receiver and the signal processing resources for the system. These systems have cooperative overlap in spatial, frequency coverage and capabilities not only within the battlegroup but also with national and joint partners. The precise mix of systems will depend on the mission assigned and the Major Regional Conflict (MRC) that the mission is assigned. Currently, each system is tasked and operated independently. What is lacking is a scalable tasking environment that will optimize the information collected by synergistic systems. Moreover, a carrier battlegroup consists of a number of ships, each with its own set of sensor, geolocation processing and countermeasures subsystems. These collective subsystems do not fully satisfy modern Information Operations requirements when deployed in battle groups in theater with national resources. The STS will be designed for network-centric operation and will control the following: (1) the radio frequency distribution unit; (2) interference mitigation resources; (3) the intercept receiver search strategies; (4) detection, ID, and recognition resources; (5) copy processors; (6) geolocation; (7) countermeasures and (8) results reporting. Sensor tasking can come from the following sources: signal recognizers, system operator, other own ship systems, STS?s on other ships within the battle group, theater and national sources. STS?s can task sensors up to the national level. Real-time response is required for own ship and in near real time within the battle group.

Depending on priority, the system will handle three types of tasks from sources: automatic, automatic with operator initiation, and manual. Initiation and the result of tasking will be communicated among and shared with any STS on the network with control. More than one STS makes up a ?distributed, collaborative? management system. In the case of multi-ship tasking and upon request, each STS will provide the requesting STS the following: resource availability projected reporting times, estimated performance (such as hearability and DF accuracy), etc. Negotiations using priorities will determine use of the resources. Data link availability, delays and capacity will also be monitored and managed with priorities.

The STS will be a GCCS-M software segment within the cryptologic unified build (CUB). If feasible, the software should be commercial-off-the-shelf (COTS) to the largest extent possible. It is anticipated that much of the software development will be in the form of application program interfaces. These interfaces should be object oriented, agent based, transportable and flexible. The software should be scalable and reconfigurable to the extent necessary to interface with diverse IW sensor and countermeasures resources. It is important that a cost and performance versus architecture/resources analysis be performed early to establish the cost-effectiveness of the system.

PHASE I: Create an initial software architecture and cost/performance vs. architecture/resources study. Identify COTS products that provide significant development savings; identify their risks. Identify, cost, and prioritize risk of development software modules.

PHASE II: Implement and demonstrate the operation of three STS software systems operating via ether net (wideband) and telephone (narrowband) networks.

PHASE III: Design a full scale STS including interfaces. Test at sea with multiple ships.

COMMERCIAL POTENTIAL: The produce being developed here is useful for any company that needs a real-time, distributed, management system. Systems associated with communications and transportation, which are distributed across large areas, require some sort of real-time control. Companies that must coordinate the manufacturing of many components to meet system integration deadlines require distributed, real-time control.

KEYWORDS: IW Sensor Management; distributed; collaborative; network-centric; controller; tasking

N00-032 TITLE: Automated Network Anomaly Detection and Fault Tolerance Toolkit

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a toolkit that utilizes Modeling and Simulation (M&S) to facilitate the study of intelligent agents for the automation of network anomaly detection and fault tolerance in mobile, multi-media environments.

DESCRIPTION: Recent investigations of intelligent agents have shown the feasibility of proactively identifying anomalous network activity and predicting network faults in simple local area network environments. These studies use experimental network data and test cases to evaluate the performance of specific intelligent agents. This effort would utilize M&S to study the composition of intelligent agents and their performance over a variety of network conditions and failures which include wireless problems in Navy and commercial mobile networks.

PHASE I: Develop a design for an Automated Network Anomaly Detection and Fault Tolerance Toolkit that facilitates the study of proactive identification of network faults and outages. The design should illustrate the feasibility of modeling network failure characteristics, network performance measures, and algorithms that predict failures from available performance measures in multi-media environments.

PHASE II: Develop and test the Automated Network Anomaly Detection and Fault Tolerance Toolkit for use in the optimization of multi-media networks. Utilize actual network data to provide validation and verification of the toolkit performance.

PHASE III: Develop a user friendly interface and documentation that provide users in military and civilian environments with proper toolkit instructional information.

COMMERCIAL POTENTIAL: This toolkit could be utilized by equipment vendors, system integrators and system maintenance personnel to optimize automated fault tolerance procedures in network environments. The toolkit could be used to assist in the development of proactive fault tolerance algorithms for commercial and custom network devices and systems.

REFERENCES: M. Thottan, C. Ji, Proactive Anomaly Detection Using Distributed Intelligent Agents, IEEE Network, September/October 1998.

KEYWORDS: Agent, automation, mobile, modeling, network, simulation

N00-033 TITLE: Trusted Workstation Using a Plug-in Encryption Module

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Demonstrate that a trusted workstations equivalent to a B-1 Compartmented Mode Workstation (CMW) can be built from a COTS PC using a plug-in hardware module.

DESCRIPTION: Many Naval systems would be easier to design and develop if specific workstations (WSs) could be trusted to maintain separation between information of various sensitivities, compartments or classifications. Such a WS needs to maintain its MLS (Multi-Level Security) capability through hardware and software failures and through attempts to defeat security via external connections (external threats) and via unauthorized users (insider threats). Without the ability to maintain separation at the WS, it is usually necessary to install, maintain and support separate LANs at the appropriate sensitivity levels. For instance, Navy ships typically maintain Unclassified, Secret, and SCI LANs. Commercial companies often have separate LANs providing separation for company-restricted information. In addition to the cost implications of redundant systems, there is often a significant operational penalty since some of the information on the separate systems must be shared. Some MLS capability has been developed using UNIX CMWs based on specific hardware platforms and trusted operating systems evaluated to meet Orange Book B-1 level criteria. However, the attendant restrictions on hardware and software are both a cost driver and a significant limitation to evolutionary system upgrades.

PHASE I: Pick a representative CMW application. Compare the expected security of a COTS PC (with plug-in security module to enforce WS security) to the security achieved using the CMW. The evaluation should be performed by the contractor using normal certification processes under the guidance of a Navy Certification Agent (CA) or team. Develop a Phase II work plan to the CA's satisfaction that would demonstrate equivalent WS/CMW assurance (for the selected application) through analysis and testing.

PHASE II: Build at least one COTS PC WS running unmodified Windows 95 (or later Microsoft OS) with plug-in security module and demonstrate that the resulting WS can meet equivalent CMW security requirements and can transparently run unmodified application programs.

PHASE III: The contractor will work with a Navy project team to demonstrate a specific MLS application running on the resulting WS. Depending on the contractor's marketing strategy, Phase III could also be used to obtain formal evaluation per the Common Criteria.

COMMERCIAL POTENTIAL: The resulting WS would be an attractive solution to a variety of commercial systems that have similar MLS requirements. However, since the WS would be functionally equivalent to other PC WSs used at government or industry sites, it could replace PCs at any seat that need greater assurance for security-related functions (e.g. access control; protection of stored programs, data or files; misuse detection; or protected communication with other stations). The high assurance provided by the workstation enables the provision of these additional security functions by the SBIR contractor or by 3rd party vendors. The potential market, therefore, is for tens of thousands of WS modules and for the add-on security products (both software and hardware).

KEYWORDS: Multi-Level Security; High Assurance; workstation; secure terminal; computer security; trusted computer

N00-034 TITLE: Wideband Radio Frequency (RF) Distribution System

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop an RF distribution system based on a scaleable/open system architecture, which is capable of operating over a potential frequency range from HF-UHF to support Communications and Information Warfare system (attack & exploit) requirements. This topic will lead to the development of a new Radio Frequency Distribution System (RFDS) that can satisfy both modern C4ISR communications and Information Warfare future goals & requirements.

DESCRIPTION: Present shipboard communications and Information Warfare systems use separate RF Distribution Systems between their respective antennas and transmitters/receivers that is based on 1960s RF technology. While a number of advanced technology programs have addressed the technical issues and design associated with combining topside antennas for modern communications and IW requirements, none have addressed the technical challenges associated with the application of advanced technology toward the design of an RFDS for Communications and IW in the frequency range of HF through UHF. Today's shipboard operations may include10 transmitters and 50 receivers operating in this frequency band simultaneously (albeit with different multicouplers, RFDSs, and antennas). The goal of this topic is to explore and apply advanced RF technology and open architecture to solve the technical issues associated with combing the functions of existing multicouplers, RFDS, RF filters, etc. to greatly enhance the shipboard capability to conduct modern communications and network-centric warfare. To satisfy present and future RFDS requirements, the RFDS must be capable of interfacing a number of shipboard HF thru UHF transmitters, receivers and antennas covering the frequency range with the flexibility to change configurations in milliseconds. The RFDS must be capable of accommodating broadband signal distribution to allow spread spectrum and frequency hopping communication and counter-communications (IW) operations. As a minimum, the technologies investigated should include high dynamic range and high speed/low loss/EMI inhibiting switching (potential technologies include optics and cryogenics), extremely wideband RF component and circuit design, sharp response filters and couplers (potential technologies include ferrite's and cryogenics), extremely low loss/linear/phase controlled transmission lines (potential technologies include optics and cryogenics) and extreme EMI management control (potential technologies include hopping filters, cancelers, excision and signal extraction).

PHASE I: This phase consists of examining present typical shipboard RF configurations for transmitting and receiving information through existing RFDSs for communications and IW (signal exploitation and counter-communications) in the HF through UHF frequency range. Based on current and advanced RF technology, conduct technological tradeoffs to determine the range of enhanced performance achievable, the degree common functions can be combined and possible basic RF design schemes. The tradeoffs must address technical risk.

PHASE II: Based on the selected basic RFDS design, complete a detailed design. Prototype and prove out key elements of the design where significant performance risk is known to exist. After identifying the technical risk associated with the design and critical RF component selection, conduct a critical design review (CDR). Following the successful CDR, build and test a prototype RFDS. The prototype testing must include a shipboard proof-of-concept feasibility demonstrations. The RF Distribution System will be developed for compatibility with shipboard communications, Cooperative Outboard Logistics Upgrade (COBLU) Phase 1, Ships Signal Exploitation Equipment (SSEE) (both PMW 163 systems), Lighthouse/AN/USG-146 (PMW 162 IW exploit/attack systems) and the Joint Tactical Radio Systems (JTRS). The latter would enable its use by all agencies of the DOD.

PHASE III: The design achieved in Phase II has numerous commercial applications where transmitters and receivers share common antennas and signal sources; e.g., Immigrations and Naturalization, Drug Enforcement Agency, Highway Patrol, Ship-to-Shore communications, commercial shipping, dispatchers, and extensive foreign sales opportunities. For the Navy, this phase would consist of manufacturing sufficient numbers of production versions of the RF Distribution System in order to demonstrate the operational viability and effectiveness of the unit. In addition, upon satisfactory completion of shipboard installation and operational testing , the RF Distribution System project would transition to the standardized process of Fleet introduction and general incorporation into both new construction and backfit modernization programs.

REFERENCES:

- DMR Performance Specification, SPAWAR-D-900, 5 July 1998, DMR AN/USC-61 Primer, 15 March 1999
- COBLU Phase 1 Functional Description Document, CDRL B00D, February 1999 (CONFIDENTIAL)
- Functional Description Documents for Lighthouse, AN/USG-146, SSEE, JTRS & (High Frequency Radio Group) HFRG
- MRFDU Technology Survey & Specification, September 1999, Eldyne/Titian

COMMERCIAL POTENTIAL: The "Wideband RF Distribution System" has outstanding potential to address commercial applications in compliance with SBIR funding "dual-technology" attributes. Commercial applications include the wireless distribution of a wide range of electromagnetic signals, including: direct broadcast (satellite) television systems, cell phone services, and personal communication systems (PCS), which utilize terrestrial, geosynchronous and low earth orbiting (LEO) satellite signals. The potential customers include the general population of private mobile users and their suppliers, and commercial entities such as internet service providers, point-of-sale terminals, and corporations and small businesses involved in the emerging fields of electronic commerce.

KEYWORDS: Radio Frequency, Direction Finding, Precision Geolocation, RF Distribution Systems, Wireless Networks, Inter-Ship Communication Networks, RF Wireless Networks, HDR LOS, IW RF Management, RF Controller, and EMI/RFI.

N00-035 TITLE: High Precision Depolarized Fiber Optic Gyro (DFOG)

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Strategic Systems Program Office

OBJECTIVE: Develop and demonstrate a method for achieving a factor of 10 random noise suppression for depolarized fiber optic gyros above and beyond that which can be achieved using an operating bias point near the dark fringe. The noise reduction method cannot substantially degrade bias performance of the gyro.

DESCRIPTION: It is well known that the Angle Random Walk (ARW) of a fiber optic gyro limited by source intensity noise can be reduced by choosing an operating bias point near the dark fringe.* It is highly desirable to further reduce the ARW. Source noise subtraction/compensation schemes have been developed for polarization maintaining fiber gyros. However, such schemes have not been demonstrated to be highly effective on Depolarized Fiber Optic Gyros (DFOG) utilizing low cost single mode fiber. In order to demonstrate the feasibility of using such a DFOG design for the SSBN Navigation application, it will be necessary to develop and demonstrate a method for achieving a factor of 10 random noise suppression for the DFOG above and beyond that which can be achieved using an operating bias point near the dark fringe.

PHASE I: Perform a study, analysis and simulation of candidate methods for depolarized IFOG ARW reduction. Select the best approach and develop a practical design that can be evaluated on a depolarized IFOG in Phase II. Provide an error budget showing the predicted ARW achievable in _rad/_hz.

PHASE II: Fabricate a depolarized FOG and run tests to evaluate the error sources in the error budget and demonstrate the ARW reduction. Provide a test report documenting the test results and verification of the error budget.

PHASE III: Design, fabricate, test and deliver low cost depolarized FOGs for various military applications utilizing the noise reduction approach demonstrated in phase II. If successful, this development would transition into the SP24 Navigation Sustainment Program.

COMMERCIAL POTENTIAL: Low cost FOG's with very low ARW have commercial application where very accurate pointing stabilization is needed. One example is in the area of high precision robotics.

KEYWORDS: Fiber Optic Gyro; FOG; Rotation; Sensor; Angle Random Walk; Random Noise Suppression

REFERENCES: Lefevre, H.C. et al., Proceedings of the SPIE, Fiber Optic Gyros, 10th Anniversary Conference, Vol. 719, September 1986, pp.103.

N00-036 TITLE: MicroElectroMechanical Systems (MEMS) for Ordnance Monitoring

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Strategic Systems Program Office

OBJECTIVE: Develop and demonstrate a MEMS integrated sensor, analyzer, and data management device and data collection/reporting system for energetic component sampling and assessment to support program and user planning and decision making during all phases of weapon system life.

DESCRIPTION: The chemical stability of energetic components is one of the primary limitations of fielded ordnance systems. Programs establish conservative environmental and service life limits to ensure both performance reliability as well as ordnance safety. Investigations of age-related performance degradation indicate that energetic components are sensitive to environmental factors through life and have resulting significant variance in service life. Precise monitoring of environmental conditions as well as the chemical state of degradation products provides the capability to significantly extend ordnance component service life. Current methods for environmental condition monitoring and chemical state assessment are expensive and influence program schedules. In addition, current methods require significant system intrusion with potential safety and availability impacts and make use of scarce and high cost resources. The insertion of low cost, high reliability monitoring technology directly into produced energetic components will provide monitoring and assessment capabilities enabling potential high-payoff life extension decisions. Approaches employing MEMS have been identified as having strong potential for low cost and high reliability energetic component monitoring. This effort will require both development of a MEMS sensor and preprocessing device as well as a data collection and communications method for real-time, on-board/on-site and off-line, remote assessment requirements.

PHASE I: Perform an application detail study, analysis, laboratory test and simulation of candidate MEMS methods for energetic component performance and material condition assessment. Reference 1 provides an overview for this application. Identify trade-offs and combinational strategies between current methods and use of embedded MEMS devices. Apply current findings of on-going DOD aging and surveillance efforts to plan advanced developments of a MEMS monitoring device. Since the effort will integrate MEMS with existing gas generators, the notional gross specifications for MEMS should follow the current gas generator specification, reference 2, as amplified below.

Specifications and Salient Characteristics:
1. Monitored Equipment: gas generator per reference 2.
2. Monitored Propellant type: double base EDD-2 per reference 2.
3. Notional MEMS population: three to twelve per gas generator assembly
4. MEMS Long Term Temperature range: -20 deg F to 180 deg F
5. MEMS peak firing pressure and time: 4000 psig, 1 sec
6. MEMS Pressure range: -10 psig (neg) to 250 psig
7. MEMS Humidity range: 0 to 100% RH
8. MEMS Immersion rated to 15 psig
9. Monitoring periodicity: quarterly over 10 year period or semiannually over 25 year period
10. Acidity: to pH 4
11. Organic Solvents: full resistance to methanol, ethanol, acetone, acetic acid, and nitroglycerin
12. Monitored conditions:
12.1 REQUIRED: temperature, pressure, humidity, presence and concentration (%) acetic acid (in gas phase)
12.2 DESIRED singly or in combination: (in gas phase) free trinitroglycerin, 1,3-dinitroglycerine, 1,2-dinitroglycerine, 2-N-nitrodiphenylamine (2-NDPA), 2-NDPA daughter products or derivatives (N-NO-2-NDPA, N-NO-2,4DNDPA, N-NO-2,4'-DNDPA, N-NO-2,2'DNDPA, 2,4-DNDPA, 2,4'-DNDPA, and 2,2'-DNDPA) (in solid or liquid phase) free nitroglycerin, 2-N-nitrodiphenylamine (2-NDPA), 2-NDPA daughter products or derivatives (N-NO-2-NDPA, N-NO-2,4DNDPA, N-NO-2,4'-DNDPA, N-NO-2,2'DNDPA, 2,4-DNDPA, 2,4'-DNDPA, and 2,2'-DNDPA), Potassium Sulfate (non-chemistry) shock (triaxial, peak), vibration, firing pressure (P) and time to peak P
12.3 REQUIRED: Special functions: track and store gas generator data - procurement specifications, serial numbers, cast location, cast date, assembly date, shipping history (date, shipper, recipient), storage location records (site and date), installation records (location, install date, remove date), firing records (date expended)

PHASE II: Fabricate a launch tube gas generator monitoring device and run tests to evaluate cost and reliability. Provide a test report documenting the test results and verification of safe device operation. Compare results between MEMS monitoring and current methods.

Specifications and Salient Characteristics:
1. MEMS detect and classification for type and concentration of stabilizer and stabilizer daughter products is within 5% relative of referenced standard laboratory (HPLC, GC, or GPC) tests for all required species.
1.1 MEMS monitor and record propellant head space temperature, pressure, and humidity within referenced specification requirements on periodic basis.
1.2 Transmit stored data to weapon system information network on demand via high reliability modality.
2. Demonstrate intrinsically safe technology to support ordnance safety.
3. Demonstration of multiple cooperative MEMS units within one gas generator to meet redundancy and functional requirements.

PHASE III: Design, fabricate, test and deliver low-cost, embedded energetic component monitoring devices for various military applications utilizing the strategies and approach developed and demonstrated in phase II. If successful, this development would transition into the SP22 Launcher Sustainment Program; and potentially to warhead and rocket motor monitoring of all weapons systems, and commercial chemical manufacturing, storage and transportation facilities.

Specifications and Salient Characteristics:
1. Specification life: 10 years (removable), 25 years (non-removable)
2. Meet reference 2 requirements for service conditions.

COMMERCIAL POTENTIAL: Low cost MEMS for energetic component monitoring have widespread commercial application where fuels and explosive product quality monitoring is required. One example is in the production, storage and transportation of hazardous materials.

REFERENCES:
1) STRATEGIC APPLICATIONS of MICROELECTROMECHANICAL SYSTEMS (MEMS) By LCDR Gary W. Sweany, USN Program Management Office, Strategic Systems Programs, PO Box 391537, Mountain View, CA 94039 ,June 1999
2) WS23136 Amendment I, Critical Item Production Fabrication Specification for Propellant Actuated Gas Pressure Generator, MK74 MOD1
3) Yazdi, Navid, "Micromachined Inertial Sensors", Proceedings of the IEEE, Volume 86, Number 8, August 1998.
4) Stark, Brian, "MEMS Reliability Assurance Guidelines For Space Applications", JPL Publication 99-1, Jet Propulsion Laboratory, Pasadena, CA, January, 1999
5) Tang, William C., "MEMS Applications in Space Exploration", SPIE Vol. 3224, 1997.
6) Gardner, Julian W., Microsensors Principles and Applications, John Wiley and Sons Ltd, West Sussex, England, 1994.
7) MEMS, Sabrie, Solomon, McGraw Hill, June 1999 (new publication)
8) Chemical Microsensors and Applications, Proceedings of the SPIE, Conference 3539, November 1998, Vol. 3539

KEYWORDS: MEMS; ordnance; energetic; life extension; safety; Condition Based Maintenance

N00-037 TITLE: Global Positioning Satellite (GPS) Receiver Test Bed

TECHNOLOGY AREAS: Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Strategic Systems Program Office

OBJECTIVE: Develop a dynamic simulation of GPS signals from the antennas on the Trident II reentry body (RB) so that the performance of various GPS receivers can be assessed relative to Trident requirements.

DESCRIPTION: The cost of determining the performance of various GPS receivers under actual dynamic RB ballistic conditions is prohibitive. A cost-effective alternative is the use of simulation to create equivalent signals as from the antennas of an RB, as it would transition through the different environmental regimes. Conditions which must be simulated include RB position and orientation as it moves, processes and nutates relative to the GPS constellation; endo-atmospheric plasma and atmospheric attenuation and noise; and aerothermal coupling. The computer model of vehicle motion will provide vehicle position and angular coordinates as inputs to the GPS signal simulation. Based on these inputs, the GPS signal simulation will generate simulated signals from the reentry body's antennas. The simulation will then provide the appropriate signals to an actual GPS receiver. The GPS receiver, such as a Magellan 5000 PRO, will furnish positional coordinates to the computer model of vehicle motion via an interface such as an IEEE 488. A comparison can then be made of the RB position and its GPS indicated position to note GPS receiver performance. The SBIR is comprised of the computer model of vehicle motion, the GPS signal simulation, the interface between these two models, and the output interface from the GPS receiver. A third interface from the GPS signal simulation to the GPS receiver is commercially available. All motion and IMU modeling will be carried out on a PC using an Intel Pentium III with Windows NT operating system.

PHASE I: Perform a preliminary design of the simulator/receiver and demonstrate feasibility including how body position, velocity, acceleration, antenna-obscuration etc. alter the simulated GPS RF signal.

PHASE II: Develop a prototype of the GPS signal simulation which will accept as input vehicle dynamic descriptors (e.g. vehicle angular velocity and acceleration). Interface a commercially available GPS receiver, which in turn will provide a stream of navigation coordinates via a standard interface. The contractor must document all work performed under this program.

PHASE III: Design, fabricate and test a GPS receiver test bed that is suitable for use in commercial satellite launches where precise placement in low earth orbit is critical.

COMMERCIAL POTENTIAL: The specific application of the innovation is in the modeling of very accurate dynamic vehicle paths. However, commercial application of an interactive GPS simulation with navigator (receiver) in place are extensive. The most obvious use is in the testing of proposed receivers (and their navigation algorithms) in an environment that is far more exhaustive than can be achieved by a single channel bench test signal. Interactive simulations, such as suggested in this work can easily find broad application to marine, aeronautical or terrestrial platforms, particularly those in a high dynamic environment e.g. ships in high sea states or vehicles traversing irregular terrain at high speeds.

REFERENCES:
1. Hatch, R. "The Synergism of GPS Code and Carrier Measurements", Proceedings 3rd International Geodetic Symposium on Satellite Doppler Positioning", Vol. 2, Feb 8-12, 1982
2. Lohnert, E. B. Eissfeller, O. Wagner, "Analysis of a Completely Integrated INS/GPS Navigation System for Re-entry Vehicles", Institute for Geodesy and Navigation, University FAF Munich, Germany

KEYWORDS: GPS; GPS Simulator; Global Positioning Satellite; Re-entry Body; Re-entry Vehicle; Navigation

N00-038 TITLE: Robotic Manipulator for Cargo/Weapons Handling

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop ultra-high capacity robotic system for moving palletized and containerized weapons and cargo aboard ship.

DESCRIPTION: Conventional cargo/weapons handling requires fork trucks to move loads to and from their stowage locations and the vertical conveyances. Fork trucks and pallet movers require personnel to operate and maintain and valuable deck space to maneuver and stow. Oversized elevator door openings are required to accommodate the fork trucks and safety devices are required to prevent the fork trucks from entering an open elevator trunk. Fork trucks put undue stress on the elevator when they are driven onto the platform and create an additional safety hazard when operated in congested areas during material handling operations. The reduction or elimination of fork trucks in cargo/weapons handling would improve the efficiency of those operations and ships' operations in general. The manning reductions mandated for future ship classes demands the development of robotics or other automation technology to replace personnel in shipboard cargo/weapons handling operations. The objective of this project is to develop a system wherein robotic manipulators are positioned to any stowage location in a magazine or cargo hold, lift the load and deliver it to the elevator platform and vice versa. This project coincides with SBIR topic N99-117 "Linear Motor Technology in the Vertical Plane". The objective of N99-117 is the development of a ropeless, linear motor driven elevator system that uses multiple, independently moving platforms capable of vertical and horizontal motion. The combined objective of N00-0S2 and N99-117 is an advanced shipboard cargo/weapons handling system capable of faster, smoother and more efficient material flow than the existing system while facilitating the proposed manning reductions. This project also coincides with, but is not redundant to SBIR topics N98-108 Grabber for Ordnance Handling Robot and N98-109 Control Approach for Heavy Payload Handling Robots. Technology developed under topic N98-109 could be leveraged for control of the hardware developed under N00-0S2. N98-108 developed a grabber for handling individual rounds vice palletized rounds. Topic N98-113 addresses manipulators, but for small payload manufacturing processes for the Marine Corps, not high capacity cargo/weapons handling aboard ship. There has been no known research and development of a robotic system with the power density necessary to manipulate payloads of this size within the confines of a space similar to a standard hold or magazine aboard a U.S. Navy ship.

PHASE I: Develop concept proposal for robotic manipulation of weapons and cargo aboard ship. Conduct a study to determine the power density and electromechanical needs necessary to deliver and retrieve containerized and palletized loads of up to 6,000 lbs. between elevator platform and stowage location under dynamic sea state conditions. A system capable of lifting, articulating, moving horizontally and lowering its payload within the confines of a hold or magazine similar to those aboard current ship classes is most desirable. Present findings with data, illustrations, related work, etc. to demonstrate feasibility of robotic manipulation of palletized and containerized loads aboard ship. Discuss any unique requirements relative to current shipboard configuration and stowage methods. Explain concepts and components to be used for phase II.

PHASE II: Develop a model, scaled in size and capacity of a system consisting of robotic manipulator(s) with end effector(s) and positioning system capable of handling an equivalently scaled standard pallet and container. The manipulator(s) must be capable of articulating as necessary to reach into a simulated elevator opening to deliver or retrieve the load, lift and move the load horizontally both forward/aft and port/starboard, lower and stack loads. Model must be sized to facilitate mounting on a ship motion simulator.

PHASE III: Develop a full scale land based test site for the testing and evaluation of robotic manipulators, end effectors, positioning devices and control for use in shipboard cargo/weapons handling. Test site will include current generation of shipboard capable robotic devices designed as a result of this project. Test site will be designed so as to facilitate change out of manipulators and positioning devices as different units are tested and future generations of robotic devices are developed.

COMMERCIAL POTENTIAL: Technology developed through this project can be applied to land based material handling applications such as manufacturing, construction and warehousing as well as the commercial shipping industry.

REFERENCES: Introduction to Robotics, Arthur J. Critchlow, MacMillan Publishing Co.

KEYWORDS: robotics, handling, manipulator, cargo, material, weapons

N00-039 TITLE: Advanced Fuel Filtration

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Human Systems

OBJECTIVE: Demonstrate an aviation fuel filtration system with a 4000 gallon per minute (GPM) capacity (double the current capacity) at a weight and volume that is half that of the current system aboard aircraft carriers.

DESCRIPTION: Future aircraft carriers will be required to project considerable more force than is capable today. This is exemplified by the sortie rate requirements in the CVNX Operational Requirements Document (ORD). The CVNX ORD dictates a surge sortie rate objective of 300 sorties per day, a 50% increase on anything carrier aviation has demonstrated to date. A key factor to achieving this faster tempo of operations is ability to fuel aircraft at a faster rate. The maximum rate at which the carrier can deliver aircraft-quality fuel is 200 GPM, even though most aircraft can receive fuel at a much higher rate - over 400 GPM. Pumping fuel at 400 GPM would help the Navy meet the sortie rate objectives that future ships will demand.

A critical limiting factor to increasing fuel flow rate is the fuel filtration system. Presently, fuel is serviced to aircraft via 2000 GPM filter vessels to 20 refueling stations on the flight and hangar decks. There are 4 filter vessels on the ship, 2 forward and 2 aft. Each vessel weighs 10,500 lbs dry and 22,500 wet and has a volume of 340 cu ft (95 in x 79.5 in x 78 in). This system is necessary in order to meet the stringent aircraft engine manufacturers' requirements for fuel quality: no more than 5 parts per million (PPM) of water and 2 mg/l of sediment.

Each of the current vessels houses 134 coalescer elements, 58 separator elements and a rotary control valve for automatic water removal. Changing of the elements, which at a minimum is a 12 hour job, utilizing six personnel, requires the individual to enter the vessel wearing protective clothing and air line hose mask, remove as many elements as possible before skin burning occurs from fuel, and quickly exit, immediately showering and in most cases will be lost for the remainder of the day due to skin irritation.

The Navy needs a fuel filtration unit that doubles the flow rate to 4000 GPM, reduces the size and weight by half, and is maintainable at no health risk to the technician (i.e. eliminates the existing filter media). An additional challenge is the ability to operate while the ship is pitching and rolling. An industry survey has shown that there are no off-the-shelf solutions available, and advanced technologies will be required.

PHASE I: Provide a concept for fuel filtration that will meet the needs stated above. Assess the concept's technical issues and offer alternatives that address those issues. Prove that the concept is technically feasible either by analysis or lab demonstration at the company's facilities. Develop a work plan and proposal for Phase II.

PHASE II: Build a prototype filtration system that meets the stated needs and test the prototype at a landbased location to be determined by the government. Candidate landbased testbeds include simulated fuel systems at the Naval Air Training Facility, Pensacola, Florida, the Naval Air Systems Command, Patuxent River, Maryland, or the vendor's site. Develop a work plan and proposal for Phase III, including an estimate of cost.

PHASE III: Build a shipboard worthy prototype filtration system or modify the Phase II prototype. Demonstrate the unit aboard a carrier during technical evaluation (Techeval) and an operational evaluation (Opeval). Develop logistics support plan and user/maintenance manuals. Build production units.

COMMERCIAL POTENTIAL: The technologies developed under this SBIR project would have numerous applications in areas where filtration of solids from liquids is required. Examples include filtration of chemicals, oil, fuel, drinking water, and sewage treatment.

REFERENCES: Both references will be available through the DTIC internet site.

1. NSTM Chapter 542,(GASOLINE AND JP-5 FUEL SYSTEMS), S9086-SP-STM-010/CH, Chapter 6, PAGE 2, PARA 542-6.2. This provides a description for the current Filter/Separator for MOGAS and JP-5 Systems. It should be noted that proposals should not necessarily be limited to the technology employed by the current filtering system, and that innovative approaches are encouraged.
2. NAVAIR Aircraft Refueling NATOPS Manual, NAVAIR 00-80T-109. This provides an overview of carrier refueling practices and establishes the requirements for aircraft quality fuel.

KEYWORDS: Aviation Fuels, Filtration

N00-040 TITLE: Fire Resistant, Labor Saving, Reduced Weight, Pipe Coupling (Flange)

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an alternative flange-like coupling for Naval and commercial service that reduces installation time[through reduction in bolts and designed-in bolt access improvement (possibly radial)], increases system survivability through enhanced fire-resistance, and is cost, weight and size comparable to existing ANSI and Navy flanges. Couplings shall be producable in materials used in Navy piping (copper-nickel, carbon steel and stainless steel), at a minimum. Modification of suitable COTS couplings, presently too costly and heavy, may be considered.

DESCRIPTION: Conventional flanges (both commercial and Navy) typically have many bolts which are axially installed around the entire circumference of the flange. This process requires equal access to all the bolts to ensure evenly torqued joints. It, therefore, frequently requires labor- intensive interference removal or results in inadequately tightened joints, leading to leakage. Conventional flanges also include gaskets which will leak in a fire scenario, due to bolt relaxation (creep).

PHASE I: Design and develop a cost-effective prototype suitable for the Naval environment. Develop a test plan to fully qualify the design for Navy environments (e.g., shock, fire).

PHASE II: Manufacture prototypes to the Phase I design and test IAW the test plan and make iterative design modifications, as warranted, until tests are completed successfully or restricted Navy applications are decided upon based on any test failures.

PHASE III: Implement the design into the fleet via commercial and Navy documentation issuance and update, and pursuit of ILS measures (e.g., training, supply support, COSAL and APL development etc.). Perform OPEVAL, as necessary, to demonstrate the couplings benefits, promulgating expeditious acceptance by the fleet.

COMMERCIAL POTENTIAL: Commercial designs having the desired features are too heavy and costly for Navy use, and are apparently only available in carbon steel. If smaller, lighter, more cost-effective couplings in a variety of materials are developed, the potential for commercial use would obviously supercede that of any similar existing designs, which are presently used in power plants, refineries and other shoreside facilities.

REFERENCES:

1. NASA Grayloc High-Pressure Couplings Test Report; TR-167-D, dated April 13, 1965
2. Grayloc Product Catalog
3. Newport News Shipbuilding and Drydock Co. Qualification Test Report on Model 4GR31, dated 12/4/98

KEYWORDS: Coupling; Fire-resistance; bolts; interference

N00-041 TITLE: <u>REMOTELY/EXTERNALLY ADJUSTABLE VALVE ACTUATORS</u>

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Sensors/Electronics/Battlespace

OBJECTIVE: Develop modifications for COTS valve actuators to support Navy shipboard application. COTS actuators use remote (hand-held or hard-wired) controls to monitor actuator torque and limit switch conditions and adjust the same without invasive, and possibly contaminating, disassembly of the control module. Annual Preventive Maintenance Schedule (PMS) "open and inspect" requirements can be significantly extended, and associated PMS-induced casualties, resulting from improper re-assembly, avoided. Significant reduction in crew labor burden, and valve and actuator maintenance costs, is expected through the installation of modified COTS valve actuators which utilize external/remote controls (eg: infrared/push-button activators and LCD display screens).

DESCRIPTION: Electric valve actuators typically require adjustment of limit and torque switches to ensure proper operation, or as part of the ships' Preventive Maintenance System (PMS). This PMS is frequently unnecessary. Adjustment consists of disassembly of cover plates, exposing electrical and mechanical components to the elements, and proper adjustment of switches by hand. This procedure leads to casualties (e.g., improper re-assembly with resultant contamination and corrosion, and subsequent improper operation). At the very least, unnecessary PMS labor burden on the crew is promulgated. Valve material condition and performance can also be impacted by improperly set torque and limit switches. Inherent in this effort is a microprocessor control capability (including newly developed software) which allow real-time and cummulative performace diagnostic profiles of the valve to help determine when the valve/actuator needs maintenance; allowing for high confidence levels in PMS extension periods mentioned above.

PHASE I: Develop engineering data supporting modification of available COTS actuators, and determine which would be most cost-effectively modified for Navy environments and operating requirements (including, but not necessarily limited to, assessment of Navy unique aspects of corrosion, fire, shock, vibration, cycling and dynamic loading, ICAS compatibility, and envelope dimension requirements). Develop an ROM estimate on the cost to reach production levels and whether industry interest and base exists for same.

PHASE II: Develop prototype(s), incorporating design modifications as needed, and procure for testing. Test prototypes, as required (some manufacturer's tests may be satisfactory for extension to Navy applications), to qualify for the most severe Navy applications envisioned for this equipment.

PHASE III: Satisfy ILS needs of documentation, supply support, and repair and operational training. Submit informational rights to the Navy for future procurements, if negotiable. Perform TECHEVAL/OPEVAL as required.

COMMERCIAL POTENTIAL: Modification of existing COTS equipment will probably reveal little additional commercial potential except for applications in industry which are similar to Navy environments and requirements. Smaller units (required for Navy manifolds), for example, may widen the commercial market to manifolds and/or restricted spaces in power plants, commercial shipping etc.. Fire hardening may serve similar purposes for more severe/critical applications in industry vis-à-vis fire resistance and post-fire performance.

REFERENCES: MR&S/Sigmatech, "Autonomics for Reduced Engineering Maintenance; Final Report", 28 February 1997, pg. 23

KEYWORDS: Electric Valve Actuator, Condition Based Maintenance, Remotely adjustable, condition based maintenance, diagnostics

N00-042 TITLE: Cabling Jackets with Zero Halogen to Meet UL910 Flame Test

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop a jacketing material for shipboard fiber optic cable to meet commercial plenum cable flammability standards

DESCRIPTION: Currently available shipboard cables rely on flame retardant additives to meet minimum Navy requirements. However the additives, hydrated metal oxides, are different than those used in the commercial sector because of the Navy's requirement for zero halogen content. Also, formulations with hydrated metal oxides do not meet the commercial plenum requirements. It would be desirable to have zero halogen additives that meet the commercial plenum requirements per UL 910 in order to have a common base with the commercial sector. Then the Navy could more easily draw on commercial products to meet its shipboard cabling requirements. Also, since the effectiveness of the hydrated metal oxide additives diminishes in a prolonged fire condition, formulations that maintain their effectiveness under more prolonged exposure to fire would also be highly desired.

PHASE I: Identify formulations that may meet the Navy's shipboard cable requirements, have less than 0.2 percent halogen content and meet the UL 910 plenum requirements. If possible, perform laboratory tests. Perform production process and cost studies.

PHASE II: Select formulations from Phase I and produce samples to determine the ability to meet the UL 910 requirements as well as the Navy cable requirements. Determine ability of candidate formulations to be used in production cable processes, evaluate process variables and provide samples to the Government for evaluation.

PHASE III: Transition a formulation from Phase II into production for use by a Navy shipbuilding program and commercial users.

COMMERCIAL POTENTIAL: This product will be used in both Navy and commercial cabling. In addition, the differences between Navy shipboard cable and commercial cable will diminish so the Navy will have greater access to the commercial cable products.

REFERENCES:

1 Standard for Test for Cable Flame-Propagation and Smoke-Density Values, UL 910, Underwriters Laboratory, Inc.

2 Cables, Fiber Optics (Metric), General Specification For, Military Specification MIL-C-85045

KEYWORDS: cable; fire retardants; flammability, shipboard cable, plenum cable, cable manufacturing

N00-043 TITLE: Enhanced Resistance to Mine Detonation

TECHNOLOGY AREAS: Weapons

OBJECTIVE: To develop technologies that may lead to enhanced resistance to mine detonation.

DESCRIPTION: Preliminary NUWC studies have shown indications that bubble screens of the type produced by ship's "maskers" (which produce a bubble field around the hull) may lead to enhanced resistance to mine detonation due to the cushioning effect. It also may be advantageous to actively cancel the "whipping" (excitation of ship's bending vibration modes) resulting from a mine detonation (see references below). This topic involves both realistic modeling as well as scale tests to determine and optimize the parameters that would be needed for a realistic system.

PHASE I: Numerical modeling of conceptual systems. Determine approximate range of desired parameters.

PHASE II: Complete numerical modeling. Conduct scale tests. Design preliminary systems for use in Navy ships.

PHASE III: Finalize and transition designs for specific Navy ships.

COMMERCIAL POTENTIAL: Initially, the primary market is expected to be Navy ships. After the technology is proven and made practical, noncombatants would represent a significant secondary market. Specifically, oil tankers that must go into shallow water regions containing mines could be equipped to preclude an oil spill that would represent a major environmental disaster.

KEYWORDS: bubble; screen; masker; whipping; mine; cancellation

REFERENCES

1. Hicks, A.N. "The Whipping Forces Experienced by a Ship Very Close to an Underwater Explosion," Naval Ship Research and Development Center Report 3271.

2. Jones, J.P. and Ortloff, C.R. "Blast Wave Hardening of Underwater Structures with Bubbly Water Layers," Air Force Report No. SSD-TR-66-199.

3. Strange, J. and Miller L. "Shock-Wave Attenuation Properties of a Bubble Screen," Army Engineer Waterways Experiment Station, Tech Report 2-564.

N00-044 TITLE: A Dynamic Configurable MCM Assessment Tool for Amphibious Assault Operations

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Mine Warfare

OBJECTIVE: Develop a computational method and prototype tool to determine the casualty-production capability of an anti-amphibious assault minefield from partial knowledge of its composition. This tool must also be able to determine the impact of the minefield's casualty-production capability on the forces safely delivered ashore subsequent to the operation of specified MCM efforts.

DESCRIPTION: Designing and assessing the effectiveness of mine countermeasure (MCM) operations is important in minimizing effects of anti-amphibious assault minefields. A computational tool that is useful in assessing the effectiveness of MCM operations in such minefields must correctly quantify the effects on casualty production and timely projection of forces ashore of a specified level of MCM effort (i.e., specified number of minesweepers in operation for a specified amount of time). More particularly, the tool should enable the user to examine the relationships among (i) the risk of delivering insufficient forces safely ashore within a specified time, (ii) the number and characteristics of boat lanes, (iii) the minesweeping resources committed, (iv) the time allocated for minesweeping, and (v) the threat mine stockpile. The user can thereby assess the resources and time needed to ensure an acceptably high probability of delivering the required forces ashore in at most the maximum allowable time.

The computational tool must accommodate the operational characteristics of threat mines, including such features as sensitivity and ship-counter settings. It should provide, in a manner suitable for the assessment of minesweeping operations, a foundation for its extension into a tactical decision aid that incorporates intelligence, surveillance, and reconnaissance information as it becomes available. It must also be suitable for execution on a high-end desktop computer.

Operational uncertainties accompany any mission involving transport of vehicles through a mined-area (e.g., operational uncertainty of behavior of mines, ships, countermeasures vehicles considered separately, plus the higher level uncertainties involved in the mine-ship and mine-countermeasures vehicle interactions that will occur throughout the mission). Successful performance of this computational tool will be measured in terms of the accuracy of stated probabilities, probability distributions and their moments -more specifically in terms of operationally useful bounds on such moments.

The idea of creating a PC-based tool to assess the effect on an amphibious assault operation of a minefield wherein only partial knowledge of the composition of that minefield is known is highly innovative, and therefore involves considerable technological risk. It will require both innovation and creativity in order to create the tool having the capabilities described herein on even a high-performance desktop computer.

PHASE I: Develop the architecture of the computational tool. Provide a report that includes a discussion of the mathematical methodology, together with illustrations showing how this methodology is utilized and how it could be extended to situations in which intelligence, surveillance, and reconnaissance information become increasingly refined. Provide a description, in the form of structural block diagrams, which specifies the architecture of the tool, including its principal components and how they interact. Define measures of effectiveness/performance by which the prototypal tool can be evaluated.

PHASE II: Develop a prototype tool that, at a minimum, implements the architecture specified in Phase I in the form of a computer program that executes on a high-end desktop PC. An alpha-test module, which may be limited in functionality but must be capable at least of performing the computations used as illustrations in the Phase I report, is to be provided one year after Phase II commences. The computational tool is to be described in a technical report. The description of its logic and mathematics is to include a discussion of the variables and parameters that are used, the derivations of the mathematical relationships among them, and a description of the computational procedures and corresponding algorithms. The use of the tool is to be explained in a draft user's manual. Also to be included is source code (ASCII files) and annotated source listings of all the modules; a symbol dictionary that defines all input variables, output variables, and program constants; and block diagrams and flow charts of the algorithms and procedures. Accompanying the source code is to be an executable file together with a set of test cases sufficient to verify the algorithms and procedures. The documentation should also include a verifiable assessment of the Phase II tool in terms of the measures of effectiveness/performance that were defined in Phase I.

PHASE III: This Phase will extend the mathematical structure of the Phase II product to incorporate intelligence, surveillance and reconnaissance (ISR) information in near real-time. The end product will be a computational tool for assessing risk in the course of an amphibious assault operation and for controlling the MCM and penetration tactics in order to minimize mission risk. This tool will be able to be incorporated into a Tactical Decision Aid (TDA) for planning, controlling and assessing amphibious assault and associated MCM operations that would be used by Commander Mine Warfare Command (COMINEWARCOM) as an MCM planning tool. This TDA would also be likely to transition into the US Navy's Mine Warfare Environmental and Decision Aids Library (MEDAL). The real-time TDA would be used by both Amphibious Task Group and MCM Commanders for planned and on-going amphibious operations and their supporting in-stride mine clearance/neutralization efforts as a part of Organic MCM.

COMMERCIAL POTENTIAL: There are numerous other applications involving complex interacting entities (man, man-made systems, markets, etc.) wherein the objective is to assess risk, potential profit, etc. The sophisticated use of non-classical optimization methods required for solving the problem at hand could be of interest to problem solvers in these other domains.

KEYWORDS: Configurable Theory; Amphibious Assault; Mine Countermeasures; Computational Tools; Tactical Decision Aids; Organic MCM

N00-045 TITLE: Laser Radar (Lidar) Remote Wind Sensor for LCAC

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Mine Warfare

OBJECTIVE: To develop a sensor using laser radar (lidar) technology that is capable of accurately measuring downrange and cross-range wind speeds to 1 m/sec accuracy at ranges from 400 to 1000 ft and altitudes from 30 to 150 ft. The system must have the capability of providing raw and/or averaged data in real time to a fire control system. The system must be capable of installation on the Navy's Landing Craft, Air Cushion (LCAC) and as such, must be capable of operating in the full range of craft environments: motions, sea spray, bow thruster exit airflow, craft-induced vibration, and hot and cold temperature extremes. The system must be able to be mounted on the LCAC superstructure without physically or operationally interfering with the existing craft systems. The estimated production cost of the final deployment system must be below $150K each and the system must be eye-safe.

DESCRIPTION: The inability to measure wind conditions is the largest error associated with launching assault breaching systems from LCACs. Currently the LCAC has no onboard sensor to measure wind speed and direction either near the craft or between the craft and the beach. Installations of mechanical and acoustic anemometers were unsuccessful because of the airflow produced by the craft's bow thrusters, lift fans, and propellers, and seawater spray escaping the skirt. The most promising system tested on the craft was a lidar; however, it was a relatively large, land-based system mounted on the craft for one test only. A compact, eye-safe system is needed that can be installed without affecting craft performance or load carrying capacity. Since lidar systems have been demonstrated to meet the accuracy/range/altitude, eye-safe and real-time data requirements, the primary risk is to develop a compact system compatible with the full range of LCAC environments within the target production cost. Success will be judged by comparing data from a land-based anemometer in the designated target zone approximately 1000 ft away with data from the candidate system operating from an LCAC hovering on cushion just outside the surf zone, with bow thrusters fully operational. Because of the high costs associated with testing the full range of craft environments, verification of performance in the extreme temperature and vibration environments will be done in land-based laboratories. Satisfaction of the cost requirement will be through a detailed cost estimate of the production system to be provided by the Contractor.

PHASE I: Review the state-of-the-art wind sensors for their applicability to the operational environment of the LCAC and the requirements herein. Design and develop a compact, safe prototype system compatible with the LCAC and meeting the operational requirements. A detailed cost estimate for the production system will also be developed during this phase.

PHASE II: Based on the Phase I design, fabricate and test a prototype. All Phase II testing will be land-based. Testing will be conducted first in the laboratory, then in a static installation and next on a motion platform capable of simulating LCAC motions. The systems will be evaluated on its the capability to measure downrange and crosswinds at distances between 400 and 1000 ft downrange.

PHASE III: Test the system installed aboard an LCAC. With the LCAC operating in a representative ABS environment, i.e., on-cushion and stationary, evaluate the system on its the capability to measure downrange and crosswinds at distances between the craft and the beach of 400 and 1000 ft. Following successful completion of the at-sea testing, develop production drawings and documentation that would enable the Navy to procure up to 36 production systems. It is expected that installation of the production systems would be implemented as part of a craft alteration.

COMMERCIAL POTENTIAL: There is considerable potential use for a rugged, compact wind sensor in the private-sector. Not only could the system be used to measure wind conditions from aircraft, sailboats and other vehicles for which wind data is necessary, but it could also be used in remote sites to measure wind conditions at airports and in support of tornado warning systems.

REFERENCES: "Coherent Lidar Wind Profiling Demonstration and LCAC Exit Air Velocity Survey, Final Report," Coherent Technologies, Inc., Report CTI-TR-9804, February 1998.

KEYWORDS: wind measurement; lidar; laser radar; in-stride breaching; mine neutralization; organic MCM

N00-046 TITLE: Non-Contact Measurement of Ocean Currents

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Mine Warfare

OBJECTIVE: Develop the methodology and equipment needed to measure in-water currents remotely from a helicopter.

DESCRIPTION: The methodology and equipment to be developed will be capable of measuring sub-surface bulk water currents to an accuracy of one knot in speed and within five degrees in direction, while correcting for surface motion due to wave action. Determining the current structure as a function of depth is also desired. The measurements must be capable of detecting a one-knot current, if present. It is anticipated that the technique will be optical in nature, but other techniques and approaches will be considered. It is intended in the Navy application to operate the developed system from a helicopter in low-altitude operation (below 500 feet), so the equipment developed needs to incorporate shock and vibration mitigation.

Although laser speed-measurement devices exist (such as police laser radars), the measurement of ocean currents is a more difficult proposition, in part due to the necessity of making sensitive measurements (to within one knot in currents which may be in the one knot range) in the presence of surface wave phenomena which provide a noise source to the desired measurement. It is necessary for the contractor to establish a measurement methodology that allows for making this correction, as well as developing the equipment necessary for making the measurements.

PHASE I: Design and develop a remote metrology system for sensing in-water currents, identifying the models, analysis, and experiments and simulation as appropriate and necessary to determine the equipment required to make the desired measurements, and establish the theoretical basis needed to analyze the resultant data. It will be the responsibility of the contractor to determine the developmental methodology and techniques to be used in this Phase, but the Navy may provide background information concerning the specific mission, expected operating platform, and such other operational information as may be required.

PHASE II: The contractor shall fabricate a prototype system based on the design of Phase I including the equipment needed to conduct a demonstration of the remote water-current measurement capability. The demonstration process may occur in two stages: the first stage demo may be executed from a fixed site, with the second stage from a Navy-supplied helicopter (or, at the Navy's discretion, from an equivalent platform). The equipment is expected to be at least at a breadboard state of development, with only such additional engineering for mission suitability as is necessary to permit routine operation from a helicopter by Navy personnel.

PHASE III: This Phase will be executed under the auspices of PEO(MIW)/PMS-210 to transition the Phase II-developed capability into a militarily-useful product. The contractor shall produce production-level drawings and documentation that would enable the Navy to procure production-quality helicopter-deployable systems.

COMMERCIAL POTENTIAL: There are numerous potential uses of such a system capable of remotely measuring ocean currents, including such diverse areas as fishery management (fish habitat location), civil engineering (at the site of proposed bridges and piers), and environmental (determining probable transport paths for pollutants). Such uses are not individually thought to provide a sufficient need that they are likely to result in the development of this capability, but are a practical market for such a capability once developed.

REFERENCES:
1. Stachnik, William "The Laser Scanning Vorticity Meter ¼", SPIE v. 208 Ocean Optics 6, p. 214 (1979)
2. Stachnik, W.J. and W. T. Mayo, Jr., "Optical Velocimeters for Use in Seawater", Oceans '77 (IEEE 77CH1272-4 OEC) V.1 p. 18A (1977)

KEYWORDS: Optical velocimetry; current measurement; physical oceanography; remote sensing; mine countermeasures; organic MCM

N00-047 TITLE: LASER Vibration Monitoring of Unmanned Machinery

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO for Submarines

OBJECTIVE: Develop machinery condition monitoring for unmanned spaces using LASER-based vibration in a comprehensive autonomic condition monitoring system.

DESCRIPTION: LASER measurement of machinery vibration levels offers potential to permit autonomic monitoring machinery health in unmanned spaces. Changes in vibration levels tracked over time may indicate impending corrective maintenance requirements or performance degradation. Large expensive equipment such as gas turbine engines already are equipped with hardwired accelerometers (mounted on the equipment) which utilize alarm and trip set points. However, the cost and upkeep of accelerometers and their associated controls is usually not warranted on less expensive equipment such as pumps, refrigeration units, etc. These equipments are grouped in Auxiliary Machinery spaces and presently are monitored by personnel. A centrally mounted LASER vibration measurement device is desired to remotely scan and monitor all the machinery in the space. The central LASER is the only component to be hardwired into a ship computer node. The technical challenge is (1) to verify that lasers can accurately measure machinery vibration, (2) to design a single source laser that is central to a space which can measure multiple machinery sources, (3) establish a baseline, trend the data and recognize anomalies.

The risk is that sufficient accuracy is not obtainable or that this technology can be demonstrated in a laboratory and not be capable of being ruggedized to withstand the rigors of fleet use.

PHASE I - Design and develop a centrally mounted, non-contacting LASER vibration measuring system that can contribute to a complete autonomic Machinery
Condition Monitoring System. Demonstrate the ability of LASER instrumentation to scan and measure vibration signatures with results comparable to an accelerometer.

The LASER vibration monitor performance must be comparable to standard hardwired accelerometers. The range of vibration must cover from zero to 15 mils (.001 inch) displacement, measurable in narrow band and broad band frequencies up to 262Khz. Vibration characteristics in both velocity and acceleration over the same ranges should be obtainable. The comparability results must agree over the entire speed range within one half mil. Reliability of the laser must be predicted to meet 20,000 hours of shipboard operation without drift exceeding .25 mil.

PHASE II - Construct and demonstrate a breadboard LASER vibration monitoring system suitable for use in Auxiliary Machinery spaces.

PHASE III - Construct and demonstrate a commercial grade LASER vibration monitoring system, suitable for shipboard demonstration and integration into a shipboard control system. Demonstrate operation of the system in controlled and at sea conditions.

COMMERCIAL POTENTIAL: Private sector applications are the same as Navy, specifically remote monitoring of machinery health. Manpower reduction requirements for cost control are pushing industry for solutions to machinery monitoring. The importance to industry is the same as the Navy. Remote (no-contact) solutions to vibration measurement will save on installation costs and integrate into a complete Machinery Condition Monitoring System.

KEYWORDS: LASER; Vibration Monitoring; Machinery Condition Monitoring.

N00-048 TITLE: Design and develop a real-time on-line RMA trends and analysis reporting assessment database for Towed Array Systems

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO for Submarines

OBJECTIVE: Develop a centralized repository for towed systems RMA data and integrate it with modeling and simulation tools to predict the health of systems analyzed.

DESCRIPTION: The availability of a submarine towed array data acquisition system can provide real time data into a database maintained at a central site. By making the central repository accessible through an internet site all data collected is automatically entered into a common database with access from data suppliers and users. The data collected into this common database is then accessible to an automated trends and analysis software suite of Reliability and Maintainability tools. As the data is collected by the database it is processed through this set of tools. Class wide results can be provided as frequently as the data is uploaded to the database; i.e. each time a ship or maintenance facility enters data. The users would be able to see reports updated in real time by visiting the web site. Current RMA cataloguing systems do not have the ability to do any real-time trend analysis and are incapable of forming a predictive model.

The use of statistics and decision analysis tools could be used to provide predictability of future system operational performance and be adaptable to real time data. Thus, an improvement in system design or operation that is expected to change reliability can be monitored for its contribution as soon as data from the ship with the improvement is entered into the system. Responsiveness of the overall towed system can be gained in shortening the design, install, operate and evaluate cycle. Additionally, users of submarine towed systems would have access to the data, see the results and have common reference for which improvements are necessary and where improvements provide the most return for the invested cost.

PHASE I: During Phase I, the contractor would design a real-time on-line RMA trends and analysis database. This design would include determining what types of information would be required from the field. The design will also include the piece of the system that will be used by field personnel to collect and access the data. They will also design the algorithms that will be used to predict reliability trends from data that was entered into the system. There should also be investigations into ways that data could be collected automatically from submarines and towed systems.

PHASE II: Build one full system, including the central database, analysis tools, and at least one of each type of data collection station.

PHASE III: Build sufficient systems for fleet use.

COMMERCIAL POTENTIAL: This system could be adapted for numerous other uses throughout the military and commercial sector, such as maintenance of transit systems, manufacturing machinery, tanks, whole ship monitoring systems, etc.

KEYWORDS: Reliability; availability; maintainability; monitoring; automatic; database

N00-049 TITLE: Innovative Signal Processing Concepts for Active Emissions

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO for Submarines

OBJECTIVE: Develop innovative signal processing techniques which can fully exploit the full detection and localization potential of sensor suites installed as part of today's combat systems. Specifically, improvements to the detection and localization of active emissions (eg. incoming torpedoes) is needed to provide a defensive capability which rapidly and clearly identifies and localizes threats. Automation of the detection, classification, and localization process is desired.

DESCRIPTION: Detection and localization processing provided by today's stand alone active emission signal processors are the limiting factor in providing needed capability, relative to the overall system potential of the acoustic sensors. Current combat system sensors can provide the ability to more rapidly detect and localize active emissions than current processing provides. Development of innovative concepts that maximize the use of various sonar sensors, automate localization and classification functions, and provide advanced visual techniques to enable rapid decision making substantially increase survivability.

PHASE I: Develop innovative signal processing concepts for the detection and localization of active emissions based on the current sensor suites of available combat systems. Identify requisite technology developments including but not limited to sensors, processing, and data presentation.

PHASE II: Design and fabricate a "brass board" prototype based on the design developed in Phase I and perform a proof of concept demonstration.

PHASE III: Develop a prototype model for qualification, test and evaluation and production purposes, including supporting software and documentation, for an active emission detection, tack, and localization subsystem that can be integrated into an existing submarine and surface ship combat system.

COMMERCIAL POTENTIAL: These approaches to innovative signal processing concepts can be transferred to other areas of the commercial world in which detection decisions are required based on the detection and localization of acoustic information. Some other applications include air traffic control systems; military ground based and airborne systems; and automated vehicular traffic control systems

KEYWORDS: Active Emission; Signal Processing; Acoustics; Multi-Sensor Exploitation; Tactical Information Processing; Display Visualization

N00-050 TITLE: Smart Tools to Support Shipboard Network Administrators

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO for Submarines

OBJECTIVE: Develop software tools to assist shipboard network administrators.

DESCRIPTION: Navy ships and submarines are becoming heavily network centric, yet the maintenance and administration of the computer networks aboard ship has, to date, been considered a 'collateral' duty. There is presently no career path for network administrators, nor is there a training curriculum to ensure that the computer networks aboard ship will be adequately maintained. There is a need for a set of software tools that can quickly provide network administrators with necessary troubleshooting and status data in a simple, easy-to-use manner.

Such a toolset would benefit network administrators by allowing them to easily ascertain the present health of the network and quickly identify network resources that may require attention. In this context, "network resources" includes both hardware (workstations, servers, routers, hubs, switches, and other devices physically connected to the shipboard network) and software (system and user applications running primarily on UNIX and Windows NT-based platforms.) It is expected that the toolset will provide administrators with a means of examining and maintaining the configuration of network resources, provide a basic test capability to ensure proper functioning of a given resource, and offer a means of alerting an administrator when a failure has occurred.

The submarine environment poses several unique challenges to the development of a network administration toolset. The tools must support a wide-range of hardware not found in most commercial network environments, must interface with custom-built Navy applications and software products, and must function in a non-invasive manner to protect the integrity of tactical applications and hardware. Such requirements have precluded the use of existing commercially available tools and will likely require the development of new approaches and tools for use in the submarine environment.

PHASE I: Establish the technical requirements for a software toolset to support network system administrators aboard Navy ships and submarines. Develop a top-level design Graphic User Interface for the toolset.

PHASE II: Complete a detailed design for the toolset. Implement the software in code and produce a prototype.

PHASE III: Demonstrate the toolsets capabilities to support system administrators on a specific Navy vessel (e.g., USS Virginia, SSN774) and extend the system to encompass other classes of Navy ships/submarines.

COMMERCIAL POTENTIAL: The use of standard networking protocols and technologies as a means to upgrade aging and/or proprietary systems and networks is becoming more and more common in the commercial marketplace. However, many of these systems and networks will continue exist in the same highly specialized environments that necessitated their original proprietary design. This will create significant commercial potential for a network toolset that can be readily adapted to support custom applications and environments.

KEYWORDS: computer networks; system administration

N00-051 TITLE: Development of a Nondestructive Evaluation (NDE) Technology for Inspecting Structural Welds under Coatings

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO for Submarines

OBJECTIVE: Develop an NDE technology to inspect, for planar and volumetric flaws, full-penetration butt welds covered by a protective and energy dissipating synthetic coating. Inspection technology must allow for all inspection work to be done from one side (through the coating), and should have potential for field deployment.

DESCRIPTION: Routine NDE inspections of hull welds in Navy ships and submarines support the lifetime monitoring each ship's structural integrity. The location and sizing of planar and volumetric defects factor into the determination of maintenance and repair plans. The recent introduction and increasing use of advanced coating systems - some with significant thickness and energy dissipating properties - presents a challenge to conducting these NDE inspections with current methods and technologies unless the coating is first removed. (This removal and subsequent reapplication process creates additional work that is undesirable.) All NDE technologies are based on physics. All technologies used by the Navy for inspecting structure are based on the ability to input an energy signal, have it interact with a defect, and obtain an output signal that can then be interpreted. The advanced coating systems, by their very nature, serve to defeat the capability to even input a conventional NDE signal. Despite attempts, no NDE technique has demonstrated the ability to pass a signal through the coating, interrogate the underlying metal structure for defects, and return a signal to the outside of the coating. Current inspection methods permit the use of either ultrasonic or radiographic technologies, although the ultrasonic technology has become the more desirable of the two since it has many advantages over conventional radiography (Ref 1). The capability to conduct inspections completely from the outboard side of the hull is a major advantage of the ultrasonic technology and will continue to be a desired characteristic of new technologies for inspecting through the hull coating. Success will be recognized when the contractor demonstrates the ability to detect, locate, and size a discontinuity from the coated side of a test panel. The discontinuity will be embedded approximately 1/2t (t= thickness of the metal) through the metal and have a maximum dimension of 1/8 inch.

PHASE I: Develop a candidate technology and demonstrate its feasibility for conducting inspections of Navy hull welds through various advanced Navy coatings. (The contractor must obtain clearance for working with classified information.)

PHASE II: Develop the technology and design/build a prototype inspection system for full-scale field trial use and in accordance with current Navy inspection capability criteria.

PHASE III: Develop a field-deployable inspection system for Navy and shipyard use.

COMMERCIAL POTENTIAL: Structural weld surveillance varies in complexity from industry to industry. Several industries make extensive use of rubber/rubber-like coatings, but the applications (primarily tank and other fluid system linings) tend to not interfere with the conduct of weld inspections.

REFERENCES: DeNale and Lebowitz, "Ultrasonics as an Alternative to Radiography for Submarine Hull Weld Inspection," DTRC_SME_90/30, February 1990. (limited distribution)

KEYWORDS: nondestructive inspection; welds; coatings; flaw sizing.

N00-052 TITLE: Application of Virtual Large Display Video Goggles to Submarine Imaging Systems

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO for Submarines

OBJECTIVE: Develop the capability to utilize Virtual Large Display Video Goggles as a peripheral display device in real time submarine video imaging systems.

DESCRIPTION: Current submarine imaging systems require large (19+ inch) video display units (either CRT or flat panel) viewed at close range in order to adequately see incoming external video. This ties the operator of the imaging system to the display console. Divorcing the operator from the display console frees him/her to interact with other operators and watch standers while viewing external video. In recent years, commercial vendors have developed virtual large display video goggles providing the equivalent display surface of an 80" television screen for personal computer games. Adaptation of one of these goggle technologies for submarine imaging systems not only frees the operator from the display console, it also provides the added benefit of elimination of high power consuming CRTs. Additionally, head-tracking capability will be considered for control of the video imaging sensor line of sight.

PHASE I: Design and develop the application and use of video goggles as a display device for submarine imaging systems. The Phase I effort should include a laboratory demonstration of realtime video imagery over video goggles, and features critical to use aboard submarines.

PHASE II: Fabricate a prototype video goggle display and associated software based on the Phase I design. Demonstrate the prototype display on a submarine imaging system. Any software required for interface must run on a Sun Sparc processor.

PHASE III: Integrate the Phase II prototype display into existing U.S. Navy submarine imaging systems. Full CSCI documentation shall be provided along with the software in accordance with standard Navy guidance.

COMMERCIAL POTENTIAL: The commercial applications for this technology include government military applications and commercial video applications. Navy surface ships and aircraft employ video display for tactical and strategic missions which could benefit from this technology. In addition, commercial high end video acquisition, processing, and editing systems used in the advertising, entertainment, and medical fields will take advantage of this research.

REFERENCES:

AN/BVS-1 video distribution drawings
AN/BVS-1 Internal Electronic Unit Critical Item Design Specification.

KEYWORDS: video, photonics, goggles, submarine, imaging, display

N00-053 TITLE: Highly Directional Compact UHF Antenna

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO for Submarines

OBJECTIVE: The objective of this topic is to develop approaches to providing a compact highly directional antenna with low side-lobes to reduce vulnerability of UHF communications to intercept/geo-location.

DESCRIPTION: Radio communications is becoming increasingly important in naval operations. A significant amount of the terrestrial communications will occur in the UHF band. In order to reduce interference and reduce vulnerability to intercept, geo-location and jamming, highly directional antennas are required. Typically, highly directional antennas at UHF frequencies, tend to be large in size which restricts their installation to either ground or large platforms. Directionality, combined with the space constraints on smaller air or surface platforms, involve technical challenges to be overcome. The objective is to provide the maximum directionality and minimum side and back lobes in the horizontal plane.

PHASE I: Develop a design for a directional UHF antenna designed to fit inside the volume enclosed in a right circular cylinder 18 inches in diameter and 35 inches high. The target frequency range for operation is 800 MHz to 2500 MHz. The contractor shall provide a detailed analysis of the expected performance of the proposed design. An appropriately scaled model of the proposed antenna shall be constructed and its performance measured. The measured performance shall be compared to the predicted performance.

PHASE II: The contractor shall construct A full scale model of the antenna design developed in Phase I of the SBIR. The performance of the antenna will be measured and compared to the predictions and measured results of Phase I.

PHASE III: A successful antenna design would lead to construction of a prototype antenna for installation on a submarine. The contractor would participate in the construction of the antenna and integration of the antenna to operate in the submarine application.

COMMERCIAL POTENTIAL: A successful antenna design exhibiting a high degree of directionality in this frequency range has potential application in the cell phone and PCS industries.

KEYWORDS: submarine antenna; directional antenna; low sidelobes

N00-054 TITLE: Non-Metallic Bearings

TECHNOLOGY AREAS: Ground/Sea Vehicles

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO for Submarines

OBJECTIVE: Identify, design, and test non-metallic bearings for Navy use.

DESCRIPTION: Develop non-metallic bearings for Navy applications. The Navy currently uses bearings that are required to operate in a variety of environments simultaneously including: dry; in a submerged marine environment; under significant physical loads; at great depths; and under ambient temperatures ranging from 30 to 125 degrees F. These bearings are used in many different types of rotating machinery, many with large diameter shafts and great loads (2 to 3 tons per shaft). There are several drawbacks to the bearings currently in use in these applications, however. They require lubrication, which must be maintained even at great depths. Inspecting and re-lubricating these bearings is very expensive. These bearings have also been known to crack under load. This effort would improve the existing implementations and allow for expanded application. Non-metallic bearings may have several advantages over metallic/roller type bearings. The challenge is to develop bearings that will meet the requirements of no lubrication, low friction, and high strength while maintaining low cost and the ability to operate in all environments mentioned above.

PHASE I: Select material and design bearings for a selected submarine application. The following criteria could be important factors in material selection: PV rating, loading capacity, seawater compatibility, water absorption characteristics, friction factor, and environmental regulation compliance. The bearings should be designed so that they require no lubrication when running in air, and are also compatible with running while submerged at great depths in seawater.

PHASE II: Produce prototype bearings for use on both land-based and at sea testing facilities.

PHASE III: Produce a quantity of bearings for Fleet use.

COMMERCIAL POTENTIAL: The industrial world has many uses for bearings for heavy rotating machinery. This includes the marine industry, heavy manufacturing, and the oil industry.

KEYWORDS: Non-Metallic; Bearing; PV Rating; Marine Environment; Breakaway Friction; Water Absorption

N00-055 TITLE: Digital Radar Receiver on a Chip

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: The objective is to develop a high performance digital receiver as a MMIC part or a large hybrid single chip part.

DESCRIPTION: In a "Digital Radar", digital T/R modules are physically located behind each radiating element in the radar antenna and only digital information is transferred over fiber optic links between the processor and the T/R Modules. Each digital T/R module converts a digital waveform to analog, frequency up-converts, amplifies and radiates it. After the radar echo arrives at the antenna, it is passes through a receiver protector, and the echo signal is down-converted in frequency, passed through an A/D converter, converted to base-band, and then transferred to the processor over the digital fiber optic link. A feature of a digital Radar is to provide an up/down conversion process at each radiating element. This process should have high performance, be on a single chip, and be fairly low cost. Current technology uses surface mount mixer, amplifier, and filter components to perform this function. There is significant flexibility in the development of the "Digital Radar Receiver on a Chip."

An example set of specifications are:

Operating frequency 3.1 to 3.5 G-Hz
First IF 915 MHz
Second IF 45 MHz
Bandwidth 10 MHz
1 dB compression at 915 MHz 95 dB at 45 MHz 80 dB
Phase noise floor -155 dBc/Hz
Size desirable MMIC chip
required large hybrid chip

PHASE I: Develop alternate design(s) for the 'Digital Receiver on a chip' suited to the digital T/R module application, select the design which achieves the best required performance from among the various alternative designs, and provide necessary design disclosure information. A successful design will constitute the first fully digital radar receiver and shall provide both small size and high performance simultaneously.

PHASE II: Fabricate prototype 'Digital Receiver on a chip' units which conform to the Phase I design within the size and cost constraint(s) and demonstrate their performance. A successful prototype will meet the size and performance requirements described herein and develop any necessary new fabrication technology.

PHASE III: Integrate the Phase II prototype 'Digital Receiver on a chip' into digital T/R modules supporting the Navy Volume Search Radar (VSR) program, and into the Advanced Multifunction RF System (AMRFS).

COMMERCIAL POTENTIAL: These 'Digital Receiver on a chip' units could find wide and ready application in the rapidly growing wireless communication industry (cellular phone relay units). Other (lower volume) applications include Law Enforcement Radar, Weather Radar, and NASA Remote Sensing Radar all of which could employ these compact digital receivers to good advantage (lighter, smaller size, enhanced performance).

REFERENCES:

1. MMIC Devices
2. MEMs Devices

KEYWORDS: Receivers; Digital Receivers; MMIC; chip; radar; multifunction

N00-056 TITLE: Low-Cost Net-Form Fabrication of Hot Gas Valve Components

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: Develop and demonstrate low cost net or near-net form manufacturing processes to produce high temperature, oxidative resistant components for ducting and controlling hot gases with temperatures over 3500°F.

DESCRIPTION: The Navy and other DOD activities are currently developing Divert and Attitude Control Systems (DACS) to provide multi-axis propulsion control authority for endo- and exo-atmospheric interceptors (i.e., Area and Theater-Wide Defense). Evolving Navy divert propulsion systems utilize solid propellant DACS technologies, which have limited performance and are very costly to produce. Future Navy divert propulsion systems need to have a combination of a higher degree of energy management flexibility, higher performance, reasonable weight and a significantly reduced cost. This combination of performance and cost characteristics is extremely challenging and yet to all be achieved in a single application. Ducting, control and energy management of solid divert propulsion systems demands development and manufacture of complex, precision and durable hot gas valve components. Future components must survive exposure to oxidative hot gases of over 3500°F, under demanding structural conditions (e.g., dynamic gas flow, valve impacts, severe thermal gradients, etc.). Components must also survive with near zero erosion, to maintain critical flow passage geometry. Currently, specialty high temperature materials must be used to support design and construction of hot gas valve assemblies. Manufacturing of these specialty materials is complex, resulting in long fabrication cycles and in very high cost. A number of high temperature materials have thermal and oxidative resistant characteristics that suggest that they might be suitable to the intended application. However, many of these materials are difficult to form into complex shapes, are difficult to join, and are not impact resistant. Other materials have the appropriate properties and can be formed into complex shapes, but they are very costly to manufacture.

The intent of this SBIR topic is to develop and demonstrate advanced hot gas valve material and manufacturing technologies which yield near-net or net-shape configurations. Demonstrated components must be fabricated of materials and in configurations which can withstand the thermal, chemical, erosive, structural and geometric requirements of future DACS propulsion systems. Selection shall be biased towards technologies which demonstrate the following attributes: (1) Near zero erosion when exposed to hot propellant gases of >3500°F for up to 100 seconds, (2) the ability to fabricate viable near-net shaped hot gas components at low cost, and (3) the ability to fabricate viable hot gas valve assemblies with short fabrication cycle times and low part counts.

PHASE I: Produce samples representative of hot gas valve components using appropriate high temperature, oxidative resistant materials. Samples must be fabricated using near-net or net forming fabrication approaches and materials intended for transition to Phase 2. Devise and conduct thermal, structural and chemical resistance testing to demonstrate viability of transition to Phase 2. Preference will be given to contractors who conduct hot-fire testing of components. Identify cost reduction, fabrication cycle time, and reduced complexity improvements over state-of-the-art hot gas valve technologies.

PHASE II: Scale-up material and fabrication processes. Fabricate net-formed hot gas valve components and validate adequacy of these components through hot gas testing (>3500°F). Conduct complete thermal and structural characterization of the selected material and fabricated components. Identify property variation versus major processing parameters.

PHASE III: Transition technologies to the STANDARD Missile vendor base.

COMMERCIAL POTENTIAL: The proposed topic has application to the following products, representing notable commercial potential: other DOD solid divert hot gas valve assemblies (AIT, LRALT Trajectory Adjustment Module, and Trident Post Boost Control System), reduced smoke solid propellant rocket motor nozzles, liquid propulsion combustion chambers/nozzles, aero-thermal protection of high-speed flight vehicles, high temperature turbine engine components, and other high temperature applications.

REFERENCES:

1. Papers (1997 JANNAF) and discussions on Rhenium and Hafnium based high temperature materials with Dr. Mark Opeka of the Naval Surface Warfare Center, Carderock, MD.
2. Martin Minthorn, April 1999 MANTECH Issue Paper (No. 2171) titled "Rhenium Fabrication Processes"

KEYWORDS: Hot Gas Valves; Divert and Attitude Control System; high temperature materials; net-form fabrication; low cost manufacturing

N00-057 TITLE: Propulsion Improvement for Long Range Guns

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: Increase the muzzle velocity and thus the range of Navy guns, without significant alterations to current Navy gun configuration, and without exceeding maximum chamber pressure, muzzle exit pressure, and projectile acceleration limits.

DESCRIPTION: This topic seeks methods to improve a gun's propulsive efficiency by increasing the area under the projectile base pressure vs. time curve. In a gun, propulsion gases occupy an expanding volume, defined by the breech and moving projectile base, and are produced by combusting propellant. In most cases, the pressure at the projectile base is lower than at the breech. The Constant Breech Pressure (CBP) analysis, a reasonably accurate method for predicting the maximum achievable muzzle velocity for a gun, assumes a linear velocity gradient for the gas from the breech to the projectile base. The topic seeks approaches, tools, models, and processes to improve the physical interaction in the gun's barrel to alter the velocity and density profiles of the propellant gas behind the projectile, to increase the base pressure (while not increasing the breech pressure) to achieve the objective. This would result in velocities greater than that predicted in the Constant Breech Pressure analysis. One method assumed to achieve improved efficiency is the 'travelling charge', in which propellant, in the form of a fast-burning rocket grain, is attached to the projectile. This design, instead of generating gas uniformly through the expanding volume, generates gas at the projectile base, with a rearward velocity. Thus an innovative combustion configuration can modify the velocity and density profiles and may produce improved performance over that predicted by the CBP analysis. However, travelling charge proposals would need to address various issues associated with the travelling charge concept such as explosive safety concerns, higher muzzle exit pressures, high sensitivity of the propellant, and increased weight (see ref (2)). Other concepts may include, but is not limited to, layered propellants, a travelling charge - conventional propellant hybrid, or Electrothermal-Chemical (ETC)-conventional propellant hybrid.

PHASE I: Develop analysis tools and recommend a method of increasing propulsive efficiency. The approach can be a travelling charge, or some other suitable method. Provide an analysis or simulation of the performance improvement. Conduct any necessary bench-scale tests to establish the suitability of, for example, propellant materials.

PHASE II: Fabricate a demonstrator and prove the effectiveness of the method. A subscale demonstrator is allowable, if analysis shows how it will scale to full-size systems such as Navy 5"/62 Mk 45 Mod 4 gun and a future DD-21 155 mm gun.

PHASE III: Demonstrate the improved performance at full scale.

COMMERCIAL POTENTIAL: Approaches to modifying the velocity, density, and flow fields resulting from a burning propellant bed, needed to enhance the gun performance, are also applicable to improvements in other combustion processes, such as fluidized bed reactors. Approaches that develop fast-burning solid propellants (as opposed to achieving fast burning by using small grains) will lead to safer propellants for commercial applications such as small arms, fireworks, signaling, and air bags. (For example, a truckload of solid propellant increments will be less likely to be scattered on the highway if the truck were to overturn, compared to a recent truckload of black powder.)

REFERENCES:

(1) William F. Oberle, Constant Pressure Interior Ballistics Code CONPRESS: Theory and User's Manual. ARL-TR-199, Army Research Laboratory, Aberdeen Proving Ground, MD, September 1993.

(2) James T. Barnes and Edward B. Fisher, Combustion Mechanisms of Very High Burn Rate (VHBR) Propellant. ARL-CR-242, September 1995.

KEYWORDS: gun; propulsion; Lagrange gradient; travelling charge; interior ballistics; pressure

N00-058 TITLE: Direct Digital Signal Synthesizers

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: Develop a small, low-cost direct Digital Signal Synthesizer (DDS) for use in digital radar that generates high fidelity analog signals at high speeds from digital signals.

DESCRIPTION: In a "Digital Radar", digital T/R modules are physically located behind each radiating element in the radar antenna and only digital information is transferred over fiber optic links between the processor and the T/R Modules. Each digital T/R module converts a digital waveform to analog, frequency up-converts, amplifies and radiates it. After the radar echo arrives at the antenna, it is passes through a receiver protector, and the echo signal is down-converted in frequency, passed through an A/D converter, converted to base-band, and then transferred to the processor over the digital fiber optic link. A critical element in this described process is the direct Digital Signal Synthesizer DDS. Commercial units currently have large spurious responses.

A set of specifications are:

Intermediate frequency	45 MHz
Bandwidth	to 10 MHz
Waveform	Complex waveform with true time delay
Phase noise	-140 dBc/Hz
Spurious signals	110 dBc
Module-to-module	uncorrelated noise
Size	few small chips
Cost	$100

NRL has experimented with a delta-sigma 1 bit DDS Unit and has achieved -130 dBc/Hz on a 40 _5 MHz sinusoid with no readily noticeable spurs using a 960 MHz over-sampled clock and a 6th order encoder at an IF frequency of 40 MHz. NRL have also generated linear FM waveforms. It was also shown that by using dithering that the waveform noise from module-to-module is de-correlated. NRL believes that the delta-sigma encoding can be performed easily in a single FPGA for waveforms having 10% or less duty cycle. For continuous waveforms or the 1st LO, it appears that the encoding may be performed in real time in one or two large FPGA.

The requirement is to develop new high performance, small, and low cost DDS units. This could be done with a new technique or by expanding on NRL's described work on delta-sigma techniques. Other criteria that should be considered in the development are equalization, time delay, Phase shift, amplitude, etc.

PHASE I: Develop a design achieving the required performance among various alternative designs. A successful design will eliminate the serious spurs present in the performance of current Digital Synthesizer Designs, for which there is no satisfactory remedy.

PHASE II: Fabricate prototypes within the size and cost constraint and demonstrate their performance. A successful prototype will meet the size and performance requirements described herein and, if delta-sigma techniques are employed, provide the necessary improvements in high-speed delta-sigma operation(s).

PHASE III: Incorporate the DDS unit into the Navy Volume Search Radar (VSR) program, and into the Advanced Multifunction RF System (AMRFS).

COMMERCIAL POTENTIAL: These DDS Units could be widely used in the rapidly growing wireless communication industry. Law Enforcement Radar, Weather Radar, and NASA Remote Sensing Radars all could use these compact and cheaper DDS Units.

REFERENCES:
1. Example Vendor - Stanford Telecom, Lowell, MA
2. S. Norsworthy, R. Schreier, G. Temes, "Delta-Sigma Data Converters," IEEE Press, 1997.

KEYWORDS: VSR, DDS, Direct Digital Synthesis, D/A, low cost

N00-059 TITLE: ADVANCED REACTIVE MATERIALS AS PROPELLANTS

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: Develop high energy reactive materials as rocket propellants, fuels, and modifiers.

DESCRIPTION: High-energy propellants will allow the Navy to develop weapons systems with longer range, lower costs, and greater flexibility. Specifically, the range should be doubled and the fly-out time halved by the year 2005, as compared to the 1995 baseline.

Technology goals include the improvement of specific impulse and mass fraction of propellant for tactical missile and/or spacecraft propulsion. This may be accomplished by increasing the overall energy content and/or burning rates. For example, changing only the burn-rate from 1-2 inches per second at 1,000 psi to 10 inches per second at 5,000 psi without a pressure exponent change, would enable propulsion designers to eliminate the center perforation yielding more propellant per unit volume.

Reactive materials may also improve the combustion rates in ram-jets, ducted rockets, and hybrid motors. The reactive materials may include an energetic material consisting of two or more solid state or liquid reactants, that together form a thermal chemical mixture that could be used/for propellants and reactive components. Typically, reactive materials are metal-metal, metal-metal hydrides, and/or metal-metal oxide mixtures, with and without binders; included are thermites, intermetallics, metal/halogenated compounds, and ultrafine powders. Of interest are also ultrafine powders of complex compounds of boron, nitrogen, and hydrogen.

Research and development in this advanced topic should include maximum innovation and flexibility, while yielding promising commercial applications or dual-use technologies. Practical processing and manufacturing are also important.

PHASE I: The initial research and development effort will assess the feasibility of existing and proposed unique capabilities, and demonstrates through bench-scale evaluation the proposed new approach and payoff to be derived, by implementing the concepts/materials. The effort should be directed toward experimentally demonstrating potential systems suited for application as new rocket propellants, fuels, or modifiers. The effort would experimentally produce and test small quantities (grams) of the reactive materials or reactive materials incorporated into the propellants. Experimental methods may include differential scanning calorimetry, thermogravimetric analysis, and combustion bomb analysis to quantify the energy increase /improvements and the reaction rate enhancements.

Samples in gram quantities should be delivered to NSWD-IHD for evaluation and safety testing.

PHASE II: Will demonstrate selected reactive material advanced technological concepts beyond bench-scale, and conduct verification that doubling the range may be achieved, with halving of the fly-out time. The verification shall be done by quantitative measurements of improvements made in energy contents and burn-rates. Preliminary manufacturing and processing should be demonstrated. The energetic material should have application to civilian space technology and novel weapons technology. The material should be delivered in 20 kg batches to NSWC-IHD for evaluation and safety testing.

PHASE III: Optimize the materials for cost, performance, safety, and ease of manufacturing. The reactive material/propellant should have application to civilian space technology and novel weapons technology. The technology should transition to air/surface weapons programs.

COMMERCIALIZATION: Commercial potential exists in the fields of air independence propulsion and space vehicle launch/control. Spin-off technologies would include reactive material ultra-fast cutting in outer space. This technology could also be used underground in the cutting of oil-well casings. Presently, the oil-well industry is dissatisfied with explosive cutting of well-pipe in horizontal well-drilling operations.

REFERENCES:
1. Sergeev G. B., Petrukina M. A., Progr. Solid State Chemistry, Vol 24, p 183, 1996.
2. Borovinskaja I. P., Mendeleev Communications, pp 47 -48, 1997

KEYWORDS: Reactive materials; propellant; high energy; fuel; modifier

N00-060 TITLE: Aerodynamic range extension of guided projectiles

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: Develop methods to extend the range of guided gun projectiles by increasing their lift-to-drag ratio

DESCRIPTION: Current designs for guided projectiles for Naval Surface Fire Support are designed to achieve their required range through a combination of rocket assistance and gliding flight. The rocket motor has a negative impact on payload fraction, cost, safety, reliability, and testability. The NSFS program would like to eliminate the rocket motor from the projectile, while still meeting most or all of their range requirement.

This topic seeks improvements to the projectile aerodynamics, including lift enhancement and drag reduction methods, that will recoup most of the range lost by deleting the rocket motor from the EX-171 Extended Range Guided Munition design.

PHASE I: Develop an approach to improving projectile aerodynamics: increasing lift, reducing drag, or both. All aerodynamic surfaces and other equipment must fit within the 5-inch gun tube, folding if necessary. The volume of the current ERGM rocket motor and warhead bay is available for use, with the requirement that the volume of the warhead bay be preserved, although it may be shifted forward or aft, or (less preferably) divided into two bays of roughly equal size. Estimate the resulting range and time of flight performance for the projectile. PMS 429 desires that any simulations developed be integrated into the Phoenix Integration Corporation Model Center product, which allows integration of component models into a system simulation. Integration requires Phoenix Integration's "Analysis Server," which is currently available at no cost on the Internet, at http://www.phoenix-int.com/

PHASE II: Implement the improvement in a test projectile or airframe, and demonstrate the improved performance through gun-launched, wind tunnel, or drop tests that provide the same flight regime in which the improvement takes effect. (That is, if the improvement only affects subsonic flight, only subsonic tests are required, if the design permits confident belief that supersonic flight characteristics are unaffected.)

PHASE III: Integrate the improvement into an NSFS projectile.

COMMERCIAL POTENTIAL: Approaches to aerodynamic lift increase and drag reduction are fundamental to improved performance of civil aircraft and other vehicles, as well as other aerodynamic and hydrodynamic flow applications including turbine engines, air flow in building HVAC, and fluid flow in industrial processes. The particular requirements of projectiles for low cost, rugged mechanisms favor approaches that are suitable for commercial application as well. The specific application will depend on the approach the contractor takes, with approaches that improve subsonic lift-to-drag having application to commercial vehicles and duct air flow, while supersonic improvements would map to turbine engine applications, for example.

KEYWORDS: Range extension; lift; drag; aerodynamics; Extended Range Guided Munition; lift-to-drag ratio

N00-061 TITLE: Effect of Ocean Waves on Tracking Low-E Objects in Multipath

TECHNOLOGY AREAS: Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: Develop and validate a model for mono-pulse radar returns from a low-E target in the ocean environment, and fabricate a realistic multi-path simulator to study tradeoffs in tracking methods for low-E targets.

DESCRIPTION: The development method is based on three assumptions: (1) a two-component "composite" sea surface; (2) neglect of the component of earth curvature perpendicular to the antenna-target direction; (3) radially symmetric scatter of the electromagnetic waves form the tilted rough surface facet. The model will build upon and extend this framework or provide alternative formulations.

PHASE I: Develop a model of monopulse radar returns from a low-E target in multipath for a given frequency-direction ocean surface wave spectrum. Implement this model in software and test numerically. Incorporation and validation of the development assumptions into a working model is an inherent risk with this approach.

PHASE II: Link the multipath model developed in Phase I to a standard tracking scheme and test by tracking real low-flying targets (aircraft) with real radar over a real ocean. There is risk that testing in a real ocean environment may uncover unforseen difficulties.

PHASE III: Prepare a complete tactical system with manual and training program and install on ships.

COMMERCIAL POTENTIAL: Possible use by satellite probing the sea surface by radar; Use by commercial airports with landing approach over water; Use in determining ocean-wave parameters by monostatic or bistatic land-based radar.

REFERENCES:

1. Groves, G. W., and W. C. Chow, 1998: Glistening-region model for multipath studies. Proc. SPIE AeroSense Conference, Orlando, FL, April 1998.
2. Kinsman, B., 1965: Wind Waves: Their Generation and Propagation on the Ocean Surface. Dover (reprinted 1984).
3. Pierson, W. J., Jr., 1955: Wind Generated Gravity Waves. In Advances in Geophysics, vol. 2. New York Academic Press, pp 93-178.

KEYWORDS: Glistening; Ocean; Waves; Spectrum; Multipath; Radar

N00-062 TITLE: Force Level Automated Certification of Downward Compatible Baseline Software

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: Develop an Automated Test Capability (ATC) to provide automated re-certification of "Downward Compatible" computer programs baselines. A Downward Compatible computer program baseline adds one or a few new capabilities for addition of a platform and new external interfaces. A Downward Compatible Baseline also maintains the functionality and interfaces from the previous computer program baseline for the existing platforms such that there are no impacts to legacy systems when the legacy system baseline is upgraded for the new platform baseline. The ATC would ensure that the new baseline is in fact Downwards Compatible with the legacy systems (i.e., the new baseline did not impact the legacy systems). An ATC would provide significant cost savings during regression testing and re-certification of the multiple legacy combat systems that receive the new Downward Compatible Baseline computer program.

DESCRIPTION: For Force level types of systems, such as the Navy's Cooperative Engagement Capability (CEC), testing and certification of the multiple Cooperative Units (CUs) has expended a lot of resources as current test and certification processes are manually intensive. This SBIR topic addresses the need for an automated test process, specifically when a new baseline impacts only one type of platform/system (new/modified systems) while not impacting others (legacy systems). For example, when CEC creates a new baseline to integrate with a new platform (i.e., SSDS Mk 2), this typically entails adding new sensors and new combat system interfaces specific to that platform only. However, CEC must be able to generate common solutions across platforms, and today this requires that all CEC units in the Battle Force receive the latest CEC baseline. To allow the latest CEC baseline to be backfit with no impact to the legacy combat systems, the new CEC baseline is designed to be "Downwards Compatible" with the previous baseline. The platforms not impacted by the CEC baseline upgrade would be candidates for automated testing (regression and re-certification) since it is envisioned, and is the purpose of this SBIR topic, that the re-certification of all the legacy units could be automated using the ATC, thus saving extensive amounts of resources. The ATC would record the test procedures and results from the previous baseline test. After the new Downward Compatible baseline is developed and backfit to the legacy units, the ATC would be used to automatically re-run the test procedures against the Downward Compatible baseline, record the results and compare the results from the previous baseline test to the Downward Compatible baseline test. If the results are the same, then the ATC has validated that the Downward Compatible baseline did not impact the legacy interfaces and systems. If the results are different, then the ATC would record the deltas so that they baseline developer can take corrective action.

The intent of this SBIR is to define what needs to be done to Military systems, such as CEC and the combat system elements, to allow an ATC to simplify and reduce the time and cost of re-certification. It is anticipated that the ATC could be used as a basis for automated testing of any new baseline development after the first vessel in a ship class and not limited to Downwards Compatible baselines. This capability will be particularly important as the Navy begins development of the Common Command and Decision (CC&D) capability which, like CEC, will require backfit of common computer programs across the Battle Force with no impact to legacy combat systems. Typically, the legacy combat systems will far outweigh the systems being upgraded, so the cost savings of not having to manually test the new Downward Compatible baseline should be very significant.

PHASE I: Develop prototype ATC (described above) where fixes and/or baseline upgrades are made to a baseline and automatically re-certified to ensure that legacy systems and interfaces have not been perturbed. Analyze the CEC System and the host platform Combat System to support this ATC for CEC and host combat systems. Describe necessary changes to baseline development and testing philosophy within CEC and the host Combat System to support an ATC and show how these changes could be made across the systems.

PHASE II: Develop ATC tools and evaluate them on the CEC System and host platform Combat Systems baseline. Create a library of cases for future re-use. If complete ATC can not be achieved, describe what additional development is required to verify and certify that the new baseline is, in fact, Downward Compatible with the previous CEC baseline (i.e., does not impact the host Combat System).

PHASE III: Extend the ATC tool to introduction of Commercial Off The Shelf (COTS) software to CEC, Combat Systems, Common Command & Decision (CC&D), Coordination Systems, or Force Level System of Systems.

COMMERCIAL POTENTIAL: Commercial software is continually upgrading its hardware and software operational base to add new platforms, operating system baselines, hardware interface drivers, etc which do no impact the basic functionality only add additional applicable equipment and processing compatibility. The ability to automatically test and re-certify existing baseline functionality when new interfaces and platforms become available is part of the commercial software expansion of the product base. Development of efficient and effective means of re-certifying the software for existing legacy systems will reduce time to market to use the latest hardware and software in the commercial marketplace. Since the Navy is also interested in utilizing the latest commercial products, as well, but has a more stringent testing requirement. Extension of the Navy's quality requirements into testing that can be used by commercial developers will raise the level of quality of commercial products and extend the product application to commercial applications, which have the same quality requirements as the DOD.

KEYWORDS: Automated Test Capability; Regression Testing; Re-certification; COTS; Availability; Reliability; Downward Compatible Baselines; Downward Compatibility

N00-063 TITLE: <u>RECONFIGURABLE MAINTENANCE AND DIAGNOSTIC ASSEMBLIES (RMDA)</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: Develop a re-configurable maintenance and diagnostic board assembly to support fielded systems based upon application of field programmable gate arrays (FPGAs). RMDA boards may be reconfigured as either Maintenance Assist Modules (MAMs) modules/boards, spare parts for interim repairs, or as a diagnostic tool for determining unique operating problems. RMDAs that reduce the required onboard inventory of special-purpose unique designs, and ultimately reduce the overall operation and support (O&S) costs, are desired.

DESCRIPTION: All shipboard electronic systems employ multiple, special-purpose unique design components. Each of these unique designs must be carried in inventory as MAMs or spare parts for interim repair. These same systems can sometimes exhibit unique operating problems which must be dealt with quickly. Getting the manufacturer's test equipment and personnel to the site would be the best solution, but is not always practical. This problem could be resolved if identical diagnostic board assemblies were available to the field operator and to the manufacturer.

To support the mulitiple application of RMDAs (as MAMs, Spares, or diagnostic tools), it is suggested to utilize FPGA technology and reprogrammable read-only memory and apply them to the RMDA's design.

This solution offers advantages over a generic diagnostic board. A manufacturer will be able to re-program any software that will reside on the board, but it will also re-program any hardware elements that they believe will be necessary to perform the diagnostics and then transmit the changes to the field for immediate testing of the system. To summarize, the manufacturer will be able to tailor what is available out in the field to the problem at hand.

The benefit of reducing onboard inventory of special-purpose unique designs is expected to be dramatic; further benefits resulting from just-in-time repairs/troubleshooting would also accrue. Additionally, because these reconfigurable MDA's may be programmed repeatedly, a reduced number of both customary MAMs and spares are expected.

PHASE I: Develop RMDA preliminary designs, and identify the shipboard electronic systems and the associated special-purpose unique design modules suited for application of RMDAs. Identify the number of required programmable electronic modules needed to assist maintainers in the repair of shipboard electronic systems and also the systems using the RMDA diagnostic board. Calculate the cost benefits associated with the use of RMDAs.

PHASE II: Design, prototype, and demonstrate one or more programmable electronic modules to implement the RMDAs. Using the RMDAs, conduct an onboard proof-of-concept with one or more electronic systems through an underway, operational period.

PHASE III: Design additional RMDAs for transition within the Navy laboratories. The contractor will support the Navy laboratories and production of the RMDAs through a specified period under a Phase III award.

COMMERCIAL POTENTIAL: The use of RMDAs has direct application in the commercial electronic service sector. The reduced inventory of RMDAs provides an innovative solution for service representatives. (The reduced inventory results in a reduced cost of outfitting service representatives.) Also, the use of re-configurable board assemblies for the identification of field problems could be utilized by the service sector. Local representatives may download the necessary programs for diagnosing problems within large systems. The main manufacturing plant would not have to send their experts out to the field.

TECHNICAL RISK: The primary risk is to ensure that the performance of the RMDA is comparable (or improved) to the original MAM or spare it is replacing. The only other risk involved would be to ensure there are no special environmental requirements in existence for the MAMs or spares that would be replaced by the RMDAs. (i.e., Shock or other military specific requirement which could negate the use of COTS components. Such systems may not be a candidate for this proposal.)

REFERENCES:

1. IEEE Std 1076-1993, IEEE Standard VHDL Language Reference Manual (LRM) copyrights 1993 by the Institute of Electrical and Electronics Engineers, Inc.
2. Douglas L. Perry, "VHDL", second edition, McGraw-Hill, New York, 1994.
3. Zainalabedin Navabi, "VHDL Analysis & Modeling of Digital Systems", McGraw-Hill, New York, 1993.
4. Lisa Maliniak, "A Beginner's Guide to VHDL", Electronic Design, pp. 75-82, October 14, 1994.

KEYWORDS: Reconfigurable; MAM; spare parts; diagnostic; programmable; electronics; maintenance; VHDL

N00-064 TITLE: Miniature RF Filters

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: The objective is to develop miniature RF Filters.

DESCRIPTION: Radars use super-heterodyne up/down frequency conversion processes in their receivers and exciters. The components for these devices have dramatically decreased in size over the years and are now mounted on microwave boards using surface mount technology. The amplifiers and mixers are quite small leaving the filters to be by far the largest element. The size of these parts become even more important in a "Digital Radar" because the up/down frequency conversion process is performed behind each radiating element. In the Digital Radar only digital information is transferred over fiber optic links between the processor and each Digital T/R Module located behind each radiating element in the radar. In these cases it is highly desirable to reduce the size of the filters so that very little space is utilized in a Digital T/R module.

An example of filters under consideration at NRL for a L-Band Digital T/R Module are as follows. Currently NRL uses 4th to 6th order filters at frequencies such as 45 MHz, 915 MHz, 1300 MHz, 2200 MHz, whose size tends to be on the order of 1 1/2" long by 1/2" x 1/2". The filters requirements are on the order of 1% to 10% bandwidths, 100 dB out-of-band rejection, a few dB insertion loss and 4th through 8th order filters. Furthermore, no parasitic resonance's are allowed up to a frequency of 20 GHz. Finally, we would desire filters on the order of a size of 1/2" x 1/2" x 1/4", and the cost in large production to be on the order of $25 a piece.

PHASE I: Develop a design achieving the required performance among various alternative designs. There is high risk in constructing miniature RF filters. All filters to date are all larger than desired. Consequently a new technology is required.

PHASE II: Fabricate prototypes within the size and cost constraint and demonstrate their performance. A successful prototype RF Filter will meet the size and performance requirements described herein and develop any necessary new fabrication technology; there is high risk in constructing miniature RF filters based on new technologies.

PHASE III: Incorporate the filters into the Navy Volume Search Radar (VSR) program, and into the Advanced Multifunction RF System (AMRFS).

COMMERCIAL POTENTIAL: These filters could be widely used in the rapidly growing wireless communication industry. Law Enforcement Radar, Weather Radar, and NASA Remote Sensing Radars all could use these compact and cheaper RF filters.

REFERENCES:

1. Example Vendor - Lorch Microwave, Salisbury, MD
2. J. Browne, "Technology Fuels Firm's Entry into Filter Market," Microwave & RF, Jan 1999.

KEYWORDS: VSR; RF filters; miniature; low cost; radar; module

N00-065 TITLE: High Velocity Combustion Processes in the Solid State

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: Develop and demonstrate a technological process for achieving ultra-high rates of combustion of the solid-solid type.

DESCRIPTION: Solid-solid exothermic reactions can proceed in three important modes: slow combustion (cm/s), fast combustion (few hundred meter per second) and detonation (km/s). The theory of slow combustion (sometimes also called SHS) is well developed. However, theory of fast combustion and detonation is in its infancy. Of interest is the theoretical development of the phenomenon of fast combustion and detonation (solid-solid), which should be further studied in systematic experimental activity.

PHASE I: The effort should be directed toward theoretically demonstrating the conditions which will lead to ultra-high rates of combustion (solid-solid). The theory should provide a model along with a typical solution. The theory should also include the mechanism of compaction of porous mixture of reactive powders with appropriate equations of state.

PHASE II: The effort should develop experimental techniques to prepare the reactive mixtures and carry out the combustion and detonation experiments. It is supposed that the contractor will carry out the experiments in the facilities of NSWC-IHD. The Phase II should gather enough experimental and theoretical data necessary for scale-up in Phase III.

PHASE III: Military applications that would benefit from this technology encompass propellants, explosives, pyrotechnics, and reactive materials. This technology should transition into Air and Surface Weaponry programs.

COMMERCIAL POTENTIAL: The mining industry can tremendously profit by having very powerful low-cost explosives available. The ultra-fine materials resulting from this combustion technology development, would, after sintering, result in super-plastic ceramic materials which are currently not commercially available. These materials are of interest to the automobile, aerospace, and metal processing industries.

REFERENCES:

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5. Gogulya, M.F. et al., "On the Characteristic Times of Chemical Reactions in Heterogeneous Systems under Dynamic Load", Khim. Fiz. 13 88 (1992)
6. Viljoen, H.J. and V. Hlavacek, "Deflagration and Detonation of Solid-Solid Reacting Systems", AIChE Journal 43 (11) pp. 3085-94 (1997).

KEYWORDS: Combustion; detonation; solid-state combustion; solid-state detonation

N00-066 TITLE: Operator Assistant for Artillery-Launched Observation Round

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: Develop an automated assistant to improve the operational effectiveness of the operators of "ALOR" Artillery Launched Observation Rounds.

DESCRIPTION: ALOR is a joint Army-Navy technology demonstration using gun-launched aircraft to function as targeting sensors and loitering munitions. As observers, these munitions will provide target confirmation, target location error reduction, battle damage assessment; as weapons, they will deliver bomblet payloads, providing fast-response firepower similar to an organic mortar squad. The technology demonstration is focusing on producing a flight-worthy airframe and sensor package; this topic seeks complementary development of prototypes of an operator's assistant for these rounds. Some functions that would be desired in the assistant include

- Navigation, airspace management, and deconfliction-assist the operator in keeping the aircraft positioned clear of other air traffic, out of high-threat areas, while maintaining a responsive station to support friendly maneuver units and gather needed targeting information.
- Information management assistance-Allow storage, processing, review and replay of sensor data gathered, assist in

extraction of tactical information from the sensor data, and facilitate reporting. Effort in this area should stress interoperability of the system with multi-service and multi-agency information reporting requirement.

- Target location and identification assistance-use Automatic Target Identification and Region of Interest Identification methods to cue the operator to potential targets. The ultimate objective is to permit the operator to more efficiently employ these aircraft for targeting and weapon delivery, so that each aircraft can generate the most tactical data and attack targets as responsively and effectively as possible, and to allow each operator to control multiple aircraft. The challenge is to produce an assistant that is seamless and efficient, not cumbersome or distracting, for an operator using a new type of weapon for which there is little operational experience or prior development. A successful assistant will relieve the operator of workload in navigating and employing the ALOR, allowing him to make best use of it and avoid unnecessary losses or mishaps.

PHASE I: First, select the capabilities to implement: Establish a set of high-payoff capabilities for a prototype ALOR operator assistant will provide. Base the selection of areas where the prototype will provide assistance on an assessment of the workload of an ALOR operator, with particular attention to the areas where ALOR operations differ from UAV operations. Assess the feasibility of current technologies in information display; expert systems; geographic information systems; navigation and routing; and video exploitation to support the prototype design. Then, develop a prototype design: produce a system design the incorporate and integrate the selected capabilities into a prototype assistant.

PHASE II: Implement the prototype Operator's Assistant, and conduct usability trials with operators. Incorporate feedback from these trials in improvements to the Operator's Assistant, in a spiral development or rapid prototyping development model. The intention of Phase II is to produce functional modules, which can be transitioned into ALOR and UAV control programs, and into similar commercial products, as needed by the military programs and the commercial market. Therefore, effort should be focused on component functionality, and not on producing a full-featured, finished product.

PHASE III: Incorporate the Operator's Assistant modules into the ALOR control system.

COMMERCIAL POTENTIAL: The algorithms and methods needed for this topic have applicability in a variety of areas, which include (1) automobile navigation and geographic information systems; (2) field data collection, especially management of video as data, in areas that include construction, forensics, traffic monitoring, and journalism; (3) machine vision; (4) aircrew workload management and air traffic control in "free-flight" operations.

REFERENCES:

1. Artillery Launched Observation Round program briefing
2. Naval Surface Fire Support Concept of Employment

KEYWORDS: assistant; software; flight control; navigation; situational awareness; aircraft

N00-067 TITLE: <u>Upward Compatible Baseline Support Framework For Effective Force Level System Regression Testing and Certification</u>

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Theater Air Defense and Surface Combatants

OBJECTIVE: To develop an Automated Certification Capability (ACC) by defining a Modularization process and set of logical baseline definitions and developing the associated Systems Engineering tool set to simplify and automate developmental, certification, and operational testing of Force level systems in a system of systems environment.

DESCRIPTION: Force level system of systems developmental, certification, and operational testing is very time consuming and manpower intensive. The variations and changes in interfacing systems for Force level system of systems requires constant configuration management upgrades using the current set of acquisition process concepts and approaches. Therefore, testing continuously changes as the baseline configurations change at the developmental, certification, and operational levels for each system in a system of systems environment is required. Automation can help make the testing at each of these levels more effective and efficient but it will require a repeatable and logical set of baseline definitions and a consistent Modularization process across Force level system of system developments, which meet the needs of systems in a Force level structure.

The goal of this SBIR topic is to develop an ACC. The ACC will include: definition of a Modularization Process, a Logically Related Force Level System of Systems Baseline Definitions, and associated Systems Engineering Tool Set to automate the design, development, testing, and certification of each system in a Force Level Structure to fit into an upward compatible baseline framework like commercial systems use. Through the Modularization Process, the Systems Baseline Definitions, and Systems Engineering Tool Set (which are developed to support the Process and Baselines) we will be able to design Interoperability into systems in the Force structure. The modularization process applies to each system and also seeks to ensure similar modularization of functions across Force level systems. Designing in and verification of Interoperability at each stage of the process will be similar to the Upward Compatibility framework for commercial systems and software. Commercial systems and software use different baselines for major functional upgrades, minor functionality upgrades, and maintenance baselines. This SBIR topic will include a significant new area, for DOD systems will be addressing modularity of threat upgrade impact on real-time system of systems types of designs. Commercial software developers are integrating previously developed applications into integrated software suites (Office 98) for data processing types of applications. The application of these concepts for real-time Force level integrated system of systems applications is a void that must be addressed for DOD systems.

A by-product of using commercial upward compatible concepts in Force level system of systems types of developments is a statically and dynamically reconfigurable baseline suite of programs. Using a survey of platform hardware and software configuration and hardware and software configuration of interfacing to determine the appropriate configuration, the actual software for the site can be built, loaded, and tested on site.

PHASE I: Research the philosophy, techniques, and concepts used by commercial system and software developers which support Upward Compatible Baselines and how this can be used for DOD systems. Research the automation of developmental, certification, and operational testing in Upward Compatible Baseline commercial systems and where this can be applied to DOD systems. Research how commercial systems modularize to support this automation and how this impacts delivery baselines. Can these approaches be used by DOD? Research commercial capabilities which survey the platform, operating system, and interfacing systems for commercial software suits and select a configuration of the software suite which will work on the system configuration discovered during the survey. Can this type of structure solve the configuration management issues for Force level system of systems for Interoperability?

Research how commercial systems load and link the selected configuration and then test the configuration before providing the operational system to the user. Can this approach be used to ensure Interoperable Force systems? Select a Force level system, like the CEC program, and apply the lessons learned to the modularization and baseline concepts for the selected system. Write up a report on the concepts discovered and what would need to be done to the selected DOD system to provide capabilities similar to those of the commercial system.

PHASE II: Extend the results from Phase I to definition of a Modularization Process, the Logically Related Force Level System of Systems Baseline Definitions, and associated Systems Engineering Tool Set to automate the design, development, testing, and certification of each system in a Force Level Structure to design Interoperability into the process. Expand the definition of the process, baselines, and tool set to address the unique threat upgrade requirements based on the history of the threats against the system selected in Phase I. Write specifications for the ACC to include the modularization process, its associated logical baselines, and Systems Engineering Tool Set for development of these tools during Phase III. Apply the results to the selected system for future baseline development.

PHASE III: Develop the integrated ACC Systems Engineering and Certification tool set specified in Phase II and apply to the next system baseline for the system selected in Phase II. Extend to COTS implementation of the baselines for the selected DOD system and show how this can be applied to the commercial market place for real-time highly reliable critical systems.

COMMERCIAL POTENTIAL: Commercial software developers, for data processing types of application suites, have integrated software packages developed in isolation initially into integrated packages (like Office 98). Commercial software applications have instituted an upward compatibility framework for software baselines to make sure that software will work on old configurations with the same capabilities expected in earlier releases. Testing of the earlier baseline capabilities can be automated to make the certification of upward compatible baseline software possible in the turn around time allowed between baselines. The automated approaches are extended to development of new baselines that are upward compatible. To make upward compatible baselines that can be tested automatically require some standardization of approaches, architectures, and modularity between baselines to simplify regression testing. The real-time processing areas have lagged behind the data processing areas in the upward compatible baseline and automatic testing area. Real-time processing applications are basic in DOD systems. This SBIR is addressing Upward Compatibility and automation of testing and certification for DOD real-time Force Level types of applications. Force Level application integration is a similar problem to integration of data processing applications into a suite of applications.

Commercial software does not have the same level of quality control and certification sophistication of DOD systems for real-time systems. Integrated COTS packages from commercial sources do not provide the level of availability and reliability as DOD developed packages. There are commercial segments, which have the same operational levels of these factors as DOD. These segments can not afford the developmental costs of testing and certification packages as DOD because of market size. Since it is in DOD's interest (and will be beneficial to raise the level of performance of COTS in standard ways), the commercial sector will benefit from DOD developed testing and certification techniques. The commercial benefit of automating certification and operational testing of COTS will yield higher levels of operational performance for all interested parties, both DOD and commercial developers. Automatic certification and operational testing processes at DOD levels of sophistication for commercial products could be extended after seed SBIR research baselines the process. Standardizing the Modularization process and baseline definitions could allow standardized automation of testing and certification, which will benefit both commercial and military segments.

KEYWORDS: Automated Certification Capability, Efficient Automated Regression Testing; COTS; Efficient Structured Automated Certification; Availability; Reliability; Upward Compatible Baseline certification.

N00-068 TITLE: Flexible Sound Source

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Undersea Warfare

OBJECTIVE: The Navy and private industry use acoustic energy to detect and locate objects in the ocean (fish) and on the ocean floor (rocks and wrecks). The most versatile systems for this purpose are towed line systems that stream aft of the towing ship. Towed line systems consist (in sequence) of a flexible cable, a sound source, some additional flexible cable, and a receiver. Presently, the sound sources are rigid and are disconnected from the flexible cable as the towed line system is retrieved. This is labor-intensive, and if the cable is long, may pose a personnel hazard under adverse sea conditions. The solution to this difficulty is the development of flexible acoustic sound sources that may be reeled unto the winch drum along with the tow cable and receiver. The sound source must efficiently transmit sound to the water with a decade of bandwidth, and adapt to and compensate for cable motions and strumming to maintain an omni-directional pattern in the sound band. Present cable arrays are recieve only.

DESCRIPTION: The Navy is interested in a flexible broad-band sound source that meets the objectives and may be reeled unto a winch drum of 20 inches or larger diameter. The broad-band sound source must have provisions to pass fiber-optic and power leads through to the down-stream sound receiver. The frequency range for the broad-band sound source must be from less than 10 kHz to greater than 100 kHz with an equivalent acoustic source level of 186 dB ref 1uPa at 1 meter from the array. The source must be capable of transmitting four simultaneous tones of 180 dB each, at frequencies not harmonically related, within the band. The transmit pattern must be omni-directional (+/- 3 dB) at all frequencies. The sound source must be capable of withstanding 20,000 lbs tensile strength (cable tension) and have a diameter of less than 4 inches.

PHASE I: Design and develop a flexible sound source that conforms to the description and requirements, and perform tests and studies as required to confirm feasibility of the proposed design to satisfy the described requirements.

PHASE II: Construct a prototype based on the Phase I design that will meet the requirements in the description and conduct tests to demonstrate the prototype's characteristics.

PHASE III: Fabricate additional prototype(s) for test and evaluation as upgrade replacement components of the AN/SLQ-25A system.

COMMERCIAL POTENTIAL: A large commercial market exists for ocean surveying equipment such as side-scan and sub-bottom profiling. The flexible sound source, when coupled with available towed line systems, will make significant improvements in the ability to survey the ocean floor with economically feasible equipment.

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KEYWORDS: Acoustic; flexible; towed; transducer; winch; omni-directional.

N00-069 TITLE: Multi-Static Active Sonar Processing with Unknown Transmission Type and/or Unknown Source Location

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Undersea Warfare

OBJECTIVE: Develop reliable active sonar processing techniques that exploit the availability of randomly occurring energy emissions (e.g., seismic exploration air guns, foreign sources, biologics or friendly sources) without knowledge of transmission type and/or provide for target localization when the active source or location is not known. The capability proposed under this topic does not exist within any existing Navy sonar system. Several unique new capabilities are required. These include the identification of random occurring acoustic signals from unknown sources occurring within the sea as 'exploitable'. Also included is the characterization of such signals in order to perform detection (i.e., form replicas or models of unknown signals); and finally the processing of signals arriving from unknown locations and extract information from the multistatic returns of such sources.

DESCRIPTION: Utilization of hostile or friendly sources without a-priori knowledge of transmission type and/or source location for active sonar processing can provide valuable tactical information to submarines operating near sources of opportunity. Random sources are not uncommon, including seismic exploration air guns, biologics, and active sonar, which ensonify the ocean and reduce the stealth of submarines in the region. Without the opportunity to process these multi-static active transmissions, submarines would be at a disadvantage relative to hostile submarines with this capability. Use of these sources for active processing presents several technical challenges. The fundamental technical challenge is real-time characterization and use of the transmission. The Navy is seeking algorithms and tools that permit reliable identification and utilization of these transmissions in a manner appropriate for use in real-time systems. The processing algorithms must include the capability of differentiation between transmission types such that the appropriate processing path in an active processor can be selected in real-time. Hydrophone saturation and distortion and its effect on real-time replica generation and classification must be addressed. Channel and source uncertainty must also be addressed.

When non-cooperating active sources are being exploited or when communications with a cooperating active source are not available, the location of the active source will not be known. Accurate source localization is necessary for accurate target localization and for optimal positioning of the receiver. The capability to localize the transmitter is therefore a necessary component of a multistatic concept of operations. The Navy is seeking algorithms and tools that permit reliable localization of active sources in a manner appropriate for use in real-time systems. Several factors must be taken into consideration, including bathymetric features and reverberation properties of the region. The tool should include algorithms for both automated source localization and manual verification by the operator. Consideration should be given to hydrophone saturation and distortion at direct blast time of arrival, the effects of array curvature and instability, and the ability to integrate the proposed algorithms into a real-time system.

PHASE I: Investigate and develop a set of algorithms useful in determination of source type (and extracting an appropriate replica) and/or source, and establish their performance based on simulated data.

PHASE II: Design and develop a prototype multi-static active processor for Navy evaluation. Using Navy-provided multi-static active tape archive data, investigate and select algorithms for use by the processor.

PHASE III: Successful algorithms will be integrated into a Navy real-time multi-static active processor. In addition to Navy use, multistatic techniques could be of use in the commercial and research arenas for tracking marine mammals across very long distances (since the location of the source and transmission types would often be unknown for these creatures).

COMMERCIAL POTENTIAL: The techniques developed under this topic would be applicable to many situations involving complex localization and classification of sources. Examples include whale tracking across ocean basins, air traffic control, weather radar, seismology, and law enforcement.

REFERENCES:
1. Isabel, M.G., Lourtie and G. Clifford Carter, "Signal Detection in the Presence of Inaccurate Multipath Time Delay Modeling," J. Acoust. Soc. Am., 88(6):2692-2694, December 1990.
2. Ainslie, C.H., et al., "Signal and Reverberation Prediction for Active Sonar by Adding Acoustic Components," J. Acoust. Soc. Am., 143(3), June 1996.

KEYWORDS: Acoustic Propagation; Shallow Water Acoustics; Multipath; Recombining; Sonar; Signal Processing; Multi-static Active; Bistatic Active

N00-070 TITLE: Innovative Broadband Signal Processing Algorithms

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Undersea Warfare

OBJECTIVE: Develop broadband signal processing algorithms capable of utilizing a nominal bandwidth of 2.4 to 50 kHz that can significantly improve effectiveness of active sonar in littoral environments. Existing Navy sonar systems can not exploit bandwidths of such extent and use of such large bandwidths for active sonar has not been previously demonstrated. This will require innovative signal processing (e.g., sub-band processing) and reverberation rejection.

DESCRIPTION: Undersea warfare operational requirements have recently shifted emphasis from the deep, blue water environment to the shallow, littoral environment. Additionally, threats have reduced radiated noise and improved acoustic capabilities, including enhanced countermeasure suites. These changes necessitate the use of advanced signal processing algorithms capable of meeting the augmented challenges of detection, classification, and localization of acoustic targets in shallow waters. Broadband processing, rather than narrow band, can accomplish these goals. Large bandwidth waveforms, however, present several technical challenges for the receiver processor, including spatial and spectral coherence, array gain variability versus frequency, spectral normalization, reverberation rejection, and contact classification. Additionally, processor throughput and implementation costs represent significant implementation issues. Proposals are sought for high performance advanced sonar signal processing techniques for broadband systems covering the 2.4 to 50 kHz frequency range. Both mono-static and multi-static processing are of interest. Methods to consider when identifying and developing these innovative broadband signal processing algorithms include the use of Chaotic Frequency Modulation (CFM, which has properties of a nearly ideal "thumb tack" magnitude squared wideband auto-ambiguity function and good suppression of distributed reverberation), the use of a modern cycle-octave wavelet time-frequency processing technique to coherently process the received signal across several octave bands, and the accurate simulation of the medium frequency (MF) broadband acoustic environment.

PHASE I: Formulate the theoretical basis for candidate innovative algorithms. Develop a prototype to illustrate basic operation and technique. Estimate or compute performance bounds. Assess software and hardware system requirements with an emphasis on low cost, commercial, open standard-based computing architectures.

PHASE II: Specify and develop a near real-time version of the algorithm(s) for a laboratory test bed. Run the algorithm software on simulated test data, or, if available, real sensor data. Compute performance statistics and document the operating range or effectiveness of key tuning parameters.

PHASE III: Refine the algorithm(s) based on Phase II results. Migrate prototype algorithm(s) to selected Navy systems for extensive in-water testing.

COMMERCIAL POTENTIAL: Techniques developed for this objective may have significant application to other fields that use active signal probing or broadcast and receive technology. Examples of commercial applications include medical imaging, seismic geophysical exploration, bottom contour mapping, fish finding, obstacle avoidance for large ships, and cellular telephone management of complex radio wave propagation.

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3. Knight, W. C/, Pridham, R. G., Kay, S. M., "Digital Processing for Sonar", Proc. IEEE Vol. 69, No. 11, Nov. 1981.

KEYWORDS: Broadband: Algorithms; Software; Signal Processing; Sonar; Reverberation.

N00-071 TITLE: Advanced Automated Sonar Operator Machine Interface

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Undersea Warfare

OBJECTIVE: Develop an advanced Operator Machine Interface (OMI) that will incorporate 3 dimensional (3-D) graphics and provides automatic graphical displays so that a dedicated operator is not required at each console/display. Utilize new display formats which convey the significant detection, classification, and localization information and do not inundate an operator with extraneous data, and maintain sufficiently low false alert rates so that a single operator can man an entire sonar watch.

DESCRIPTION: This effort will develop an automated OMI for acoustical data displayed on tactical sonar systems, using techniques potentially applicable to all undersea warfare platforms. The desired OMI will display automatic alerts for significant events received over appropriate interfaces (e.g., threat detections). Where possible, automation will be provided, thus freeing ship's personnel for other tasks. New display formats will be developed that present sensor data in a manner such that a typical person can interpret it without the need for extensive sonar training or experience. The use of graphical displays and 3-D graphics in a user-friendly and easily understood OMI environment is envisioned.

PHASE I: Develop the automation of alerts, new display formats based upon advanced graphics and 3-D, and conduct a demonstration of the benefits and capabilities of the new.

PHASE II: Construct and laboratory test a prototype automated OMI. Government furnished data, recorded during at-sea operations, will be provided for the test sequence.

PHASE III: Interface the new OMI with candidate sonar systems via the Advanced Build Process.

COMMERCIAL POTENTIAL: 3-D graphics, Virtual Reality, computer games (displays and OMI)

KEYWORDS: Sonar; Displays; Automated Alerts; Operator Machine Interface; Advanced Graphics; 3-D Graphics

N00-072 TITLE: Multistatic Acoustic Source for Unmanned Underwater Vehicles (UUV)

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: PEO Undersea Warfare

OBJECTIVE: Demonstrate the feasibility of integrating an acoustic projector with a torpedo sized UUV. The projector is to be capable of producing an acoustic source level of at least 205 db per microPascal @ one meter (higher source levels are advantageous) in the frequency domain of 300 Hz to 500 Hz with signal and power provided by the UUV (self contained). Such an acoustic signature would support use of the UUV as a multi-static source.

DESCRIPTION: Unmanned Underwater Vehicles carrying low frequency acoustic sources will provide a mobile maneuverable source for multistatic target detection operations in shallow water areas. The focus of this effort is on technologies associated with transduction and appropriate signal power amplification needs when constrained to operate in a torpedo sized UUV testbed. High transducer efficiency is critical to UUV needs. The acoustic projector should have directionality capability and be size and weight constrained to operate in mobile unmanned undersea vehicles. It is advantageous that the acoustic system has the capability to output a variety of waveforms.

PHASE I: Develop a new, low cost, high source level, size/weight constrained, and directional acoustic source with appropriate power amplification system. Conduct parameter modeling as needed to verify assumptions.

PHASE II: Fabricate and conduct in-water tests on a prototype system demonstrating its acoustic capability as a stand-alone system.

PHASE III: Integrate the prototype acoustic system into a UUV. The technologies developed and demonstrated will transition directly into the Mission Reconfigurable UUV Program (Program start FY03) sponsored by PMS403.

COMMERCIAL POTENTIAL: Acoustic source for conducting underwater geophysical/seismic surveys. Application of this technology to underwater geophysical/seismic surveys would be environmentally friendlier than present day methods.

KEYWORDS: Multistatics; Unmanned Undersea Vehicles; UUV; Underwater Acoustic Source; Underwater Acoustic Projector; Littoral Warfare.

N00-073 TITLE: Advanced Compression for Digital Terrain Elevation Data

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop new compression capability for digital terrain elevation data that preserves important terrain information, guarantees geographical and topological accuracy of the compressed data, and enables efficient reconstruction of the data as well as exploitation of compressed data directly.

DESCRIPTION: Digital terrain elevation data is an indispensable source of information for applications that use geo-spatial information. It requires very large amounts of memory, for example, it requires 18.5 MB to cover a 2km x 2km area with 1 meter resolution. This puts significant strains on bandwidth during transmission and computer storage as well as manipulation of the data. While existing compression technologies have been demonstrated to be useful tools for image compression, these technologies have not exhibited high fidelity for compressing digital terrain elevation data. The current challenge is to create a new compression methodology with a data representation scheme that exploits the peculiarities of the digital terrain elevation data to effectively compress the data while preserve important terrain information without distorting geographical and topological accuracy.

PHASE I: Investigate the mathematical characteristics of the digital terrain elevation data. Provide rigorous mathematical analysis on data structure and metric suitable for compressing such data. Provide an assessment on achievable levels of compression.

PHASE II: Develop and validate data structures and compression techniques with associated optimal metrics that are capable of preserving feature and removing noise; that allows accurate and efficient reconstruction of the terrain for analysis and visualization; and that enables direct manipulation with compressed data coupled with other image processing tasks, updating the master terrain database, and multi-resolution terrain data search / retrieval. Develop a realistic software prototype demonstrating these capabilities.

PHASE III: Prepare commercial products for use by civilian and military geo-spatial information analysts in terrain analysis and visualization and generation of maps.

COMMERCIAL POTENTIAL: The technology and product developed will benefit anyone who generates or uses maps. Applications range from all-weather autonomous navigation, autonomous landing system for commercial aircraft, flight simulation, mapping of planet surfaces, to virtual travels via 3D fly-through over the Internet.

KEYWORDS: Compression; digital terrain elevation; data structure; optimal metrics; geographically accurate; topologically accurate

N00-074 TITLE: Modeling and Simulation of Decision-making Under Uncertainty

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop software tools that will model, analyze, interpret, and simulate the process of human decision-making in operational and tactical situations and in the presence of uncertainty and stress.

DESCRIPTION: The human decision-making process under stress and in the presence of uncertainty is a complex phenomenon. Commercial knowledge-based system technology has proven successful for decision making in an environment with relatively little uncertainty and low stress, but can not support broad ranges of observations and actionable conditions, typical of the modern military environment and of many industrial and medical situations. The Navy's Tactical Decision Making Under Stress (TADMUS) program was tasked to define the tactical decision problem, to develop measures of performance for tactical decision making and to collect data to analyze the impact of stress. Based on this work there is a sufficient understanding of decision-making under stress to formally model the underlying process. The SBIR project described here seeks to explore new technologies, e.g., algorithms, computational methods, visualization concepts, etc., to model and automate aspects of decision-making, especially under time constrained conditions or conditions of excessive uncertainty.

PHASE I: Describe and develop the algorithms, techniques and system design for tools that will model and simulate the process of decision-making under uncertainty and stress.

PHASE II: Develop, implement, and validate a system that extends the understanding of human decision-making under uncertainty and stress to provide accurate complex process behavioral prediction. This should include the ability to visualize complex interactions of critical components leading to rapid human understanding of the situation.

PHASE III: Implement the models and algorithms in a comprehensive package that would include an intuitive graphical user interface (GUI). Transition possibilities include the Testing Experimentation Assessment Modeling and Simulation facility at NSWC, Dahlgren Division and the Marine Corps Warfighting Lab.

COMMERCIAL POTENTIAL: These tools would be useful for analyzing decision-making situations in the civilian sector and for training the decision-makers. Some examples of where these occur are financial companies (e.g., risk analysis, investment strategies), air traffic control, and national security intelligence analysis, all of which must attend to a broad range of observations, information, and actionable conditions that cannot be enumerated beforehand.

REFERENCES:

1. J. Cannon-Bowers, & E. Salas, (eds.), (1998), Making Decisions Under Stress, Implications for Individual and Team Training, American Psychological Assoc., Washington, DC.
2. C. Zsambok & G. Klein (eds.), (1997), Naturalistic Decision Making, Erlbaum, Hillsdale, NJ.
3. W. Zacahary, J. Ryder, and J. Hicinbothom, (1998), "Cognitive task analysis and modeling of decision making in complex environments," in Making Decisions Under Stress, Implications for Individual and Team Training, American Psychological Assoc., Washington, DC.

KEYWORDS: Decision-making, Modeling and Simulation, Cognitive Task Analysis, Human Factors

N00-075 TITLE: Low-Distortion Microwave Active Filters

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: This work seeks to exploit advances in circuit design to develop rapidly tunable, low-distortion microwave active filters for commercial and military applications

DESCRIPTION: With commercial and military electromagnetic systems for communications, radar, and electronic-warfare applications moving toward multi-signal, frequency-agile operation, microwave filter technology has become a critical issue. Particularly needed are filters offering broad (and for military applications, rapid) tunability, low distortion, small size, and affordability.

Microwave filters that employ active circuit elements to enhance frequency selectivity can be made very small and at a low cost, but exhibit higher levels of signal distortion than can be tolerated in most multifunction systems. Approaches that surmount this limitation through reliance on novel circuit architectures are being sought. Bandpass performance goals include: wide center-frequency tunability (ultimately seeking 5:1 tuning ratios at frequencies in the 1-to- 20-GHz range, with separation into multiple sub-bands initially acceptable), low intermodulation distortion, low passband insertion loss, and high out-of-band rejection. The ability to vary passband width is also desirable. Initial approaches should focus on receiver applications where incident signal levels do not exceed 1 W, with subsequent efforts aimed at accommodating higher power levels. The work should be structured into three phases.

PHASE I: The contractor shall design, numerically simulate, and experimentally demonstrate an active-circuit approach to microwave bandpass filter design that has the following performance goals: passband center-frequency tunability over an octave anywhere within the 1-20 GHz band, a third-order intercept point greater than 30 dBm, low passband insertion loss of less than 0.5 dB, and an out-of-band signal rejection better than 60 dB. The ability to also vary the passband width is desirable, ultimately seeking to achieve 50-to-500 MHz variability in 1-5-GHz band, and up to 2 GHz variability in the 4-20 GHz band. Phase I work should focus on incident power levels up to 1 W.

PHASE II: The contractor shall optimize the design of the prototype filter demonstrated in Phase I to fully achieve stated performance goals, while extending center-frequency tunability to accomplish a 5:1 tuning ratio, possibly through division of the aggregate tuning range into multiple sub-bands. The optimized design shall be reduced to practice. A commercialization and manufacturing plan shall be developed. Approaches suitable for transmitter applications at high power levels (over 1 kW at 5 GHz and 250 W at 20 GHz) should also be addressed in Phase II.

PHASE III: The contractor should be able to compete in the market place as a supplier of high-performance tunable microwave filters for commercial communications and military EM systems.

COMMERCIAL POTENTIAL: This work is expected to engender low-cost, wideband- tunable, low-distortion filters for wireless communications.

KEYWORDS: microwave: filters, active, tunable

N00-076 TITLE: Wide Bandgap AlGaN Based Solar Blind Ultraviolet Photodetectors

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop compact high solar blindness, high sensitivity and low dark current ultraviolet photodetectors based on AlGaN wide bandgap semiconductors.

DESCRIPTION: Compact solid-state solar blind ultraviolet photodetectors are needed as sensors in potential applications such as missile defense and countermeasures, covert space-to-space communications, portable battlefield chemical/biological warfare analyzers, flame detection and control. A key characteristic in such devices is their solar blindness, that is the capability to detect light with wavelengths <270 nm, while being insensitive to longer wavelength radiation. Another important attribute is the detector sensitivity, as the light intensity in the UV region is much lower than in the visible or infrared spectral region due to atmospheric absorption. Current solid-state UV photodetectors are based on Si, SiC and diamond materials. Because they have indirect bandgaps and because Si and SiC are not intrinsically solar blind, these materials lead to devices that poorly qualify for the applications envisioned. An alternate approach is to utilize AlGaN materials to take advantage of their direct bandgap, intrinsic solar blindness in the spectral region of interest. The purpose of this effort is therefore to investigate and produce high solar blindness, high sensitivity and low dark current AlGaN based UV photodetectors.

PHASE I: Demonstrate the fundamental technologies necessary to produce high solar blindness, high sensitivity and low dark current AlGaN UV photodetectors. Design and test optimum device type and structure for the applications envisioned.

PHASE II: Produce, package and demonstrate operational, high solar blindness, high sensitivity and low dark current AlGaN UV photodetectors.

PHASE III: Develop reliable AlGaN UV photodetector product applicable for integration in missile defense and countermeasure systems, covert space-to-space communications, portable battlefield chemical/biological warfare analyzers, flame detection, flame combustion/engine control and monitoring, etc.

COMMERCIAL POTENTIAL: Such detectors will be useful for space-to-space communications secure from detection by Earth-based receivers by taking advantage of the absorption by the ozone layer in the 250-300 nm spectral region, for controlling the operation of UV light sources, UV exposure, and in UV astronomy. These photodetectors will also be effective in battlefield situations where toxic chemicals or biological reagents may be released. The physical robustness of AlGaN materials make such devices particularly attractive for applications in a high temperature environment (e.g. flame / combustion control) and in outer space.

REFERENCE: M. Razeghi and A. Rogalski, "Semiconductor ultraviolet detectors," Journal of Applied Physics 79 (1996), 7433-7473.

KEYWORDS: ultraviolet photodetectors; AlGaN; solar blindness; missile defense; sensor; flame detection.

N00-077 TITLE: Four dimensional (4-D) Atmospheric and Oceanographic Instrumentation

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop low-weight, low-power, and low-volume instruments/sensors/techniques to autonomously measure atmospheric and/or oceanographic parameters.

DESCRIPTION: Innovative sensors and measurement techniques are solicited to obtain meteorological and oceanographic (METOC) variables (e.g., physical, chemical, optical, acoustic, geophysical or biological) in 3-D space and time. The emphasis should be placed on (1) novel approaches and concepts for measuring a particular parameter coherently in 4-D, (2) observations that can be conducted as autonomously as possible (i.e. for independent operation on Remotely Piloted Aircraft (RPA), Autonomous Underwater Vehicles (AUV's), buoys or with expendable instruments), (3) providing a significant reduction in instrument weight and volume without reducing fidelity or resolution as compared to current state-of-the-art devices, and (4) developing the next generation of low cost, potentially expendable instrumentation usable in both navy operational scenarios as well as in S & T environmental data collection. Examples of some of the types of instruments solicited include: bathythermographs, in situ ocean wave directional spectral instruments, instruments capable of measuring near-surface atmospheric parameters and the next generation of low cost METOC expendable instrumentation. The term Expendable Instrumentation includes both one time usage as well as long time in situ usage, and the sensors should be affordable if expendability is required but reusable if not. Included are instrumentation development efforts that would result in significant improvements and costs savings for existing expendable instrumentation, or would develop new expendable capabilities for measurements currently obtainable by other means (such as aerosol properties, visibility, IR extinction, etc.). All platform deployment scenarios (shipboard, submarine, and aircraft) are included. Priority is given to devices that can lead to substantial improvements in anti-submarine warfare (ASW), mine warfare (MIW), ship self-defense, airstrike targeting and special operations, through improved battle space environmental knowledge.

PHASE I: Provide both an exact description of the parameter to be measured including accuracy and sensitivity along with the instrument design concept for achieving the measurement.

PHASE II: Produce a viable prototype system and demonstrate its ability to support field measurements from an operating research platform.

PHASE III: Transition the technology to scientific use in the atmospheric, oceanographic or environmental monitoring research communities, and operational DOD systems.

COMMERCIAL POTENTIAL: New instruments can be used in a wide variety of commercial environmental monitoring systems.

KEYWORDS: meteorology; oceanography; instruments; miniaturize; automation; expendable

N00-078 TITLE: Heavy Power Transmission for Positioning and Actuation

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Demonstrate an advanced user-friendly reliable and maintainable lightweight, small footprint, omni-directional human-strength-amplifying for use on surface vessels.

DESCRIPTION: The U. S. Navy has the mission to conduct, develop, and deploy technologies for handling and transportation of ordnance and cargo, and operations of weapon systems with variable and high rates of fire. Though manpower is a primary component of all weapons/cargo handling functions, the most critical function is loading (mating) the weapons to the weapon systems due to the precision required in positioning heavy payloads in storage or in preparation for launch. Manpower is also a primary component of cargo handling, which needs to be reduced through automation, while increasing safety and speed of operation. This effort will develop the needed technology, design and demonstrate a heavy power transmission system for positioning and actuation. The designed system should have the ability of lifting payloads in the range of 100-3000 lbs, with a safety factor not less than 2. In addition the positioning accuracy should be within a small fraction of an inch. This may require a more sophisticated approach than presently available, especially with regard to manipulation of ordnance.

PHASE I: Design a system for precise positioning for heavy loads, through both rotational and translational motion. This system should have full control of the motion, and act as a human amplification for material handling applications.

PHASE II: Develop and test a scaled down prototype that can be operated by a single individual to manipulate and load ordnance/stores and translate the fidelity of control/motion generated through the individual's inherent eye-hand coordination to the respective payload.

PHASE III: Prepare a full scale design of an ordnance handling system which is adaptable to multiple surface platforms (i. e., aircraft carriers, landing helicopter assault ships, ammunition/supply ships etc.

COMMERCIAL POTENTIAL: The technology developed under this effort can be used by commercial shipping, warehousing, chemical/munitions manufacturing, mining and a multitude of other applications where man can be replaced by machine for heavy, precise manipulation of heavy or dangerous materials.

REFERENCES: Proceedings of the IECON/International Conference on Industrial Electronics, Control, and Instrumentation. International Conference on Industrial Electronics, Control, and Instrumentation; Bekey, George A., Autonomous robots. (DIGITAL); Browne, Antony, Neural network perspectives on cognition and adaptive robotics.

KEYWORDS: Ordnance, weapons, material handling, robotics, power transmission, logistics

N00-079 TITLE: Conjugated Polymers for Corrosion Inhibition

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Enable scientists to explore the feasibility of using conjugated polymers as replacement for chromium in corrosion inhibiting applications, and to explore the feasibility of synthesizing large quantities of conjugated polymers via an environmentally benign route.

DESCRIPTION: Electrically conducting polymers show great promise for use as corrosion inhibiting coatings. The mechanism of corrosion protection by conductive polymers is still unproven, but may involve annodic protection. The corrosion protection appears not to be sensitive to the absolute value of electrical conductivity above some threshold value. It may turn out that the life time of the coating depends on the starting conductivity but not enough is known. The particular polymer of interest is poly(bis-N-methyl-N-hexylamino phenylene vinylene), which has been demonstrated to protect aluminum alloys from corrosion in istonic sea water. This polymer has an intrinsic conductivity of about 10exp(-10) S/cm in the undoped state. The conductive polymer can be stabilized with conventional UV and antioxidant additives in coating formulations. The purpose of this effort is to scale-up the current synthesis to 1-2 kilograms of this polymer and to find more environmentally benign alternatives to the current synthetic procedure described in the reference.

PHASE I: Synthesize 1-2 kilograms of polymer using the literature procedure. Perform small scale (10-20 grams) test reactions on environmentally benign alternatives.

PHASE II: Improve and refine the alternative methods.

PHASE III: Transition the environmentally benign method to 10 –20 kilogram scale.

COMMERCIAL POTENTIAL: Corrosion costs the US industry alone over 10 billion dollars per year. If a suitable replacement for chromium could be found, the payoff would be tremendous for both civilian and military applications.

REFERENCES: Stenger-Smith, J. D., Zarras, P., Merwin, L. H., Shaheen, S. E., Kippelen, B., and Peyghambarian, N., Macromolecules, 31(21), 7566-7569 (1998).

KEYWORDS: Conducting Polymer, corrosion protection, environmentally benign synthesis.

N00-080 TITLE: Low Thermal Conductance Torque Tube

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop design methods, material selection criteria, and construction techniques for low thermal conductance, lightweight motor torque tubes (shafts) for low speed, high torque, superconductive ship electric propulsion machinery.

DESCRIPTION: The Navy has selected the High Temperature Superconducting (HTS), ac synchronous motor as an advanced machinery technology to be investigated and developed for ship electric propulsion systems. The torque tube of this motor is in physical and thermal contact with the rotating HTS field winding and is a major source of unwanted heat input to the superconducting magnets, which are maintained at cryogenic temperatures. Minimizing this heat leak is essential for the optimum performance of the HTS magnets and for the heat load on the cryogenic refrigeration system of the motor. High strength methods of attaching the end connections to the torque tube shall be developed. Test samples of candidate composite materials shall be measured to determine their thermal conductivity and mechanical stress and strain properties at room temperature and at temperatures of 20 K or lower. Test specimens of the developed torque tube/end connection attachment methods shall be fabricated and measured for mechanical strength and reliability over the temperature range of 20 K to room temperature.

PHASE I: Investigate and develop low thermal conductivity, composite material, torque tube designs and fabrication techniques that will have the capability of transmitting more than 1.8 million Newton-meters of mechanical torque. Methods will be developed and materials selected to fabricate the torque tube and its warm and cold end connections.

PHASE II: Design, fabricate and test reduced scale, model torque tube assemblies. A scaling analysis shall be performed to select the appropriate reduced size torque tube that will accurately duplicate the mechanical and thermal properties of a full-scale torque tube and its end connections. A sufficient number of model torque tubes, with warm and cold end attachments, shall be fabricated and tested to develop a property data base and verify the consistency and adequacy of the measured mechanical and thermal properties. The model torque tubes will be tested under the same conditions of mechanical stress, strain and temperature that will be experienced by the full size torque tube of a 19 megawatt (25,000 hp), ship propulsion, HTS synchronous motor. A sufficient number of tubes, having the best measured performance properties, shall be selected for testing to failure to determine the ultimate strength and mechanical fatigue properties of the design and fabrication methods used.

PHASE III: Design and fabricate a full size torque tube with its end connections for a 19 megawatt, ship propulsion, HTS synchronous motor. The full size torque tube unit will be tested to full-scale motor parameters.

COMMERCIAL POTENTIAL: The development of high efficiency, HTS motors at power levels of 5000 hp to 25,000 hp will have significant commercial applications in industry, manufacturing and commercial ship propulsion. High strength, lightweight, and non-metallic motor torque tubes will also have commercial application in normal conducting electric motors and other rotating machinery and engines. The torque tube design and construction methods developed can also be applied to static, non-rotating applications such as lightweight, high strength, low thermal conductivity supports for equipment and components.

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1. Kalsi, S., Gamble, B., Bushko D., "HTS Synchronous Motors for Navy Ship Propulsion," Proceedings of the Naval Symposium on Electric Machines, October 1998.
2. Doyle, T., Stevens, H., Robey, H., " An Historical Overview of Navy Electric Drive," Proceedings of the Naval Symposium on Electric Machines, July 1997.
3. Gamble, B., Goldman, J., "High Temperature Superconducting Motors and Generators for Submarines and Surface Ships," Proceedings of the Naval Symposium on Electric Machines, July 1997.
4. Schiferl, R., Zhang, B., Driscoll,D., Shoykhet, B., Dykhuizen, R., "Development Status of a 125 HP Superconducting Motor," Advances in Cryogenic Engineering Materials, Plenum Press, NY, 1996
5. Dade, T., "Advanced Electric Propulsion, Power Generation and Power Distribution, Naval Engineers Journal, March 1994.

KEYWORDS: propulsion, motors, superconductivity, composites, torque tube

N00-081 TITLE: Quiet Turning and/or Nonrotating Devices for Marine Propulsion

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Develop a quiet turning device for marine propulsion utilizing changing shape or geometry at the exit of a shrouded propulsor, perhaps using smart materials, to effect turning of the momentum vector over the speed range up to 30 knots with low acoustic signatures and water surface disturbances. Apply smart materials, such as magnetostrictive actuators, to marine propulsion using a traveling waveform along the axis of an internal tube to force the fluid with high momentum and thus eliminate traditional rotating machinery in the through flow.

DESCRIPTION: Traditional turning devices such as rudders produce cavitation and vibration unacceptable in some signature and habitibility conditions, and produce large wakes with environmental erosion in confined waters. The desire is to use shrouded propellers to shape the ship wake to minimize these adverse effects. The need is to develop a turning method that does not require a redirection of the shrouded propeller. It is envisioned that some form of geometry deformation, perhaps using smart materials and sensors, would be employed to deflect the exit flow to effect a turning vector. An alternate or additional effort would be directed at replacing traditional propulsors with novel concepts. Traditional rotating propulsors are subject to cavitation and vibration that is often performance degrading from the perspective of noise and maintenance. The need is to develop a propulsor that does not include a traditional rotating propeller or other so-called blade row. An alternative is a device that uses a streamwise deformation of the bounding surface of an internal flow path to impart energy to the water to effect forward propulsion. The emergence of smart materials and sensors makes possible the deformation of the surface of an internal passage in such a way as to effect a momentum transfer to the water and a consequent forward force on the vehicle.

PHASE I: Perform studies of the cost and realistic design for a 25,000 HP device

PHASE II: Design the device with specific attention to efficiency, cavitation, vibration

PHASE III: Conduct model scale demonstrations at approximately 12th scale – this phase will entail assess to and generation of classified reports.

COMMERCIAL POTENTIAL: This system could be used to reduce wake erosion and other environmental impact, and can reduce on-board vibrations adversely affecting human habitability.

KEYWORDS: Propulsors, smart materials, marine vehicles, wakes, hydrodynamics, cavitation

N00-082 TITLE: SiC Bipolar Junction Transistor (BJT) High Power Switch for the Advanced Quite Electric Drive Motor

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors/Electronics/Battlespace

OBJECTIVE: Develop a high speed, high power, high current and voltage SiC Bipolar Junction Transistor (BJT) switches for incorporation into the new advanced ship board electric propulsion system-quite electric drive.

DESCRIPTION: Advanced motor technology will require substantially larger, more efficient and very high-density power electronics for control and quite operation. Conventional power electronics will lead to a motor controller that is large, heavy and costly due to the need to stack large numbers power switches, manage the heat losses and incorporate large low frequency filter capacitors and inductors. A recently published paper(1) indicated that an old class of devices, Bipolar Junction Transistor (BJT), becomes a SUPER TRANSISTOR when on Silicon Carbide. Thus, a SiC BJT power switch provides the power density, voltage range and high frequency switching that can enable new, innovative motor control designs essential for the Advance Quite Electric Drive. The advantages of the SiC BJT device must be exploited. To be competitive these devices must show 10X improvement over conventional silicon IGBT or similar devices. We are looking for device operation at switching frequencies between 20 and 150KHz under load, with a blocking voltage between 2500 and 4500V and at currents between 100 and 300A. Since this technology will ultimately be incorporated into Navy systems, there must be a heavy emphasis on robust operation, high reliability and low cost manufacturing.

PHASE I: Develop, fabricate and demonstrate 2500 V and 4500V BJT devices. Develop, optimize and demonstrate functioning and operating BJT power switches at their target currents and switching frequencies. Integrate these switches into a suitable package along with companion SiC diodes to form functional half and full bridge modules. Test, characterize and evaluate BJT power device performance in a power electronics circuit. Demonstrate device processing and fabrication on large diameter SiC wafers of 75 mm or greater.

PHASE II: Customize the device to the Navy advance motor control application by coordinating with Navy contractors, and manufacture robust BJT devices that are packaged to conform to the advanced propulsion system requirements for motor controllers. Develop a module package containing switches and rectifying diodes. Collaborate with the motor control designers to incorporate this technology in power electronics system and reduce the total system costs with this SiC technology.

PHASE III: Customize the device to the Navy advance motor control application by coordinating with Navy contractors, and manufacture robust BJT devices that are packaged to conform to the advanced propulsion system requirements for motor controllers. Develop a module package containing switches and rectifying diodes. Collaborate with the motor control designers to incorporate this technology in power electronics system and reduce the total system costs with this SiC technology.

COMMERCIAL POTENTIAL: Advance motor control for commercial luxury ships, heavy-duty motor control for mining application where high temperature operation is an issue. Utility level solid state breakers and switches.

REFERENCES: 1) Jue Wang and B. W. Williams; "Evaluation of High-Voltage 4H-SiC Switching Devices"; IEEE Trans. Electron Devices (ED), vol. 46, p. 589, March 1999, and 2) The following WEB Site http://pebb.onr.navy.mil

KEYWORDS: Silicon Carbide, Bipolar Junction Transistor, and Advanced Quiet Motor

N00-083 TITLE: Development of a Finite Element Analysis for Failure Prediction of Large Composite Structures Under Dynamic Loads

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Develop add-on software modules for commercial finite element programs to address failure predictions of large composite structures under severe thermo-mechanical dynamic loads.

DESCRIPTION: The increased emphasis in composite material applications has brought a demand for accurate failure predictions of composite structures under service loads. The design and analysis of engineering components relies on the finite element (FE) method. However, the current state of failure analysis of engineered composite components using FE methods is inadequate. The problem lies in the fact that composites are made up of at least two uniquely different materials (constituents) that have drastically different properties. Failure in a composite initiates at the constituent level and, in fact, may be limited to a single constituent. Current FE structural analysis technology smears the properties of the constituents and models the composite as an idealized homogenous material. As a result, critical information about the failure state of the individual constituents is sacrificed.

Recently developments in microstructural theories (MST) and their associated numerical algorithms allow constituent stress and strain fields to be extracted from those of the composite during a routine structural finite element analysis with a minimal computational time penalty. Constituent information allows implementation of failure prediction methodology at the constituent level where failure initiates. Although MST has been proven to increase the predictive accuracy of elastic behavior in composite laminates composed of unidirectional (two constituent) layers, the theories must be extended to accommodate woven fabrics with viscoelastic (time and rate and temperature dependent) material behavior typical of large composite structures.

Improvements in a rate dependent kinetic theory of fracture (KFT) for polymeric materials have also been recently achieved. The combining of these theories (MST and KFT) holds particular promise in the area of damage mechanics. MST allows modeling of composite failure based on mechanisms developed at the constituent level and examining their progress to the structural level. The most prominent failures to be studied are matrix degradation and reinforcement rupture based on stress states within the matrix material. Thermo-viscoelasticity theory should be implemented in an MST capable FE code. Matrix based KFT should be incorporated into the viscoelastic, dynamic loading capable FE code.

PHASE I. Develop the finite element micromechanics models necessary for an MST analysis of woven fabric composites.

PHASE II. Interface the MST's developed in phase I as user-defined-modules to commercial finite element programs such as ABAQUS, ALGOR, ANSYS, MARC, NASTRAN, and NISA. Develop additional microstructural models to accommodate particulate reinforced and chopped fiber composites which are common in industry applications. Develop accurate constituent based failure criteria for the microstructural models and establish an MST material database.

PHASE III. Bring the commercially developed software to market. The software should maintain high computational efficiency and numerical accuracy while being cast within a traditional FE analysis. Extend the MST material library/database through material testing and micromechanics development. Make material database available (fee based) through a World-Wide-Web page.

COMMERCIAL POTENTIAL: The finite element industry currently has annual revenues of $300 million. The industry is experiencing steady growth of 10-15% annually. The current finite element composite market represents 5-10% of total revenue.

The unique capabilities contained in the software discussed are not available in any general purpose finite element software currently on the market. Consequently, there is a high potential for penetrating the finite element analysis of composite materials market, as well as a high potential for rapid long term growth of a company. Furthermore, the software developed is expected to significantly improve current design methodologies for composite structures.

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1. Garnich M.R. and A.C. Hansen, "A Multicontinuum Theory for Thermal-Elastic Finite Element Analysis of Composite Materials, Journal of Composite Materials, Vol. 31, No. 1, 1997.

2. Garnich M.R. and A.C. Hansen, "A Multicontinuum Approach to Structural Analysis of Linear Viscoelastic Composite Materials, Journal of Applied Mechanics, Vol. 64, No. 4, 1997.

3. Hansen, A.C. and J. Baker-Jarvis, "A Rate Dependent Kinetic Theory of Fracture for Polymers", International Journal of Fracture, Vol. 44, 1990

KEYWORDS: Composite materials, failure, finite element analysis, multicontinuum, constituents, micromechanics, microstructural, dynamic

N00-084 TITLE: Composite Gun Barrel

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop autofrettage techniques and composite material outer wraps for Naval gun barrel applications.
The navy has a requirement a composite light-weight rifled gun barrel suitable for high energy projectiles and propellants. The barrel must have superior fatigue life and superior cooling and heat dissipation characteristics. Composite material contributions to these capabilities are expected to include: superior residual stress patterns (resulting from swage autofrettage) and cooling characteristics (due to internal liquid cooling passages woven into the outer composite wrap structure).

DESCRIPTION: The contractor will develop and test composite materials and manufacturing techniques (weaving, wrapping, autofrettage, etc.), which could be used to produce a gun barrel with superior cooling, wear and dynamic performance characteristics for the DD 21 Advanced Gun System. Presently, mono-block steel gun barrels are swage autofrettaged. This process greatly increases the safe fatigue life of such barrels. This project would explore applying this technique to composite barrels. Autofrettage techniques would be explored that would leave residual compressive stresses formed by plastic deformation for superior fatigue life. Composite materials might be used as outer wraps to an inner metallic and/or composite gun barrel tube creating a hybrid rifled gun barrel. The ultimate goal would be to produce a gun barrel for the DD 21 Advanced Gun System with superior safe fatigue life, cooling, and dynamic performance.

PHASE I: Develop engineering data and materials to support gun barrel application of composite materials. The contractor will analyze the precise in-bore environment (temperature profile, pressure) and wear characteristics of the proposed charge and projectiles. The contractor will then propose composite materials (e.g.: carbon/carbon, etc.) and manufacturing techniques that would offer superior cooling capability, dynamic stiffness, and strength for the AGS barrel.

PHASE II: Phase II will consist of construction of a prototype barrel using the proposed composite over wrap techniques followed by swage autofrettage processing. Emphasis will be placed on the outer wrap's ability to keep the inner composite/metallic rifled inner tube below alloy steel austentizing temperatures, and the ability to support and contain the residual stresses from swage autofrettage.

PHASE III: Phase III will consist of transition of the composite outer wrap concept and swage autofrettage technique into the AGS manufacturing process. The SBIR contractor will serve as the technical liaison and component supplier (if applicable).

COMMERCIAL POTENTIAL: Composite/Metallic manufacturing techniques have been used in many aerospace structural applications. However, the challenge of applying such techniques to the high temperature, high-pressure environment of a major caliber gun barrel is unique. Additionally, it is not know how well the residual stresses resulting from the swage autofrettage process would be retained by such a hybrid barrel. Such a process would be applicable to a wide range of industries where high pressure/high temperature environments are present. Examples would include automotive (engine components), mining, jet engines, pressure vessels subjected to cyclic high pressure loading, and rocket motors.

REFERENCES: AGS Performance Specification on Barrel Life and Rate of Fire dated May 1999

KEYWORDS: Barrel, Wear, Plating, Gun, Composite, Autofrettage.

N00-085 TITLE: Development of a LonTalk Drive Chip (LDC) for High Performance Custom LonTalk Nodes

TECHNOLOGY AREAS: Ground/Sea Vehicles, Sensors/Electronics/Battlespace

OBJECTIVE: Develop and demonstrate a LDC that implements the lower 3 layers of OSI protocol stack, uses any microprocessor and allows microprocessor to communicate directly to the LonTalk network.

DESCRIPTION: Although LonWorks provides a level of flexibility and interoperability in distributed control that has never been realized before now; there are shortcomings. The primary one being that all LonWorks products are based on a Neuron chip. All Neuron chips are 8 bit microprocessors running at 5, 10, or 20 MHz. This provides limited computing power especially in light of some of the speed critical applications. To compensate for lack of computing power, it is possible to create a hosted node configuration. Essentially a hosted node is a combination of Neuron and a higher level processor. The Neuron then acts as a communication gateway to the LonTalk network, and the higher level processor performs all the application tasks. The processor can then communicate to the Neuron either through a parallel port or shared memory. Though more powerful than a stand alone Neuron, the hosted note design has its own set of drawbacks. These drawbacks include larger board size, communication speed limited by Neuron, 15 address table bindings in Neuron, and programming a hosted node is very different than programming Neuron (longer learning curve).

PHASE I: Develop the preliminary design of a LDC and do a feasibility study of creating a 'system-on-a-chip' (SOC) version. The LDC would allow nodes to be created without the use of a Neuron chip. It should allow a single microprocessor to be connected directly to more that one LonTalk network. The SOC refers to integrating the LDC, microprocessor, and other external devices into a single chip..

PHASE II: Construct an affordable LDC. Demonstrate full functionality as a full LonTalk node, significantly higher throughput than a Neuron chip, and on two different microprocessors.

PHASE III: Bring commercially designed LDC to market. The chip should maintain robustness, reliability, be compatible with commercial systems and be affordable.

COMMERCIAL POTENTIAL: Automation is increasing in use and complexity in industry. The LDC would have application in complicated machinery control, routers and supervisory nodes responsible for maintaining the availability of network services.

KEYWORDS: LonTalk, network, machinery control.

N00-086 TITLE: Metrics for Evaluation of Cognitive Architecture-Based Collaboration Tools

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop measures of effectiveness for the application of collaborative technologies/tools to complex, higher order decision making.

DESCRIPTION: Collaborative tools have focused on the retrieval, processing and presentation of data for decision making and the information technology capabilities necessary to support this function. There has been little effort directed toward assessing the value of collaborative tools when used to support decision making that involves complex cognitive functions and the solution of judgmental, course-of-action problems that are time sensitive and dependent on diverse, rapidly changing sources of data. Progress is being made in the development of descriptive models of these cognitive processes and have been presented in the form of cognitive architectures. Methods are needed to assess collaboration tool performance in support of these processes.

PHASE I: Develop a taxonomy of cognitive architectures that could be applied to high-level decision making and develop a taxonomy of collaborative tools that could be aligned with complex cognitive processes. Propose a methodology that would evaluate the utility of collaborative tools across various situations where cognitive architectures are used in high level decision making.

PHASE II: Explore available evaluation tools from past and current domains. Select candidate tools and demonstrate their utility through empirical test. Develop metrics for the application of collaborative tools to a range of cognitive architectures.

PHASE III: Prepare generic guidelines for evaluation of collaborative techniques and provide software, procedures and instructions for application. Demonstrate and quantitatively evaluate selected procedures in an operational setting.

COMMERCIAL POTENTIAL: The guidelines and evaluation tools could be applied to a wide range of economic, corporate and national political decision making situations.

REFERENCES: Gray, W.D., Young, R.M., & Kirschenbaum, S.S., HUMAN-COMPUTER INTERACTION: Introduction to Special Issue on Cognitive Architectures and Human-Computer Interaction, 1997, Volume 12, pp 301-309. Klein, G., (1998), Sources of Power; How People Make Decisions, Cambridge: The MIT Press.

KEYWORDS: Collaborative; Cognitive; Decision-Making; Metrics; Evaluation; Taxonomy

N00-087 TITLE: Real-Time Operator State Assessment Technologies

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop, integrate and test state-of-the-art technologies (e.g., dry electrode biosensors, miniature eye-activity recording cameras) and algorithms for the purpose of detecting fatigue and very high workload states within individual human operators of process control consoles or vehicles.

DESCRIPTION: Three factors present the opportunity and requirement to monitor human operator state in real time. First, there is significant pressure to optimize manning in numerous military and commercial settings, resulting in greater job demand for members of rightsized organizations. The resulting greater job demand increases the likelihood that operators will encounter periods of drowsiness and periods of task overload – potentially disastrous to any system. Second, the evolution and development of video and electrical sensor technology presents the opportunity to obtain psychophysiological state data in a nearly unobtrusive manner. Dry electrode technology will allow collection of heart and brain signals without typical electrode preparation, as is required currently. Advances in video signal processing make for robust and low cost collection of eye activity data (blink, fixation, pupil measures). Finally, significant advances in signal processing techniques of psychophysiological data makes possible the near real-time assessment of operator state. There is now significant need and technological opportunity to develop a robust operator-state monitoring system for use in military (aircraft cockpits, command and control consoles) and commercial environments.

PHASE I: Procure and test biosensor technologies (e.g., dry electrodes, eye activity monitoring systems) for robust and high fidelity data acquisition. Design operator state system for phase II.

PHASE II: Build a prototype operator state monitoring system that would obtain psychophysiological data and return measures reflecting operator state of arousal (drowsy through overloaded). Using psychophysiological algorithms developed by DON and other agencies, test and refine the system within several operational environments (simulated process control, vehicle operation). Finally demonstrate the system within an actual operation environment.

PHASE III: Develop a field-ready and marketable operator state assessment system using technologies and concepts developed under Phases I and II. The system should be modular, allowing flexible configuration of biosensors for specific application environments. Success of the system would enable transition of the system to next generation USN and USAF aircraft and tri-service command and control environments. Detection of drowsiness and the desire to avoid high workload states are common themes central to the development of many next generation human-centered systems.

COMMERCIAL POTENTIAL: Commercial potential is significant. Commercial trucking, railway, airline, and process control environments (e.g., air traffic control, power plant operation) have use for operator state monitoring. "Black box" devices designed to collect vehicle system information are beginning to appear in personal automobiles. Easily augmented with operator state data, these devices could become required by law and an industry standard within 10 years.

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1. Alertness/Vigilance - Relevant Publications, Scott Makeig, Tzyy-Ping Jung, and colleagues, Naval Health Research Center, San Diegohttp://www.cnl.salk.edu/~scott/alert.html
2. Adaptive Interface Technology, Crew Systems Interface Division, Air Force Research Laboratory, Point of Contact: Michael W. Haas PhD. (937)-255-8768
http://cfhnetra.al.wpafb.af.mil/new_docs/hecpb.html
3. Eye activity correlates of fatigue during a visual tracking task, Van Orden, KF, Jung, T-P. & Makeig, S. http://mac088.nhrc.navy.mil/Pubs/Abstract/98/4.html
4. Eye activity correlates of workload during a visuospatial memory task. Van Orden, K.F., Limbert, W., Makeig, S., & Jung, T-P. Submitted. Preprint available, vanorden@spawar.navy.mil
5. 3D visualization and eye-controlled interaction. Pastoor, S., Liu, J., & Renault, S. IEEE Transactions on Multimedia, 1(1) 1999.
6. Van Orden, K. F., Jung, T-P., & Makeig, S. (1999). Combined eye activity measures accurately estimate changes in sustained visual task performance. Submitted.

KEYWORDS: operator state, biosensors, eye activity, eeg, fatigue, workload

N00-088 TITLE: Optimum Organization of Maintenance Aiding Information

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Determine optimum organization and presentation of maintenance information in job-aiding and how it may vary with the maintainer's level of expertise.

DESCRIPTION: The Navy is rapidly transitioning to the presentation of maintenance documentation in electronic form. Furthermore, there is an expectation that sophisticated forms of electronic maintenance documents will be able to serve performance aiding functions. It is hoped that these performance-aiding electronic documents will make it possible for a generalized maintainer to deal with maintenance problems in a wide range of specific systems, without specialized training in the specific system. Little is known about how information should be organized to meet user needs. There are some research results suggesting that different organizations of information are most useful for users varying in their experience and expertise as maintainers.

PHASE I: Review relevant literature. Propose hypotheses concerning alternative approaches to designing the organization of information in electronic documents for maintenance aiding. Propose hypotheses concerning the interaction between expertise and optimum organization of information. Special attention should be given to the problem of effectively presenting graphic information such as large circuit diagrams on the relatively small and low resolution displays (as contrasted to paper) of portable computers. Design study to address these hypotheses.

PHASE II: Execute the alternative approaches to develop prototype versions of electronic manuals that can be compared for their effectiveness in use. Conduct an experimental comparison of their utility for users of varying levels of expertise.

PHASE III: Develop a computer-aided process for the developing of new electronic manuals consistent with the outcomes of this research and market to government and industrial users.

COMMERCIAL POTENTIAL: Nearly every industry has large scale maintenance aiding and training problems. The commercial potential of a successful product or service in this area is extremely large.

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2. J.J. Fuller, R.P. LeBeau, A.S. Mavor, T.J. Post & C.R. Sawyer. (1988) Test and Evaluation of the Navy Technical Information System (NTIPS) An/SPA-25D Field Test Results. Bethesda, MD: David Taylor Research Center, Technical Report DTRC-88/035.
3. W.W. Zachary & J.M. Ryder (1998) Decision Support Systems: Integrating Decision Aiding and Decision Training. In: Martin Helander, Thomas K. Landauer, and Prasad V. Prabhu (Eds) Handbook of Human Computer Interaction. Amsterdam: Elsevier Science, ISBN: 0444818766.
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7. Eric L. Jorgensen. (1994) DoD Classes of Electronic Technical Manuals; Carderock Division, Naval Surface Warfare Center; Bethesda, MD; CDNSWC/TM-18-94/11

KEYWORDS: Job performance aiding; Interactive Electronic Technical Manuals; Information organization; Hypermedia, Human Computer Interaction, Mental Models.

N00-089 TITLE: Compact, Light Weight Color Night Vision Goggles

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: New electronic technology (digital and analog) creates the possibility for extremely high computational speed, in a small package, consuming low power. Those capabilities will lead to the design and development of high resolution color night vision goggles, converting inputs from infrared CCDs, CMDS sensors or intensified CCDs to realistic full color displays.

DESCRIPTION: A new generation of architectures is being employed to develop image-fusion technology that generates a full-color image of night scenes. These image processors typically combine inputs from a pair of infrared sensors, compares the intensities at each point of the return at different wave lengths and generates a full-color representation. The technology should be capable of decreasing or eliminating "blooming" effects from sensors, assigning priorities in time and space to the most information-rich sensors.

PHASE I: Develop the feasibility of implementing color night vision goggles. Refine the algorithms, define the spectral characteristics and size of infra-red or intensified CCD sensors, define the display technology to be used with the processors, design the head - mounted device.

PHASE II: Develop a working prototype of the goggle system, capable of being comfortably worn, generating appropriate color information.

PHASE III: Transition the technology to DoD and the commercial market. Possible applications include models for police, sportsmen, surveillance personnel and other organization requiring enhanced night vision capabilities.

COMMERCIAL POTENTIAL: Color night vision goggles would be of great value to policeman, sportsman, surveillance personnel, FBI and other organizations requiring enhanced night vision capabilities. Variations on this design could improve drive vision in cars and trucks traveling at night, and would be particularly useful in fog or other conditions that obscure viewing but are transparent to the infrared.

REFERENCES: A.M. Waxman, A.N. Grove, D.A. Fay, J.P. Racamato, et.al.Color Night Vision: opponent processing in the fusion of visible and IR imagery. Neural Networks, vol 10, pp.1-6, 1997. T. Roska, A. Zarandy, L.O. Chua. Color Image Processing using multi-layer structure. Circuit Theory and Design 93, Elsenier, Amsterdam, 1993.

KEYWORDS: Image fusion, infra-red sensors, head mounted displays, night vision goggles

N00-090 TITLE: Innovative Air and Surface Strike Weapons Technology

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: The Navy will consider proposals in areas relating to Air or Surface Ship delivered Strike Weapon Technologies that present an extraordinary opportunity for improving the way the Navy performs Strike Warfare and extends the state-of-the-art with capabilities which in turn will become commercial off the shelf (COTS) capabilities.

DESCRIPTION: The US Navy recognizes that, at the leading edge of technology, innovation and opportunities arise from creative minds and entrepreneurs. Proposals for this program should compliment exploratory development projects focused on guidance and control for air and surface weapons, including seeker development, signal and image processing; ordnance technology including warheads, fuzing, safe and arm devices, and energetic materials; aero/structures including steady and unsteady aerodynamics associated with axi-and non-axisymetric missile airframe shapes as well as the use of composite materials for missile structural components; propulsion technology including solid rocket propulsion and airbreathing propulsion for missiles as well as propulsion for navy gun-launched projectiles; fire control/targeting/mission planning for both air-launched and ship-launched weapons; systems investigations to perform performance trade-off studies leading to affordable technology investment strategies at the component level. This call is for breakthrough technology with great market potential beyond the standards or state-of-the-art from those topics listed above, with capabilities measurable in orders of magnitude of improvement compared to existing fielded naval weapons systems. Proposals previously submitted as part of another SBIR topic or submitted concurrently are not considered acceptable. Proposals will receive a preliminary screening that may reject them without full technical review since they may not offer enough of an extraordinary opportunity; and the topic may be rejected solely on the basis that the technology does not produce a significant improvement to existing systems or commercial off the shelf items available.

PHASE I: Concept development and conduct system level bench tests. Develop Phase II Plans and identify three (3) specific commercial transitions of technology for Phase III. Identify all manufacturing plant and facilities requirements.

PHASE II: Demonstration of capabilities through actual testing of prototype production samples. Prototypes should be tested in actual operating environments, or as closely matching operational requirements as physically possible with funding levels currently expected for Phase II effort. Development of a production and manufacturing plan for Phase III. Manufacturers capable of production quantities identified in commercialization plan, and appropriate licence agreements exercised.

PHASE III: Transition technology and prototype systems into production for Commercial off the shelf (COTS) application appropriate for DOD use.

COMMERCIAL POTENTIAL: Affordable Commercial Off the Shelf (COTS) technologies and marketable items must be made available to industry and government alike at the end of the effort (phase III), and private sector applications and benefits must be inherent in the objective of the proposed effort.

REFERENCES: Sections of the 1997 Science and Technology Requirements Guidance (STRG) relating to Air and Surface Strike Technology is available in Chapter 3, Air Warfare and Chapter 4, Surface Warfare, and is available on the Internet (http://www.hq.navy.mil/N091/STRGCOVR.HTM) and information on existing Navy Systems are available from the Navy Factfile Internet Site (http://www.chinfo.navy.mil/navpalib/factfile/ffiletop.html). Air and Surface Weapons Technology (ASWT) program briefing materials with additional expectations and technology focus areas are available by request of Mr. James Chew, ONR at the numbers provided below.

KEYWORDS: Conventional Weapons; Weapons; Missiles; Ammunition; Explosives; Munitions

N00-091 TITLE: Technology for Shipbuilding Affordability

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective of the project is to develop and implement innovative technologies that will reduce the cost to construct ships and thereby improve the competitiveness of the domestic shipbuilding industrial base and reduce the cost of military ships.

DESCRIPTION: During the last year, 9 shipyards along with suppliers, owners, operators, and government personnel have developed the MARITECH Advanced Shipbuilding Enterprise (ASE) Strategic Investment Plan (SIP). This plan contains an industry led strategy to promote commercial competitiveness and reduce the cost of military ships. It identifies Major Initiatives and Sub-Initiatives that are the R&D requirements for this industry. This entire plan is available for review on the World Wide Web at http://www.nsrp.org/. Coordinating with U.S. shipbuilders to adapt and implement "World Class" commercial best practices is encouraged. The application of best practices can cover areas such as production methods, production planning and control, accuracy control, supplier relations and design for Producability. Proposals under this topic can address any of the 34 research areas identified in that plan. However, six projects were awarded in June, 1999 as a result of Small Business Technology Transfer (STTR) Topic N99-01 Technology for Shipbuilding Affordability. Information on these awards is available on the Navy SBIR/STTR web site. Proposals that overlap or duplicate these ongoing STTR projects will not be considered under this SBIR topic. The following project types would be appropriate for SBIR proposals in support of the plan:

Technology Development Projects - Technology development projects targeting development of new or improved technological solutions for an individual or a narrow range of process areas. These projects are expected to have a more narrow impact on the business process and address a limited range of sub-initiatives. Examples include individual process or system development, robotic and automated tooling, new product designs, and new materials or coatings development.

Implementation Projects - Implementation projects designed to assist shipyards and other industry participants to implement and assimilate processes and technology that can be tailored to meet shipyard requirements. These projects are expected to target a single shipyard or corporation and may have either a broad or narrower focus. Examples include the implementation of new business and manufacturing processes, adaptation of product design and material standards to new market segments or shipyard processes, and the implementation of new software and robotics.

Proposals should specifically describe the technology, how it will be developed, what the estimated benefits will be and how it will be transitioned into the shipbuilding industry. Teaming with the shipbuilding industry to form integrated project execution and implementation team will improve transition potential and is strongly encouraged. Shipbuilding industry contacts for each Major Initiative are available on the web site.

PHASE I: Prove feasibility for improvements being developed and detail where and why they will impact shipbuilding affordability. Include a Return-On-Investment (ROI) analysis for industry implementation.

PHASE II: Develop a working prototype production system or prototype product to demonstrate its performance characteristics. Present the technology being developed to the MARITECH ASE Major Initiative teams, develop a commercialization (Phase III) plan, in coordination with MARITECH ASE members, including descriptions of specific tests, evaluations and implementations (including sites and points of contact) to be performed.

PHASE III: Implement the Phase III plan developed in Phase II in coordination with the MARITECH ASE Program.

COMMERCIAL POTENTIAL: The technology developed under this topic shall be applicable to commercial shipbuilding practices.

REFERENCES: MARITECH ASE Strategic Investment Plan, available on line at http://www.nsrp.org/

KEYWORDS: shipbuilding; affordability; production; manufacturing; processes; maintainability

N00-092 TITLE: Combat System Automated Testing

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

OBJECTIVE: An innovative approach for automated testing of COTS hardware and software is needed to manage combat system life cycle cost following initial development and fielding. The rapid pace of technology obsolescence and relatively low procurement cost elevate the labor for system test and integration into a major life cycle expense category. If the current labor intensive process and test methodologies could be automated, the cost of maintenance, sparing, technology refresh, and technology insertion could be dramatically reduced.

DESCRIPTION: The effort required to test and certify complex weapon systems is currently a manual, time consuming process. COTS hardware and software are quickly becoming a normal part of the Navy's tactical shipboard environment, with lower cost/higher technology systems being introduced at an increasingly faster rate. The potential pitfall to this COTS proliferation is the cost of keeping pace with relatively short COTS supportability time spans. While the procurement cost of tech refresh itself remains relatively affordable, significant labor expense results from manual regression testing and re-certification of combat system functionality. This challenge applies to the COTS components of the shipboard tactical Local Area Networks being employed in the fleet, as well as the tradition sensor, signal processing, display, and weapons launch hardware/software strings. An innovative approach to automate the integration and test process would reduce both developmental and life cycle costs. A complete solution should consider the overall development process. This may involve up front changes in the way the system is designed or architected, changes to simulation/stimulation requirements, or requirements for additional built in test signals and/or software test code.

PHASE I: Develop a system level approach which could be applied to automation the integration and test of large, complex COTS based systems, such as the VIRGINIA Class submarine combat system, SSN688 backfit combat system upgrade, SQQ-89 surface combatant combat system upgrade, DD21 future surface combatant combat system, or any similarly challenging COTS based system/environment. This research should develop methodologies and requirements for tools that could reduce the cost and time required for initial test and integration, as well as regression testing following obsolescence replacement actions. It should identify necessary augmentations that may be needed to the tactical system or non-tactical simulation/stimulation subsystems and also provide process changes to the development efforts to ensure non-evasive techniques are established early in the design cycle.

PHASE II: Develop a prototype system that provides automated capabilities for testing a COTS combat system. The approach must be non-intrusive and fully validated against results from a proven system test baseline.

PHASE III: Establish an automated test program that is integrated with the mainstream tactical system system development efforts and can be used in multiple system applications and platforms. Provide hardware and software tools that can be augmented to existing systems or be utilized as a stand alone test support suite.

COMMERCIAL POTENTIAL: This system could be applied in any work environment where large scale COTS hardware and software systems are employed and subject to the expense of complex and time consuming test and integration. (tele-communication systems, commercial airliners, oil exploration systems, etc)

REFERENCES: Contact the TPOC listed above for access to literature on COTS combat system architectures.

KEYWORDS: certification, regression test, configuration management, change, COTS technology

N00-093 TITLE: The Manufacture and Integration of Power Building Blocks and Cells for PEBB

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

OBJECTIVE: Develop, manufacture and integration of power building blocks (cells) into a standardized architecture for Plug and Play Power Electronics System.

DESCRIPTION: The PEBB (Power Electronic Building Block) model and approach to has been successfully demonstrated (1) as an alternative to traditional power electronic system design. The global building blocks that comprise a PEBB are: thermal management system, the passive components used as filters, input/output interconnections, power switch modules, and partitioned controls and their related systems. In this solicitation, we wish to transform these PEBB elements into a family of manufactureable building blocks (cells) that can be assembled into a power electronics system of any topology and functional upon assembly at any power level for a variety of applications. The blocks then will have standardized interface (2,3) that are plugged together or snapped together forming a pre-engineered power system determined by the PEBB architecture. Thus, the objective of this SBIR topic is the development and manufacture of generic integrated blocks (cells) that form the smallest design unit of the PEBB. We are looking for the integration and manufacture of blocks composed of discrete power components that were previously hand assembled into the Power Electronics System. The Plug and Play concept for Power Electronics will have been demonstrated at the time of this solicitation at the PCIM Conference in Chicago, IL on 7-11 November 1999 (4).

PHASE I: Design and develop PEBB blocks such as control blocks, filter blocks, and thermal cooling blocks that can snap together and plug and play with other standardized interconnections such as the Coordinated Interconnect System, CIS, (2,3) or the IEEE Standard 1461.

PHASE II: Optimize the level of integration in each block, develop and manufacture a family of blocks for different power ranges and application, identify and standardize on plug and play interface. Demonstrate products in high, medium and low Power Electronic Systems.

PHASE III: Manufacture high reliability building blocks and supply these blocks to Naval Power Electronics Systems Developers.

COMMERCIAL POTENTIAL: These blocks (cells) will be used in nearly power electronics applications; for example in motor controllers or motor drives for industrial applications and automotive electric vehicles; in high and low voltage power supplies and power converters.

REFERENCES:

1)http://pebb.onr.navy.mil;

2) Arthur W. Kelley, Mark Harris, Dennis Hartzell, and Dennis Darcy, Coordinated Interconnect: A Philosophical Change in the Design and Construction of Power Electronic Converters, Conference Record of the 1998 Industry Applications Conference, 33rd IAS Annual Meeting, October 12-15, 1998, St. Louis, Missouri, USA, pp. 1105-1110. http://eprc.ncsu.edu/Papers/98IAS-CoordInter/99IAS-CoordInter.html

3) Arthur W. Kelley, Mark Harris, John Cavaroc, Mark Jones, Ralph Linkous, Dennis Hartzell, and Dennis Darcy, Bus Connector for Coordinated Interconnect: Laboratory Measurement and Finite Element Simulation, Record of the 1999 Applied Power Electronics Conference, March 14-18, 1999, Dallas, Texas, USA, pp. 325-331. http://eprc.ncsu.edu/Papers/99APEC-BusConn/99APEC-BusConn.html

4) http://www.powersystems.com/cfp99/pcim.html

5) http://grouper.ieee.org/groups/1461/

N00-094 TITLE: Fast-response Sensor for the Measurement of the Optical Properties and Carbon Content of Organic Aerosols

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: To measure and carbon content and optical absorption of natural and anthropogenic aerosols in the marine boundary layer from buoys or airborne platforms.

DESCRIPTION: Marine aerosols have a significant impact on the optical properties of the atmosphere. Extinction by aerosols in both solar and infrared wave-lengths strongly affects the performance of EO/IR sensors. While scatter is easily measured with existing technologies, an instrument that can measure black carbon aerosol content is lacking. Such an instrument will have a direct impact on the understanding of extinction in the marine boundary layer. A significant fraction of aerosols in marine boundary layer contain organic compounds. The chemical properties of these aerosols have a strong influence on radiative properties of the atmosphere. The black carbon content of aerosols is particularly important to the radiative impact of these particles. Current technology for measuring the optical and chemical properties of these aerosols is limited to the analysis of filter samples that must be exposed over long time periods. These sample times can be significantly longer than the time scales of processes that produce these aerosols. An instrument that can measure in real-time the characteristics of black carbon aerosols is needed to understand the optical impact of these aerosols in the marine environment. The black-carbon instrument should classify by number and size the amount of black carbon in the atmosphere at resolutions of at least one hertz.

PHASE I: Formulate initial concepts, provide theoretical or laboratory proof-of-concept sensor designs for the development of a real-time black carbon quantifying detector.

PHASE II: Fabricate a prototype black carbon detector. Conduct studies with laboratory generated aerosols to demonstrate sensitivity, time response, and accuracy. Deploy the instrument on an aircraft or ocean buoy to acquire a sample data set for analysis and evaluation of capabilities.

PHASE III: Transition prototype to a commercial product.

COMMERCIAL POTENTIAL: Organic compounds form the major fraction of urban aerosols. The potential of urban aerosols for affecting human health is clearly recognized and there is a growing demand for sensors that can monitor and quantitatively measure the properties of these aerosols for regulatory purposes. The development of a completely automated, turnkey system for both monitoring and research applications would be a very attractive commercial product.

REFERENCES: Bond, T.C., T. L. Anderson, and D. Cambell, 1999: Calibration and intercomparison of filter-based measurements of visible light absorption by aerosols, Aerosol Science and Technology, 30, 582-600.

KEYWORDS: organic aerosols, fast response aerosol sensors, aerosol carbon content

N00-095 TITLE: Real-time Interactive Analysis and Visualization Interface for Environmental Research Data

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop an interactive command and control system that records, monitors, disseminates and displays user-configurable real-time data from multiple payload to remote users, exploiting SATCOM and Internet technologies.

DESCRIPTION: Real-time data collection and monitoring require a high degree of flexibility in transmitting and representing data. Mission controllers, mission scientists and sensor engineers must have access to relevant observational data to support mission critical decisions and data quality assurance. Research efforts require that multi-sensor data are made available to remote scientific investigators, in a manner that supports their evaluation of and participation in the observational activity. Graphical interfaces must be designed to allow user-configurable transmission and display of a broad range of instrument and navigational data. Such a system must process and filter up-link commands to instruments during flight missions, as well as providing user-extensible feedback on the operational status of the sensors, data link, and aircraft. An intelligent system should manage real-time data collection, display, dissemination, command and control processing and multiple operator communications in a manner that maximizes available bandwidth and limits dropouts, utilizing interfaces to SATCOM data links and the Internet.

PHASE I: Design and develop a prototype system architecture that performs basic remote operation, real-time mission data management, dissemination, and data display.

PHASE II: Develop and demonstrate a fully capable remote site data management system for use with multi-sensor and multi-user field experiments. The system should support multiple payloads and customizable instrument displays. Develop a commercialization (Phase III) plan, including descriptions of potential customers, missions, demonstrations and transition efforts to be performed.

PHASE III: Transition the system into a commercial large-scale distributed data and display system. Support system integration for customer-specified platforms.

COMMERCIAL POTENTIAL: Private sector applications and benefits are inherent in the objective of the proposed effort. Existing data management systems used by government or private research organizations should benefit from the added interactive data dissemination and display features of this system.

REFERENCE: http://web.nps.navy.mil/~cirpas/

KEYWORDS: Real-time Data Collection; Visualization; SATCOM; Internet; Data Management; and Instrument Control

AIR FORCE
SMALL BUSINESS INNOVATION RESEARCH
PROPOSAL PREPARATION INSTRUCTIONS

The Air Force Research Laboratory, Wright-Patterson Air Force Base, Ohio, is responsible for the implementation and management of the Air Force SBIR Program. The Air Force SBIR Program Manager is Mr. Steve Guilfoos, 1-800-222-0336. Do not submit SBIR proposals to the AF SBIR Program Manager under any circumstances. Addresses for proposal submission and numbers for administrative and contracting questions are listed on the following pages, AF-4 through AF-5.

Technical questions may be requested using the DTIC SBIR Interactive Technical Information System (SITIS). For a full description of this and other technical information assistance systems from DTIC, please refer to section 7.1 of this solicitation.

Air Force Nine-Month Phase I Contract

For the Air Force, the contractual period of performance for Phase I shall be nine (9) months, and the price shall not exceed $100,000. The Air Force will consider only one cost proposal with a nine-month contractual period of performance.

The Phase I award winners must accomplish their primary research during the first six months of the contract. This primary research effort, alone, is used to determine whether the AF will request a Phase II proposal. We anticipate no more than 80% of the total cost will be expended within the first six months. After the first six months, additional related research should further the Phase I effort and put the small business in a better position to start Phase II, If awarded.

The last three months of the nine-month Phase I contract will provide project continuity for all Air Force Phase II award winners so that no modification to the Phase I contract should be necessary. The Air Force will accept proposals for modifications to maintain project continuity under special circumstances such as Fast Track.

Our evaluation of the primary research effort and the proposal will be based on the factors listed in Section 4 of the solicitation, in the following descending order of importance: a) the soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution; b) the qualifications of the proposed principal/key investigators, supporting staff, and consultants (qualifications include not only the ability to perform the research and development but also the ability to commercialize the results) and c) the potential for commercial (government or private sector) application and the benefits expected to accrue from this commercialization. (The only exception is Fast Track Phase II proposals, which will be selected for Phase II award provided they meet the "technically sufficient" standard in Section 4.3.) The actual assigned weightings will not be disclosed outside of the DoD. Please note that where technical evaluations are essentially equal in merit, and as cost and/or price is a substantial factor, cost to the government will be considered in determining the successful offeror.

You must receive a written invitation before submitting a Phase II proposal (all Fast Track applicants will be invited). The Air Force will select Phase II winners based solely upon the proposal submitted, including Fast Track applicants.

Air Force Cost Proposal

Phase I cost proposals shall reflect a nine month effort not to exceed $100,000. Remember, the first six months constitutes the primary research effort and will be used to evaluate whether a Phase II proposal will be requested.

The Air Force anticipates that pricing will be based on adequate price competition. Proposals, including costs, are limited to 25 pages. However, if the Air Force selects your company to receive an award, be prepared to submit further documentation to substantiate costs. This further information is necessary to facilitate the contracting process.

Air Force Fast Track

Detailed instructions on the Air Force Fast Track and Phase II proposals consistent with this solicitation will be made available by the awarding Air Force activity at the time of Phase I contract award. The Air Force encourages businesses to consider a Fast Track applications when they can attract outside funding and the technology is mature enough to be ready for application following successful completion of the Phase II contract.

Air Force Phase II Enhancement Program

On selected Phase II awards, the Air Force will invite Phase II awardees to apply for a Phase II Enhancement. This program will extend the existing Phase II contract award for up to one year. The Air Force will match dollar for dollar up to $250,000 of outside (non-SBIR) matching funds. Because of the limited amount of available funds, the Air Force will competitively select applications for funding. The main purpose of the program is to address new unforeseen technology barriers that cropped up during the Phase II work. Applications will require written commitment by an Air Force program office that they will acquire and/or use the SBIR technology at the completion of the enhancement program.

Commercial Potential Evidence

An offeror needs to document their Phase I or II proposal's commercial potential as follows: 1) the small business concern's record of commercializing SBIR or other research, particularly as reflected in its Company Commercialization Report (www.DoD.sbir.net/companycommercialization); 2) the existence of second phase funding commitments from private sector or non-SBIR funding sources; 3) the existence of third phase follow-on commitments for the subject of the research and 4) the presence of other indicators of commercial potential of the idea, including the small business' commercialization strategy.

Submission of Final Reports

All final reports will be submitted to the sponsoring agency. **Companies will not** submit final reports directly to DTIC.

Proposal Submission Instructions

Your proposal will be REJECTED if you do not meet all of the following criteria.

1. The Air Force Phase I proposal shall be a nine month effort.

2. You must use the electronic format described in the Electronic Submission described below. The Air Force will not accept any proposals that do not have electronic forms of the Proposal Cover Sheet (formerly, "Appendix A and B"). The electronic forms submitted must match the paper copies submitted via mail/express delivery.

3. A copy of the Company Commercialization Report with summary page must be submitted with all proposals. (See Section 3.4n. of the solicitation.) Even if you have no Phase I or Phase II information to report, you must submit a Company Commercialization Report. Your proposal will not be penalized in the evaluation process if your company never had any SBIR Phase I's or II's in the past.

4. Both the electronic submission of the Proposal Cover Sheet and the paper copies of your proposal must be received on or before the deadline. The Air Force will not accept late proposals, or incomplete proposals. If you have any questions or problems with submission of your proposal allow yourself time to contact the Air Force and get an answer to your question. Submit the electronic Proposal Cover Sheet and Company Commercialization Report early, as computer traffic increases, computer speed slows down. Do not wait until the last minute. The Air Force will not be responsible for late proposals caused by computer systems or servers being "down" or inaccessible.

Electronic Submission of the Proposal Cover Sheet:

Prepare your SBIR proposal to the Air Force using the DoD Electronic Submission Web Site at http://**www.dodsbir.net/submission**. This site allows your company to come in at any time (prior to the closing of the solicitation) to add, edit or print out your Proposal Cover Sheet. The Air Force will not accept any Proposal Cover Sheet except those from the Electronic Submission Web Site as valid proposal submission forms.

Note: The Air Force period of performance for Phase I is nine months.

Once you have prepared, printed, and signed the Proposal Cover Sheet, mail it along with one original and four copies of your entire proposal (the copies should include four copies of the signed Cover Sheet) to the appropriate Air Force offices at the addresses listed below.

PROPOSAL SUBMISSION INSTRUCTIONS

For each Phase I proposal, both the electronic submission of the Proposal Cover Sheet and the paper copies (original and 4 copies) of your proposal must be sent to the office designated below. Be advised that any overnight delivery may not reach the appropriate desk within one day. Be sure to read the Air Force instructions on the previous page for the nine-month Phase I contract to avoid the rejection of your proposal. To request notification of proposal receipt, send request (Ref A on page Ref 1) with a self-addressed stamped envelope. Do not call to ask whether your proposal has been received; due to time constraints, we will not be able to answer such telephone calls.

TOPIC NUMBER	ACTIVITY/MAILING ADDRESS	CONTRACTING AUTHORITY
	(Name and number for mailing proposals and for administrative questions)	(For contract questions only)
AF00-001 thru AF00-017 AF00-021 thru AF00-024	Directed Energy Directorate AFRL/DE 3600 Hamilton Avenue SE Kirtland AFB NM 87117-5776 (Robert Hancock, (505) 846-4418)	Dave Tuttle (505) 846-8133
AF00-031 thru AF00-033 AF00-035 thru AF00-042 AF00-044 AF00-047 thru AF00-069	Space Vehicles Directorate AFRL/VS 3600 Hamilton Avenue SE Kirtland AFB NM 87117-5776 (Robert Hancock, (505) 846-4418)	Francisco Tapia (505) 846-5021
AF00-070 thru AF00-074	Space Vehicles Directorate AFRL/VSOT 29 Randolph Road, Bldg 1107, Rm 235 Hanscom AFB MA 01731-3010 (Noreen Dimond, (781) 377-3608)	John Flaherty (781) 377-2529
AF00-075 thru AF00-076 AF00-078 thru AF00-095 AF00-097 thru AF00-100	Human Effectiveness Directorate AFRL/HEOP 2610 Seventh Street Wright-Patterson AFB OH 45433-7901 (Sabrina Davis, (937) 255-2423 x226)	Mary Jones (937) 656-6273
AF00-104 thru AF00-113 AF00-115 thru AF00-128 AF00-130 thru AF00-133	Information Directorate AFRL/IFB 26 Electronic Parkway Rome NY 13441-4514 (Jan Norelli, (315) 330-3311)	Joetta Bernhard (315) 330-2308
AF00-139 AF00-141 thru AF00-151 AF00-153 thru AF00-163 AF00-165 thru AF00-168 AF00-172	Materials & Manufacturing Directorate AFRL/MLOP 2977 P Street, Rm 419, Bldg 653 Wright-Patterson AFB OH 45433-7746 (Marvin Gale, (937) 656-9221)	Terry Rogers (937) 255-5830 Bruce Miller (937) 255-7143
AF00-173 thru AF00-181 AF00-183 thru AF00-190	Munitions Directorate AFRL/MNOB 101 W Eglin Blvd, Suite 140 Eglin AFB FL 32542-6810 (Richard Bixby, (850) 882-8591 x1281)	Stacey Darhower (850) 882-4294 x3411

AF00-195 thru AF00-215	Propulsion Directorate AFRL/PROB 1950 Fifth Street, Bldg 18 Wright-Patterson AFB OH 45433-7251 (Dottie Zobrist, (937) 255-6024)	Susan L. Day (937) 255-5310 Anthony Everidge (937) 255-4818
AF00-219 thru AF00-233	Propulsion Directorate AFRL/PROI 5 Pollux Drive Edwards AFB CA 93524-7033 (Sandi Borowiak, (661) 275-5617)	Donna L. Thomason (661) 277-8596
AF00-235 AF00-237 thru AF00-246 AF00-248 thru AF00-253 AF00-255 thru AF00-263 AF00-265 thru AF00-266	Sensors Directorate AFRL/SNOX 2241 Avionics Circle, Rm N2S24, Bldg 620 Wright-Patterson AFB OH 45433-7320 (Marleen Fannin, (937) 255-5285 x4117)	Kenneth P. Smith (937) 255-5201
AF00-268 thru AF00-285	Air Vehicles Directorate AFRL/VAOP 2130 Eighth Street, Bldg 45 Wright-Patterson AFB OH 45433-7542 (Madie Tillman, (937) 255-5066)	Douglas Harris (937) 255-4427
AF00-292 thru AF00-295	Air Force Flight Test Center AFFTC / XPST 195 East Popson Avenue Bldg 2750, Rm 218 Edwards AFB CA 93524-6843 (Abe Atachbarian, (661) 275-7135)	Donna Thomason (661) 277-8596
AF00-297 thru AF00-300	Arnold Engineering Development Center AEDC/DOT 1099 Avenue C Arnold AFB TN 37389-9011 (Ron Bishel, (931) 454-7734)	Gloria Fairchild (931) 454-7843
AF00-302 thru AF00-303	Warner Robins ALC WR-ALC / TIECT 420 Second Street, Suite 100 Robins AFB GA 31098-1640 (LT, Andrew J. Lofthouse, (912) 926-6617)	Brenda Hopson (912) 926-3985
AF00-305 thru AF00-306	Ogden ALC OO-ALC / TIEH 5851 F Avenue, Bldg 849, Rm A-15 Hill AFB UT 84056-5713 (Bill Wassink, (801) 777-2977)	Martha Scott (801) 777-0199
AF00-308 thru AF00-309	Oklahoma City ALC OC-ALC / TIET 3001 Staff Drive Suite 2AG70A Tinker AFB OK 73145-3040 (Don Boedeker, (405) 736-5364)	David Cricklin (405) 739-4468
AF00-310 thru AF00-312 AF00-314	Air Armament Center AAC/XPP 101 W. D Avenue, Suite 129 Eglin AFB FL 32542-5495 (Dave Uhrig, (850) 882-8096)	Capt. Rich Ward (850) 882-4141 x4551

AIR FORCE 00.1 TOPIC INDEX

DIRECTED ENERGY DIRECTORATE, KIRTLAND AFB NM

AF00-001	Opto-Integration of Nonlinear Optical Wavelength Converters
AF00-002	Phase-Locked Fiber Laser Array
AF00-003	High-Brightness Fiber-Coupled Laser Diodes
AF00-004	Polarization-Maintaining Dual-Clad Yb-Doped Fiber
AF00-005	Psuedo Anechoic Chamber for Electromagnetic Measurements
AF00-006	Direct Frequency Doubled Diode Laser
AF00-007	Electro-Optic Device for Search and Rescue
AF00-008	High-Efficiency Mid-Infrared Solid State Lasers
AF00-009	High Power, High Brightness Beam Combination of Semiconductor Lasers
AF00-010	Portable Microwave Refractometer System for Sensing Refractive Index and Humidity Fluctuations
AF00-011	Advanced Chemical Iodine Lasers for the ABL
AF00-012	Wave Optics Simulation
AF00-013	Multi-conjugate Optics
AF00-014	Novel Wavefront Sensing Techniques
AF00-015	Advanced High Bandwidth, Large Dynamic Range, Large Size, Fast Steering Mirror
AF00-016	Tracking in High Scintillation Environments Using a-Priori Information
AF00-017	Development of 1.8 to 3.5 Micron Semiconductor Lasers for IRCM Applications
AF00-021	Compact Semiconductor Laser-Based Environmental Monitoring System Development
AF00-022	Gratings for High-Power Yb-Doped Fiber Lasers
AF00-023	Cost-Effective, Scalable, High-Power, Mid-IR Optically (laser) Pumped Molecular Laser Source
AF00-024	High-Power Fiber Laser

SPACE VEHICLES DIRECTORATE, KIRTLAND AFB NM

AF00-031	Very High Speed, Low Power, Radiation Hard, CMOS & BiCOMOS Circuits for Space Applications
AF00-032	Advanced Micro-Mechanisms for Small Satellites
AF00-033	Advanced Integrated Spacecraft and Launch Vehicle Technologies
AF00-035	Composite Flywheel Structure
AF00-036	Threat Warning / Attack Reporting Laser Sensor
AF00-037	Advanced Satellite Docking Mechanisms and Ports
AF00-038	Expert System for Predicting Vibroacoustic Environments
AF00-039	Thermally Conductive Hinge Materials for Deployable Radiators
AF00-040	Boiling Enhanced Micro-Channel Heat Sink for Electronic Cooling
AF00-041	Payload Fairing Active Noise Cancellation
AF00-042	Artificial Intelligence Hybrid Range Scheduler
AF00-044	GPS-based User Equipment (glue) for all Altitude Tracking
AF00-047	Low Power Fast Fourier Transform for Handheld GPS Receivers
AF00-048	Extremely Rugged Electron Emission Sources
AF00-049	New Space Power Electronic Components
AF00-050	Extremely Fast Variable Initerial Sensor
AF00-051	Stacking of Magnetic Memory Chips
AF00-052	Radiation Hardened DSP
AF00-053	Non-Volatile Rams Based on Self-Contained Energy Sources
AF00-054	Low Power Field Programmable Technology
AF00-055	Space Qualified, Low Cost Compact Disk Data Storage / Retrieval System
AF00-056	Long Life, High Efficiency Pulse Tube Cryocooler
AF00-057	Techniques for Assessing Approach for Migrating to Different Processors
AF00-058	High Speed, Radiation-Tolerant Glue Logic
AF00-059	On-Board Intelligent Software for Spacecraft Autonomy
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AF00-061	High Speed RH Level-2 Cache
AF00-062	Effective Low-Temperature p-type Doping for HgCdTe IR Photodiodes
AF00-063	Multi-waveband Interconnect Technology

AF00-064 Advanced Cryocooler Technology
AF00-065 Low-Cost Miniature Flight Control System
AF00-066 Inflatable Structures for Lightweight Solar Arrays
AF00-067 Integrated Payload Dispenser for Multi Micro-Satellite Missions
AF00-068 Miniaturized Vibration Isolation System (MVIS)
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AF00-070 Advanced Space Particle Detectors for Microsatellites
AF00-071 Spacecraft Charge Control Technology
AF00-072 Advanced Algorithms for Exploitation of Space-Based Imagery
AF00-073 Surface Luminescent Dust Sensors
AF00-074 Innovative Techniques for Remote Sensing, Threat Detection and Typing

HUMAN EFFECTIVENESS DIRECTORATE, WRIGHT-PATTERSON AFB OH

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AF00-090 Breakaway Helmet Mount for Night Vision and Targeting Displays
AF00-091 Laser Aircrew Safety and Education Demonstrator-Flight (LASED-F)
AF00-092 Software to Manipulate Large 3-D Voxel-Based Computer Model
AF00-093 Universal Biological Sensor
AF00-094 Vision Corrective Wraparound Spectacles for Laser Eye Protection (LEP)
AF00-095 Remote Thermographer
AF00-097 Human Performance Model for High 'G'
AF00-098 Enhancing the Usability of Computer Generated Forces
AF00-099 Aircraft Prognostics: Identifying Imminent Failures in Aircraft and System Components
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AF00-106 Operational Level Inter-Model Lift Planner
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AF00-108 Security Management and Protection for Large-Scale Information Systems
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AF00-112 Improved Command and Control Modeling and Simulation
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AF00-121 Voice Authenticated Wireless Communication
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AF00-124	Dynamic Architecture Signal Processor Technology
AF00-125	Airborne JTIDS Net Controller
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AF00-133	Data Intensive System Implementation for Battlespace Awareness

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AF00-141	Processing of Inflatable Parabolic Reflectors from Polymeric Thin Films
AF00-142	Durability of Bonded Joints for Low Cost & Lo Repair of High Performance Composite Structures
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AF00-148	Improved Life Prediction of Turbine Engine Components
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AF00-180	High Frequency Motion Simulation for Hardware-in-the-Loop Testing
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AF00-186	Real Time Kinetic (RTK) Carrier Phase GPS from Startup to Impact
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AF00-198	Data Fusion for Gas Turbine Engine Diagnostics and Predictive Diagnostics
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AF00-200	Stochastic Modeling of Gas Turbine Engine Blade HCF Capacity
AF00-201	Innovative Damping Concepts for Extreme Environmental Capacity
AF00-202	Smart Fuels for the Future Air and Space Force
AF00-203	Turbine Burner for Near-Constant Temperature Cycle Gas Turbine Engine
AF00-204	Active Combustion Stability Control During Scramjet Altitude and Mach Number Transients
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AF00-223	Rapid Prototyping of High Temperature Ceramic and/or Metal Liquid Rocket Engine (LRE) Combustion Components via Low Pressure Spray
AF00-224	Extraction of Rocket Propellant Physical Properties via Computed Topography
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AF00-242	Low Power InP MMICs for Low Noise Receivers
AF00-243	Antenna Control Computer for TT & C Phased Array Antenna
AF00-244	Low Cost T/R Module for TT & C Phased Array Antenna
AF00-245	Affordable Beamforming Network for TT & C Phased Array Antenna
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AF00-251 Sensor Systems for Combat Identification
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AF00-260 ATR / Fusion Virtual Development and Evaluation Testbed
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AF00-262 Registration of Images for Polarimetric Dual-Band FOPEN Radar
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AF00-266 Space Based Sensors

AIR VEHICLES DIRECTORATE, WRIGHT-PATTERSON AFB OH

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AF00-269 Repair of Ceramic Matrix Composite Structures
AF00-270 Design for Limited Life Airframes
AF00-271 Development of Advanced Structural Life Analysis / Enhancement Methodology
AF00-272 Verification and Validation of Integrated and Adaptive Control Systems
AF00-273 Plasma Flow Control Technology
AF00-274 Simulation Techniques to Coordinate Large Numbers of Air Vehicles
AF00-275 Flow Control for Weapons Integration / Vehicle Propulsion / Wing Performance
AF00-276 Network Centric Distributed Vehicle Management Systems
AF00-277 Simulation Based R & D for Space Vehicle Concepts
AF00-278 Evaluation of Vehicle Wiring System
AF00-279 Guidance and Control Techniques for Hypersonic Vehicles
AF00-280 Enhanced Boundary Layer Transition Prediction
AF00-281 Innovative Structural Concept Modeling for Affordable Vehicles
AF00-282 Aeronautical Sciences and Flight Control Technology for Military Aerospace Vehicles
AF00-283 Innovative Weight Efficient Combined Structure / TPS Concepts
AF00-284 Multifunctional Structures
AF00-285 Low Speed Test Techniques for Powered Lift Configurations

AIR FORCE FLIGHT TEST CENTER, EDWARDS AFB CA

AF00-292 Jet Engine Test Cell Air Pollution Control
AF00-293 Embedded Global Positioning System (GPS) / Inertial Navigation System (INS) – Encoded Radar Transponder
AF00-294 Directional Airborne Telemetry Antennas
AF00-295 Low Cost Global Positioning System (GPS)-based Collision Avoidance System

ARNOLD ENGINEERING DEVELOPMENT CENTER, ARNOLD AFS TN

AF00-297 Motion Enabling Device for Virtual Flight Test Application
AF00-298 Turbine Engine Augmentor Rumble and Screech Indicator
AF00-299 Thin High Z Converter Foils
AF00-300 Miniaturized Robust Multichannel Telemetry System

WARNER ROBINS ALC, ROBINS AFB FL

AF00-302 Intelligent Near Net-shape Manufacturing Cell
AF00-303 Reduction of EMI from Hybrid Electric Drivetrains

OGDEN ALC, HILL AFB UT

AF00-305	Portable, Field-Functionalized, Multi-component Vapor Detector
AF00-306	Conversion of Static Models and Stinulus Files to Digital Test Interface Format (DTIF)

OKLAHOMA CITY ALC, TINKER AFB OK

AF00-308	Model Characterizing Electromagnetic Pulse Response from Continuous Wave Electromagnetic Data
AF00-309	Virtual Office Application for Next Generation Internet (NGI)

AIR ARMAMENT CENTER, EGLIN AFB FL

AF00-310	Micro-Miniature, Wireless, Telemetry Sensors
AF00-311	Advanced Global Positioning System Hybrid Simulator
AF00-312	Directed Energy Weapons (DEW) Vulnerability and Lethality Analysis
AF00-314	Electro-Optical Scene Simulation Projector (EOSSP)

AIR FORCE 00.1 TOPICS

AF00-001 TITLE: Opto-Integration of Nonlinear Optical Wavelength Converters

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop highly opto-integrated nonlinear optical (NLO) wavelength converters for high-power, highly efficient, compact, electrically driven fiber lasers for adjunct Space Based Laser (SBL), Airborne Laser (ABL), and other Directed Energy (DE) AF missions.

DESCRIPTION: Fiber lasers have demonstrated efficient optical-to-optical power conversion into a diffraction-limited laser beam. Air Force DE missions require electrically efficient, compact, scaleable architectures leading to tens of kilowatts of continuous-wave power in a diffraction-limited beam. Because alternative wavelength operations are required by some missions, it is desired to implement a similar philosophy of ultracompactness as that being applied to the development of these new Yb-doped (1.1-micron) fiber laser devices. The ultracompactness of components may benefit from the manufacturing techniques and lessons learned from such industries as those in integrated electronics and fiber communications. This solicitation is for the development of highly opto-integrated NLO devices such as second harmonic generators, optical parametric oscillators, and sum frequency mixers or difference frequency mixers. Optically integrated devices might consist of all-fiber or waveguide construction with the pump coupling and signal/idler resonance/extraction being accomplished via fiber couplers. It is expected that micro-optics, fiber or waveguide gratings, or other wavelength division multiplexing technology may be useful. It is imperative that ultracompact packaging conducive to machine-vision assembly and mass-producible manufacturing methods be utilized and that the device be robust. Such an envisioned device may simply be attached to a fiber laser via a simple fiber coupler by the end user. Successful proposals will be keen on power scaleable, mass-producible (x20 long-term cost reduction) architectures or technologies demonstrating high-power density packaging (approaching 10W/cm3).

PHASE I: Design, model, and perform adequate proof-of-principle demonstrations to give confidence for the success of a Phase II program.

PHASE II: Based on Phase I designs, models, and proof-of-principle demonstrations, conduct in-depth testing and refinement of prototype hardware to show a maturity of technology toward potential commercial and military applications.

PHASE III DUAL USE APPLICATIONS: Air Force directed energy applications for this technology (weapons, illuminators, counter-measures) have important commercial parallels in such areas as in communications (e.g. pump sources, WDM systems), medical, printing, and materials processing (e.g. welding, marking, cutting) markets.

REFERENCES:
1. "35-Watt CW Single-mode Ytterbium Fiber Laser at 1.1-microns", M. Muendel, B. Engstrom, D. Kea, et al., Conference on Lasers and Electro-Optics, CPD-28, May 1997.
2. "High-power Fiber Lasers", Sandra G. Kosinski, Daryl Inniss, Conference on Lasers and Electro-Optics, CTuE3, May 1998.
3. "Fiber Laser Oscillators and Amplifiers", Elias Snitzer, Conference on Lasers and Electro-Optics, CWE1, May 1998.
4. "Optical parametric oscillation excited by an incoherent conical beam," A. Piskarskas, V. Smilgevicius, and A. Stabinis, Opt. Commun. 143, 72--74 (1997).

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-002 TITLE: Phase-locked Fiber Laser Array

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop phase-locked fiber laser array technology leading to high-power, high-brightness lasers operating in the 1100 nm portion of the IR spectrum.

DESCRIPTION: Fiber lasers have demonstrated efficient optical-to-optical power conversion into a diffraction-limited laser beam. Air Force DE missions require electrically efficient, compact, scaleable architectures leading to tens of kilowatts of continuous-wave power in a diffraction-limited beam. The power output of an individual diode-pumped fiber laser will ultimately be limited by the damage threshold of the fiber core and cladding materials.

Currently, the state-of-the-art for such a laser in the laboratory is on the order of 100 Watts and about half this for commercially available lasers. A coherent array of such lasers, however, may be capable of scaling to the multi-kilowatt level.

In such an array comprising N individual fiber lasers, the peak intensity delivered to a target can be increased by as much as N squared if the lasers are phase locked over the case where all the lasers are independent. This solicitation is for the development of techniques to accomplish the goal of phase-locking an array of fiber lasers to deliver a high-brightness beam. The proposed technique(s) may, for example, be all optical in nature, such as injection locking via evanescent coupling in a multi-core fiber. Alternatively, a hybrid approach employing optical and electronic elements could be used, implementing phase control in a master-slave configuration via opto-electronic devices such as acousto-optic modulators or phase modulators employing the electro-optic effect in solid-state media. Optical coupling between fibers via intra-fiber gratings, Talbot imaging, or phase-conjugate mirrors might also be of use.

PHASE I: Design, model, and perform adequate proof-of-principle demonstrations of phase-locking technology to give confidence for the success of a Phase II program.

PHASE II: Based on Phase I designs, models, and proof-of-principle demonstrations, conduct in-depth development and refinement of prototype hardware to show a maturity of technology toward potential commercial and military applications.

PHASE III DUAL USE APPLICATIONS: Military applications for high-power compact fiber lasers such as those resulting from this proposal are principally weapons-related. Examples of commercial applications for a high-brightness, high-power phased array include laser cutting and welding, laser machining and materials processing, possible medical applications and any other area where a compact, efficient and mechanically robust source of intense infrared radiation is required.

REFERENCES:

1. "High-power Fiber Lasers", Sandra G. Kosinski, Daryl Inniss, Conference on Lasers and Electro-Optics, CTuE3, May 1998.
2. "A CW Diode-pumped Single-silica Fiber Comprising 40 Cores used as Active Elements for a High-power Fiber Laser at 1050nm", P. Glas, M. Naumann, A. Schirrmacher, Th. Pertsch, Conference on Lasers and Electro-Optics, CTuK5, May 1998.
3. "The Talbot Effect", Mansur Mansuripur, Optics and Photonics News, April 1997, pp.42-47.
4. "Self-pumped, continuous-wave phase-conjugator using internal reflection", J. Feinberg, Optics Letters, 7, pp. 486-488 (1981).

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-003 TITLE: High-Brightness Fiber-Coupled Laser Diodes

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop high-brightness, high-power, fiber-coupled diode laser sources to pump high-power fiber lasers for adjunct Space Based Laser (SBL), Airborne Laser (ABL), and other Directed Energy (DE) AF missions.

DESCRIPTION: Fiber lasers have shown efficient optical-to-optical power conversion into a diffraction-limited laser beams. Air Force DE missions require electrically efficient, compact, scaleable laser architectures, for which fiber lasers show great promise. The drivers for such systems will likely consist of banks of fiber-coupled diode lasers. The diode banks could be constructed using an array of diode bars, single emitters, or other possible building blocks. The fiber coupled outputs will then be combined to produce high-brightness, high-power modules suitable for pumping a fiber laser. The details of the design will ultimately depend on factors such as cost, compactness, heat sinking, wavelength control, power supply design, robustness, and serviceability. The primary challenge is to optimally preserve the inherent brightness of the laser diode emission in the fiber coupling and fiber combining processes. Possible approaches might employ technologies such as: bonded and/or shaped waveguides (glass or epitaxial), fiber tapers, fiber end lensing, fiber fusing, or WDMs. Emphasis should be placed on coupling efficiency, simplicity, cost, compactness and robustness. The baseline diode wavelength should be in the 915 nm region for pumping dual-clad Yb doped fiber lasers. A target fiber coupled pump module should provide ~100 W in a single fiber or bundle of fibers with a brightness approaching 1 MW cm-2 sr-1. The target physical dimensions (without driver electronics, but with heat dissipation) are better than 50 W/kg and 0.1 W/ cm-3. The candidate system should be constructed in a way that leads to a significant reduction in unit cost for near-term commercial systems.

PHASE I: Develop a conceptual design based on research, modeling, and producibility. Consider issues associated with manufacturing and assembling the key optical elements. Perform proof-of-principle tests to give confidence for the success of a Phase II program.

PHASE II: Based on Phase I designs, models, and proof-of-principle demonstrations, conduct in-depth testing and refinement of prototype hardware. Build 100 W prototype fiber coupled arrays of diode with a brightness (bundle or single-fiber) significantly exceeding that of currently available technologies. Packaging, heat sinking, original equipment manufactured parts, manufacturing, and commercialization issues should also be considered in the final prototypes to show a maturity of technology toward potential commercial and military applications.

PHASE III DUAL USE APPLICATIONS: Many Air Force directed energy systems and concepts could benefit from this technology. Markets such as those associated with medical lasers, materials processing systems, and laser pump sources could be explored.

REFERENCES:
1. High-Power Diode-Laser Arrays, Endriz Jg, Vakili M, Browder Gs, Devito M, Haden Jm, Harnagel Gl, Plano We, Sakamoto M, Welch Df, Willing S, Worland Dp, Yao Hc, Ieee Journal Of Quantum Electronics V. 28(#4) Pp. 952-965 Apr 1992.
2. Near-Diffraction-Limited Single-Lobe Emission From A High-Power Diode-Laser Array Coupled To A Photorefractive Self-Pumped Phase-Conjugate Mirror, Maccormack S, Eason Rw, Optics Letters V. 16(#10) Pp. 705-707 1991
3. Modal Properties Of An External Diode-Laser-Array Cavity With Diffractive Mode-Selecting Mirrors, Leger Jr, Mowry G, Li X ,Applied Optics V. 34(#21) Pp. 4302-4311 Jul 20, 1995
4. Individual Holographic Optical-Element For Output-Emission Improvement Of A Diode-Laser Array, Spring R, Luthy W, Weber Hp, Helvetica Physica Acta, V. 67(#2) Pp. 221-222 May 1994
5. Numerical-Analysis Of Flared Semiconductor-Laser Amplifiers, Lang Rj, Hardy A, Parke R, Mehuys D, Obrien S, Major J, Welch D, Ieee Journal Of Quantum Electronics, V. 29(#6) Pp. 2044-2051 Jun 1993
6. High-Intensity Rectangular Fiber-Coupled Diode-Laser Array For Solid-State Laser Pumping, Morris Pj, Luthy W, Weber Hp, Applied Optics, V. 32(#27) Pp. 5274-5279 Sep 20, 1993
7. Iii-V Semiconductor Wave-Guiding Devices Using Adiabatic Tapers, Moerman I, Vermeire G, Dhondt M, Vanderbauwhede W, Blondelle J, Coudenys G, Vandaele P, Demeester P, Microelectronics Journal, V. 25(#8) Pp. 675-690 Nov 1994
8. The Shape Of Fiber Tapers, Birks Ta, Li Yw, Journal Of Lightwave Technology, V. 10(#4) Pp. 432-438 Apr 1992
9. Design Approaches For Laser-Diode Material-Processing Systems Using Fibers And Microoptics, Chen Wq, Roychoudhuri Cs, Banas Cm, Optical Engineering, V. 33(#11) Pp. 3662-3669 Nov 1994

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-004 TITLE: Polarization-Maintaining Dual-Clad Yb-doped Fiber

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop polarization-maintaining (PM), dual-clad Yb-doped fiber to enable high-power, linearly polarized, fiber lasers for adjunct Space Based Laser (SBL), Airborne Laser (ABL), and other Directed Energy (DE) AF missions.

DESCRIPTION: Fiber lasers have demonstrated efficient optical-to-optical power conversion into a diffraction-limited laser beam. Air Force DE missions require electrically efficient, compact, scaleable architectures leading to tens of kilowatts of continuous-wave power in a diffraction-limited beam. This solicitation is for the development of polarization-maintaining (PM), dual-clad Yb-doped fibers for linearly polarized (1.1-micron) fiber lasers. Linearly polarized fiber lasers are necessary for non-linear wavelength conversion and may enable coherent beam combining for kilowatt-class fiber laser arrays. Innovative fibers specifically designed for high power (>35W) fiber lasers must meet a number of critical requirements for success. Among these are cladding geometry to efficiently couple the pump-cladding modes to the lasing core, all-glass fibers to eliminate outer-clad burning, and integration of possible diode-pump schemes into the design of the fiber. Successful proposals will offer innovative solutions for a linearly-polarized fiber laser with focus on PM fiber designs that enable single fiber power scaling to a kilowatt (100W near-term goal), enhance or enable new methods for diode-pump coupling, PM mode control, or other laser design constraints that require a reengineered fiber. Successful proposals will be keen on scaleable, mass-producible (x20 long-term cost reduction goal) fiber laser architectures or technologies leading to high electrical efficiency (approaching 30-40%) and high-power density packaging (approaching 10W/cm3).

PHASE I: Design, model, and perform adequate proof-of-principle demonstrations to give confidence for the success of a Phase II program.

PHASE II: Based on Phase I designs, models, and proof-of-principle demonstrations, conduct in-depth testing and refinement of prototype hardware to show a maturity of technology toward potential commercial and military applications.

PHASE III DUAL USE APPLICATIONS: Air Force directed energy applications for this technology may have important commercial parallels such as communications, printing, and materials processing lasers.

REFERENCES:
1. "35-Watt CW Single-mode Ytterbium Fiber Laser at 1.1-microns", M. Muendel, B. Engstrom, D. Kea, et al., Conference on Lasers and Electro-Optics, CPD-28, May 1997.
2. "High-power Fiber Lasers", Sandra G. Kosinski, Daryl Inniss, Conference on Lasers and Electro-Optics, CTuE3, May 1998.
3. "A CW Diode-pumped Single-silica Fiber Comprising 40 Cores used as Active Elements for a High-power Fiber Laser at 1050nm", P. Glas, M. Naumann, A. Schirrmacher, Th. Pertsch, Conference on Lasers and Electro-Optics, CTuK5, May 1998.

4. "Single-mode Photonic Crystal Fiber with an Indefinitely Large Core", T.A. Birks, J.C. Knight, R.F. Creagan, P.St.J. Russell, Conference on Lasers and Electro-Optics, CWE4, May 1998.

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-005 TITLE: Pseudo Anechoic Chamber for Electromagnetic Measurements

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Research the possibility of performing low-level electromagnetic characterization of antennas and systems without using anechoic chambers or open-air test facilities.

DESCRIPTION: Currently, the measurement of antenna patterns, coupling transfer functions (both time and frequency domain), and electromagnetic scattering can only be done in an anechoic chamber or at a large open-air test site because of the isolation required. Such facilities are expensive to build and operate, and quite often, they are not the right size or are not located where they are needed; however, recent improvements in electronic measurement systems and data processing techniques open up new possibilities for improving such characterization systems and reducing or eliminating the need for special chambers or facilities. Ultra-wideband/short pulse and spread-spectrum electromagnetics are two examples of emerging technologies that may provide this capability. There are also other concepts that may prove worthy of investigation. The offeror is free to investigate any and all and select the approach with the lowest perceived risk or greatest improvement over current technology. Concepts considered under this effort must also address potential interference with others and FCC frequency authorization issues that will affect the application of the technology.

PHASE I: Demonstrate the basic feasibility of the proposed technology and characterize the developmental risk associated with the technology. Specific approaches will be investigated and critical development requirements will be identified for the Phase II effort. The final report shall also include possible Phase II partners and an approach for commercialization in a Phase III effort.

PHASE II: Develop and fabricate a prototype measurement system for performing electromagnetic characterization of antennas and other systems without the use of an anechoic chamber or open-air test facility. Conduct laboratory and other tests that will demonstrate a capability with clear commercial potential. Develop commercial partnership interests for a Phase III production and marketing program.

PHASE III DUAL USE APPLICATIONS: The pseudo anechoic chamber approach should be applicable to both military and commercial needs for characterizing antennas, communications systems, shielded systems, and for the measurement of broadband radar signatures of aircraft, camouflaged systems, and buried objects.

REFERENCES: C.E. Baum, ed., Ultra-Wideband, Short-Pulse Electromagnetics 3, Plenum Press, 1997.

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-006 TITLE: Direct Frequency Doubled Diode Laser

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop an efficient, low cost, and compact laser that operates at a wavelength between 460-550 nm by taking light directly from a diode laser operating at a wavelength between 920-1100 nm and frequency doubling it.

DESCRIPTION: The current method of obtaining laser light at wavelengths between 460-550 nm using a diode laser is to use the diode to pump a Nd laser that is then frequency doubled through a nonlinear crystal such as KTP. The goal is to eliminate the requirement to pump a Nd:Yag laser and instead double the diode output directly. Because the current maximum efficiency of Nd lasers is near 50%, this technique could yield lasers in the wavelength regions of interest that are more efficient. In addition, by eliminating the requirement of having a solid-state laser cavity, it may be possible to shrink the size of the laser considerably. It may even be possible to obtain a green laser-on-a-chip; however, this may be difficult due to the beam quality of diode lasers.

PHASE I: Design and fabricate a deliverable breadboard demonstrator of a direct frequency doubled diode laser system that operates in the wavelength region of 460-550 nm. The focus of this phase should be on finding a nonlinear crystal that can efficiently frequency double the diode output. Considerations during this phase include the beam quality required, spectral bandwidth required, and the temperature tolerance of the nonlinear crystal.

PHASE II: Optimize the design from Phase I with an emphasis on output power and compactness while maintaining high efficiency. The ideal goal should be to arrive at a design that will allow a blue to green laser-on-a-chip to be produced with output powers greater than 100 mW.

PHASE III DUAL USE APPLICATIONS: Military applications envisioned include handheld and vehicle-mounted visible laser illuminators. Many commercial applications are known such as video displays, video laser projection systems, laser pointers, and mass storage devices.

REFERENCES: 1. Casey H.C., and Panish M.B., Heterostructure Lasers, Academic Press, NY, 1978.
2. Dmitriev V.G., G.G. Gurzadyan and D.N. Mikogosyan, Handbook of Nonlinear Optical Cyrstals, 2nd Ed., Springer-Verlag, Berlin, 1997.
3. Verdeyen, Joseph T., Laser Electronics, Prentice-Hall Inc., NJ, 1989.

KEYWORDS: Nd lasers, PPLN, frequency doubling, green and blue lasers, laser diodes, nonlinear optics

AF00-007 TITLE: Electro-Optic Devices for Search and Rescue

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop an accurate, reliable, and low-cost electro-optical search and rescue (SAR) system for locating and tracking downed combat personnel.

DESCRIPTION: A number of organizations and countries, including the USA, are developing and/or expanding their combat search and rescue capability (CSAR). Due to the ever-increasing NATO role and peacekeeping involvement, US military personnel are at risk of being lost in unfamiliar terrain or being downed in enemy territory or unfriendly waters. Technological advances have been made on many SAR fronts, but they either have not been fully integrated, are not available to all SAR units, or suffer from technical deficiencies. As an example, the SARSAT (Search and Rescue Satellite) can locate RF beacons to within 20 km, then SAR personnel must use other means (e.g. electro-optics and handheld beacons) to pinpoint the exact location of downed personnel. To facilitate local area search, electro-optical systems like FLIRs are being used to locate the thermal signature of downed personnel. However, due to the high cost (>$100K) per copy, only a limited number of FLIRs are used in SAR missions. Since FLIRs detect temperature differences, they have limited use when the body temperature of the downed individual is close to that of the surroundings (e.g. in water or in the desert on a hot day). Other systems are being developed to compensate for the FLIR deficiencies and/or augment the FLIR's benefits. These systems use low light level (LLL) sensors (LLL television and night vision goggles [NVG]) for SAR missions, with and without the aid of laser illuminators. However, these systems have their limitations as well. LLL systems, without augmented illumination, have limited utility under cloud-covered and moonless sky conditions. When continuous-wave (CW) lasers are used as illuminators, NVG vision can be hampered by cloud or aerosol backscatter that is close to the rescue vehicles. To compensate for the backscatter problems, research is being conducted using pulsed lasers and range-gated, image-intensified cameras. However, pulsed systems may not be eye-safe at all operating ranges. Laser illumination has two benefits--it aids in better scene illumination, and it can be used with retroreflective tape, paint or corner cubes to precisely pinpoint the location of the downed individual. Use of retroreflectors is inherently advantageous since the laser beam returns in the direction of the interrogator, thereby adding covertness to the search and tracking part of the mission. Modulation of the retroreflected signal can facilitate false target discrimination and confirm the identification of the downed individual. Another electro-optic technology being investigated is the use of laser-induced fluorescent (LIF) paint. LIF paint, when applied on an aircraft, uniforms, or a person's skin, could be detected by SAR vehicles equipped with laser illuminators and LIF-sensitive receivers. However, for long standoff distances, extremely sensitive LIF receivers are necessary and high power laser illuminators may make the system not eye-safe.

Research is needed in wide-area electro-optical SAR technology to speed up the search time while maintaining accuracy and tracking capability. The CSAR should be capable of tracking a downed individual once he/she is detected, either while the SAR vehicle is in motion, or the downed person is on the move. The system should be able to interface with any SAR vehicle, operate in all weather conditions, at any time of the day or night, and provide real time information. The system must locate downed combat personnel in any number of environments ranging from maritime, mountainous regions, desert, jungle, densely wooded areas, arctic, and farm clearings to urban terrain.

Innovative proposals are sought that address existing technical CSAR deficiencies, speed up detection times, and improve the accuracy of detecting and tracking downed personnel. AFRL is interested in receiving proposals in any of the following technology areas: a) wide-area, high-power (multi-watt), semiconductor laser illuminators (pulsed or CW); b) high through-put beam-combining optics to produce lasers identified in "a"; adjustable beam divergence, low-loss transmission telescopes to produce the wide-area illumination beam and handle the lasers identified in "a"; c) matching sensor to operate with laser identified in "a"; d) use of optical augmentation or retro-reflectors for pinpointing personnel location; or e) LIF paints and sensors.

PHASE I: Identify the technology and approach that is being proposed. Demonstrate through analysis the benefits and performance of the proposed system. Design and develop a working electro-optical wide-area SAR system for a proof-of-principle demonstration. Hardware deliverables are highly desired for future government field testing. The government will conduct tests and vehicle integration at no cost to the contractor. Design the SAR system to be platform independent. The deliverable items will include a final report, test results, and hardware. The final report will include a system design, operating and maintenance instructions, parts list, drawings, schematics, block diagrams and vendor literature. Proposals for a subset of a SAR system will be accepted if it can be shown that the subset is a major element of a SAR system that can be integrated and demonstrated in Phase II.

PHASE II: Capitalize on the work performed in Phase I and the lessons learned from the field trials, and incorporate feedback from the SAR community to optimize the system design, and to deliver a prototype CSAR system that can be integrated with a combat SAR vehicle. The goal will be to have a wide-area, electro-optical CSAR system that exceeds existing field-of-view and/or illumination diameters by at least a factor of three; this will increase the area of the search by nearly an order of magnitude over existing SAR systems. Show by analysis how this goal can be achieved and the impact on the laser, sensor and optical design. The system should include provisions to provide the location of the downed individual, as well as tracking information should the individual be on the move.

PHASE III DUAL USE APPLICATIONS: During Phase III the emphasis will be to transition this technology from the Air Force to DoD-wide CSAR units and the Coast Guard SAR. Other applications include local law enforcement SAR, commercial (e.g. oil rig) SAR, foreign commercial SAR, and NATO and coalition partners CSAR. Other non-SAR applications include non-lethal illuminators for crowd control; covert tracking of personnel, vehicles, and vessels; looking through heavily tinted windows; IFF; target location and tracking.

REFERENCES:

1. Beal, C and Hewish, M., Air Search and Rescue Capability Up, Budgets Down, International Defense Review (IDR), 1 February 1993, p. 117 v.26 no. 02.
2. Rabin, J. Forward-Looking Infrared: Capabilities for Search and Rescue,
3. Miller J.L. and Kelly J. Flight Testing of a Gimballed Active Television Using A Fiber-Optic Coupled Laser Spotlight, Laser Radar Technology and Applications, G. Kamerman, ed., SPIE Proceedings #3380, 1998.

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-008 TITLE: High-Efficiency Mid-Infrared Solid-State Lasers

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop a mid-infrared solid-state laser producing greater than 5J/pulse with limited duty cycle operation and minimal thermal control.

DESCRIPTION: Many applications require lasers which can produce high pulse energies in the mid-infrared region with high beam quality. Additionally, these applications frequently require small, robust lasers which are highly efficient. Unfortunately, the requirements often are conflicting-the engineering tradeoffs made to make a small, highly efficient laser often conflict with those necessary for high beam quality and high pulse energy. However, by relaxing other performance parameters, it may be possible to simultaneously satisfy these primary requirements. For instance, by relaxing the operational requirement from continuously available laser operation to limited duty cycle operation, it may be possible to dramatically reduce the thermal problems which often prove a barrier to laser performance. The goal of this project is to produce a laser-producing pulsed output at a wavelength in the 2 to 5 micron band. The laser should produce pulsed output at a pulse repetition rate of 10 Hz or greater for a minimum of 0.5 s; this "on time" can be followed by a short recovery time where the laser cannot be operated. During this recovery time, the laser can continue to draw power from the main power supply system and "recharge". The amount of recovery time will vary depending on the device design tradeoffs, and any proposal should address the potential tradeoff between size (weight, volume, and thermal mass), recovery time, and output power. The desired output power levels for this device depend on the output wavelength--at 2 microns, the desired pulse energy is 5 J/pulse, while at 4 microns the desired pulse energy is 1.5 J/pulse. The laser must operate without any consumables (such as liquid nitrogen) and has an overall wall-plug efficiency goal of 5%. While it may not be able to simultaneously satisfy all these requirements, any proposal must clearly identify the potential design tradeoffs.

PHASE I: Design a laser capable of satisfying performance goals based on analysis of the engineering tradeoff-offs between duty cycle, efficiency, and device size. Laboratory assessment of the crucial technical concepts and risk areas is desirable and will be a factor in topic selection.

PHASE II: Verify engineering tradeoffs by laboratory demonstration. Refine and produce the laser design; the laser must be rugged enough for field test in a minimal maintenance environment.

PHASE III DUAL USE APPLICATIONS: The technology produced by this SBIR would be useful in applications which require high output energies, but which are severely power- and space-constrained and only require limited-duty cycle operation. Candidate platforms for this technology are unmanned air vehicles, man-portable systems, certain space systems, and others. Candidate military application areas are remote sensing, active imaging, target designation, and others. Candidate commercial applications are those which required limited duty cycle mid-infrared radiation; examples of these areas are remote sensing for environmental monitoring and some medical applications.

REFERENCES:

1. J. Williams-Byrd, U. Singh, N. Barnes, G. Lockard, E. Modlin, and J. Yu, "Room-Temperature, Diode-Pumped Ho:Tm:YLF Laser Amplifiers Generating 700 mJ at 2 micron", Proc.of the ASSL Conf., TOPS V10, Coeur D'Alene, 1997, P199.
2. T. Chuang and R. Burnham, "All Solid-State Mid Infrared Laser Source", Proc.of the ASSL Conf., TOPS V10, Coeur D'Alene, 1997, P262.

KEYWORDS: 2 to 5 micron, duty cycle operation, high beam quality, high pulse energy, mid-infrared, pulsed output, recovery time, solid-state lasers, wall plug efficiency

AF00-009 TITLE: High-Power, High-Brightness Beam Combination of Semiconductor Lasers

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop a new generation high-power, high-brightness semiconductor arrays for industrial and military applications.

DESCRIPTION: Over the past several years, the Air Force has concentrated on developing high-power laser systems for a variety of ranged applications. Semiconductor lasers offer the advantages of compact size, high efficiency, robustness, and electrical pumping.

Numerous methods have been used to achieve near-diffraction-limited diode arrays with relative success. In the past, many different coherent combination techniques (e.g. master-oscillator power-amplifiers, nonlinear beam combination, locked oscillators) have been used to produce phased arrays. More recently, efforts using incoherent beam combination (e.g. polarization combining, spectral combining/wavelength-division multiplexing) are being attempted.

Recently, high-power semiconductor and fiber laser technology has focused on wavelengths in the 980-1100 nm range. Current requirements for applications also require novel wavelengths, especially wavelengths longer than 1500 nm.

The main goal of this topic is to develop a spatially-coherent (i.e. diffraction-limited) beam by combining multiple semiconductor lasers into a single aperture. Both coherent and incoherent combination techniques are acceptable, provided the output beam is diffraction-limited and carries an output power of 10-100 W cw and has a nominal operating wavelength near either 980 nm or 1.5 microns.

PHASE I: Propose, demonstrate, and characterize performance of small-scale, multi-element, beam combination technique with near-diffraction-limited performance. Demonstrate system scalability to larger and/or multiple apertures for higher power levels for Phase II effort.

PHASE II: Develop, characterize, and deliver a prototype array system with state-of-the-art operating levels for brightness and power (10-100 W cw) operating near 980 nm or 1.5 microns.

PHASE III DUAL USE APPLICATIONS: The technology developed in this program has many commercial and military applications. Typical high-brightness applications include laser communications, infrared illumination, remote sensing and environmental testing, laser surgery, optical data recording, wavelength conversion, and industrial cutting and welding.

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2. S. MacCormick, et al., Optics Letters, vol. 22, pp. 227-229, 1997.
3. Fiber-Optic Communication Systems, G. P. Agrawal. New York: John Wiley & Sons, Inc., 1992.

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-010 TITLE: Portable Microwave Refractometer System for Sensing Refractive Index and Humidity Fluctuations

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/TM)--Airborne Laser (ABL)

OBJECTIVE: Develop a portable microwave refractometer system for sensing refractive index and humidity fluctuations.

DESCRIPTION: There is a need in the atmospheric sciences community for a portable microwave refractometer that can be used for sensing the atmospheric refractive index and humidity fluctuations at high speed. The system is needed for fine-scale research measurements and for examining the performance of clear-air radars over time. Refractometers have been used to interpret radar returns (Lane and Meadows), and an early description of their designs and operation can be found in Bean and Dutton's Radio Meteorology. The system should be capable of being used with an aircraft platform, being mounted on a tower, or carried aloft by a tethered balloon or kite. State-of-the-art sensors and electronics (COTS when available) must be incorporated into the new system with a wide range of sampling capability (sampling rates, gains, etc.). Displays and software must be "user friendly" and be maintained easily. A calibration method for the system is required. The system should be of moderate size so that it can be mounted on aircraft, carried by balloons/kites, etc., and be operated reliably. The system should be designed to operate in conditions of strong acoustic fields due to jet noise. High subsonic conditions must be considered for mach numbers up to 0.85.

PHASE I: Produce a conceptual design and prototype for the microwave refractometer system, including associated required sensors and software needed to extract humidity and refractive index fluctuations as well as calculate the refractive index structure parameter. Produce and demonstrate a detailed analysis of the predicted performance (range of parameters sensed, accuracies, electronics specifications, etc.). Perform preliminary field tests.

PHASE II: Finalize the design and fabricate a microwave refractometer system using the design. Produce complete documentation. Extensively field test and evaluate the system under various conditions.

PHASE III DUAL USE APPLICATIONS: Although several DoD programs such as the ABL and ground-based laser programs would greatly benefit from a microwave refractometer system using state-of-the-art electronics and sensors, the atmospheric research and radar communities also have shown great interest in such a system. Several measurement campaigns would benefit with information from such a system, and the system would provide needed in situ measurements for calibration of clear-air radars. The system would provide long-term checks of the calibrations. Inquiries as to availability, possible costs, etc. of such a system often arise from researchers. A commercially available system would be very beneficial, particularly since there are networks of clear-air radars in operation.

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1. Lane, J. A., and R. W. Meadows, 1963: Simultaneous radar and refractometer soundings of the troposphere, Nature, Vol. 197, 35-36.
2. Bean, B. R., and E. J. Dutton, 1966: Radio Meteorology, U. S. Govt. Printing Office, Washington, D. C., 431 pp.

KEYWORDS: electromagnetic propagation, humidity fluctuations, radar calibration, refractive index, site characterization, turbulence

AF00-011 TITLE: Advanced Chemical Iodine Lasers for the ABL

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/TM)--Airborne Laser (ABL)

OBJECTIVE: Demonstrate innovative concepts that will impact an alternative chemical iodine laser.

DESCRIPTION: The AF Space and Missile Center (SMC) is interested in conducting research and development on various aspects of advanced iodine chemical laser concepts in support of the Airborne Laser (ABL) program. The current weapon device concept is based on the chemical oxygen iodine laser (COIL) system. The iodine atom lasant operates at a wavelength of 1.3 um, which is nearly ideal; however, the current two-phase oxygen generation technique presents a number of issues that increase program risk. Alternative chemical concepts for transferring energy efficiently to the iodine atom are of interest. The ABL Program Office would like to pursue a variety of R&D topics in this area. The most important issues to be addressed are included in the phase descriptions below.

PHASE I: 1) Define and model a promising all-gas-phase chemical iodine laser concept, including the key chemical and kinetic reactions, and arrive at a laser design concept. Or 2) investigate the issue of safe storage and handling of hydrazoic acid in the gas phase. Conduct small-scale experiments to demonstrate the concept. Or 3) investigate high-density flow rates of relevant atomic species such as fluorine and chlorine atoms. Define concepts and carry out small-scale verification experiments.

PHASE II: Continue the effort initiated in Phase I. Design, construct and carry out the key experiment(s) identified in Phase I. Construct a kinetic model, exercise the model to predict system behavior, and compare with experimental results. Generate an engineering design for a full-scale device and predict its performance using the model.

PHASE III DUAL USE APPLICATIONS: This phase would involve the generation and implementation of a marketing plan for the technology developed during the first two phases. These technologies are expected to have applications in a variety of manufacturing industries and elsewhere. Possible applications are nuclear reactor decommissioning via robotic fiber-delivered high-power laser output and robotic (aluminum) welding for the auto industry.

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1. A. J. Ray and R. D. Coombe, "An I Laser Pumped by NCL (a1D)" Journal of Physics and Chemistry 99, pp. 7849-7852 (1995).
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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-012 TITLE: Wave Optics Simulation

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/TM)--Airborne Laser (ABL)

OBJECTIVE: Design, code, and document a user-friendly simulation environment for the study of control and tracking systems for laser propagation and imaging through the atmosphere.

DESCRIPTION: There is increasing military and commercial interest in laser and imaging systems that operate in the atmosphere, at least over part of the propagation path. Increasing performance requirements make it necessary to optimize control and tracking algorithms for such systems. This necessitates the integration of wave optics propagation codes, control and tracking codes, and data analysis environments. To date this has proved difficult, since the expertise for tracking and control algorithm design and for propagation studies rarely resides in one individual. Further, simulation paradigms for the respective areas are not compatible. The challenge of this effort is to provide an integrated, user-friendly, software environment that accesses wave optics propagation tools, control design tools, and data analysis tools.

It is expected that the successful offerer will integrate existing code, rather than develop it under this effort. In particular, offerers should be familiar with wave optics propagation codes, optical sensor modeling and standard control techniques usually associated with adaptive optics and tracking systems. The offerer should also be familiar with the MATLAB* software environment since it is this data analysis and control paradigm that we suggest be integrated into the software paradigm..

Generally we seek packaging of existing code in a user-friendly way, rather than code development that starts from scratch. Many companies have there own internal wave optics modeling capability. It is this capability we wish to capture in a user-friendly way. Two examples of code that goes part way are the Adaptive Optics Toolbox and ABLSim. The former is a commercial product that is marketed as a MATLAB Toolbox. Information on this product can be viewed at http://www.mathworks.com/products. The latter is not a commercial product but some information on this code and its interfaces can be viewed at http://www.MZA.com/ABLSim. These references are provided to give the offeror an idea of the type of code we are interested in and a concept of two types of interfaces that might be useful.

PHASE I: Design, code and document a prototype software environment that integrates propagation code with the MATLAB control design and data analysis software in a user-friendly, integrated software environment. The environment should contain interfaces for creating and modifying adaptive optics geometry, building wind and turbulence profiles, specifying sensors, and incorporating target and receiver characteristics. It should further allow easy incorporation of track and control algorithms. A block diagram interface for creating both the optical and control systems is envisioned. The code should also allow for easy integration with MATLAB in order to incorporate control and tracking algorithms and for data analysis. The final product should be capable of running under Windows NT and Unix operating systems. Phase I will not necessarily provide robust code, but rather a conceptual design and enough software to clearly demonstrate feasibility of the approach.

PHASE II: Design, code, debug, document, alpha and beta test the above-described software package, so that the Air Force research community has ready access to the tool. The tool must be robust and well documented so that a generally knowledgeable person in either the control design community or the propagation community will find it an effective tool for integrated studies. The code and the documentation should be such that the user can extend the code to study a variety of systems, e.g. Airborne Laser, Space Laser, Relay Mirror and imaging systems. We seek incorporation of as many useful sensor, mirror, camera, and target models as resources allow. Offerors who don't already have many of the standard models used in the laser propagation and imaging community will be at a disadvantage.

PHASE III DUAL USE APPLICATIONS: The final product of Phase II will be a robust flexible code for the study of laser propagation and imaging through the atmosphere. Government programs such as the Airborne Laser, Ground Based Laser and Relay Mirror are highly likely customers. The astronomical community is also a potential customer. Commercial applications include analysis at firms building imaging systems for TV news helicopters, those providing visual information for Geographical Information Systems, and helicopter imaging systems for power line insulator damage detection.

* MATLAB, a registered trademark of MathWorks, is an integrated technical computing environment that combines numeric computation, advanced graphics and visualization, and a high-level programming language. Further information can be found at www.mathworks.com.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-013 TITLE: Multi-conjugate Optics

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/TM)--Airborne Laser (ABL)

OBJECTIVE: Develop a hardware and software architecture for adaptive optics systems utilizing multiple deformable mirrors and wavefront sensors that would enhance the performance, over that of conventional systems, of directed energy, or imaging, systems propagating or imaging over long horizontal atmospheric paths.

DESCRIPTION: Due to atmospheric scintillation, adaptive optics systems that operate over long horizontal paths are limited by current technology in compensating the entire path. An adaptive optics system with two or more deformable mirrors and/or wavefront sensors theoretically could better compensate for the atmosphere by having part of the atmospheric path compensated by one deformable mirror and another part of the path compensated by another deformable mirror, thereby providing a modicum of amplitude compensation in addition to phase compensation.. The resulting system could avoid some of the limitations imposed by phase-only (one-mirror) adaptive optics systems. Solutions utilizing a multiple mirror concept have not progressed because the location of the optimal conjugate planes has been elusive. In addition, the apparent need for a real focus in a high energy laser train has made the multimirror approach challenging. Creative and innovative approaches are clearly required to address these limitations. This topic permits the design and testing of a multiconjugate adaptive optics system for use over long horizontal paths to ameliorate the effects of atmospheric scintillation. Non-linear optical system approaches are not covered under this topic.

PHASE I: Using a multi-conjugate adaptive optics system approach, develop an optical system design, and test the design using wave optics simulations and a control system model.. As a starting point the offeror's design should anticipate that the ultimate applications are for 1-4 meter class optical optical systems and evaluate the performance, as well as the limitations, of the proposed concept. Accordingly, the study should encompass a parameter trade space that reflects the intended range (for ABL) or elevation angle (GBL, imaging, power beaming, etc.), turbulence condition, optic size, and adaptive optic system prescription (number and location of mirrors, actuator requirements, and wavefront sensor). The breadboard design, whatever the intended application(s) and method of testing, should be scaled accordingly

PHASE II: The multiconjugate adaptive optics system is to be implemented on a breadboard scale and tested over a real, or laboratory-simulated, horizontal path. The offeror may: (1) test the laboratory breadboard at his own or other facility, if such suitable facilities are available, or (2) at the offeror's request, the AFRL may arrange to conduct test, evaluation and analysis of the prototype's performance at the ABL Advanced Concepts Laboratory operated by MIT Lincoln Laboratory or at the Air Force Research Laboratory's North Oscura Peak Facility. The results of the latter evaluation, if chosen, and analysis will be provided to the contractor at no cost to the contractor or the SBIR Program.

PHASE III DUAL USE APPLICATIONS: It is anticipated that a multiconjugate adaptive optics system successfully demonstrated under this research, with economical considerations folded in, would have both commercial and military applications. The military applications include the ABL and follow-on systems, the Starfire Optical Range, and any DOD program utilizing adaptive optics for directed energy systems. The system would also have airborne imaging applications (military as well as commercial), especially for reconnaissance and surveillance systems that must image through turbulent boundary layers. The commercial market includes such areas as astronomy (retrofitting astronomical sites), laser communications systems, power beaming, as well as other potential applications. It is expected that the contractor will focus on flexible Phase I designs which would maximize both the commercial potential and the military potential.

REFERENCES:

1. Michael C. Roggerman and Byron Welsh, Imaging through Turbulence, CRC Press, Boca Raton, 1996.
2. Robert K. Tyson and Peter B. Ulrich, "Adaptive Optics", in The Infrared and Electro-Optical Systems Handbook, Volume 8, SPIE Optical Engineering Press, Bellingham WA, 1993, pp 167-240.
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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-014 TITLE: <u>Novel Wavefront Sensing Techniques</u>

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/TM)--Airborne Laser (ABL)

OBJECTIVE: Develop a wavefront sensor with improved performance over wavefront sensors currently in use in closed-loop adaptive optics systems.

DESCRIPTION: Closed-loop adaptive optics systems use wavefront sensors to measure the incoming phase from a beacon so that the appropriate conjugate phase can be put on a deformable mirror, thereby improving performance. The current Hartmann sensors are limited by camera frame rate, inability to sense waffle mode, sensitivity of alignment to registration errors, and a general incompatibility with branch point reconstructors. These limitations result in overall closed-loop performance considerably below the theoretical limit, and suggest that improved wavefront sensors could dramatically improve the overall system performance.

PHASE I: Using the proposed wavefront sensor concept, bring it to a conceptual design and test the design using wave optics simulations and other design tools.

PHASE II: Build the wavefront sensor prototype and demonstrate its performance on a laboratory breadboard system. The offeror may: 1) test the laboratory breadboard at his own or other facility, if such suitable facilities are available; or 2) at the offeror's request, the AFRL may arrange to conduct test, evaluation and analysis of the prototype's performance at the ABL Advanced Concepts Laboratory operated by MIT Lincoln Laboratory. The results of the latter evaluation, if chosen, and analysis will be provided to the contractor at no cost to the contractor or the SBIR Program.

PHASE III DUAL USE APPLICATIONS: It is anticipated that a wavefront sensor approach successfully demonstrated under this research, with economical considerations folded in, would have both commercial and military applications. The military applications include the ABL and follow-on systems, the Starfire Optical Range, and any DoD program that utilizes adaptive optics for directed energy systems. The system would also have airborne imaging applications (military as well as commercial), especially for reconnaissance and surveillance systems that must image through turbulent boundary layers. The commercial market includes such areas as astronomy (retrofitting astronomical sites), laser communications systems, and power beaming, as well as other potential applications. It is expected that the contractor will focus on flexible Phase I designs which will maximize both the commercial potential and the military potential.

REFERENCES:

1. Michael C. Roggerman and Byron Welsh, Imaging through Turbulence, CRC Press, Boca Raton, 1996.
2. Robert K. Tyson and Peter B. Ulrich, "Adaptive Optics", in The Infrared and Electro-Optical Systems Handbook, Volume 8, SPIE Optical Engineering Press, Bellingham WA, 1993, pp. 167-240.
3. Todd D. Steiner and Paul H. Merritt, editors, Airborne Laser Advanced Technology, Proceedings of SPIE, Vol. 3381.

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-015 TITLE: Advanced High Bandwidth, Large Dynamic Range, Large Size, Fast Steering Mirror

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/TM)--Airborne Laser (ABL)

OBJECTIVE: Develop a large fast steering mirror capable of high bandwidth, large through closed-loop operations

DESCRIPTION: Commercial Off the Shelf (COTS) Fast Steering Mirrors (FSMs) greater than 8 inches in diameter are currently not capable of high bandwidth (>500 Hz), accurate control operations for error rejection tilt errors greater than 1 mrad. Piezo-ceramic actuators have shown great promise for high bandwidth accurate control applications, but are limited to small tilt error rejection due to the low shear strength of ceramics. Voice coil-based actuators, on the other hand, are limited by the accuracy and bandwidth restrictions associated with control of the coil. Recent strides in voice coil control by Schrader suggest a control architecture that could accommodate large size mirrors capable of large, accurate tilt error rejection at high bandwidth.

PHASE I: Perform initial analysis and modeling in order to establish concept feasibility. Develop preliminary design for a large size (>8 in dia.) fast steering mirror capable of >1KHz error rejection for tilt errors greater than 1 mrad.

PHASE II: Finalize Phase I design. Develop, test and deliver prototype mirror with performance characteristics described above.

PHASE III DUAL USE APPLICATIONS: A new FSM with the above listed capabilities would be useful for a number of space and airborne systems including ABL, SBL, and other imaging systems. The potential commercial applications for this technology include real-time mirror coating growth monitoring for high definition TV systems and power line insulator damage detection.

REFERENCES: Schrader, Karl N., "A Modulated White Light Interferometer for Sensing Sub-Wavelength Structural Disturbances," Ph.D. Thesis, University of New Mexico, May 1998.

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-016 TITLE: Tracking in High Scintillation Environments Using a-Priori Information

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/TM)--Airborne Laser (ABL)

OBJECTIVE: Demonstrate the use of maximum a-priori information for tracking in high scintillation environments.

DESCRIPTION: The Air Force is interested in tracking in high scintillation environments for laser propagation and imaging systems. A primary application is the Airborne laser. Conventional and time-tested tracking paradigms do not provide maximum tracking accuracy for these cases. We seek an investigation of algorithms that make optimal use of a-priori information--information such as knowledge of target shape and use of noise statistics--in a unified statistical framework (Bayesian, Max Likelihood, etc.). To date, various modifications of conventional algorithms have been tested and have failed to provide improvement over simple centroid tracking techniques. Most of these investigations have been ad-hoc. While this approach may well result in the sought-for improvements, this solicitation seeks to carry out tracking algorithm investigations in an integrated theoretical framework that sheds light on the failure of recent investigations and leads to new theoretically sound approaches.

PHASE I: Provide a sound paradigm for the general investigation of tracking algorithms in high scintillation environments. Use the paradigm to investigate performance of existing algorithms (e.g. matched filter approaches such as correlation track, various centroiding concepts such as binary, weighted and biased centroid) and to develop new algorithms which make maximum use of a-priori target and noise information. Consideration should also be given to optimally deriving such information on-line. Simulation and analysis will be performed to determine viable candidates for implementation. Select one or more candidates for implementation in Phase II.

PHASE II: Perform final high-resolution simulation of tracker algorithms developed in Phase I and down select to an algorithm(s) that promises considerable tracking enhancement in the high scintillation regime. Develop and test a prototype tracker that incorporates the favored algorithm(s). Possible test sites include the ABL ACT test site at North Oscura Peak, NM and the Advanced Concepts lab at MIT.

PHASE III DUAL USE APPLICATIONS: A tracker which is capable of performing accurate track in a high scintillation environment will have wide application in the DoD community, where long-range tracking through extended atmospheric paths is required. A primary application is for the Airborne Laser System. Other applications include Airborne imaging and shipboard tracking of long-range targets through extended atmospheres. Strictly commercial applications include tracking for imaging systems for TV news helicopters and helicopter imaging systems for power line insulator damage detection.

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1. Brown, W.P., "Simulation of Laser Propagation on Long Stratospheric Paths" Proceedings of SPIE, Aerosense, 3065, Orlando, FL, 23-25 April, 1997.
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4. Ulick, B.L., "Overview of Acquisition, Tracking, and Pointing System Technologies", Proceedings of SPIE, Acquisition, Tracking, and Pointing, 887, 1988.

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-017 TITLE: Development of 1.8 to 3.5 Micron Semiconductor Lasers for IRCM Applications

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop mid-infrared semiconductor lasers emitting in the 1.8 to 3.5 micron range for Band I and II infrared countermeasure applications.

DESCRIPTION: Recent improvements in semiconductor lasers have made them sources practical for use in compact systems for countermeasure applications. Their small size and high efficiency, along with significant improvements in beam quality, mode control, frequency and thermal stability, and output power point to a future in which diode lasers will play a significant role in countermeasure applications. New mid-infrared semiconductor laser material systems are showing tremendous potential and are improving steadily. For example, devices incorporating such designs as the broadened waveguide and tapered amplifier have enabled semiconductor lasers to operate at beam quality and power levels sufficient for infrared countermeasure applications.

PHASE I: Determine laser specifications for infrared countermeasure applications and demonstrate proof of concept. At the end of Phase I, conduct a demonstration of a semiconductor laser capable of operating at 100's of milliwatts peak power (25% duty cycle) with scalability to higher power levels at a wavelength in the range of 1.8 to 3.5 microns

PHASE II: Build and optimize a semiconductor laser meeting infrared countermeasure specifications including 1 watt peak power (25% duty cycle) at a wavelength in the range of 1.8 to 3.5 microns. Deliver a prototype by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Lasers emitting in the range of 1.8 to 3.5 microns have tremendous potential in many commercial and military applications. Not only can these devices be used in infrared countermeasure applications, but also for environmental monitoring applications. Both of these areas are of great interest in the commercial sector as well as for military applications. In particular, these semiconductor laser devices are needed to replace current inefficient, bulky flash lamps in the Band I and II frequency range for countermeasures.

REFERENCES:
1. H. K. Choi, "Current Status of Mid-Infrared Semiconductor Lasers," Annual OSA Meeting, Baltimore MD, October, 1998.
2. H. Q. Le et al, "High Power, High Efficiency, Quasi-CW 4mm Sb-Based Laser," MRS Fall Meeting, Boston MA, December, 1998.

3. H. K. Choi and S. J. Eglash, "High Power Multiple Quantum Well GaInAsSb/AlGaAsSB Diode Lasers Emitting at 2.1 mm with Low Threshold Current Density," Appl. Phys. Lett., Vol 61, pp.1154-1156, 1992.
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KEYWORDS: diode lasers, environmental monitoring, infrared countermeasures, mid-infrared lasers, mode control, semiconductor lasers, thermal stability

AF00-021 TITLE: Compact Semiconductor Laser-Based Environmental Monitoring System Development

TECHNOLOGY AREAS: Chemical/Biological Defense, Sensors/Electronics/Battlespace

OBJECTIVE: Develop mid-infrared semiconductor lasers for in situ and remote environmental monitoring and detection of chemicals.

DESCRIPTION: Recent improvements in semiconductor lasers have made them sources practical for use in environmental monitoring/analysis. Their small size and high efficiency, along with significant improvements in beam quality, mode control, frequency and thermal stability, and output power, point to a future in which diode lasers will play a significant and dominant role in environmental sensing. Advances in semiconductor "quantum-well" lasers have enabled engineers to "dial-in" the laser emission wavelength. Of particular interest are wavelengths from 2 to 10 microns. In the 2 to 5 micron wavelength region, small molecules found in industrial environments, such as CO2 and CH4, could be monitored. Also in that range, detection of molecules such as tributyl phosphate, known to be important in the production of weapons of mass destruction, is possible. Organic molecules associated with chemical warfare could be detected using semiconductor lasers at longer wavelengths. For example, mustard gas has a strong absorption line at 8.2 microns. Given the advances noted above and the co-technology advances in monitoring methodologies, it is desirable to research and develop fieldable, rugged, and sensitive diode laser-based environmental monitoring systems. It is important to demonstrate that the proposed semiconductor laser-based system has a clear advantage over conventional systems.

PHASE I: Demonstrate proof of concept. Select a promising application using semiconductor lasers, and perform a preliminary investigation to determine laser specifications for the chosen application and required system design parameters. Carry out experiments to prove concept potential. Deliver a preliminary design at the end of Phase I.

PHASE II: Develop demonstrate, and deliver a semiconductor laser prototype device. Ideally, demonstration of the device should be conducted in the operational area in which it will be used.

PHASE III DUAL USE APPLICATIONS: With the increasing pressure for industry to monitor its environmental impact the commercial market for environmental monitoring is tremendous. Military applications include the need to detect manufacturing plants for chemical weapons, testing and detonation of chemical weapons, and even detecting vehicle fumes to monitor convoy activity. A specific example of a military application is a hand-held chemical detection system capable of detecting, identifying, quantifying, and warning personnel of the presence of chemical weapons.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-022 TITLE: Gratings for High-Power Yb-doped Fiber Lasers

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop gratings for use with high-power Yb-doped fiber laser systems.

DESCRIPTION: The Yb-doped dual-clad fiber laser is a leading candidate for use as a compact high-power continuous wave laser system. There are efforts to scale the power of individual fiber lasers to the limits of the dual-clad fiber. Arrays of fibers are envisioned to allow power scaling even further towards kilowatt class lasers. An enabling technology for power scaling of individual fibers and fiber arrays is the use of gratings; among others, the gratings may include Bragg gratings, holographic gratings, and conventional gratings. Bragg grating applications include single wavelength operation (for potential phasing of fiber arrays), enhancement of coupling waveguided pump light to the lasing core, mitigation of nonlinear optical effects, etc. Gratings may be applied in alternative methods for coupling laser diode pump light to the fiber laser. Improved gratings can be useful for beam combination of laser diodes or fiber lasers. The grating implementation should be capable of handling high powers commensurate with scaling goals: ~ 100 W for individual lasers, ~ 1 kW for fiber arrays. Successful proposals will provide an innovation or improvement in grating application or grating technology that will benefit the power scaling of individual fiber lasers or fiber arrays.

PHASE I: Design, model and perform adequate proof-of-principle demonstrations of improved gratings or grating applications to give confidence for the success of a Phase II program.

PHASE II: Based on Phase I designs, models, and proof-of-principle demonstrations, conduct in-depth testing and refinement of prototype hardware to show a maturity of technology toward potential commercial and military applications.

PHASE III DUAL USE APPLICATIONS: Air Force directed energy applications for this technology may have important commercial parallels such as communications, printing, and materials processing lasers.

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KEYWORDS: Bragg gratings, beam combination, diode coupling, gratings, high power fiber laser, holographic gratings

AF00-023 TITLE: Cost-Effective, Scalable, High-Power, Mid-IR Optically (laser) Pumped Molecular Laser Source

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Conduct R&D on novel concepts for cost-effective, scalable, high-power mid-IR laser-pumped molecular gas lasers.

DESCRIPTION: The Air Force Research Laboratory (AFRL) is interested in conducting research and development in cost-effective, high-power, scalable, laser-pumped, mid-infrared (mid-IR) molecular laser sources. Future AF missions will require high-power lasers with output in the mid-IR spectral region. Current gas phase system concepts for high-power lasers utilize gas and chemical laser technology to exploit the inherently scalable nature of these media. However, these sources of high-power radiation are typically large, can be expensive to operate, and may require significant logistical support to enable long-term operation.

Alternative techniques for the efficient production of high-power mid-IR light using optically pumped, laser-pumped molecular gas lasers are sought. These devices are envisioned to be cells that are filled with a molecular gas. The gas is then optically pumped at short wavelengths with a solid state laser source, laser diodes, or fiber lasers, to a high-lying vibrational level. This produces a population inversion and lasing between the pumped level and lower adjacent vibrational levels at longer wavelengths.

This is fundamentally a different concept than direct lasing from a solid state material in the 2 - 5 micron range. Instead laser photons are resonantly absorbed by a gas at short wavelengths on a high vibrational level, for example, V = 2,3, or 4. Cascade lasing in the molecular gas can then occur sequentially on DV = 1 transitions. AFRL/DELC has demonstrated 25% (theoretical) conversion efficiency on a number of hydrogen and deuterim halides with pumping from V=0 to V=2 and lasing from V=2 to V=1. The DV = 1 vibrational frequencies of the hydrogen and deuterim halides lie between 2.7 and 5 microns. Potential advantages of this approach are the following: (1) The pump laser does not need good beam quality although it does need narrow bandwidth to match the line width of the molecular absorption. (2) Arrays of unphased pump lasers can be used to excite the gas. (3) Phasing of the pump radiation can then occur on the down converted radiation with the gas cell resonator.

(4) It may be possible to use highly developed pump lasers between 1 and 2 microns such as neodymium in different hosts, arrays of diodes, or arrays of diode pumped fiber lasers. The key technical issues that must be addressed are: (1) narrow banding the pump source and; (2) developing multipass optical designs that will maximize the absorption of the pump radiation. Concepts that can show significant cost reduction benefits through leveraging from technologies currently developed for, and employed in, high volume industrial applications are especially of interest. Continuous wave or pulsed pumping techniques employing direct or resonant pumping schemes should be evaluated.

PHASE I: Evaluate the laser pumped molecular laser concepts using a solid state pump between 1 -2 microns and select the optimum configuration. An optimum wavelength is 4.0 microns and the HBr Laser is a good candidate. Perform a proof-of-principle demonstration showing the feasibility of the optical pumping architecture. This verification experiment, along with applicable modeling and analysis, will lead to a scalable laser design concept.

PHASE II: Assemble and test an appropriately scaled version of the laser design developed in Phase I. The performance of this device if pulsed will produce 5 J/pulse at 10 Hz and if CW will produce 50 watts. Address key issues and experiments identified in the Phase I analysis. Demonstrate scaling concepts using the chosen pump source. Generate an engineering design for a scaled device by mutual agreement with AF representatives and predict its performance using appropriated modeling.

PHASE III DUAL USE APPLICATIONS: This phase will involve the generation and implementation of marketing plans for the technology developed during the first two phases. These technologies are expected to have applications in a variety of high volume commercial applications in the medical, materials processing and other industries.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-024 TITLE: High-Power Fiber Laser

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop High-Power, Highly Efficient, Compact, Electrically Driven Fiber Lasers for Adjunct Space Based Laser (SBL), Airborne Laser, and other Directed Energy (DE) AF missions.

DESCRIPTION: Fiber lasers have demonstrated efficient optical-to-optical power conversion into a diffraction-limited laser beam. Air Force DE missions require electrically efficient, compact, scaleable architectures leading to tens of kilowatts of continuous-wave power in a diffraction-limited beam. This solicitation is for the development of enabling technologies that make possible kilowatt-class, Yb-doped, (1.1-micron) fiber lasers. These new technologies may benefit from the manufacturing techniques and lessons learned from such industries as those in integrated electronics and fiber communications. New enabling technologies may include: 1) all-glass fibers, photonic crystals, polarization-preserving and other innovative fibers specifically designed for high-power fiber lasers; 2) efficient micro-optic, waveguide, or other novel optic systems for coupling of diode-laser emission into fibers; 3) ultra-compact packaging conducive to machine-vision assembly and mass-producible manufacturing methods; 4) novel uses of Bragg gratings for fiber laser performance enhancement, nonlinear optical effects mitigation, or pump-coupling; 5) multi-core fibers, fiber bundles, and novel techniques for coherent and incoherent beam-combining arrays. Successful proposals will be keen on scaleable (kilowatt-class), mass-producible (x20 long-term cost reduction goal) fiber laser architectures or technologies leading to high-electrical efficiency (approaching 30-40%) and high-power density packaging (approaching 10W/cm3).

PHASE I: Design, model, and perform adequate proof-of-principle demonstrations to give confidence for the success of a Phase II program.

PHASE II: Based on Phase I designs, models, and proof-of-principle demonstrations, conduct in-depth testing and refinement of prototype hardware to show a maturity of technology toward potential commercial and military applications.

PHASE III DUAL USE APPLICATIONS: Air Force directed energy applications for this technology may have important commercial parallels, such as communications, medical, printing, and materials processing lasers.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-031 TITLE: Very High Speed, Low Power, Radiation Hard, CMOS and BiCMOS Circuits for Space Applications

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: Develop process(es) for dramatically faster p-channel devices compatible with standard silicon-based, radiation hardened CMOS technology for use in very high-speed circuits for space-based applications.

DESCRIPTION: Silicon-based circuits have enjoyed a sustained, incremental improvement in performance through reduction in the size of device lithographic features. However, currently the highest speeds are 1-10GHz. One of the important fundamental limiting factors is the significantly lower hole-mobility relative to electron mobility in silicon. One possible avenue to increasing the speed of silicon circuits is the use of silicon-germanium alloys. Silicon-germanium HBT technology has matured dramatically. Silicon-germanium has been integrated into a silicon-based process by IBM and has found application in RF-circuits. Another promising application of the silicon-germanium system is the p-MOSFET. Because the hole-mobility in germanium is almost five times as large as that in silicon, insertion of silicon-germanium p-MOSFETs into a CMOS technology has the promise of considerably increasing the overall circuit speed. To date, however, only modest improvements in bulk hole mobility (50%) and in effective channel mobility (90%) have been realized. Recently, it has been found that silicon-germanium-carbon holds even greater promise as a channel material. For space applications, either of these material systems would have to exhibit tolerance to high-energy radiation. It has been previously demonstrated that silicon-germanium HBTs are remarkably tolerant to radiation; however, to date there is no literature on the behavior of the silicon-germanium p-MOSFET. There is also no data at all on the radiation behavior of devices based on silicon-germanium-carbon. The goals of this SBIR are threefold: First, we want a optimized growth process for p-channel devices that demonstrates significant (at least a factor of three) improvement in the hole mobility over conventional silicon in a fully fabricated p-MOSFET. Second, we want an evaluation and, eventually, an optimization of the radiation response of these optimized devices. Third, we want these devices integrated into a silicon-based CMOS process. Proposals for materials systems other than Si-Ge or Si-Ge-C are welcomed, but the proposal must show how these systems are compatible with silicon processing, and how they are economically competitive.

PHASE I: Develop a conceptual process or processes for layer growth that will lead to bulk and channel mobilities for p-channel MOSFETs that are increased by a factor of 2-3. Demonstrate proof of concept and that these processes can be integrated into silicon CMOS processing. Provide a process plan for prototype devices that uses 0.8 micrometer design rules.

PHASE II: Deliver prototype integrated circuits that include the high-performance p-MOSFETs. Fabricate the circuits with 0.8 micrometer design rules. Optimize the channel characteristics and evaluate the radiation tolerance of the prototype ICs. We expect a proof of concept that these are scaleable to at least 0.2 micrometer design rules.

PHASE III DUAL USE APPLICATIONS: Integrate the process and, if necessary, optimize the process for radiation tolerance. Deliver a CMOS circuit with high-speed p-channel devices with identical, or nearly identical geometry to the n-channel devices.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-032 TITLE: Advanced Micro-Mechanisms for Small Satellites

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Demonstrate low cost, ultra-lightweight, miniaturized spacecraft mechanisms for deployment and precision pointing that can meet future DoD small spacecraft requirements.

DESCRIPTION: The new paradigm for spacecraft calls for performing missions at lower cost with satellites weighing approximately 100 kilograms rather than the 1000-kg satellites currently used. Current spacecraft mechanisms for release, deployment, and precision pointing are far too large and expensive to be considered, and scaling down may be impractical for microsat (<100kg) and nanosat (<10kg) applications. In recent years, a number of new technologies have emerged which make it feasible to construct extremely small, lightweight, and inexpensive mechanisms for use on small satellites. The primary goal is to reduce both the weight and the cost of mechanisms for deployment and precision pointing by a factor of 10 over what is available in Commercial Off-The-Shelf (COTS) technology. A key component of the program will be to take advantage of the multi-functionality. Emphasis will be placed on hardware demonstration.

PHASE I: Develop conceptual designs of the mechanism based on preliminary analysis. Perform sufficient hardware development and testing to insure that the system requirements can be met. Conduct proof-of-concept demonstrations to indicate the practicality of the design in meeting operational requirements and objectives. Perform a comprehensive review of small sat requirements.

PHASE II: Finalize the mechanism design and validate its performance by meeting Air Force requirements. Develop and demonstrate full-scale operational flight hardware for a specific satellite. Demonstrate scalability of the hardware for satellites of different size (10-100 kg) and function.

PHASE III DUAL USE APPLICATIONS: Commercial and military applications exist for the development of miniaturization spacecraft mechanisms to support the future DoD small satellite requirements. Military applications include programs such as TechSat 21, the AFRL's XSS technology demonstration series, and the Air Force Space Test Program payloads. Commercial applications include the small university payloads and experiments that are now being launched on small/micro satellites.

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KEYWORDS: deployment, low-cost, mechanisms, multi-functional, precision pointing, separation, spacecraft

AF00-033 TITLE: Advanced Integrated Spacecraft and Launch Vehicle Technologies

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop advanced technologies for launch vehicles and that will reduce the spacecraft life-cycle-costs.

DESCRIPTION: Existing technologies may not be able to meet requirements for future DoD satellite programs. The use of pyrotechnics, for example, will expose fragile sensors and electronics to high shock levels, and sensitive optics might be subject to contamination. In the past ten years, several new technologies have been developed that are having or could have an impact on the aerospace industry; these technologies include isolation, integral damping, composite structures, integral thermal protection, low shock separation, acoustics, etc. Some examples of new structural concepts that have been recently developed are Grid stiffened structures, Chambercore structures, Wavy Fiber Composites, and Multifunctional structures. We are looking for innovative ways to integrate these newly developed technologies into a new system (shrouds, adapters, etc.) that can result in significant cost, reliability, and weight savings for expendable launch vehicles and their satellites. The integration of key technologies could have significant weight reductions that will result in more payload capability for that launch vehicle going to orbit. Each of these new technologies, while promising, currently has significant risks that must be addressed through development, demonstration, and integration. The technologies that are to be developed need to address issues such as reliability, safety, weight, low cost manufacturability and integration, reduced part count, and the ability to meet requirements of that spacecraft/launch vehicle. It is desired that one or a combination of these advanced technologies be integrated.

PHASE I: Formalize and provide supporting analysis for an innovative concept for incorporating the advanced technologies for space systems. Proposers need to define the problem, including specifications and any potential restrictions or limitations faced in the implementation of the technology or technologies with the launch vehicle and satellite manufacturers.

Identify the main parameters that influence the integration. State system-level performance goals and develop system component/system level conceptual designs. Present analytical and simulation results to demonstrate performance of the system.

PHASE II: Perform component and ground tests to demonstrate and validate the concept developed in Phase I. Design, fabricate, and test a full-scale demonstration for evaluation.

PHASE III DUAL USE APPLICATIONS: DoD, NASA, and commercial launch vehicle and satellite manufacturers are interested in developing innovative technology that will save weight, cost, and time. This technology will reduce the environment that the spacecraft will need to be designed against, which consequently will reduce the number of satellite failures that occur. This technology will allow the use of instrumentation, sensors, and equipment that currently survive the existing environments. Potential military applications of this technology include Space Based Radar, Space Based laser, SBIRS Low and High, and the Air Force Launch Vehicle Offices. Potential commercial users include Orbital Sciences and Lockheed Martin who are already using isolation technology for their small launch vehicles.

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KEYWORDS: acoustics, composites, isolation, low cost, low-shock separation, multifunctional structures, spacecraft expendables launch vehicles

AF00-035 TITLE: Composite Flywheel Structure

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop a methodology for the design and manufacture of composite flywheels for spacecraft using novel concepts and with an emphasis on high fiber volume fraction.

DESCRIPTION: Spacecraft flywheels show great promise to reduce spacecraft mass through the integration of energy storage and attitude control functions. Additionally, flywheels have the ability to charge and discharge very rapidly and repeatedly to depths much greater than batteries. Composites have been proven to be an ideal material for flywheel applications, and AFRL and NASA are developing prototype systems based on state-of-the-art unidirectional winding techniques. Past AFRL/NASA efforts have focused and continue to focus on exploring the limits of this rotor technology. These traditional rotors have been limited by their strength in the radial direction. Typical high-fiber volume fraction composite manufacturing techniques provide for high strength inplane to the fibers but low strength through the laminate thickness. Therefore, the radial stresses developed during the high rotation speeds of flywheels tend to limit the flywheel's top speed. Alternative manufacturing techniques that include radial-direction fibers tend to lower the fiber volume fraction, and therefore the strength/weight ratio of the flywheel.

PHASE I: Show by analysis & testing an approach to building composite flywheels with high fiber volume fraction and/or reduced susceptibility to radial stresses.

PHASE II: Fabricate a full-scale flywheel using the developed technique and demonstrate by testing its improved characteristics.

PHASE III DUAL USE APPLICATIONS: Potential commercial applications for this technology include all future commercial space vehicle systems. Effective flywheels mechanisms will lead to lighter and cheaper commercial satellites of all kinds, including telecommunication, weather, monitoring and entertainment applications. Potential DoD applications include all future DoD space vehicle systems. This technology will result in lighter, cheaper and more reliable DoD satellites and spacecraft. Additionally, this technology can be considered enabling for DoD systems with high power surge requirements such as Space-Based-Radar and Space-Based-Laser. Potential NASA applications include International Space Station and future earth observing satellites.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-036 TITLE: Threat Warning/Attack Reporting Laser Sensor

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: Develop cost-effective technologies to detect, identify, locate, characterize, and report laser attacks or interference against U.S., and Allied and Commercial satellites.

DESCRIPTION: The program will focus on the demonstration of a threat warning and attack reporting laser sensor. The objective is to miniaturize the sensor package to reduce the weight and power requirements from current capabilities. The laser technology program will demonstrate the laser sensor on the ground with eventual demonstration in space. A visible and infrared subassembly should be used to cover the required wavelengths while maintaining the needed sensitivity and false alarm rejection. The laser sensor should provide two types of information--incident information, and threat information. Incident information is an alert that a threatening event has taken place, and includes where and when the sensor perceived the event. Threat information is used to determine what type of system delivered the attack and where it is based. There are several design issues involved with this effort, including determining performance threshold and goals, evaluating the laser sensor concept for maximum optimal performance, evaluating the candidate detector, modeling the performance of the optical and electronic elements, formulating efficient detection and signal characterization algorithms, and evaluating the sensor packaging technique. Since the laser sensor is intended for nearly universal deployment, the design goals place emphasis not only on sensor performance, but on miniaturization, low mass, and low power consumption. A laser sensor must be sensitive to energy levels many orders of magnitude lower than those which can damage; however, this same sensor ideally must be able to survive any damage. In order to conserve mass and power usage, it is hoped that a single, uncooled detector will suffice for the entire waveband of interest; however, while a cooled detector could greatly enhance infrared detection performance, the cost in both power and weight would be unacceptable. The sensitivities of available uncooled detector arrays, as well as the need for increased sensitivity at visible wavelengths, requires the use of a dual band system.

PHASE I: Design and characterize the laser sensor concept.

PHASE II: Develop a prototype of the laser sensor and test it under appropriate conditions for space and other high performance commercial and military applications.

PHASE III DUAL USE APPLICATIONS: The laser sensor technology developed in Phases I and II will be transitioned to the production of sensor systems suitable for both military threat warning/attack reporting systems and similar systems for laser-sensitive commercial spacecraft. A sensor that could detect and warn of laser emissions would add another safety factor for people involved in the use and study of lasers.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-037 TITLE: Advanced Satellite Docking Mechanisms and Ports

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop a satellite docking port that provides mechanical, power, data, fluid, and thermal connections, suitable for attaching an orbital replacement unit (ORU).

DESCRIPTION: Cost effective, on-orbit, satellite servicing (assembly, maintenance, supply, etc) requires that servicing activities be automated. In the near term, this requires reducing the complexity of servicing activities to a level compatible with current intelligent machines. One way to simplify operations is to provide docking ports, on satellites, to which servicing micro-satellites can mechanically dock, connect an ORU, and leave. Such a port would also allow the micro-satellite to connect directly, acting as a temporary ORU. It is therefore necessary to design these docking ports--both satellite and servicer sides--including mechanical docking hardware and connections for data, power, heat, and fluid transfer. Ideal designs would be mechanically simple, low cost, low power, and self-aligning and/or impact absorbing, allowing error in service craft position, orientation, and velocity during docking. They would provide all required connections, and have a low likelihood to fail, leak, or leave fluid behind when disconnected. Mechanisms should be consistent with automated, camera guided rendezvous by the servicing micro-satellite.

PHASE I: Identify components that could become ORUs. Determine required connections for these components. Evaluate existing and/or new designs for suitable connectors. Determine the optimal set of connectors to support a variety of ORUs while minimizing weight and complexity. Produce one or more designs for ORUs and ports, including ports with all connections, and ports with reduced sets. Provide notional designs of docking mechanisms required to attach the ORUs to the ports.

PHASE II: Downselect to one design for each type of port (communication only, fluid transfer, hardware attachment, etc.), and build one or more prototype ports. Also build prototype docking mechanism(s) and ORUs compatible with the ports. Demonstrate manual docking, connection, and transfer of fluid, heat, data and power across the interface. Identify and/or implement improvements that would be necessary to upgrade the system to work in space.

PHASE III DUAL USE APPLICATIONS: PHASE III DUAL USE APPLICATIONS: Military and commercial potential exists for maintaining and refueling new GEO satellites, and any new, large/expensive LEO satellites. In addition, the technology could decrease production costs for satellites mass produced for constellations by facilitating post-production customization and allowing simple retrofits to repair defects discovered during a production run or during ground testing. Potential DoD, NASA, and commercial applications include on-orbit maintenance/refueling for the Air Force SBIRS Low and High programs, Space Based Radar, Space Based Laser, and Iridium, Teledesic, etc.

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KEYWORDS: connectors, couplings, docking, docking power, on-orbit servicing, orbital replacement unit (ORU), refueling

AF00-038 TITLE: Expert System for Predicting Vibroacoustic Environments

TECHNOLOGY AREAS: Information Systems, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/CL)--Launch Programs

OBJECTIVE: Develop an expert system of software to perform vibration, acoustic and shock environmental predictions based on previous vibroacoustic spacecraft launch data and recent advances in mid-frequency acoustic prediction tools.

DESCRIPTION: Prediction of vibroacoustic and shock environments for both DoD and commercial launch vehicles, as well as spacecraft, has become a costly, labor-intensive process, yet such analysis is essential to assure reliability of vehicle structure and airborne equipment. The objective of this topic is to develop an analytical tool that will use a combination of theoretical and empirical methods to provide--in an automated sequence--a more accurate prediction of the vibroacoustic and shock environments. The theoretical methods should explore increased accuracy in the prediction of vibroacoustic environments in spacecraft launch vehicles. In particular, finite element methods and boundary element methods have been shown to have sufficient accuracy at relatively low frequencies, but are computationally expensive and loose accuracy at higher frequencies. Statistical energy methods, on the other hand, have been shown to be accurate at relatively high frequencies but lose accuracy at lower frequencies. Recent advances in mid-frequency prediction have the potential to greatly improve the accuracy of vibroacoustic prediction methods in spacecraft launch vehicles across the entire frequency band. Improved accuracy in prediction should result in fewer spacecraft failures and possibly reduced testing requirements. In addition, improved accuracy would greatly facilitate current efforts at AFRL/VSDV investigating innovative methods of vibroacoustic control in launch vehicles. The analytical tool to be developed will allow the user to perform analyses at the spacecraft/launch vehicle location of interest.

PHASE I: Develop software prototype program with analysis and database capability. Provide a proof-of-concept demonstration.

PHASE II: Refine, debug and simplify the software, and generalize input and processing in a manner to make the final product usable by a wide variety of potential customers in aerospace applications. Provide demonstration of software prototype and compare to experimental results on representative mutually agreed vibroacoustic testbed.

PHASE III DUAL USE APPLICATIONS: Provide full-scale demonstration to (Air Force/Contractor) specifications on mutually agreed launch vehicle and compare to test data. The final software product should be usable for many types of military and commercial structural applications--it should be applicable not just to space vehicles, but also in the civil engineering, aircraft design, automotive design and other similar structural fields.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-039 TITLE: Thermally Conductive Hinge Materials for Deployable Radiators

TECHNOLOGY AREAS: Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop deployable radiator hinge configurations to facilitate heat rejection in future satellites.

DESCRIPTION: At today's level of technology, conventional spacecraft have surface areas capable of rejecting internal waste heat using structural panel radiators or body mounted radiators. Present (commercial and military) trends are that satellite power will increase and satellite size will decrease (with the use of high-density electronic packaging techniques). At some point, there will not be adequate area on the satellite to reject the internally generated heat, and advanced radiators will be necessary. Within the next five years, the need for deployable radiators will be obvious. However, the critical design feature for high heat rejection on a deployable radiator is transporting the waste heat across the hinge. Thermal straps and high conductivity composite hinge materials, although they have an advantage in their simplicity, are not feasible because of high interface resistance which limits the heat transfer capability and reduces the heat rejection potential. Other methods of transporting heat across the hinge (e.g., heat pipe, flexible bellows, and coiled tubes) have been investigated in the past. Among the key technologies for future deployable radiators is the development of reliable lightweight hinge materials and systems. Considering the severe weight constraints of future spacecraft, the technological challenge is high. Some combination research should be focused on the above-mentioned technologies with fiber materials. In all cases, the increases of heat transport across the deployable radiator hinges require proper design and selection of materials. To this end, the sensitivities of the thermal design with respect to material characteristics and flight environment have to be well understood. This topic solicits proposals for innovative new concepts for new materials and systems having extremely good interface thermal conductance (100 Watts/degree C) and heat transport capability (1000 Watts). The radiator operating temperature range is -75 to 100 degrees C with the deployable angle which lies between 85 degrees to 185 degrees.

PHASE I: Address the identification of promising hinge materials for use in advanced deployable radiator systems. Emphasis should be placed on the heat path across and around the hinges and dependence of heat transfer on material properties and characteristics. Consider the dependence on hinge diameter, weight and contact area. Thermal analysis should include all heat transfer modes (e.g., radiation, conduction and convection). Identify candidate materials and hinge designs. Provide demonstrations of the heat transfer characteristics of breadboard material/hinge configurations.

PHASE II: Finalize material selection and hinge designs. Manufacture and test prototype, flight configuration, and material/hinge assemblies to mutually agreed specifications and environments.

PHASE III DUAL USE APPLICATIONS: Material/hinge assemblies developed as a result of this topic shall be applicable to future commercial and military satellites alike.

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KEYWORDS: deployable radiators, heat rejection, interface resistance, radiator hinges, spacecraft, waste heat

AF00-040 TITLE: Boiling Enhanced Micro-Channel Heat Sink for Electronic Cooling

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop a heat removal device to enhance high density integrated circuit (IC) cooling.

DESCRIPTION: In recent years, advances in microfabrication technology have enabled the increasing miniaturization of many systems. Apart from the enabling technologies in electronic design, the importance of the associated problem of thermal control to prevent the electronic components such as IC (integrated circuit) chips from overheating cannot be overemphasized. For example, the large number of transistors on an IC chip, and the packing of multiple chips into a compact module, result in a substantial amount of waste heat dissipation that must be removed. The effectiveness of utilizing heat conduction or forced convection is limited by the available heat transfer area and by the relatively small effective heat transfer coefficient. There is a need for compact, higher capacity cooling devices. For example, micro heat exchangers consisting of numerous minute flow channels with hydraulic diameters ranging from 10 to 100 micrometers have an extremely high surface-to-volume ratio. For aerospace systems, the higher heat removal capability of micro heat transfer devices enables effective thermal control of densely packaged high power avionics/space-based equipment. A thermal control device with extremely high heat transfer rate--such as the Boiling Enhanced Micro-Channel Heat Sink (BEMCHS) which consists of numerous micro-channels with micro-configured surfaces--can be used to enhance boiling heat transfer for the cooling of electronics. BEMCHS is an active (mechanically pumped) device, as compared to other passive micro-scale heat transfer devices (e.g., micro heat pipes and micro heat exchangers). BEMCHS can consist of multiple parallel banks of micro flow channels of about 100 micrometers in hydraulic diameter, which are fabricated by microdiamond machining. The micro-configured surfaces, which are produced by microelectrical discharge machining, consist of a regular pattern of cavities on an otherwise smooth surface to serve as nucleation sites to enhance boiling. Heat transfer rates in excess of 1000 Watts/cm squared have been demonstrated. Boiling from micro-configured surfaces has been shown to increase heat transfer from smooth surfaces by over 300%. Successful, innovative development of BEMCHS will yield a substantial increase in the thermal control capability of high-power electronics and integrated circuits, resulting in substantially increased IC chip packing density of electronic devices.

PHASE I: 1) Investigate the feasibility and the application of BEMCHS for electronic cooling, as well as generate analytical data on the micro-scale transport processes. 2) Perform a trade study to determine the optimal operating limit of micro heat pipes and micro heat exchangers as compared to BEMCHS. Consideration should be given to utilization of passive fluid flow designs for BEMCHS application. 3) Design, construct, and demonstrate a breadboard BEMCHS device.

PHASE II: 1) Finalize the design and development of a BEMCHS device. 2) Construct, demonstrate and characterize its thermal performance by both test and analyses.

PHASE III DUAL USE APPLICATIONS: The application of BEMCHS in the thermal control of DoD and commercial aerospace will result in significantly denser packing of avionics equipment within a given space.

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KEYWORDS: boiling enhanced micro-channel heat sink (BEMCHS), electronic cooling, heat transfer coefficient, integrated circuit chips, micro heat exchangers, thermal control device

AF00-041 TITLE: Payload Fairing Active Noise Cancellation

TECHNOLOGY AREAS: Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MV)--Evolved Expendable Launch Vehicle (EELV)

OBJECTIVE: Develop/demonstrate an active noise cancellation system to reduce the acoustic energy within the launch vehicle payload fairing during launch.

DESCRIPTION: The acoustic energy generated during the launch process can damage the payload (spacecraft). Present methods to reduce acoustic energy levels in the payload environment include sound absorbing blankets and Helmholtz resonators. These methods consume payload fairing volume and introduce cleanliness problems. An active noise cancellation system would eliminate the need for these passive devices and could result in further reduction of acoustic levels. NASA Langley is currently developing piezo electric film systems to cancel noise in aircraft; this approach (among others) might be applied to launch vehicle noise reduction. Piezo electric films would consume negligible payload fairing volume.

PHASE I: 1) Conduct a thorough review and evaluation of applicable noise cancellation technologies. 2) Evaluate alternatives resulting in the selection of the design approach best suited to this problem. 3) Design a system using the selected alternative. 4) Simulate the design showing expected performance with typical launch vehicle acoustic levels and frequencies together with expected power consumption of the active system, estimated system energy level reductions, volume savings, and system cost.

PHASE II: 1) Produce final design/manufacture of a prototype active cancellation system to be used for testing. 2) Perform a complete test and analysis (to Air Force/contractor mutually agreed specifications) of system performance/reliability, including (among other issues) energy level reduction from 0 to 10,000 Hz, power consumption, and actual cost to manufacture the system.

PHASE III DUAL USE APPLICATIONS: An improved Active Noise Cancellation System design will be applicable to military and commercial satellite launch systems. A more effective system design would benefit commercial launch systems, allowing more payload area volume and simplified cleaning procedures.

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2. D. L. Palumbo, S. L. Padula, et al., "Performance of Optimized Actuator and Sensor Arrays in an Active Noise Control System," Presented at Aeroacoustics Conference, 2nd , State College, PA, 6-8 May 1996. NTIS: N19970001270, Order from NTIS at 1-800-553-NTIS.
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KEYWORDS: helmholtz resonator, launch vehicle noise reduction, noise cancellation system, piezo electric film, reduction of acoustic levels, sound absorbing blankets

AF00-042 TITLE: Artificial Intelligence Hybrid Range Scheduler

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/CW)--Satellite/Launch Control

OBJECTIVE: Develop hybrid artificial intelligence techniques for resource scheduling in mission systems.

DESCRIPTION: The scheduling of ground and space resources, e.g., antennas, communication lines, sensors, computers, etc. for complicated mission operations while satisfying many constraints in priority, temporal and location dependency, criticality, etc. is a very complex nonlinear problem. Conventional mathematical optimization techniques have not been able to solve this type of problems with reasonable computation time. Current automated scheduling schemes are not capable of producing near optimal results in real-time for maximum system performance and resource utilization. Use of a single artificial intelligence (AI) technique (e.g., neural networks, fuzzy-logic, genetic algorithms, adaptive problem solvers, etc.) for real-time, automated resource scheduling has been only successfully demonstrated for simple systems such as vehicle dispatching and data routing with small number of constraints. Each of the above-mentioned AI techniques has specific strengths and weaknesses in solving large complex scheduling problems. The purpose of this research is to develop innovative hybrid AI techniques for resource scheduling of large, complex mission systems such as satellite control operations with adaptive and learning capabilities that can respond to changing rules, constraints and scenarios in real-time. At least two intrinsically different techniques should be developed. Each candidate technique will be assessed in terms of computation (response) time, optimality of its scheduling results, generality, extensibility, and degree of human intervention required.

PHASE I: The Phase I effort shall include, but not limited to (1) characterization of resource scheduling problem for large complex mission systems, (2) establishment of scheduling performance measures and evaluation criteria for ranking different techniques developed, (3) formulation of candidate hybrid AI scheduling algorithms, (4), development of hybrid AI techniques suitable for resource scheduling application, and (5) demonstration of the feasibility and performance of each hybrid scheduling algorithms against a representative mission system such as the satellite contact scheduling of the Air Force Satellite Control Network.

PHASE II: The Phase II effort shall include, but not limited to (1) refinement of the scheduling algorithms developed in Phase I to improve scheduling performance and efficiency, (2) expansion of the scheduling generality and flexibility to cover more mission application areas, (3) implementation of a test bed for the experimentation and evaluation of various hybrid AI techniques against different mission systems, and (4) documentation of research results, algorithms coding and test bed for possible technology transfer and insertion to actual mission system development programs.

PHASE III DUAL USE APPLICATIONS: The hybrid AI scheduling techniques and algorithms developed from this research are applicable to a wide range of military and commercial systems that require resource scheduling capability.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-044 TITLE: GPS-based User Equipment (GbUE) for all Altitude Tracking

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/CW)--Satellite/Launch Control

OBJECTIVE: Develop a prototype low cost, low power, lightweight and miniaturized GbUE unit and GPS-based tracking operation procedure for all altitude satellite tracking applications.

DESCRIPTION: Driven by the need to reduce cost, and simultaneously to enhance tracking performance for the Air Force Satellite Control Network (AFSCN), the DoD has initiated studies in recent years to determine alternative navigation/tracking technologies for future implementation. GPS has emerged as the most promising candidate technology to achieve this ambitious goal. A GPS user needs to have four or more GPS satellites in view in order to determine its own position. This visibility requirement easily can be satisfied for users on or near the earth surface, even including low earth orbit (LEO) satellites. GPS applications to high-altitude space users pose special challenges. For instance, the number of GPS satellites visible to a geosynchronous orbit (GEO) user varies between zero and three, which is inadequate for a determinate position solution. If augmented by a Kalman filter, it has been shown that GPS tracking of space vehicles at high altitudes (up to GEO) is feasible, although the performance at those altitudes needs further exploration. Moreover, satellite thruster firings (for maneuvers, momentum unloading, etc.) can result in large tracking errors when the number of visible GPS satellites is inadequate, especially when it is zero. These errors may exceed AFSCN's tracking accuracy and timeline requirements. GPS-based user equipment technologies that deal with these issues and are compatible with AFSCN operations need to be developed. GPS tracking could significantly simplify the implementation of autonomous Guidance, Navigation and Control (GN&C) in upper stages and satellites. Even if full autonomy is not used, GPS tracking potentially could shorten the orbit determination process because a single contact would be adequate to determine the position of a satellite after a maneuver. This offers the potential for compressing the mission timeline for satellites using multi-burn transfers that could take days to reach mission orbit, or satellites requiring more frequent momentum unloading or other maneuver burns. The objectives of this project are: a) to develop a GPS-based tracking operation procedure including necessary software modules; and b) to determine the feasibility and benefits of autonomous operation and compressing AFSCN's operation timelines.

PHASE I: 1) Conduct a status review on space qualified GPS receivers and their flight experience. 2) Determine disturbance sources that can lead to significant transients. 3) Identify GbUE design options and GPS-based tracking operations procedure capable of dealing with these transients in the presence of poor GPS visibility at high altitudes. 4) Develop a preliminary GbUE design, including test plans, with emphasis on achieving low cost, low power, lightweight, and small size for long-life space missions at all altitudes. 5) Determine feasibility and benefits of timeline compression and autonomous operation for a candidate satellite system using GPS tracking as compared to using SGLS ranging.

PHASE II: 1) Develop a detailed GbUE design based on the preliminary design. 2) Develop a detailed test plan. 3) Fabricate and test a prototype GbUE. 4) Demonstrate performance and cost advantages to mutually (AF/contractor) agreed specifications.5) Deliver the prototype GbUE including hardware and software. 6) Develop detailed tracking operation procedure for tracking multiple satellites using GbUE and deliver software modules together with source code and documentation.

PHASE III DUAL USE APPLICATIONS: The prototype GbUE and GPS-based tracking operation procedure is applicable to DoD, Civil, and commercial satellites and their ground control networks. It is projected that as many as 1,500 commercial satellites may be launched during the next 10 years. Launch and satellite tracking and their traffic management will be paramount issues.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-047 TITLE: Low Power Fast Fourier Transform for Handheld GPS Receivers

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SCM/CZ)--Global Positioning System (GPS)

OBJECTIVE: Develop a very low power Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT).

DESCRIPTION: Frequency domain digital signal processing offers enhanced performance over time domain signal processing for navigation, radar, communications and computer systems with less complex hardware implementation. A major application of frequency domain processing is in the area of adaptive filters for the excision of narrowband jamming waveforms in spread spectrum systems such as the Global Positioning System (GPS). As jamming power increases, the need exists for filters with jamming suppression capabilities approaching 60 dB. Simulations have shown that these suppressions can be obtained by processing in the frequency domain. The current FFTs dissipate excessive amounts of power and are therefore not applicable for many GPS receivers such as handhelds. A need exists for the development/demonstration of a low power, low cost and small size FFT and IFFT prototype which can be integrated in a handheld GPS receiver.

PHASE I: 1) Investigate technologies applicable to the design of a low power, low cost, small size FFT/IFFT compatible with a handheld GPS receiver. 2) Develop detailed models of candidate FFT/IFFT designs. 3) Perform analyses/cost and trade studies. 4) Select final design based upon performance/cost/power criteria. 5) Based on selected design, provide a limited proof-of-concept demonstration to mutually (Air Force/contractor) agreed upon performance requirements. The basic focus would be the integration by simulation with a GPS receiver in the loop.

PHASE II: 1) Produce final detailed design of the FFT/IFFT. 2) Produce a prototype FFT/IFFT capable of demonstrating all key performance features. 3) Conduct tests/demonstrations to mutually (Air Force/contractor) agreed upon performance requirements to measure/verify FFT/IFFT performance. Provide final FFT/IFFT cost/power analysis.

PHASE III DUAL USE APPLICATIONS: Development of FFT and IFFT will have significant impact on both DoD and Commercial application in the future for communication. Currently, only 1 Watt FFT is available as COTS (commercial off the shelf).

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-048 TITLE: Extremely Rugged Electron Emission Sources

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop the technology to fabricate wide band semiconductor microtips and vacuum field effect transistors.

DESCRIPTION: Electron emitting microtips made of wide band gap semiconductor (WBGS) materials, such as diamond, SiC, etc., could have considerable potential to significantly improve high power, high frequency power sources for both commercial and military applications. In spite of the promise of cold cathode concepts, to date, concurrent requirements of high current, high voltage, fast switching and durability with efficiency have not been achieved. Present techniques lack efficiency and longevity and are not scaleable. Novel approaches are required that optimize emissions material and geometry and have tip stability and practicality. An array of these microtips should be capable of > 10A/cm2 emission flux while demonstrating no operational degradation over multiple mission intervals. A single microtip can also be used as the source in a vacuum field effect transistor (VFET), which is essentially a miniaturized solid state vacuum tube processed by microelectronic fabrication techniques. The conduction channel in the VFET is a vacuum. These types of devices can be modeled, designed and fabricated to create a new genre of space electronics that are faster, lighter, and less power consumptive than any present solid state microelectronic technologies. Because the conduction channel is a vacuum, VFET-based devices are expected to be highly immune to damage or upset by any form of man-made or natural radiation. These devices are exceedingly rugged and are expected to operate through extremely severe environments, short of thermal depositions that would melt the supporting framework.

PHASE I: Model, design, fabricate, and demonstrate prototype electron emitting microtip structures using WBGS materials. Demonstrate the fabrication of rugged, efficient two-terminal microtip devices such as diodes. The goal is to develop the knowledge and skill needed to design and fabricate three-terminal VFETs based on WBGS microtips.

PHASE II: Based on Phase I results, model and design prototype VFET devices. Fabricate and demonstrate the operation of WBGS microtip VFETs. Package these prototypes and determine their performance. Test the thermal stability and radiation hardness of the packaged devices over an extended range to determine the ruggedness of the VFETs. Using the information generated, define the Phase III manufacturing plan--i.e. market development, technology transfer, production device demonstration, etc.

PHASE III DUAL USE APPLICATIONS: The WBGS microtip VFET technology developed in Phases I and II will be transitioned to a commercial scale production process. The production plan shall include both military and commercial grade devices since this class of devices is expected to have numerous applications in both arenas. The superior radiation hardness of the VFETs should benefit both military and commercial satellite communities. The temperature stability will allow the VFETs to be used in environments hostile to conventional silicon or GaAs based technologies.

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KEYWORDS: cold cathode, electron emission source, microelectronic, microtips, vacuum field effect transistor (VFET), vacuum microtip

AF00-049 TITLE: <u>New Space Power Electronic Components</u>

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/CW)--Satellite/Launch Control

OBJECTIVE: Develop radiation hard, thermally and electrically rugged, reliable space power electronic components.

DESCRIPTION: In both commercial and military space programs, numerous on-orbit anomalies, permanent or intermittent, are frequently traced to the failure of the most simple, fundamental components of the electronic hardware--a capacitor blown, a resistor overheated, or a diode overdriven. Wide band gap semiconductor (WBGS) materials, such as SiC, GaN, and diamond, are very radiation tolerant, have very large breakdown tolerance, a large on-to-off current ratio, and large Joule and high thermal conductivity. These materials have been demonstrated to perform well as resistors, capacitors and diodes at the microelectronics level and may provide the technology needed to develop next-generation discrete electronic components that will have superior reliability and survivability for applications in extremely hostile environments. The goal of this SBIR is to develop the infrastructure necessary to design, fabricate and manufacture such WBGS electronic components.

The success of the manufacturing capability should be demonstrated by developing prototype analog and digital subcircuits such as a current mirror or a single SRAM cell. The technology should be able to withstand an interplanetary mission with expected radiation doses in excess of 20 Mrad and temperature variations between 100 and 600 degrees Kelvin.

PHASE I: Design fabrication process for WBGS counterparts for the following electronic components: resistors, capacitors and diodes that will operate in the thermal range of 100-500K. Demonstrate proof of principal for these designs.

PHASE II: Design, fabricate and characterize prototype WBGS counterparts of electronic components: resistors, capacitors and diodes. Demonstrate low power, high speed FET design, capable of operating in an extended temperature range. Measure and evaluate their power density, breakdown voltage, thermal stability, radiation hardness, etc.

PHASE III DUAL USE APPLICATIONS: Develop the production processes to manufacture WBGS electronic components with extended performance range (i.e. above 10 GHz, ultra low power for CMOS type of devices, very high operating temperature). Package and test the components for space and other high performance commercial and military applications. Characterize critical parameters such as size, weight, energy density, current density and thermal loading. Develop a technology insertion and manufacturing plan based on the knowledge gained.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-050 TITLE: Extremely Fast Variable Emitter Inertial Sensor

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop an innovative replacement technology for conventional inertial sensors and gyroscopes.

DESCRIPTION: An innovative replacement technology for conventional inertial sensors and gyroscopes is required for next generation military and commercial control systems. Such technology must be inexpensive, highly sensitive, rugged and conducive to miniaturization and large-scale production. The nature of the sensing mechanisms might be capacitance, atomic force, electron tunneling, coulombic attraction, field emission (Fowler-Nordheim process) or other means. In principle, the microelectro-mechanical system (MEMS) technology can be employed to build the entire gyroscope, or conversely, a gyroscope can be put together using discrete inertial sensors fabricated by the MEMS technology. An example of a MEMS inertial sensor would be a vacuum field effect transistor (VFET) with the emitter affixed on a flexible or deformable substrate. This variable emitter structure acts as the sensing element that converts weak inertial and related forces into strong electronic signals. With the use of the appropriate wide bandgap semiconductor (WBGS) materials, such as diamond, SiC, GaN, etc., this class of devices would be very insensitive to radiation, temperature, shock, and cross axis interference. Development of MEMS technology for the mass production of rugged, small and inexpensive inertial sensors and gyroscopes will have far-reaching benefits to both military and commercial space programs.

PHASE I: Develop the variable emitter structure. Design, fabricate and demonstrate prototype two-terminal devices with the emitter attached to a flexible platform. Characterize these prototype devices to establish dynamic range performance envelope. Finalize the variable emitter VFET design using the knowledge gained.

PHASE II: Fabricate prototype variable emitter VFET inertial sensors devices. Package these sensors and measure their performance. Design and fabricate prototype gyroscopes using the inertial sensors developed. Test the mechanical and thermal stability and radiation hardness of these devices over an extended range to determine their ruggedness. Using the information generated, formulate the Phase III manufacturing plan--i.e., market development, technology transfer, production device demonstration, etc.

PHASE III DUAL USE APPLICATIONS: The VFET inertial sensor gyroscope technology developed in Phases I and II will be transitioned to a commercial scale production process. Rugged, small and inexpensive inertial sensors and gyroscopes are expected to have numerous applications in control systems. The production plan will include manufacture of these devices for both military and commercial applications.

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KEYWORDS: force sensor, gyroscope, inertial sensor, microelectro-mechanical system (MEMS), vacuum field effect transistor (VFET), variable emitter

AF00-051 TITLE: Stacking of Magnetic Memory Chips

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop a technology to stack magnetic memory chips to increase data storage capacity.

DESCRIPTION: Stacking of memory chips has been shown to be an efficient way to increase the storage capacity of semiconductor memory devices for both advanced military and commercial applications. So far, the bulk of the development work has been carried out on SRAMs (Static Random Access Memory) and DRAMs (Dynamic Random Access Memory). Very little work has been done on stacking of non-volatile magnetic memories. Since non-volatile magnetic memory chips are becoming available as a result of both commercial and government funding, it is timely to develop a technology for stacking the magnetic memory chips. While a good deal of knowledge and technology developed for stacking SRAMs and DRAMs would be transferable, the stacking of magnetic memories presents its own unique set of challenges--stray fields from current lines, magnetic coupling between chips, etc. A program is needed to develop the methodologies required to overcome the challenges specific to stacking of magnetic memory chips. Successful development of this technology offers high payoff for space programs where volume and weight are at a premium.

PHASE I: Examine existing magnetic memory circuit layouts to determine their suitability for stacking. Develop design principles for laying out magnetic memory circuits for stacking. Investigate techniques for suppressing inter- and intra-chip magnetic interference. Provide breadboard demonstration of basic principles.

PHASE II: Fabricate memory stacks using existing magnetic memory chips. Demonstrate/verify the performance of the memory stacks. Develop designs to accommodate drop in of higher density memory chips as they become available.

PHASE III DUAL USE APPLICATIONS: High density non-volatile memories are expected to have numerous commercial applications, i.e. portable computers, mobile telephones, consumer appliances, etc. In military/commercial space programs, this technology has the potential of reducing weight and power requirements for the spacecraft and allowing the spacecraft to recover gracefully after an expected power interrupt.

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1. S. P. Kleczkowski, D. E. Norton, "Disk Selection in a Stack of Stabilized Flexible Disks," IBM Technical Disclosure Bulletin, vol. 20, no. 3, pp. 914 - 915, Aug 1977.
2. T. Leone, "Variable-Capacity Magnetic Memory Systems," Journal: L'Antenna, vol. 43, no. 12, p. 464-465, Dec 1971.

KEYWORDS: dynamic random access memory (DRAM), magnetic cross talk, magnetic interference suppression, magnetic memory, multichip stacking, static random access memory (SRAM)

AF00-052 TITLE: Radiation Hardened DSP

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop a high performance, ultra low-power, rad-hard Digital Signal Processor for satellite applications.

DESCRIPTION: Digital Signal Processing (DSP) performs a key role in both DoD and commercial communication satellites. To minimize size, mass, and power, and to maximize data throughput, it is necessary that the DSP hardware operate at low power and high speed. While leading edge commercial DSP components can satisfy most satellite system performance requirements, they are generally sensitive to both incident ionizing and particle radiation. Ionizing radiation degrades performance, leading to premature system failure. Single-event-effects (SEEs) produce frequent upsets and possibly catastrophic failure due to either single-event-induced latchup or transistor gate rupture. One approach to achieving the desired performance and alleviating the commercial DSP components' sensitivity to radiation is to fabricate the microelectronics on a Silicon-On-Insulator (SOI) substrate. Unfortunately, SOI processes are not available which can accommodate the direct translation of DSP components from their present commercial bulk CMOS (Complimentary Metal-Oxide Semiconductor) versions. For example, SOI process yields currently limit the chip size (and gate count) significantly below leading edge CMOS bulk processes. It is important, therefore, in developing an SOI DSP capability for communication satellites to identify the specific types of signal processing that are required so that the DSP architecture and chip partitioning can be customized to the limitations of the SOI fabrication process. In optimizing the DSP, it is also necessary to consider the types of memory components and the software macros that are required.

PHASE I: 1) Identify an optimized mix of memory, memory management, DSP architecture, and I/O bandwidth that maximizes the utility of the DSP chips across several space applications. 2) Investigate and identify high-level macros and super cells to develop in a radiation hardened SOI CMOS process. 3) Provide analysis which verifies that the designs are capable of withstanding total ionizing dose levels encountered in typical orbits, and that the designs are insensitive to SEEs. 4) Develop a report and/or a computer simulation that demonstrates feasibility of the concepts and provides a road map for Phase II and III.

PHASE II: Develop and fabricate prototype DSP chip(s) using an SOI process. Evaluate chips in terms of their electrical performance, their tolerance to total ionizing dose, and their sensitivity to SEE. Design a DSP subsystem based on the prototype DSP chips and the test results.

PHASE III DUAL USE APPLICATIONS: The DSP capabilities developed in this program could be exploited for use in many of the DoD and commercial satellite systems that are now under consideration for future development and deployment. There are also a variety of ground-based commercial applications in which the microelectronics are exposed to either high temperature or industrial radiation sources that could benefit from the chips and technologies that are developed in this project.

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1. R. Berger, W. G. Lyons, and A. Soares, "A 1.3 GHz SOI CMOS Test Chip for Low-power High-speed Processing," IEEE Journal of Solid State Circuits, Vol. 33, No. 8, p. 1259-1261, Aug 1998.
2. L. E. Thon, G. P. Coleman, Et al., "250-600 MHz 12b Digital Filters in 0.8-0.15 mm bulk and SOI CMOS Technologies," 1996 Intl. Symposium On Low Power Electronics and Design, Digest of Technical Papers, p. 89-92, 12-14 Aug 1996.

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-053 TITLE: Non-Volatile RAMs Based on Self-Contained Energy Sources

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Design a high-capacity, radiation-hardened, non-volatile SRAM device with self-contained energy source for medium- to long-duration space missions.

DESCRIPTION: Satellite components may experience brief disruptions in power for a variety of reasons. Non-volatile memory is typically provided to preserve software programs and parameter states during these periods. Current total dose-hardened (100K to 1M rad) non-volatile memory devices (i.e., packaged die) are significantly less area efficient than comparably hardened volatile memory devices. The goal is to combine the latest technology hardened SRAMs (Static Random Access Memory) with an innovative approach to providing local (i.e., contained within the same package) energy storage which will supply sufficient power to retain memory contents during periods when regular satellite power is briefly disrupted. At least one such battery-based commercial solution with a 5-year lifetime exists for non-hardened electronics. Energy storage technology has evolved, and it is time to reassess the practicality of this approach to space-based, non-volatile memory. The desired solution should be an SCES capable of withstanding missions of up to 15 years with a total radiation dose exposure of up to 1Mrad while providing memory retention for periods of power supply disruptions up to one hour in duration. Local SCES energy backing can offer size/weight savings in localized circuits as well as provide an extremely rapid recovery mechanism over more centrally organized energy-backed storage schemes (e.g., programs retained in the relatively high-speed energy-backed SRAMs can be ready immediately for use without a need to wait for memory reload).

PHASE I: 1) Investigate alternative approaches to providing a single-package, radiation-hardened, energy-backed SRAM. 2) Investigate relative implementation difficulty, including impacts on boards and systems, of alternatives. 3) Assess relative performance and qualities, including life time and reliability, of alternatives and compare to typical spacecraft needs. 4) Select the (mutually agreed upon) leading alternative SCES configuration for prototype implementation. 5) Develop a preliminary design and provide a breadboard demonstration of operational principles.

PHASE II: Complete final prototype design of selected SCES and fabricate multiple copies of prototypes to evaluate critical characteristics. This design should be as faithful as possible to an expected production version of the selected concept in order to maximize the applicability of test results. Test prototype SCESs to mutually agreed specifications, to demonstrate as many key characteristics as possible given limitations of the prototype with respect to a production version of the design.

PHASE III DUAL USE APPLICATIONS: This technology will be useful for DoD/ commercial satellite applications to minimize service outages due to on-orbit events temporarily disrupting power.

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1. Benchmarq Microelectronics, Inc., "bq4017/bq4017Y 2048Kx8 Nonvolatile SRAM," product description (May 1995).
2. Dallas Semiconductor, "DS1270Y/AB 16M Nonvolatile SRAM," product description (April 1998).
3. Honeywell Space Systems Group, "Non-Volatile Memory for Technology and Producibility Assessment Review," prepared for Follow-on Early Warning System (FEWS), preliminary version (25 May 1993).

KEYWORDS: energy backed SRAM, microelectronics, non-volatile SRAM, radiation hardened SRAM, self-contained energy source (SCES), static random access memory (SRAM)

AF00-054 TITLE: Low Power Field Programmable Technology

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop the basic technology and architecture of a low-power, high-speed based field programmable devices.

DESCRIPTION: Field programmable technology enables circuit designers the ability to configure hardware to perform specific functions as needed. Commercially, Field Programmable Gate Arrays are extensively used as prototyping and initial production devices. The ability to configure existing hardware can save non-recurring costs for satellite and other manufacturers. Field programmable technologies can either be one-time, permanent configurations, or reconfigurable. Field programmable technologies could be applied to arrays of programmable logic (as in conventional Field Programmable Gate Arrays) or to the connections between more complex fixed logic elements, or to connections between arrays of analog functional blocks, as well as combinations of the above. Desirable qualities include high speed, low power, ability to meet a variety of applications, and applicability to utilize generally available manufacturing processes (silicon and non-silicon). For space use, insensitivity of the programming technology to single event effects (high energy particle strikes, for example) is required and low power is very important. Tolerance to ionizing radiation is also important for space use. For other potential markets, high performance is most critical. Due to the small size of the space market, synergy with commercial markets and processes is important. Development of this technology will contribute to "System-On-A-Chip" concepts that enable fewer components to perform a given function at lower cost, reduce non-recurring costs for prototype and limited production systems, and reduce turnaround times for equipment redesign and upgrade.

PHASE I: Develop a flexible field programmable technology concept, including process concept and utilization concept(s). Determine how the devices will be integrated into existing fabrication processes with little or no modification to the process. Determine how the devices will be integrated into usable architectures to form new products or reduce component counts on existing products.

PHASE II: Fabrication of working programmable structures and devices, including test structures for proof of concept and evaluation, and possibly small-scale product prototypes. Refine and improve manufacturing techniques and application techniques for the technology. Evaluation of structures and devices

PHASE III DUAL USE APPLICATIONS: Prototyping, limited production systems, field upgradeable systems, reconfigurable computing and processing. Limited production systems notably include military, civil, and commercial space electronics. Field upgradeable and reconfigurable computing and processing will also have applications in space.

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2. A. Haines, "Field-Programmable Gate Arrays with Non-Volatile Configuration", Microprocessors and Microsystems, Vol. 13, No. 5, pp. 305-312, June, 1989.
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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-055 TITLE: Space Qualified, Low Cost Compact Disk Data Storage/Retrieval System

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Demonstrate that commercial, formatted, CD/Mini disk recorders can be ruggedized/configured as spacecraft compatible, long life, data storage/retrieval mechanisms.

DESCRIPTION: Digital Compact Disk (DCD), and Mini Disk Recorders/Players use low cost magnetic media and electronics to record/transmit low to moderate Gigabits of data at medium data rates. A vast installed base of commercial hardware assures well exercised logic and control electronics; this same installed base assures robust media, low cost/extensive reliability statistics. Consumer implementation is focused on analog processing, but the core of the commercial Compact Disk/Mini Disk is digitally processed. Although conventional transport hardware and control electronics are in place for the consumer electronics market, the application of this technology in space requires conversion to more robust systems. Space use demands low weight, low power consumption devices that can survive the high shock/vibration of launch, years of low activity, no maintenance, high reliability, radiation hardness, large temperature excursions, and the rigors of a vacuum environment. Advanced electromagnetic bearing technology with integrated, low coging motors may provide the basis for a high reliability transport mechanism that is suitable for space environment. Development of this technology with control algorithms and associated electronics is needed to coordinate the electromagnetic actuators with the storage device. Space qualified transport mechanisms will require re-fitting conventional bearings and drive motors with enhanced electromagnetic devices based on state-of-the-art magnetic bearing technology. The standardized commercial formats for data storage should be maintained to the largest degree possible, including the physical characteristics of both the media and transport mechanisms. A flexible control interface system is required to handle format conversions from commercial storage format to a spacecraft compatible format. The control system should be capable of handling transport control as well as data transfer. Firmware developed for this program should provide a seamless interface between the spacecraft format and the drive's native format. For space application, a pure digital interface is required. Protocol and data format translation between the commercial device and established spacecraft format should be considered.

PHASE I: Evaluate commercially available DCD/Mini disk transport mechanisms and their potential for successful conversion to spacecraft use. Develop a conceptual electromagnetic based transport mechanism design. Design and prototype a combined motor/electromagnetic bearing and demonstrate its suitability for DCD/Mini disk transport mechanism application.

PHASE II: Design and retrofit a commercial transport mechanism with electromagnetic devices and appropriate control electronics. Demonstrate the modified transport mechanism and analyze a full-up model of the device to compare size, weight, power consumption, reliability and other appropriate parameters to space-based application requirements.

PHASE III DUAL USE APPLICATIONS: DCD/Mini Disks are natural candidates for low cost, pure digital storage/retrieval application in DoD and commercial space requirements. Digital still and video photography is just emerging as a consumer item. Photo/video transport--on the Internet, video conferencing and telephone--is finding acceptance in commercial application. The demonstration of a space grade, low cost, rugged, digital storage device could establish a new standard for consumer and commercial markets.

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2. Peal, K. R., Prada, K. E., "Optical Disk Recorders in Arctic Instrumentation," Woods Hole Oceanographic Institution, MA, Report WHOI-CONTRIB-7411, 26 Sep 90, 7p. NTIS: AD-A229315/7, Order NTIS at 1-800-553-NTIS.
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KEYWORDS: control electronics, data storage/retrieval mechanisms, digital compact disk, digital interfaces, general purpose recorders, transport hardware

AF00-056 TITLE: Long Life, High Efficiency Pulse Tube Cryocooler

TECHNOLOGY AREAS: Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop, design and demonstrate a miniaturized, high efficiency, long life pulse tube cryocooler.

DESCRIPTION: Satellite-based infrared systems require cooling to temperatures of 77K or lower for high sensitivity discrimination. Ideal satellite-based cryocoolers have a life of 10+ years, are compact, operate efficiently, and are vibration free. None of today's cryocooling technologies meets these requirements: 1) (Staged) thermoelectric devices are inefficient. 2) Stirling cryocoolers offer efficiency and small size, but they demonstrate substantial (cryo-side) vibration and have too short a life, primarily due to their use of moving parts in the cryogenic zone. 3) Pulse tube cryocoolers demonstrate long life (no moving parts in the cryo-zone) and create minimal cryo-side vibration; they do not, however, provide the cooling capacity and efficiency of Stirling cryocoolers when miniaturized (e.g. on the order of 100's of milliwatts). In addition, some pulse tube cryocooler configurations do not lend themselves to the "cold finger" (cryostat) geometry favored in satellite IR (Infrared) systems. The purpose of this R&D effort is to improve the satellite dedicated cyrostat geometry, cooling capacity and efficiency of miniaturized pulse tube cryocoolers, making them superior to Stirling cryocoolers. Potential areas of investigation (among others) include: a) recovery of cold expansion work and implementation of a split compressor cycle to increase efficiency and cooling capacity, and b) development of an "L" shaped pulse tube configuration to improve "cold finger" access.

PHASE I: 1) Investigate Pulse Tube Cryocooler deficiencies in relation to satellite application requirements. 2) Devise innovative methods of improvement. 3) Design, develop, and demonstrate the feasibility of a breadboard prototype miniaturized pulse tube cryocooler suitable for efficient, vibration free, long life satellite application.

PHASE II: 1) Finalize design and build a prototype miniaturized Pulse Tube Cryocooler for satellite application. 2) Demonstrate prototype to mutually agreed specifications. 3) Finalize design of a flight-ready Pulse Tube Cryocooler suitable for satellite application.

PHASE III DUAL USE APPLICATIONS: Many DoD/commercial satellite applications (e.g. communications, weather) would benefit from the availability of a miniaturized, efficient, long life cryocooler.

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KEYWORDS: "cold finger" (cryostat) geometry, cooling capacity, cryo-side vibration, pulse tube cryocooler, stirling cryocoolers, thermoelectric devices

AF00-057 TITLE: Techniques for Assessing Approach for Migrating to Different Processors

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop techniques for assessing approach for migrating between different computer processors.

DESCRIPTION: The capability to introduce technologically advanced computer processors in an embedded system has become even more difficult to obtain with the rapid development and introduction of higher capacity processors in the market. Typically, an embedded system developer must assess the impact of introducing a different processor into a target system and must repeat the same assessment every time a potential new processor is identified. This process will occur more frequently with the expected increase in both the commercialization of military products and the adoption of commercial products for military use. In this project, a technique will be developed to efficiently assess all the factors affecting a target system during the migration to different processors. A template methodology (generic approach) shall be derived with directions on the critical processes under evaluation.

PHASE I: Identify both the critical and non-critical factors on migrating to different computer processors in an embedded system. Analyze the relationship between these factors and their effect on the migration process; utilize data from previous migration efforts in the commercial sector for these analyses. Air Force assistance will be available to obtain data to be analyzed from the military sector. Use the analysis results to develop/demonstrate one or more techniques that will increase the efficiency of the migration process.

PHASE II: Finalize development of all required migration techniques. Coalesce all the techniques developed into a single template methodology (generic approach). Provide the embedded system user with directions on the critical processes to follow in the migration process. Develop the capability for the user to extend the template methodology by enabling tailoring to specific processors. The result shall indicate the probability of success and the associated risks when migrating to a specific processor. Develop a standard which will allow for easily capturing processor-specific data for input into the methodology. The final product will be a prototype graphical tool executable in different computer platforms which will implement this methodology. Demonstrate the final prototype graphical tool to a mutually agreed specification.

PHASE III DUAL USE APPLICATIONS: The methodology developed under this project will benefit the military and commercial embedded system user in migrating from one processor to another. This benefit is magnified by the expected increase in both the commercialization of military products and the adoption of commercial products for military use.

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KEYWORDS: computer processors, critical and non-critical factors, embedded system, migration to different processors, target system, template methodology

AF00-058 TITLE: High-Speed, Radiation-Tolerant Glue Logic

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop generic radiation-tolerant glue logic devices for space systems applications.

DESCRIPTION: Glue logic circuit(s) (GLCs), such as line drivers, latches, buffers, multiplexers, etc., comprise a substantial percentage of the part types in DoD and commercial spacecraft architecture, but are frequently overlooked during component development in favor of the microprocessors, signal processors, ADCs, and memory. The speed of many spacecraft functions is frequently determined by the performance of these GLCs. The relative simplicity of the GLCs allows their implementation as radiation-tolerant commercial Application Specific Integrated Circuits (ASICs) with general applicability to multiple space systems. This approach allows exploitation of the performance available from advanced radiation-tolerant foundry processes that can (through novel circuit design and cell layout) ensure immunity to single-event upset (SEU) and single-event latchup (SEL) in the space environment. A need exists to identify a radiation-tolerant ASIC design methodology that employs high-performance commercial foundry processes that ensure the manufacture of high speed GLC ASICs with substantial total dose tolerance immunity to SEU and SEL.

PHASE I: . Develop innovative approaches using developing technologies (such as LVDS and system-on-a-chip) to perform glue-logic functions and increase throughput rates. Select (with AF assistance) a typical spacecraft or payload architecture and identify at least six specific "glue logic" functions as candidates with emphasis on high-speed data transfer technologies. The techniques selected for study must be amenable to implementation as a radiation-tolerant ASIC Design one candidate part type using a radiation-tolerant ASIC methodology, and can be manufactured in a radiation-tolerant foundry process, with a goal total dose tolerance greater than 100 krad(Si), SEU immunity better than 1E-3 error/day in the Adams 90% worst-case environment, and SEL linear energy transfer threshold better than 60 MeV-cm2/mg.

PHASE II: Use the techniques explored in Phase I to design a candidate part to perform the glue-logic function as radiation-tolerant ASICs, and manufacture them in at least two radiation-tolerant foundry processes. Demonstrate the ASICs to the same radiation tolerance goals and specific speed performance goals as in Phase I.

PHASE III DUAL USE APPLICATIONS: This enabling technology effort develops the means to apply existing commercial CMOS foundry services to the manufacture of radiation tolerant hardware for space. The successful completion of this effort will make high-performance commercial microelectronics technologies available for both commercial and military space applications.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-059 TITLE: On-Board Intelligent Software for Spacecraft Autonomy

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop intelligent on-board autonomous satellite cluster control.

DESCRIPTION: Control of a spacecraft is costly in terms of number of operators, their training, and operations that run 24 hours, 7 days a week for the lifetime of the satellite. For a cluster of cooperating satellites the operations complexity is magnified. Based on existing technology (processors, memory, software, sensors), it is timely to develop the architecture and algorithms for on-board autonomous spacecraft cluster control and management. This involves both functions on-board a single satellite such as thermal management, power balancing, attitude determination and control, and payload control and inter-satellite functions such as communications, redundancy management, and distributed processing. From the ground perspective this requires an on-board cluster architecture which allows for the command and control of the cluster as opposed to individual satellites. On-board autonomous control of satellites provides benefits by: a) reducing the size of the ground crew; b) reducing the required bandwidth of the satellite-to-ground link; c) decreasing the need for scheduled or dedicated ground assets (antennas, control stations); d) handling complexity; e) being able to reuse the intelligent controller; and f) reducing cost. Development of an on-board control system for on-board subsystems must include functional control over state-of-health monitoring and maintenance, thermal control, power balancing, intelligent payload control, and automatic ephemeris generation, among other application-specific functions. Technologies such as model-based reasoning, case-based reasoning, diagnostic reasoning, fault tolerance, and intelligent agents may be useful development tools. Requirements (among others) for such a system include: high reliability, concurrent activity, ability to meet hard constraints and deadlines, system validation, adaptation to changing environments, cooperative/collaborative behavior, goal execution, reprogrammability, ability to respond to (ground or other) interrupts, graceful degradation, and intelligent data and information management. The intelligent system must communicate with other satellites, sensors, ground controllers, and other systems. It must be able to reason about time, context, location, and have the ability to learn, plan, and adapt.

PHASE I: 1) Create prototype designs for the architecture/ algorithms required for autonomous satellite cluster control and maintenance (based upon a thorough knowledge of the research approaches previously taken by NASA and the Commercial satellite industry from both intra- and inter-satellite perspectives). 2) Based on a minimum of three satellites select two to three generalized subsystems, one of which must be a payload, in which to apply the architecture/algorithms, define the requirements/constraints, develop a risk assessment and validation strategy, and demonstrate/validate a preliminary cluster control system. To ensure the prototype system meets Air Force objectives the preliminary architecture will be mutually agreed upon by the contractor and the government technical representative prior to implementation. An example of an acceptable payload from which to demonstrate the cluster control architecture would be a surveillance payload where payload data is shared across the cluster.

PHASE II: Develop/finalize/build the architecture/algorithms required to provide an on-board autonomous cluster control system covering at least three satellites and two to three subsystems, one of which is a payload subsystem. The developed prototype will integrate ground control with on-board cluster control. Develop an operations plan for how the system would be used and how the existing system might be transitioned to the autonomous system. Assess the risk of the proposed autonomous system, identifying critical and non-critical operations, and develop a plan to mitigate that risk (e.g. redundancy, ground-based backup, on-board diversity). Demonstrate/validate the architecture/algorithms of the autonomous, on-board cluster control system (to mutually agreed specifications).

PHASE III DUAL USE APPLICATIONS: On-board autonomous spacecraft control can be a significant cost saver for both commercial and military spacecraft. The capabilities that are developed for an on-board system may also be relevant for ground stations and mobile platforms (e.g., van-based satellite control, ships), as well as for control of complex terrestrial systems that need to be automated (e.g., ocean-based oil rigs, equipment operating in severe weather locations).

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-060 TITLE: RH (Optical) Microcircuit Interface

TECHNOLOGY AREAS: Information Systems. Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop ASIC chips capable of increased signal throughput.

DESCRIPTION: Application Specific Integrated Circuit (ASIC) gate counts have been growing exponentially with shrinking feature size, and in order to accommodate the large amount of input/output (I/O) associated with higher gate counts, the ASIC pin counts have increased significantly in recent years. Both commercial and space electronics are rapidly reaching the point at which it will be no longer feasible to conventionally route all of the needed signals through the microcircuit package pins. It is evident that the single line Internet idea, and its protocols, can be applied to reducing the number of pins in ASIC designs; that is, serialization of groups of slow speed signals can be implemented. Of course, protocols will have to be defined for different types and rates of serial ports. These ports, embedded into the microcircuit package, should offer the opportunity to alleviate the pending connectivity shortfall. It is envisioned that groups of signals (like control, address, data) will need to be formatted then routed out of the chip through a transmitter. This high speed line could be electronic or optical. At the receiving device, a "receiver deformatter" would extract the values (states) of many signals. On-chip formatting and deformatting will entail embedding additional logic to accommodate the necessary protocols, but this real estate should be very small compared with the savings in number of pins. The testing of the chips should also be addressed by these implementations.

PHASE I: Define and propose several data format standards and protocols. Explore ASIC on-chip processing options to prepare data for transfer. Prepare simulations and timing analysis. Design an innovative rad-hard (RH), high speed and Single Event Upset (SEU) immune interface (electronic or optic) utilizing the design rules and chip technologies of well known rad-hard foundries to create an entire design and layout activity (i.e. Honeywell Complimentary Heterostructure Field Effect Transistor [CHFET] GaAs technology).

PHASE II: The contractor should work closely with a selected foundry to embed the designed interface into several prototype ASICs chips and demonstrate consequent pin-saving solutions.

PHASE III DUAL USE APPLICATIONS: ASIC chips, capable of increased signal throughput, are applicable/ desirable in almost any electronic assembly.

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KEYWORDS: application specific integrated circuit (ASIC), complimentary heterostructure field effect transistor, gate counts, increased signal throughput, pin counts, rad-hard foundries, single event upsets

AF00-061 TITLE: High Speed RH Level-2 Cache

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MC)--Military Satellite for Communications (MILSATCOM)

OBJECTIVE: Develop RH, SEU immune level-2 cache chips to reduce memory access time.

DESCRIPTION: The need for faster access time for program and data continues to grow with processor speed. Most integrated processor architectures already include a "cache on the chip" to accelerate the fetching of instructions and the read and write of data to and from memory. A second cache is becoming common on commercial computers; this "level-2 cache," as it is called, is placed between the processor and the memory with the goal of reducing the memory access time. An example of this, for

Pentium and PowerPC chips, is the Mitsubishi M5M5V1132A 1Mbit synchronous. This and other similar parts existing or in development for commercial use do not meet needs of space users, most notably in the areas of radiation hardness (both ionizing dose and single event effects), high reliability, and low power.

PHASE I: Investigate feasibility of high speed, very low power synchronous RAM technology using innovative space-qualifiable processes. Device design should address the widest possible range of application to present and future space computer systems. Fabrication technologies to realize the design could include upcoming hardened CMOS processes, including Silicon On Insulator (SOI), modifications of commercial technologies for use in radiation environments, or other processes with radiation hardening potential such as complementary GaAs.

PHASE II: Develop detailed design strategies for implementation of memory device(s) at one or more foundries able to produce space-qualified microelectronic components. Fabricate proof-of-concept components for evaluation of environmental and performance characteristics.

PHASE III DUAL USE APPLICATIONS: Development of RH and SEU immune level-2 cache chips or level-2 cache on chip architectures would be employed on practically any DoD/commercial space-based computer to reduce memory access time.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-062 TITLE: <u>Effective Low-Temperature p-type Doping for HgCdTe IR Photodiodes</u>

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MT)

OBJECTIVE: Develop effective p-type doping of HgCdTe at low temperatures, and use it to develop p/n HgCdTe LWIR detectors with improved performance.

DESCRIPTION: The US Air Force is actively pursuing the development of high performance p/n HgCdTe long-wave infrared (LWIR) detectors for several applications. Growth of HgCdTe by molecular beam epitaxy (MBE) is being established as an important growth technique for these detectors, since it is a low temperature process and leads to sharp interfaces. In the p-on-n photovoltaic devices, the cap layer is usually doped with As because of arsenic's relatively low diffusion coefficient. However, at low temperatures, As atoms go into the Hg lattice sites, where they act as donors, leading to n-type HgCdTe cap layer. Activation anneals at temperatures of about 400C are needed to make the cap layer p-type. This procedure makes the sharp interfaces (obtained due to low temperature MBE growth) become diffuse, and degrades the device performance. Hence there is a need to develop effective p-type doping of HgCdTe at temperatures less than the currently used activation anneal temperature of As.

PHASE I: Develop/demonstrate the ability to obtain high quality p-type films of HgCdTe at temperatures significantly less than the currently used activation anneal temperature of As.

PHASE II: Optimize the p-type dopant element and doping process in order to obtain p/n HgCdTe LWIR detectors with quantum efficiency and zero-bias resistance better than that of As doped detectors annealed at 400C. Develop at least two (2) lots of detectors, evaluate their performance, and make the detectors available for government verification of improved performance.

PHASE III DUAL USE APPLICATIONS: Military applications of this innovation include improved surveillance and threat warning capabilities (the ability to detect fainter objects at greater distances). Commercial applications include industrial and auto- emission monitoring, tumor detection, environmental monitoring, fire and volcano detection etc.

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KEYWORDS: HgCdTe, LWIR detector, arsenic, infrared, molecular beam epitaxy, p-type dopant

AF00-063 TITLE: Multi-waveband Interconnect Technology

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MT)

OBJECTIVE: Develop interconnect technology between multi-waveband detector layers of a large-format detector array and its corresponding readout array which preserves detector fill-factor.

DESCRIPTION: Space-based platforms which host infrared (IR) sensors for the purpose of acquiring and tracking cold objects in space constitute one component of a national missile defense system. At large acquisition distances, such objects--possibly missile warheads, dummy warheads, or complicated decoys--can be tracked, but will not be spatially resolvable by the IR sensors. However, these potential targets will produce blur spots which contain spectral information that may be exploitable for purposes of object discrimination. In recognition of the value of simultaneously acquired, spatially co-registered spectral information, stacked dual-waveband IRFPAs have already been developed. A significant hurdle to the extension to three or more wavebands is the limitation posed by conventional interconnects (viz., indium bump bonding) between the detector and readout arrays. These indium bumps take up space and reduce detector fill-factor.

PHASE I: Develop/demonstrate the capability to achieve mechanical and electrical interconnection between stacked, multi-waveband detector arrays and their corresponding readout arrays while preserving greater than 85% fill factor in all detector wavebands.

PHASE II: Finalize interconnection methodology and demonstrate its approach by fabricating a large format (at least 64x64) multi-waveband (at least three wavebands) detector/readout array. Simulated detector and readout arrays would prove adequate for this demonstration; the goal is demonstration of innovative interconnection technology, and not the development of multi-waveband detector arrays or readout arrays.

PHASE III DUAL USE APPLICATIONS: Military applications of this innovation include discrimination of point targets in acquisition and tracking sensors onboard space platforms or interceptor seekers and background/clutter rejection for imaging sensors. The availability of affordable multi-waveband IRFPAs will enable commercial providers to offer IR spectral imagery of earth for environmental monitoring and natural resource management.

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KEYWORDS: detector array, focal plane array (FPA), infrared (IR), interconnection, multi-waveband, readout array

AF00-064 TITLE: Advanced Cryocooler Technology

TECHNOLOGY AREAS: Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center (SMC/MT)

OBJECTIVE: Develop/demonstrate cryocooler technology for next generation spacecraft cooling applications.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require revolutionary improvements in cryocooling technology and revolutionary improvements in performance and ease of integration in order to meet projected requirements for high duty cycle heat loads, cryogenic component redundancy with low parasitic heat penalties, long cryogenic transport distances, highly flexible cryogenic transport, and versatile components with multiple applications at different cryogenic temperatures.. Exploitation of technology with minimal to no moving parts, minimal mass, minimal input power, minimal vibration, high efficiency, high reliability, and that meets advanced cryogenic needs for thermal storage, thermal transport, thermal switching, ease of integration, integrated cryocooler and cryogenic thermal management concepts, and reduction of thermal contact resistance are essential to meet cryocooling goals for increasingly compact/higher density Air Force and Department of Defense infrared sensing payloads. Specific interests include, but are not limited to advance thermoelectric coolers, low temperature (between approximately 10 and 20 K) regenerators, advanced regenerator technology and modeling, laser or fluorescent cooling, cooling across a gimbaled joint, continuous sorption cooling, single and dual volume cryogenic thermal storage units, passive and active cryogenic thermal transport systems, mechanical and gas-gap cryogenic thermal switches, cryogenic integration schemes, and cryogenic high thermal conductivity and low thermal contact resistance interface materials. In addition to these needs, producibility, reliability, and manufacturability are important to AF, DoD and commercial applications.

PHASE I: Phase I SBIR efforts should concentrate on demonstrating the adaptation of an innovative technology in a breadboard format. This should include demonstration of a fundamental physical principle in a format that illustrates how this technology can be utilized in a cryocooler. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Phase II SBIR efforts should take the innovation of Phase I and design/develop/construct an operational prototype device or cooler. This device may not be optimized to flight levels, but should demonstrate the ability of the working prototype device to meet mutually (Air Force/contractor) agreed operational specifications. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort.

PHASE III DUAL USE APPLICATIONS: Applications of this technology could potentially be far reaching. Typical AF and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Including NASA, civil, and commercial users, user applications include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. If the developed innovation is low cost, potential applications include CMOS (Complimentary Metal-Oxide Semiconductor) cooling of workstations and personal computers.

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KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-065 TITLE: Low Cost Miniature Flight Control System

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop and demonstrate a low cost, lightweight, miniature flight control system capable of performing guidance, navigation and control functions for small launch vehicles.

DESCRIPTION: AFRL/VS is interested in developing innovative new concepts for a lightweight, low cost, miniature flight control system capable of performing guidance, navigation and control functions for small launch vehicles. The Air Force is currently evaluating the reuse of certain classes of missiles within its inventory for the launch of small satellites. In addition, the Air Force is evaluating the use of reusable launch vehicle technology for launch on demand applications. As part of this evaluation, new technology concepts are being considered to decrease overall life-cycle cost and to upgrade and enhance system performance. One area of possible consideration is the development of low-cost, lightweight, flight control systems consisting of miniaturized avionics to perform the guidance, navigation and control functions of small launch vehicles. The preferred system would be developed with Commercial-Off-The-Shelf (COTS) parts to minimize overall cost and decrease fabrication time. The system must be designed to withstand launch loads or address how vibration isolation and thermal management will be handled to insure survivability.

PHASE I: Develop preliminary design, identify potential components, and conduct preliminary analysis to show packaging and system survivability.

PHASE II: Finalize design, develop prototype hardware, and conduct demonstration tests.

PHASE III DUAL USE APPLICATIONS: A successful product could be used in any of the SMC small launch vehicle programs, the orbital maneuver vehicle, and other small, inexpensive launch vehicles. Commercially, the system could be used on any number of new, small inexpensive launch vehicles developed in the past decade or currently in development. Currently, SMC is in the process of converting some ICBM assets to launch DoD payloads. The current flight control systems for these ICBM assets are outdated and heavy and need to be replaced with low cost and lightweight systems. There is also a potential market for DoD, NASA, and commercial reusable launch vehicles such as the Air Force's Space Maneuvering Vehicle, NASA's X-34 and X-38, Lockheed Martin's X-33, and Kistler's K1.

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KEYWORDS: GN&C, avionics, flight control, guidance, low cost, navigation

AF00-066 TITLE: Inflatable Structures for Lightweight Solar Arrays

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop concepts for inflatable masts for microsatellite deployable solar arrays (0.5-2 kW).

DESCRIPTION: Future large spacecraft missions may be accomplished through the use of collaborating constellations of microsatellites. These multiple satellite constellations are conceptualized to included small 1 kW satellites that can be packaged in very small volumes for launch and deploy on orbit. Several of these concepts include flexible solar energy generation structures that must be deployed from a very small package. Inflatable booms, with possible inflatable substrates, are being baselined for this mission due to their small stowed volume. One prominent concept of this type is the TechSat 21 concept which utilizes an inflatable cylindrical mast and a flexible solar array blanket. Other concepts include an inflatable mast and solar cell substrate for support of flexible thin film arrays. Several challenges still exist toward the development of such a mast including controlled deployment and downward scalability of the inflatable mast structure. The inflatable masts must have very small storage volumes, gentle & controlled deployment (bearing in mind the sensitivity of many array technologies), potential rigidization after deployment, high post deployment stiffness, and, if possible, high post deployment damping.

PHASE I: Develop inflatable boom concept and prove its ability to be analyzed and fabricated.

PHASE II: Fabricate full-scale structure for deployable mast, designed around an AF mission need for possible flight demonstration. Develop all necessary analysis, design and manufacturing methods to apply the new concept to space vehicle applications.

PHASE III DUAL USE APPLICATIONS: Potential commercial applications for this technology include all future commercial microsatellite space systems for space-based sensing and communications. Potential DoD applications include all future DoD microsatellite systems including space concepts like TechSat21. This technology will result in lighter, cheaper and more reliable DoD satellites and spacecraft.

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KEYWORDS: MicroSats, TechSat21, energy generation, flexible solar array, inflatables, solar cell substrate

AF00-067 TITLE: Integrated Payload Dispenser for Multi Micro-Satellite Missions

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop advanced dispenser technologies for Micro-Satellites that will reduce the spacecraft life-cycle-costs.

DESCRIPTION: Despite growing worldwide interest in small satellites, launch costs continue to hinder the full exploitation of small satellite technology. In the United States, the Department of Defense (DoD), NASA, other government agencies, commercial companies, and many universities use small satellites to perform space experiments, demonstrate new technology, and test operational prototype hardware. In addition, the DoD continues to study the role of small satellites to fulfill operational mission requirements. However, US government agencies are restricted to the use of US launch vehicles, which eliminates many lucrative launch opportunities. Additionally, many small satellite users are faced with shrinking budgets, which limits the scope of what can be considered an "affordable" launch opportunity. In order to increase the number of space experiments that can be flown with a small, fixed budget, the government needs to develop a low-cost solution for the small satellite launch problem. An increasing number of DoD small/micro satellite programs could be launched on a single launch vehicle through the development of an integrated adapter. The Air Force has a need to develop advanced innovative technologies that can be integrated into a multi-satellite dispenser for micro-satellites. Existing technologies may not be able to meet mechanism requirements for future DoD micro-satellite programs. The use of pyrotechnics, for example, will expose fragile sensors and electronics to high shock levels, and sensitive optics might be subject to contamination. The dispenser shall accommodate 2 to 10 satellites of 40 to 150 lb. Technologies of interest include on-board propulsion, dispenser isolation, non-pyrotechnic satellite release systems, and composite materials. The technologies that are to be developed need to address issues such as reliability, safety, weight, reduced part count, low cost manufacturing and integration, and the ability to meet requirements of that spacecraft. It is desired that one or a combination of these advanced technologies be integrated into the dispenser.

PHASE I: Conduct supporting analysis for an innovative dispenser incorporating advanced technologies for micro-satellites. Define the problem---this includes specifications of the environment to be attenuated, and any potential restrictions or limitations faced in the implementation of the technology or technologies with the launch vehicle and satellite manufacturers. State system-level performance goals and develop system component/system-level conceptual designs. Analytical and simulation results will be presented to demonstrate performance of the system.

PHASE II: Perform component and ground tests to demonstrate and validate the concept developed in Phase I. Design, fabricate, and test a full-scale demonstration for evaluation. Phase III will provide a commercial dispenser system for flight demonstration.

PHASE III DUAL USE APPLICATIONS: Currently, there are a growing number of small/micro satellites being launched by the government and universities to support small space experiments. However, the launch industry has not adapted to this sudden shift in paradigm from the large single payload to several small payloads. In order to reduce soaring launch costs, DoD, NASA, and the commercial sector have a need to launch multiple small satellites on a single launch vehicle. Military applications include programs such as TechSat 21, XSS-10, and the Air Force's "Space Test Program"; commercial applications include the small/micro satellites, university payloads, and experiments that are now being launched.

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KEYWORDS: composites, deployment, low cost, mechanisms, multi-functional, multiple payloads, separation, spacecraft

AF00-068 TITLE: Miniaturized Vibration Isolation System (MVIS)

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Demonstrate a miniaturized, retrofittable isolation system to provide 14-20 dB (5:1 - 10:1) RMS reduction in transmitted vibration load to satellite payloads from the spacecraft bus.

DESCRIPTION: AFRL/VS is interested in developing innovative new concepts for a miniaturized vibration isolation system. The motivation is based on previous experiences where vibration of satellite optical systems due to on-board disturbances--such as reciprocating cryocooler components, solar panel gimbals, and attitude control system actuators such as reaction wheels--can seriously degrade the performance of such systems, consequently jeopardizing mission capability. These problems are often not detected until late in the design process for the system, where the costs of a system redesign are high, both financially and in terms of slipped schedules.

The resulting system is intended to be a retrofittable solution for payloads that discover during integration and testing that vibration loads from the spacecraft bus exceed their operating tolerance. The device is envisioned to be ultra-low profile, requiring less than 1.5 inches of clearance between the component to be isolated and its mounting surface. The proposed solution must have a passive baseline system in parallel with an active component for low-frequency isolation. Design emphasis must also include low power consumption and light weight. The system must also be able to withstand launch loads without latching or any other form of launch restraint system.

Micro-controller technology developed under a parallel AFRL program will be considered as potential GFP in the Phase II effort to decrease costs. System hardware design must show ability to be space qualified.

PHASE I: Complete preliminary hardware design of the hybrid passive/active actuator. The preliminary design must also include control system development and simulation results.

PHASE II: Develop prototype hardware and control system and demonstrate in a realistic environment.

PHASE III DUAL USE APPLICATIONS: Flight demonstration. A candidate optical system will be identified and the MVIS system will be offered as a retrofittable solution. Potential military applications include isolation for interceptors, surveillance, imaging, etc. Commercially, the system could be used on any number of new commercial imaging satellites to better stabilize the camera system. This technology can be used wherever a low-profile isolation system is required to meet system requirements.

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KEYWORDS: active vibration isolation, active/passive hybrid, low cost, low power, low profile, miniature, passive vibration isolation, retrofittable

AF00-069 TITLE: High Power. High Rate Launch Vehicle Batteries

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Demonstrate feasibility of new launch vehicle battery technology that would replace Silver Oxide/Zinc batteries used in launch vehicles.

DESCRIPTION: In the space battery arena, there has been a significant push toward designing and producing lighter, more robust, higher energy density batteries. This level of effort is not surprising when one considers that it can cost upwards of

$40,000 per kilogram of payload to launch a satellite into a geosynchronous orbit, and that every kilogram by which the mass of the power system is reduced can result in an additional kilogram of satellite payload. While the majority of research has been in the area of satellite batteries, launch vehicle battery improvements could also yield increases in satellite payloads. Furthermore, current AgO/Zn launch vehicle batteries have significant problems, such as a very limited wet shelf life, poor cycle life, and high cost of cell components. The Air Force is interested in new launch vehicle battery technologies that meet or exceed the power density and the volumetric and gravimetric energy densities of AgO/Zn. These new batteries will also need to be capable of high rate discharges. In addition, a wet shelf life of at least 6 months is needed (compared to approximately 15 days for AgO/Zn), and a wet shelf life of several years would be preferable for military applications. Finally, a rechargeable system, while not required, is highly desirable.

PHASE I: Investigate potential chemistries for launch vehicle batteries. Demonstrate feasibility of concept with small capacity cells.

PHASE II: Initial optimization of chemistries identified in Phase I. Place several cells in several configurations on test (storage, shelf life, and sample mission profile). Identify industry partners interested in producing and commercializing final product.

PHASE III DUAL USE APPLICATIONS: With satellite launches increasing greatly, a large market exists for launch vehicle battery technology. Because the commercial sector produces those launch vehicles, they could be very interested in advances in the technology. Further, the military is trying to maintain its fleet launch vehicles, and battery upgrades may be necessary for that effort.

REFERENCES: Linden, David. Handbook of Batteries, 2nd ed., McGraw-Hill, New York, 1995.

KEYWORDS: battery, energy storage, launch vehicle, small capacity cells, space power, wet shelf life

AF00-070 TITLE: Advanced Space Particle Detectors for Microsatellites

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: Develop innovative and miniaturized charged and neutral particle detectors for microsatellites

DESCRIPTION: In-situ measurements of the near space environment are fundamental to situational awareness, mission planning, and improved performance of satellite, surveillance, communications, and navigation systems. The Battlespace Environment Division has requirements for measuring space particles ranging from meteoroids to thermal plasma to extremely relativistic ions, electrons and neutrals. This SBIR Topic seeks innovative and miniaturized instruments and techniques to measure space particles with a strong emphasis on suitable designs for micro-satellites (defined to be a satellite with much less than 100 kg total payload weight). Laboratory hardware needed to support the design and calibration of space particle detectors is within scope.

PHASE I: Develop conceptual designs or bench level prototype devices that can establish proof-of-principle for a detector. The Phase I results should allow for accurate estimation of the scope and cost of a flight test experiment. Designers should consider such issues as autonomous operation and scalability. The potential for application on both conventional and microsatellites should be addressed.

PHASE II: Develop and demonstrate a working prototype of the device or system. This prototype may be a complete flight-ready system depending on the complexity and result of the Phase I study. The contractor may assume that the USAF will provide access to space for flight-ready systems. At a minimum, the Phase II effort should provide a proof-of-principle demonstration of operational capability in the lab or, preferably, space. Commercial viability must also be established as a prerequisite to Phase III continuation.

PHASE III DUAL USE APPLICATIONS: In Phase III the prototype shall be developed to meet the requirements of power, size, weight, lifetime, volume, efficiency and cost necessary for a commercially viable product. Example applications include military microsatellites and civil/commercial satellites requiring data for anomaly resolution.

REFERENCES: "Compact Environmental Anomaly Sensor (CEASE): A Novel Spacecraft Instrument for In Situ Measurement of Environmental Conditions", IEEE Trans. On Nuc. Sci. Vol 45, NO 6, Dec 1998.

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-071 TITLE: Spacecraft Charge Control Technology

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop detection and mitigation techniques for spacecraft charging.

DESCRIPTION: The survivability of both DoD and commercial spacecraft and mission success can be threatened by the buildup of electrostatic charge on spacecraft surfaces and within internal dielectrics. Areas of concern are high voltage charging in geosynchronous and polar earth orbits, dielectric charging in high radiation orbits, induced charging by onboard or external sources, and low voltage charging which can compromise the function of scientific instruments. Innovative solutions are sought that will provide small and efficient detection, control, and mitigation techniques.

PHASE I: Develop conceptual designs or bench-level prototype devices that can establish proof-of-principle by either analysis or laboratory testing. The Phase I products should be useful for estimating the scope and cost of an actual flight test experiment. Designs should consider such issues as autonomous operation and scalability. The potential for application on both conventional and/or micro (< 100 Kg total payload) sized satellites should be addressed.

PHASE II: Develop a working prototype of the device or system. The prototype may or may not be a complete flight ready system depending on the complexity of the proposed system, GFE components, or other considerations of scope which should be coordinated with the AF and addressed in the proposal. The contractor may assume the AF will provide access to space for flight ready systems. At a minimum, the effort shall provide for proof-of-principle demonstration in the lab or space and establish commercial viability as a prerequisite to Phase III continuation.

PHASE III DUAL USE APPLICATIONS: In Phase III, the prototype shall be developed to meet the requirements of power, weight, size, lifetime, volume, efficiency, and cost necessary for a commercially viable product. Both military and commercial spacecraft in GEO and polar orbits have need of a bolt-on solution for spacecraft charging to reduce losses of expensive satellites. It is expected that when the size, weight, and power consumption of charging mitigation devices become small enough, commercial owners and operators of large fleets of satellites will routinely employ them on their satellites to reduce their susceptibility to catastrophic failure or to operations interruptions due to spacecraft charging.

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1. "An Autonomous Charge Control System at Geosynchronous Altitude: Flight Results For Spacecraft Design Consideration", IEEE Trans. On Nuc. Sci. Vol 44, NO 6, Dec 1997.

2. "Active Spacecraft Potential Control", Riedler, W.; Torkar, K., Ruedenauer, F., Fehringer, M., Pedersen, A., Schmidt, R., Grard, R. J. L., Arends, H., Narheim, B. T.; Troim, J., Space Science Reviews (ISSN 0038-6308), vol. 79, 1997, p. 271-302.

KEYWORDS: autonomous control, charge mitigation, dielectric charging, micro-satellites, spacecraft anomalies, spacecraft charging, spacecraft survivability

AF00-072 TITLE: Advanced Algorithms for Exploitation of Space-Based Imagery

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop innovative algorithms to optimize techniques for detection, identification and tracking of targets in structured environments.

DESCRIPTION: The Air Force Research Laboratory's Background Clutter Mitigation Branch (AFRL/VSBM) is interested in innovative techniques for the mitigation of clutter effects in an effective and computationally efficient manner to optimize the search, detection, and tracking performance of space-based optical (ultraviolet/visible/infrared) systems. Mitigation requires advanced algorithms based upon spatial, temporal, and spectral techniques. Data from airborne and space-based missions has led to a data base of optical data (ultraviolet, visible, and infrared) to characterize the optical properties of the environment. It is expected that the proposer will exploit these data bases to explore potential space-based detection techniques for clutter-mitigation/ contrast-enhancement techniques to optimize target detection, to identify materials, and to identify and quantify atmospheric constituents/effluents. It is expected that, as a result of this effort, new algorithms will be devised and tested. Figures of merit in assessing algorithm effectiveness include improvements in materials identification, enhanced probability of target detection in structured backgrounds and reduced false-alarm rates.

PHASE I: Conduct analyses, using real data, to develop algorithms for clutter-mitigation / contrast-enhancement techniques to optimize target detection, search, and track capabilities in structured environments, to identify materials, and to identify and quantify atmospheric constituents/effluents. Compare and contrast the candidate algorithms.

PHASE II: Perform detailed analyses and demonstrate the efficacy of algorithms for target detection, search, and track in structured environments, for materials identification and for the identification and quantification of atmospheric constituents/effluents. Conduct tests, as required, to assess the effectiveness of the algorithms. Develop and demonstrate an automated, near-real-time, processing system using real-world data sets.

PHASE III DUAL USE APPLICATIONS: The novel algorithms and processing techniques developed under this effort will potentially be useful in Phase III in military systems requiring autonomous stand-off detection under stressing conditions of sensor clutter induced by scene structure and the data-collection process, and spectral interferences. They will potentially also be useful for non-military applications involving autonomous detection under similar conditions of scene-induced and sensor-induced clutter and noise and spectral interferences; potential commercial examples include a processing system for application in fields such as medicine, industrial processing and quality control.

REFERENCES:
1. Algorithms for multispectral and hyperspectral imagery, SPIE Conference Proceedings, Orlando, FL, Apr 1994, A.E. Iverson, ed.
2. Thermal imagery spectral analysis, B.H. Collins et al., Proceedings of the SPIE Meeting, San Diego, CA, 28-30 Jul 1997, "Imaging spectrometry III", p. 94-105.
3. Target detection in a forest environment using spectral imagery, R.C. Olsen et al., Proceedings of the SPIE Meeting, San Diego, CA, 28 -30 Jul 1997, "Imaging Spectrometry III", pages 46-56.
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5. Targeting and intelligence electro-optical recognition modeling: a juxtaposition of the probabilities of discrimination and the general image quality equation, R. G. Driggers et al., Opt. Eng. 37 (3) 789 (Mar 98).
6. Scene classification and segmentation using multispectral sensor fusion implemented with neural networks, L.E. Lazofson and T.J. Kuzma, Proceedings of the SPIE Meeting, "Applications of Artificial Neural Networks IV", Orlando, FL, 13-16 April 1993, pages 392-399.
7. Classification of hyperspectral images using wavelet transforms and neural networks, T. Moon and E. Merenyi in "Wavelet applications in signal and image processing III", Proceedings of the SPIE Meeting, San Diego, CA, July 12-14, 1995. Pt. 2, Vol. 2569, 1995, pages 725-735.

KEYWORDS: Terrain Data, Elevation Data, Facet Models, Wire-Frame Models, NIMA, Data Format Conversion Tools

AF00-073 TITLE: <u>Surface Luminescent Dust Sensors</u>

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop luminescent dust for remote detection of hazardous chemicals on surfaces.

DESCRIPTION: It is well known that chemisorption of chemicals on surfaces can some times lead to emission of light. Reference studies have shown luminescence of molecules such as chlorine on surfaces of zirconium and sodium-doped zirconium. Similar observations have been made for hydrazine adsorbed on a variety of surfaces, including silica. The objective of this SBIR is to develop sticky polymeric material which can undergo reactions with specific families of compounds, such as the hydrazine family or chemical agents. Designing the polymeric materials so that they can be dispersed in the form of pellets or dust would then generate luminescence which would be detectable by remote passive sensors. The advantage of manufacturing the polymers in the form of dust or pellets is that they can be spread over large areas where contamination or use of dangerous materials is suspected, and the area can be monitored remotely. Further modification of the polymeric detectors can change their optical and infrared properties so that the products of their reaction with the chemicals of interest can fluoresce either in the infrared or optical regions of the spectrum, making it possible to conduct active remote probing, as, for example, by the use of a laser. The use of UAV platforms for either active or passive probing can, for example, save personnel from the need to be exposed to dangerous chemicals. Such techniques also have applications for surveillance. It is expected that the development to carry the program to large scale manufacturing will cost less than $10M.

PHASE I: Develop a preliminary sensor design and test polymer materials for passive/active optical detection of known hazardous chemical agents, e.g. members of the hydrazine family.

PHASE II: Develop a prototype of the selected design, extend the design to the generation of sticky, polymeric dust and test against an application specification.

PHASE III DUAL USE APPLICATIONS: These detectors have potential applications in the civilian sector. For example, they can be used to detect pesticides, chemicals that may be used in terrorist attacks, and dangerous chemicals near toxic waste sites. They can also be used to provide early warning of chemical agent attacks in civilian areas.

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1. B. Kasemo, Photon emission during chemisorption of oxygen on Al and Mg surfaces, Physical Review Letters, 32, 1114-1117, 1974.
2. M. Grunze, The interaction of hydrazine with an Fe(111) surface, Surface Science, 81, 603-625, 1979.
3. R. H. Prince, R. M. Lambert, and J. S. Foord, Chemisorptive Emission and Luminescence. I. Chlorine/Zirconium, Surface Science, 107, 605-624, 1981.

KEYWORDS: airborne surveillance, chemical weapons detection, chemiluminescent dust, dust, encapsulate, luminescent chemicals, space-borne surveillance

AF00-074 TITLE: Innovative Techniques for Remote Sensing, Threat Detection and Typing

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: Develop electro-optical data collection and processing techniques for early threat detection, threat typing, and reduction of false alarm rates.

DESCRIPTION: A significant emerging surveillance requirement involves detection of foreign missile launches--both theater and longer range. These emerging missile threats require: 1) continuous global launch detection, preferably at the moment of ignition on the launch pad; 2) immediate information on the nature of the threat (typing) to optimally utilize scarce and expensive interceptors; and 3) significant reduction in false alarm rate, so that attention is drawn only to real threat events. The most stringent requirement is timeliness, as flight times may be measured in minutes. An additional requirement is false alarm reduction. The battlespace commander must not be diverted by false detections. Information must be provided under all battlespace conditions, including not only clear sky, but also optically thick cloud and haze cover and conditions of high temporal variability. Theater missile launches involve a very short time line, and detection at the moment of ignition is desired. Detection at ignition provides seconds of advance warning of a launch (with a potential time line of minutes), and permits deployment of radar resources for trajectory determination. The proposed technology should work both day and night, in all weather conditions, and be suitable for deployment from a space platform. The proposed technology ideally will make use of commercial hardware and data analysis techniques, and should be relatively inexpensive and robust. The Air Force Research Laboratory's Battlespace Environment Division (AFRL/VSB) is interested in innovative electro-optical techniques for earliest detection and characterization of threats under realistic battlefield conditions, and reduction of false alarm rates. The emphasis is on, but not limited to, space-based applications.

PHASE I: Develop the proposed concepts of threat detection and typing, make an initial proof-of-principle demonstration or justification of the proposed technology, and show commercial involvement. Demonstrate that the proposed technology does in fact have the potential for false alarm reduction and significantly improved threat detection and typing.

PHASE II: Develop, test, and deliver a prototype product or process that performs the proposed solution to threat detection, typing, and false alarm reduction. This phase should include rudimentary proof-of-principle data.

PHASE III DUAL USE APPLICATIONS: The development of the techniques and methodologies under this effort potentially will be useful in space-based, UAV-based, or aircraft-based (i.e. ABL) military systems requiring autonomous threat detection, threat typing, and false alarm reduction under actual stressing battlespace conditions of optically thick cloud and haze cover. The proposed technology ideally will make use of available commercial technology both in instrumentation and in techniques of threat recognition and characterization. Commercial applications include: resource definition, environmental monitoring, forest fire detection, pollution detection, chemical and biological detection and identification, remote sensing for prospecting, and a host of as-yet-unidentified applications involving the use of space-based remote sensing technology.

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2. Target detection in desert backgrounds--Infrared hyperspectral measurements and analysis, M. T. Eismann et al., in "Signal and data processing of small targets", Proceedings of the SPIE Meeting, San Diego, CA, July 11-13, 1995, Vol.2561, 1995, pages 80-97.
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KEYWORDS: false alarm reduction, imaging, missile launch detection, remote sensing, spectral signatures, threat-typing

AF00-075 TITLE: Behavioral Toxicology - Integration of Chemical Exposure Threats into Command Decision Processes

TECHNOLOGY AREAS: Information Systems, Biomedical, Human Systems

OBJECTIVE: Develop technology capable of predicting human behavioral/performance impact of chemical exposures typical of deployment operational settings.

DESCRIPTION: The Neurobehavioral Effects Laboratory of Tri-Service Toxicology has developed a comprehensive battery of animal neurobehavioral tests (NTAB). The government seeks innovative proposals to integrate existing data from standardized NTAB tests with human clinical performance endpoints, derived from data developed from positive control compounds with well-characterized human activity. NTAB data for up to 10 compounds (drugs of abuse or psychotherapeutics) will be provided to the successful proposal awardee. The Air Force seeks a tool that will predict the human effects based on NTAB analyses and subsequently report confidence boundaries of that prediction. The technology should be capable of analyzing NTAB data obtained from exposures to chemical compounds and presenting an easily understood summary report predicting the effect on human behavior/performance. The resulting analysis and prediction should be presented in a fashion that facilitates rapid comprehension by the user and that can be easily used for command decisions to prevent adverse impact on the performance of military personnel.

PHASE I: Explore how to collect human data from the literature and determine the feasibility of incorporating both human and animal (NTAB) data into the appropriate software. Because there is a broad range of existing human data, this phase must develop an approach which will lead to meaningful integration of all existing data. The government originator will provide NTAB datasets for as many as 10 positive control compounds. Develop a work plan and set of milestones for Phases 1-3.

PHASE II: Develop prediction system that links NTAB databases with human performance. The system should address variability analysis techniques - such as Monte Carlo simulation - to report likelihood estimates for the accuracy of predicting various human behavioral changes.

PHASE III: This phase will result in an integrated software-based tool that rapidly assesses patterns among test datasets and reports analysis and prediction, including confidence boundaries, in a user-friendly, graphically-based platform. The tool will be adapted for implementation in a standard Microsoft Windows(r) operating environment.

PHASE III DUAL USE APPLICATIONS: Numerous industries use chemical compounds in manufacturing processes, production/repair, and fabrication. The Occupational Safety and Health Administration (OSHA) regulatory guidelines mandate worker health protection against injury or illness that could result from chemical exposures in the workplace. This technology will be essential for business managers seeking to prevent worker injury that could result from exposure-related performance or behavioral degradation. It also has the potential to become a powerful tool in the drug discovery process and will create the capability to quickly generate and interpret data on exposures to chemical mixtures, an area in which there is minimal existing information.

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KEYWORDS: neurobehavioral tests, behavioral degradation, software tool

AF00-076 TITLE: High-Resolution Visual System Development

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Development of advanced high-resolution visual system components for Distributed Mission Training (DMT).

DESCRIPTION: Long-standing problems associated with wide field-of-view head-mounted displays for ground-based simulator-training applications have been poor resolution, too much weight, and poor center-of-gravity characteristics. The resolution problem is being addressed through current Air Force efforts to develop color head-mounted imaging systems with greater than 5K x 4K, non-interlaced pixel resolutions. In an attempt to resolve the weight and center-of-gravity problems, the USAF solicits industry to design and construct light-weight, head-mounted visor optics for displaying high-resolution color imagery. The concept is to optimize the display's center-of-gravity and incorporate projection optics with curved surface visor display materials that could be integrated into a flight helmet. Projector systems with greater than 5K x 4K, non-interlaced pixel resolutions are in development by the Air Force. These projectors will present out-the-window imagery in high-performance flight trainers as well as other display applications. The Air Force is looking to capitalize on the rapidly developing PC-based graphics market to provide imagery for these systems and is seeking innovative PC-based technologies capable of presenting 5K x 4K, 60 HZ, non-interlaced video. Communication between the graphics system and the projectors will be via a non-proprietary parallel digital interface. Capabilities such as multiple view modes, multi-window, multi-channel, and large area databases should be considered a requirement.

PHASE I: Provide a technical report determining the feasibility of the concept and provide a feasibility demonstration.

PHASE II: Phase II will result in prototyping, demonstrating, and testing the concept proposed under Phase I and a technical report.

PHASE III DUAL USE APPLICATIONS: An improved light-weight, head-mounted visor optical system has the potential to provide tremendous improvements in weight and center-of-gravity characteristics of head mounted displays. This work, combined with ongoing Air Force efforts to increase image resolution, would have immediate benefit to the expanding world of virtual reality for industrial (auto, boat, manufacturing), medical, special effects applications in the electronic media and motion picture industries, and CAD/CAM.

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KEYWORDS: Helmet Mounted Optics, Helmet Mounted Display, Visually Coupled System, Helmet, Simulator, Crew Systems, Human Resources, Personal Computer, Graphics, High-Resolution, Image Generator, Low-Cost, 3-D

AF00-078 TITLE: Automated Material Classification Toolset

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a toolset to automatically classify materials contained in multi-spectral imagery for use in real-time multi-sensor simulation.

DESCRIPTION: In order to provide a realistic environment to support combat mission training and rehearsal, a high fidelity, correlated multi-sensor simulation capability is required. The solution for a given sensor requires that materials with their attributes be identified correctly at a high level of resolution. The source material is multi-spectral imagery obtained from satellites and aerial photography. The current process for material classification is extremely slow, costly and labor-intensive. Existing tools have little or no automatic features automated and low resolution. The development of an automatic material classification system would facilitate rapid database development, making high fidelity simulation affordable. The purpose of this effort would be to develop an automated capacity to accurately identify and classify materials. Given an image, the tool will be able to say, "that is concrete", "that is dirt", "that is grass". It is likely that such a tool will require the use of an intelligent agent that is capable of self-learning.

PHASE I: Provide a technical report assessing the feasibility of the concept, an analysis of alternative approaches for cost, accuracy, and speed, and recommended approach.

PHASE II: Development and demonstration of a system, which can accurately, automatically, and quickly, classify materials from satellite imagery sources at the pixel level for use in real time simulation. An initial goal would be to have the capability of automatically classifying materials at 1-meter resolution of a 2-deg X 2-deg area within 6 hours with 98% accuracy.

PHASE III DUAL USE APPLICATIONS: The toolset could be used by a wide variety of governmental agencies and commercial entities dealing with environmental imaging, geological, agricultural, space, and global resource management could use this tool and realize substantial savings in time and cost.

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KEYWORDS: Multi-spectral imaging, material classification, intelligent image processing, real-time simulation, databases

AF00-079 TITLE: Information Warfare Training Models

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: To develop a cost effective distributed situation assessment and decision making training system originating from inventive development tools in a C2 /C4ISR team performance environment.

DESCRIPTION: Training budgets within the DoD are undergoing massive cuts at a time when effective training is more essential than ever before. C2 and C4ISR training is critical to information and space warfighter support especially with the new methodology of war which is technologically faster, shorter, and more direct.

Training technologies are needed for global access to C2 and C4ISR among warfighting forces to ensure optimum linkage for maintaining real time global awareness and force execution capabilities. Anytime, anyplace virtual help for all C2 and C4 Centers training for both procedures and systems is critical. Cognitive modeling of information warfare operations and tactics is necessary in the development of simulated wargaming exercises to train real time, wartime critical thinking skills. Distributed interactive training is necessary in implementing a capability to relate simulated task training to actual event training with elements of operations security, psychological operations, deception, physical destruction, and electronic warfare. These studies are in support of military operations, planning, exercises, and training at the Air Staff, Joint Forces Air Component Commander, and Joint Command levels. This is an area of training research that has been completely missed due to size and depth of scope and lack of technological feasibility. The purpose of the SBIR is to create a distributed situation assessment and decision-making training system in a C2 /C4ISR team performance environment. Development tools containing characteristics like embedded training capabilities, the ability to create and maintain computer based training for National Sensors and Mission ground Stations, and methodologies for battlespace simulations gives this training system the flexibility in an ever-changing global battlefield. In addition, this training system will implement constructivist & experiential learning theories in a web-based, secure environment. The training system will include synchronous & asynchronous capability and real-time collaborative intelligent wargaming exercises in a virtual simulation environment while at the same time providing analysis routines for defining training needs based upon operator dynamics. This prototype is to be supported through both synchronous and asynchronous communications and can be used by military personnel to create C2 teams in a range of information warfare environments. Communications, classifications, recognition, collaboration, team performance, and human performance are the training areas that can be well integrated into the models being prototyped. Due to the nature of the subject area, security in a synchronous and asynchronous state must be demonstrated.

PHASE I: Phase I should end with a technical report describing the problem and technical challenge in layman's terms. A fully functional prototype development should also be completed demonstrating the feasibility of the training models in the secure asynchronous and synchronous environments. Training tool feasibility will also be demonstrated at the end of Phase I, as shown with prototype operation.

PHASE II: Phase II should end with a full-up training environment with a technical report which presents appropriate evaluation data reflecting student learning and team performance within the training models.

PHASE III DUAL USE APPLICATIONS: Training models have a specific commercial potential to all industry and public education and training sectors, as specific training development tools will be available for use in any training environment.

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http://www.cudenver.edu/~mryder/itc_data/constructivism.html
http://www.tiac.net/users/lsetter/learn.htm
http://www.c2tic.hurlburt.af.mil
http://www.c4isr.com/

KEYWORDS: Distributed training, team performance, asynchronous & synchronous, situation assessment, decision-making, mission rehearsal, information warfare, artificial intelligence, multimedia, computer-based training, performance measurement, security environment, desktop 3-D virtual simulation, web-based training, internet/intranet, constructivist learning model, experiential learning theory, adult learning, collaboration, wargaming, C2, C4ISR

AF00-080 TITLE: Agent-Based Measurement System for Advanced Distributed Learning Technologies

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Conduct exploratory research to develop deployable methods for capturing cognitive, behavioral, and affective information related to performance in operational contexts.

DESCRIPTION: A requirement exists to develop automated, deployable methods for capturing, representing and synthesizing individual operator and workgroup interaction, knowledge and core competencies for use in rehearsal, training and performance support. This effort will conduct exploratory research to develop deployable methods for capturing cognitive, behavioral and affective information related to performance in operational contexts. It will also develop methods for using this information to model individual activities and actions in intelligent software agents that can participate as passive or active members of a rehearsal, training, or operational event. Furthermore, this effort will demonstrate a capability to use these models to develop pedagogically valid learning technologies. Recent advances in distributed methods for training, simulation, and performance support indicate that it may be feasible to develop an online (near-real-time) capability to decompose elements of work activity into knowledge-, behavioral-, and competency-based components. The development of such a capability will permit near-real-time knowledge elicitation and specification for developing models of expertise and for identifying key aspects of performance required to meet mission requirements. Intelligent agents are computer programs that have the potential to participate in actively accomplishing tasks, providing feedback about key activities of a user, and can actually participate in team training and rehearsal activities. This effort will also demonstrate the use these components to develop autonomous agents that can represent the behavior of individuals for rehearsal and training purposes. Presently, eliciting key cognitive, behavioral and affective performance characteristics is time consuming, labor-intensive, and inaccurate. There are also no reliable tools that can take the information and instantiate it in the form of software agents that could become members of a training or rehearsal team as substitutes for human players. It might even be possible to demonstrate that reductions in crew size are possible with these agents in place.

PHASE I: Phase I activities will result in a proof-of-concept technology for representing knowledge and competencies to drive training and performance support development. Phase I proposals must include a detailed market survey activity and letters of interest/commitment from potential commercial partners must be obtained for Phase II consideration.

PHASE II: Phase II will fully develop, apply, test, refine, and validate the elicitation and representation methodology and will develop intelligent agent-based team instructional events. Proposals should assume that the technology and agents will run in a platform-independent environment.

PHASE III DUAL USE APPLICATIONS: Commercial application potential is significant as no assessment capability such as the one described herein exists. The benefits from such a capability to Government and Private Sector agencies could help organizations save considerable time and expenditures by developing models of human performance that are actually capable of assuming some interactive roles in training and operational contexts. There are many instances where an entire marketing or product development team cannot meet at the same time. Having a capability to insert software agents that can "participate" in the team interaction for training and other purposes is of considerable value. The results from this effort are of considerable interest to the Private Sector as competency-based selection, placement, and training approaches become commonplace with increased job enlargement and workforce globalization.

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KEYWORDS: Competency-based assessment, intelligent agent architectures, intelligent agent-based models, knowledge elicitation and representation, performance enhancement, performance measurement, team effectiveness, workgroup effectiveness

AF00-081 TITLE: Distributed Human Performance Management with Emphasis on Team Performance

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop innovative concepts, technologies, and methods to support distributed human performance management with emphasis on team performance.

DESCRIPTION: In recent years, human performance disciplines have demonstrated remarkable success in modeling and optimizing the performance of individuals. Team performance is not nearly as well understood as individual performance, and instructional models to optimize team performance are virtually nonexistent. No comprehensive taxonomies have been developed to provide systematic dimensions of variation across team tasks. The few postulated models of team performance account for very narrow categories of actual team task types, and are generally not specified sufficiently to support the generation of instructional models. One approach we are interested in pursuing would allow us to build on successful work in individual performance and combine that with promising approaches for modeling and optimizing team performance. Prior research in team performance has produced a variety of models for team performance. For example, the TADMUS (Technical Decision Making Under Stress) program (Salas, Cannon-Bowers, Johnston (1997) has shown the utility of identifying Shared Mental Models (using TADMUS) and Cross Training (using Team Model Trainer) methods. Salas, Dickenson, Converse, and Tannenbaum; 1992 propose a team performance model consisting of variables that are internal or external to the team. Variables external to the team include workload (Bowers, Urban, and Morgan, 1992; Kleinman and Serfaty, 1989), time pressure (Adelman, Zirk, Lehner, Moffett, and Hal, 1986), and task structure (Kleinman and Serfaty, 1989; Bowers, Urban, and Morgan, 1992; Urban, Bowers, Monday, and Morgan, 1995). Variables internal to the team include team cohesiveness (Gal 1986; Bowers, et al., 1992), task cohesiveness (Zaccaro, Gualtieri and Minionis, 1995), and interpositional uncertainty (Volpe, Cannon-Bowers, Salas, and Spector, in press. Situation Awareness in is probably an important concept in understanding team performance (Salas, Prince,Baker, Shrestha 1995), but team SA involves two poorly understood abstractions. Individual SA may be defined as an individuals ongoing awareness of changing contextual realities that modify task goals or contingencies, but much diversity currently exists in operational definitions of SA. Team processes are teamwork behaviors and cognitive processes that facilitate team process, but again there is little agreement in the literature on how to model these. The TeamTRAIN (Team Training Research for Automated Instruction) model (Regian & Elliott; 1997) is an example of a taxonomic approach to identifying the characteristics of team task. Dimensions include information distribution and display, differentiation of team member function, differentiation of team member expertise, and type of decision process (e.g. collaboration, negotiation, rule-based, autocratic). Fleishman and Zacarro (1992) proposed a taxonomy of team performance functions that has been applied to team performance assessment. In a structured approach to the measurement of team performance the TARGETs method (Fowlkes, Lane, Salas, Franz, et al; 1994) supports team performance measurement that encompasses theoretical, psychometric, and operational issues. This approach involves structured observation in which task events are introduced to provide opportunities for teams to demonstrate specific team-related behaviors; acceptable team responses to each of the events are determined a priori by utilizing team task analyses, subject-matter experts, and so forth; and the appropriate responses to events are scored as either present or absent.

PHASE I: Phase I should end with a technical report describing the problem, the technical challenge in layman's terms, and a review of the literature. Specifications for a software product to be constructed in Phase II should also be included.

PHASE II: Phase II should end with a software product related to the proposed topic, an application of the software product in a domain mutually agreed to by the proposer the AFRL technical monitor, and a final technical report.

PHASE III DUAL USE APPLICATIONS: Team training models have large commercial potential for industry, public education and training sectors, and the defense industry.

REFERENCES: http://train.galaxyscientific.com

KEYWORDS: team performance modeling, team situation awareness, team tasks, team training, team decision-making, performance measurement, collaborative training, command and control

AF00-082 TITLE: Psychological Warfare Training via Advanced Distributed Learning Technology

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: The goal is to develop a quality Advanced Distributed Learning approach for psychological warfare training.

DESCRIPTION: Information warfare (IW) involves the protection, manipulation, degradation, and denial of information. IW is not a separate technique for waging war, but rather the umbrella for several distinct types of warfare related to the ebb and flow of information. One example is psychological warfare (PSYW). PSYW seeks to utilize information against the human mind. Cognitive modeling of psychological operations tactics is necessary in the development of training exercises to train wartime critical thinking skills. Advanced Distributed Learning takes advantage of technologies for directing instruction at dispersed individuals via networking technology (e.g., internet).

This effort will: define cognitive principles of PSYW. Based on these principles, instructional strategies and methods for training these principles will be developed. The researchers will then determine if these strategies and methods are amenable to be implemented via Advanced Distributed Learning (ADL) technologies. If so, develop instructional, software, and networking specifications for PSYW ADL training will be developed. An ADL testbed for PSYW training will then be developed and evaluated.

This topic responds to training needs/ deficiencies identified by ACC/DR in the "Aircrew Training Needs" document (1 Nov 97), under the heading of "Predictive Modeling and Campaign Simulation." The specific focus area is "Information Warfare Models" and the need to model the effects of information warfare and integrate their effect into planning and campaign models.

PHASE I: End product is a description of cognitive principles of PSYW; an instructional strategy for teaching PSYW; instructional, software and engineering specifications for an ADL approach to distributed PSYW training.

PHASE II: Develop and test a prototype ADL system for PSYW. Users will be AF PSYW personnel. Evaluate instructional effectiveness of prototype testbed.

PHASE III DUAL USE APPLICATIONS: The instructional, software and networking specifications, which will result from this project, will be commercializable. Advanced Distributed Learning is required in the commercial sector for a variety of industrial and commercial purposes. In addition, education at all levels can make use of ADL principles and technologies.

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- https://www.ac2isrc.org/

KEYWORDS: advanced distributed learning, team performance, asynchronous/synchronous, situation assessment, decision-making, mental modeling, cognitive modeling, mission rehearsal, psychological operations, psychological warfare, artificial intelligence, performance measurement, secure environment, adult learning, collaboration, wargaming

AF00-083 TITLE: Graphical User Interface Techniques for Assessing Autonomous Vehicle "Behavior"

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop graphical user interface techniques for presenting actions of multiple autonomous vehicles.

DESCRIPTION: Challenges for operators of future autonomous systems, e.g. an unmanned combat air vehicle (UCAV), will be understanding what the vehicle (or vehicles) is doing and planning to do, deciding if what is planned is acceptable, determining appropriate corrective actions if it is not, and then implementing these corrective actions. To carry out this responsibility, operators must have insight into the vehicles' current and projected 'behavior' and the context in which the behavior will occur.

UAVs are being developed to make higher order decisions independent of operator input. For example, if the UAV perceives a pop-up threat, it will determine the type of threat and its vulnerability and then decide the best course of action, e.g. avoidance, or attack. This capability to "decide" constitutes a new set of challenges for UAV operators; they need to understand system intent and, when appropriate, "get inside the head" of the UAV to determine how and why these decisions are being formulated. An effective graphical-user interface (GUI) is needed so that operators can gain insight into the intent of remote vehicle(s) under their supervision and assess the impact of planned actions on mission objectives.

PHASE I: Analyze current/projected UAV missions to identify design requirements and constraints for the operator-vehicle interface and specific operator-vehicle functionality that must be supported by the GUI. Identify human-computer interface technologies that augment the GUI and develop a GUI design. The Phase I deliverables shall be 1) a demonstration of a GUI for a portion of autonomous operations, 2) a report documenting the GUI, including drawings and descriptions of GUI formats/functionality and operating instructions. The report shall include design rationale and sufficient detail to permit GUI software development.

PHASE II: Develop, integrate, and demonstrate the GUI in a mission simulation of multiple autonomous UAV in the Vehicle-Pilot Integration Laboratory (VPIL) at WPAFB. Interface with VPIL's simulation environment and aero and mission planning models. The GUI shall be hosted on VPIL computers and be interactive allowing real-time GUI operation in the context of a mission scenario.

PHASE III DUAL USE APPLICATIONS: Interface methods developed apply to complex systems where operators must have insight into what an autonomous system is doing and why. The solutions could apply to air traffic control stations to alleviate uncertainties associated with 'Free Flight' operations, to power plant control stations to help an operator quickly understand automated diagnostics and prognostics, and to intelligent highway traffic management.

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KEYWORDS: Information Visualization, Graphical User Interface, Intent Inferencing, Supervisory Control, Distributed Decision-Making, Human-Computer Interaction, Intelligent Systems, Autonomous Vehicles, Autonomous Agents, Associate Systems, Automation, Unmanned Aerial Vehicle, Task Network, Concept Mapping

AF00-084 TITLE: Integrated, Hands-free Control Suites for Maintenance Wearable Computers

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop integrated control suites that provide maintainers with hands-free operation of wearable computer systems.

DESCRIPTION: The Air Force is evaluating the use of wearable computer systems to support aircraft maintenance operations. With the availability of electronic technical manuals and diagrams, wearable computers and head-mounted displays (HMDs) will permit technicians to readily access the required information without the need for bulky paper documents. Suites of nonconventional controls are needed to support hands-free interaction with wearable systems. Analysis of maintainer interactions with wearable computers suggests that these control suites must provide "point", "click" and text entry functions. Speech recognition is available with wearable systems, but it is inefficient for pointing operations and is constrained by the communication requirements and noise typical of many maintenance environments. In addition, the use of a multiple-controller approach enables the interaction to be tailored to task and environmental constraints, as well as user preferences. For example, a software-based speech recognizer, an inertial head tracker, and a facial gesture detector might be configured in a variety of ways to provide the required functionality (This is provided only as an example and should not constrain a company's innovation.). Companies should not propose the development of a single control technology unless it can efficiently support complete interaction with a wearable computer.

PHASE I: Select a future USAF weapon system and identify maintenance requirements supportable with wearable computer technology. Identify the requirements for interaction with the wearable computer system using tools such as projective task analysis. Identify potential hands-free control technologies that would support these requirements. Document the results of these analyses and the integrated design concept(s) in a technical report. A concept demonstration is a highly desirable product. Integration of low-cost, off-the-shelf, components functioning on a desktop computer is satisfactory for this demonstration.

PHASE II: Develop, demonstrate, and evaluate two prototype control suites that satisfy the requirements identified in Phase I. These control suites should be integrated with a wearable computer system including an appropriate HMD. The system should include prototype maintenance software that can support performance evaluations. Conduct preliminary evaluations with a sample of maintenance personnel to 1) provide data on the effectiveness of wearable computer interaction with the candidate control suites and 2) guide the development of a fully functional Phase III product design. At the completion of Phase II, deliver a final technical report, control suite prototypes, wearable computer system, and preliminary Phase III product design to the Air Force Research Laboratory.

PHASE III DUAL USE APPLICATIONS: Hands-free controllers for wearable computers have application well beyond maintenance environments. The Army and Navy are evaluating wearable systems for foot soldiers, damage control specialists, and medical ship connectivity. Civilian applications for disaster relief, inventory management, troubleshooting and repair are under consideration or development. Each of these represents commercialization targets for the control suites developed under this SBIR.

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KEYWORDS: Human-Computer Interaction, Wearable Computers, Head-Mounted Displays, Hands-Free Control, Nonconventional Control

AF00-085 TITLE: <u>Novel Situational Awareness Concepts for Command & Control of Space Assets</u>

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop visualization technologies to enhance situational awareness of space operation center personnel for satellite constellations.

DESCRIPTION: For effective space operations, space operation center (SOC) personnel must conceptualize the operational status (i.e. global coverage, continuous operation, system failure, intolerant environment, etc.) of on-orbit assets. Global coverage and continuous operations require a need for visualizing global continuous communications for both commanding the satellite as well as providing payload data to worldwide users. There is a need to be able to observe threat levels and to depict blue force operations so that the SOC staff can develop courses of action. Space operation visualizations should go beyond just the spatial dimension of the battlespace. They should describe and depict how and where space activities interact with other forces, assets (friend and foe), and movement in the battlespace. The proposition is that existing SOC capabilities can be greatly enhanced by understanding and developing specific visualization, and decision aiding technologies to improve the situational awareness and decision making in the SOC. Furthermore, training should be an integral part of any concept such that training, mission rehearsal, and operations should be conceptually indistinguishable. At the Air Force Research Laboratory, we have been performing a variety of command and control studies and experiments utilizing visual and auditory displays and cognitive analysis. Prior studies in North American Air Defense (NORAD) command and control have shown that adequate information presentations exist, but they are not optimized for problem solving, decision making, or cross-communication between command personnel. Understanding the operational environment is paramount in developing technologies to improve the situational awareness and decision making of SOC personnel.

PHASE I: Phase I efforts shall provide proof-of-concept technologies to apply in improving the situational awareness and decision making of SOC personnel. Specifically, Phase I shall (a) identify and document the SOC's electronics mapping requirements; (b) identify and document visualization (visual and aural) activities that can be most usefully integrated with other information presented to the SOC command staff; (c) identify measures of effectiveness that can be embedded in such visualizations; and (d) demonstrate selected visualization technologies that can aid space operations, giving special attention to human factors and human computer interactions.

PHASE II: Phase II efforts shall develop and a SOC visualization capability to demonstrate the effectiveness of applied technologies in performing SOC operations. Special considerations shall be given to designing these technologies such that they are compatible with distributed mission training environments and in making them affordable and maintainable.

PHASE III DUAL USE APPLICATIONS: Commercial applications of these technologies are possible for commanding and controlling equivalent commercial communication satellite constellations as typified by constellations such as Iridum and Teledesic.

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KEYWORDS: Displays; Visualization, Cognitive Analysis, Command and Control, Situational Awareness, Space Operation

AF00-086 TITLE: Auditory Devices for Remote Threat Detection

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Human Systems

OBJECTIVE: Develop innovative methods to detect, identify, and display remote threats using acoustic sensors to enhance the performance of the security force commander and deployed squads. Develop advanced acoustic signal processing in a stand-alone configuration or in conjunction with other detection techniques to reduce false alarm rates.

DESCRIPTION: Acoustic detection methods are sought in the following areas to improve human response to perceived threats: 1) Remote listening devices; 2) Improved algorithms for detection of personnel or vehicle motion and direction; 3) Adaptive algorithms for learning background sounds from transient threat actions; 4) 3D integration into command and control for security forces including 3D audio for deployed forces; 5) Improved low power wireless telemetry systems to feed full 3D audio and video signals to a remote receiver greater than 1-2 miles away; 6) Low power (microwatt) remote acoustic and video buffering systems for replay of captured signals.

Base security and Force security issues are mandating the use of remote detection to handle the reduction in manpower present in all areas of the military. The Force Protection SPO has developed the Tactical Automated Security System (TASS) that uses trip wires, infrared detectors, motion detectors and vibrations sensors to identify threats. This system concentrates on developing better sensors but not the processing of this information for threat identification and response. This system also does not contain any acoustic sensors or processing of acoustic data. Reduction of false alarms yet retaining a one hundred percent detection rate from remote systems is critical to the long-term success of any mechanical/electronic surveillance system. Use of multisensor and cross data type processing is critical to reducing false alarm rates yet retaining high detection rates.

The objective of this topic is to explore the use of acoustic data for rapid identification of threat location, motion and lethality. The concentration will be on using acoustic data along with other data collected by TASS and other systems to increase the probability of detection while reducing the false alarm rate of the overall system. Concentration will be on the unique methods to reduce human response time to threat and enhance the ability of deployed forces through the use of auditory signals.

PHASE I: Develop initial designs, methods, and associated analysis to select the most promising approach to reduce human response time to threats. Preliminary demonstration of the chosen design is preferred but not required. Document the approach, initial designs and preliminary results (if available) in a final report.

PHASE II: Fabricate, demonstrate, and deliver the final prototype system demonstrating the reduction in threat identification time and reaction time to threat situations. Evaluate results and develop a plan for follow-on commercial and military development. Prepare a final report describing the design along with the test results and recommendations for insertion of the design into applicable Air Force and commercial systems.

PHASE III DUAL USE APPLICATIONS: These problems are generic to security worldwide. Problems that can be solved to enhance the AF security forces have an immediate commercial application to civilian and corporate security forces such as gunfire localization within city limits and security of local and state governments.

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KEYWORDS: Audio Displays, Audio Detection, Audio Signal Processing, Audio Perception, Audio Motion Detection, Threat Detection, Crew Safety and Protection

AF00-087 TITLE: Sensor Fusion and Information Warfare

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Human Systems

OBJECTIVE: Develop a system to assess, integrate, and evaluate the robustness and vulnerabilities of sensor fusion technologies in an information warfare environment.

DESCRIPTION: With major advances in sensor-related and computing-related infrastructure technologies over the last several years, and with new visions of theater architectures depicting highly-distributed but highly-connected systems, extensive opportunities are evolving for the application of sensor fusion techniques. However, as much as these architectures and capabilities offer opportunities for significant improvements in the overall quality of information available to warfighters, they also create opportunities for information attack on such systems. In spite of the application of advanced concepts of information protection and security, it is generally agreed that perfect protection of these systems is either technically impossible or unaffordable, or both. Since sensor fusion processes will likely be important elements of these vulnerable systems and architectures, it is important to understand the specific vulnerabilities and dependencies of sensor fusion processes on informational components, and to conceptualize and specify how to both protect the integrity of the information within these processes and how to overcome the effects of information corruption on sensor fusion operations. Additionally, it is of interest to assess how new and creative concepts of employment of sensor fusion processes can contribute to the realization of effective counter-information and counter-deception techniques, and the general notion of employing the sensor fusion process as a weapon. Finally, since sensor fusion processes most typically function in a decision-aiding framework, it is of interest to understand and evaluate the impacts of information operations on the human role in sensor fusion systems.

PHASE I: Phase I will result in a proof-of-concept consisting of comprehensive performance evaluation of potential information warfare methods and of data/sensor fusion approaches. Emphasis will be on the role of the operator in systems in which the fusion processes are employed as decision-aiding capabilities and the information attack is directed against the decision-making process. Specific examples will be identified and described. The effects of dissonant information on decision making will also be explored. The methodology and findings of the Phase I effort will be documented in a technical report.

PHASE II: Phase II will result in the development and conceptual demonstration of a prototype consisting of a suite of analysis and design support tools which apply specifically to the sensor/data fusion capabilities of management and control systems. The demonstration will focus on the specific fusion applications identified during Phase I. A detailed technical report and a completed working model of the analysis/design system will be delivered.

PHASE III DUAL USE APPLICATIONS: Many non-military information systems and functions may well be the targets for information warfare (e.g., financial, transportation, power distribution, etc.). These systems all rely in some significant way on sensor/data fusion technologies and methods. This effort would provide methods and guidelines for assessing the vulnerability of this system to information warfare attacks and for enhancing their robustness against such attacks.

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KEYWORDS: Information Warfare, Cognitive Engineering, Sensor Fusion, Data Fusion, Decision Aiding

AF00-088 TITLE: Advanced User-System Interface Technologies for Untethered Computer and Visual Display Interactions

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Capitalize on emerging, low cost technologies such as large bandwidth personal data-links and smart room technologies to allow untethered, mobile access to computing and visual display capabilities within Information Operations (IO), and Command and Control (C2) environments.

DESCRIPTION: The Air Force currently seeks untethered, natural input and output devices (User System Interfaces) for use by operational personnel in multi-user Information Operations (IO), and Command and Control (C2) environments. These devices will allow IO and C2 personnel to physically move throughout the work environment for collaboration among work nodes without loss of data/information normally available only at a stationary work station. As a compliment to wearable computers, this technology will allow operators to stay linked to the collective knowledge base for both input and output while moving among collaborators, interacting with large screen information displays, or working in locations remote from desktop PC support. New untethered user-system interface (USI) technologies are necessary to facilitate communications and common understanding among co-workers (horizontally) and the command structure (vertically). The technology to be developed must support personnel tracking in IO and C2 multi-user environments, including tracking of the users orientation within the environment to allow use of speech recognition/speech generation, 3D audio, laser pen control of large screen displays, and eye tracking. User data input and system control devices must be portable, unintrusive, and have the ability to interact with common display systems (large screen video and audio speaker systems) through the appropriate datalinks. Interaction with visual display systems needs to include both continuous (e.g., pointing/cursor control) and discrete (e.g., "click"/toggle) inputs allowing full control of remote displays. It is expected that the technologies to be developed under this SBIR program will augment or replace the common use of the keyboard and mouse as USI technologies. Multi-sensory input and output mediums (audio, visual, sensory) are preferred.

PHASE I: Analyze operational use of the mobile computing interface, to identify requirements and constraints on the user and user environment. Complete a task analysis to identify input/output requirements for the projected IO and/or C2 tasks. Identify potential technology for integration into a mobile computing interface suite.

PHASE II: Develop and demonstrate a mobile interface satisfying the requirements of Phase I. The mobile suite should be completely integrated with stationary, wearable and remote desktop computer systems. Conduct evaluations with Air Force operational C2 users. Deliver the mobile suite to the Air Force Research Laboratory.

PHASE III DUAL USE APPLICATIONS: Commercial potential of this technology is very high. Computer systems supporting medical, package delivery, inventory management, traffic management (ground and air), and troubleshooting/repair operations (ground, air, and space) can be linked remotely to the user. Mobile information operations, and command and control suites, developed under this SBIR would be equally applicable in these commercial environments and to NASA Extra-Vehicular Activity (EVA) missions.

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KEYWORDS: User-System Interfaces, Communications, Mobile Computing

AF00-089 TITLE: Human-Centered Technologies for Information Superiority

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop assessment techniques and enhancement, hardening, and/or remediation strategies to improve the performance of the human decision maker in the context of information warfare, specifically in cases where decision support and situation assessment capabilities may have been disrupted or degraded by information attacks. Support Defense Technology area Plan (DTAP) objectives in Human Systems (HS). Specifically, the information display and performance enhancement (ID&PE) HS subarea technologies support future joint and service-unique warfighting needs in data visualization and situational understanding, aural and visual interface, immersive interface, intelligent aiding and decision support, decision-centered staff process control, supervisory control and teleoperation, and physical aiding.

DESCRIPTION: The Air Force has established Information Superiority as one of its six core competencies. Fundamentally, Information Superiority is achieved when friendly decision-makers (commanders, intelligence analysts, etc.) can reliably execute faster, more flexible, and/or more thoroughly evaluated decisions than can an adversary. Friendly systems may, however, be susceptible to a wide range of information warfare attacks. AFDD 2-5, "Information Operations," identifies Information Superiority as an "enabling function" and points out that "through information operations new target sets emerge, new weapons are available, and the opportunity to directly influence adversary decision making through delays, disruption, or disinformation is a reality." Obviously, an adversary can attempt to conduct information operations against our information functions and processes.

One critical result of an information attack, actual or perceived, may well be the loss of trust which the decision maker has in the information or decision support system. Operators tend to adopt more conservative decision rules when the integrity of the human system interface is brought into question, reducing the effectiveness of the observe-orient-decide-act (OODA) command and control loop. A second, related, factor is that of decision making with dissonant information. If an information attack has taken place, some of the data sources or data bases may have become intentionally corrupted. Operators tend to become more uncertain, take more time, and commit more errors when confronted with dissonance. Technologies which may prove fruitful in quantifying and/or overcoming the trust and dissonance issues may include: operator/user models of intent (from the intelligent agent domain), advanced visualization capabilities, adaptive decision aids (e.g., data fusion), and cognitively-derived display formats.

The research and development/technical risks of this effort are assessed to be high because highly innovative and robust solutions will be required to overcome the emerging threats.

Specific metrics which are expected to be applicable to this effort include achieving and sustaining significant reductions (approximately 25%) in physical, perceptual, and cognitive workload and improvements (approximately 100%) of critical decision making accuracy and reliability in the context of information attack.

PHASE I: The Phase I effort will identify human-centered technologies which may reasonably be expected to contribute to achieving and maintaining human-centered Information Superiority in the face of a full range of adversarial capabilities to wage information warfare. The deliverable will be a proof-of-principal demonstration, including a quantitative performance analysis.

PHASE II: Optimize the technology(s) demonstrated in Phase I and design, produce and deliver a functional prototype for Air Force evaluation and testing.

PHASE III DUAL USE APPLICATIONS: Enhancements to training capabilities will have direct application in the commercial market, especially as employee reductions and corporate restructuring continue. Innovations in interface design technology and performance aiding will have wide application in the entertainment, services, strategic planning, crisis management, and process control/facility management industries.

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KEYWORDS: Information Superiority, Information Dominance, Information Warfare, Personnel Selection, Training, Decision Making, Decision Aiding

AF00-090 TITLE: Breakaway Helmet Mount for Night Vision and Targeting Displays

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop breakaway helmet mount for night vision and targeting displays when exposed to excessive forces.

DESCRIPTION: Current night vision devices (NVDs) employ a mount that attaches these devices to the helmet for use by pilots flying night missions. The NVDs remain firmly in place with all head movements and with maneuvering flight up to 9 Gz (1 Gz is a downward force equal to the pull of gravity; 9 Gz is equivalent to nine times the force of gravity). The NVDs will release with a downward force between 10-15 Gz, to protect aviators during crashes or with the rapid upward acceleration of ejection seats. However, there is not an engineered breakaway solution to upward or sideways forces applied to the NVDs as is seen with windblasts up to 600 kts, or with parachute risers pulled across the helmet. Such events exert large forces on the head and can tear the helmet off or cause lethal neck injuries. Helmet mounted displays (HMDs) in development likewise pose these hazards, but do not have an engineered release system.

The Combat Air Forces have expressed an interest in a low cost breakaway mount for helmet mounted NVDs, as well as other helmet mounted devices, that would release those devices when they are exposed to excessive forces regardless of the direction. It must be low cost, easily replaced, very lightweight, mount to currently used NVDs, and hold the NVD in place until released. Additionally, the mount must not require any modifications to equipment other than the helmet, adversely affect the wear and function of current equipment, or damage the helmet during breakaway.

PHASE I: Investigate the integration requirements of a helmet/NVD connector with other life support equipment components and with currently used NVDs. Design a test that measures the force required to release downward the current NVD from its mount with a slow pull as well as a jerk force. Design and demonstrate a breakaway mount that replicates the current NVD release under force, but in all directions.

PHASE II: Demonstrate the manufacturability of such a breakaway mount. Demonstrate a capability to similarly mount a dissimilar device (such as a flashlight) on a helmet. Test the mount's capability to maintain an NVD stable on a helmet with head movement and with forces up to 9 Gz. Test the device with windblasts at 450 and 600 kts using current flight gear on an instrumented manikin capable of recording neck forces.

PHASE III DUAL USE APPLICATIONS: A breakaway mount has application beyond protecting aviator's helmets and heads with NVD and HMD use. Parachutists, cyclists, spelunkers, construction workers, etc. often mount lights or cameras on their helmets that can translate forces from falls to their necks, or can point load the protective helmets causing failure. This breakaway device would protect surfaces (on vehicles, equipment, etc) from damage when force is applied to mounted devices, when weight and size is a factor.

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1. Armstrong Laboratory, Organization Brochure, Unclassified. Public Release. Copies may be obtained from the Defense Technical Information Center (DTIC), Telephone Number 1-800-363-7247.
2. Task, H.L. (1992) Night vision devices and characteristics. AGARD Lecture Series 187: Visual Problems in Night Operations (pp. 7-1 - 7-8) Neuilly Sur Seine, France: NATO Advisory Group for Aerospace Research and Development. (AD-A253 927) (NTIS No. AGARD-LS-187).

KEYWORDS: Night Vision Device, Helmet Mounted Display, Life Support Equipment, Helmet, Crew Systems, Human Resources, Aerospace Medicine, Individual Protective Equipment, Ejection, Head Injury, Neck Injury

AF00-091 TITLE: Laser Aircrew Safety and Education Demonstrator-Flight (LASED-F)

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Demonstrate the glare and flashblindness effects on aircrew caused by hostile situations, accidental or malicious misuse of lasers/laser pointers.

DESCRIPTION: A requirement exists for a portable, self-contained unit which has an integrated visible laser unit. The laser must be capable of safely producing flashblindness in the user within the human aversion response time. The desired degree of flashblindness is a one degree scotoma with respect to the display for 3-5 seconds. Anywhere the laser light can be seen outside the unit under proper use, the output must be eye-safe in accordance with ANSI Z136.1 safety standards. The timing of the laser light delivery must be random within a small window near mission-key flight events on the simulator such as take-off, landing, ordnance delivery, or any other flight essential activity requiring visual ability and appropriately timed user response. Viewing aperture of the unit must be compatible with a user who is wearing laser eye protection. User interface must be a reasonable representation of an aircraft cockpit (i.e. at a minimum flight stick or yoke control). The flight simulator should be easy to operate with a learning time necessary to operate the unit of less than 5 minutes. The simulator program should be turn-key and should not include activities extraneous to the key flight events. Operation of the unit should not require technical expertise on lasers. A users manual should be included. To be considered portable the unit needs to be crate-able for commercial airline transportation. A critical purpose of the device will be to educate aircrews on protective devices which will permit safe evasion without compromising the mission or safety of flight. The unit must be capable of safely but realistically demonstrating both the effectiveness and limitations of laser eye protection (LEP) in the simulated flight environment. For that reason, the successful offeror(s) must work closely with AFRL/HEDO to integrate the LEP training experience.

PHASE I: The first phase of this effort is to prove the feasibility of incorporating a visible laser into a standard cockpit simulator for both military and civilian multi-engine transport operations. The design should be robust enough to migrate to various flight simulators including military-unique fighter aircraft. The design must permit programming of the laser flash at certain points in flight operations such as take-off and landing.

PHASE II: This phase will refine the proposed design from Phase I and build a prototype of the laser simulator unit and accompanying software. Successful completion of Phase II will be demonstration of an integrated program in which the flight simulator will function as a replica of an in-cockpit experience of a laser exposure.

PHASE III DUAL USE APPLICATIONS: Instances of laser glare or laser flashblindness in commercial aviation are becoming more common. The FAA and the Airline Pilots Association worked with the Air Force and other agencies to develop and implement interim guidelines for outdoor Laser light shows because of some incidents connected with these entertainment venues. Despite cooperation from all recognized users of such devices, there still are incidents of laser beams for special events as well as from laser hooligans. Thus far there have not been any serious physical injuries, but in several cases the pilot was so startled that he had to hand controls over to a second pilot. This device would have widespread interest among commercial aviators who would rapidly come to an understanding of the proper procedures to follow in the event of an illumination. General aviation pilots could potentially benefit the most since, in most cases, they do not have a co-pilot to take over in the event of an incident.

REFERENCES:
1. American National Standard for the Safe Use of Lasers, ANSI Z136.1-1993.
2. Medical Management of Combat Laser Eye Injuries, USAFSAM-TR-88-21R, Oct 1988, revised Dec 1990.
3. David Sliney and Myron Walbarsht, Safety with Lasers and other Optical Sources, Plenum Press, 1980.

KEYWORDS: Laser, Laser flash, Laser flashblindness, Laser targeting, Laser safety, Laser incident, Laser education

AF00-092 TITLE: Software to Manipulate Large 3-Dimensional Voxel-Based Computer Model

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop an automated process to manipulate digital anatomical models to approximate natural poses.

DESCRIPTION: Increasing use of computer modeling to supplement and extend the applicability of empirical measurements has created a requirement for software to create and modify complex voxel-based computer models. An example of this is a digital anatomical model of the human body the Air Force has created to predict energy absorption during exposure to electromagnetic fields (EMFs). This model was created using photographic images from the National Library of Medicine's Visible Human Project. The EMF dosimetry model has a resolution of 1 mm and is over 365 million bytes in size. It is several orders of magnitude better than previously available EMF dosimetry human models. However, the detail that makes it a superior model, makes manual modification extremely labor intensive. Modifications, which would allow the model to be posed for specific applications such as kneeling or sitting in a cockpit or automobile, could require man-year(s) to implement manually. Existing technology developed to produce computer animation or computer aided design (CAD) avoids this problem in two ways. First, the level of detail is much lower and second, the models lack complex internal structures. Attempts to transport even the simplest 3-D voxel based models into the CAD environment have produced unmanageable results. Required is a 3-D editor for voxel-based models. The editor would allow for positioning of limbs while maintaining the integrity of internal structures such as muscles and blood vessels in the case of a human model. It would also allow the addition of objects such as helmets, headsets, and clothes. Models produced in this way could be used to simulate any action which could be described mathematically, including microwave dosimetry, collision simulations, projectile impacts, thermoregulation, etc. Of course, the list need not be limited to human models. Voxel-based models have been used to evaluate the radar signature of aircraft. This topic will require an innovative approach that may be forced to blend the CAD and voxel-based paradigms currently in use.

PHASE I: Demonstrate ability to modify the position of at least a single joint such as an elbow or jaw showing stretching and compression of appropriate voxels, appropriate movement/rotation in the joint and preservation of tissue structures adjacent to the joint (e.g., blood vessels or nerves).

PHASE II: Demonstrate ability to interactively manipulate the entire Air Force provided human EMF dosimetry model into arbitrary yet realistic poses such as sitting or kneeling. Also demonstrate ability to insert objects into the model space such as helmets and weapons.

PHASE III DUAL USE APPLICATIONS: Commercial applications of this software are numerous and include human factors, collision simulations, forensic reconstruction, simulating ballistic impacts, medical education, and more.

REFERENCES:
1. Visible Human Project, National Library of Medicine, 8600 Rockville Pike, Bethesda, MD 20894 (http://www.nlm.nih.gov/research/visible/visible_human.html).
2. Kunz K. S. and Luebbers R. J. The Finite Difference Time Domain Method for Electromagnetics. CRC Press, Boca Raton, Florida, 1993.
http://www.brooks.af.mil/AFRL/HED/hedr/dosimetry.html

KEYWORDS: Human Factors, Anatomy/Physiology, Modeling/Simulation, Directed and Kinetic Energy, Visible Human Project

AF00-093 TITLE: Universal Biological Sensor

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop passive, inexpensive sensors for biological warfare agents that can be read remotely or with a hand-held reader on a variety of surfaces without damaging the surfaces or otherwise revealing the sensors' presence.

DESCRIPTION: Currently, AFRL/HEDB has a Joint Services Tech Base Program funding to do basic research (6.1) and early applied research (6.2) to develop a biological agent sensing diode. It is coated with DNA and an organic semi-conductor that binds biological agents, in turn, causing changes in the light emission colors or the conductivity of the diode. A large array of DNA with different binding properties is generated by a random process and the binding properties are selected for a given collection of biological agents and for certain components that may be common to many such agents. Signature patterns on the array are generated for both categories, preventing technological surprise (the enemy using an agent for which a specific binding DNA has not been generated). The DNA not only binds other DNA but also proteins, lipids, carbohydrates, RNA, and even small molecules contained in or on the agents.

PHASE I: Determine the feasibility of a "spray paint" version of the sensor. This version can be sprayed on surfaces such as clothing, vehicles, aircraft surfaces (internal or external), buildings, grounds, etc. that are suspected of being contaminated with biological agents.

PHASE II: Collect the first "paint" signature response for a simulant agent, such as Bt or toxin. Breadboard a portable reader.

PHASE III DUAL USE APPLICATIONS: Commercial applications of this technology are use by first responders for suspected bioterrorism events, for determining bacterial contamination of walls, fixtures, and equipment in areas such as operating theaters and restaurants, and for ensuring a safe food supply from production facility all the way to the consumer.

REFERENCES:
1. Kiel,J.L. The Ultimate Biosensor. Aviation, Space and Environmental Medicine 65 (5, Suppl.): A121-A124, 1994 .
2. Kiel,J.L., O'Brien, G.J., Dillon, J., and Wright, J.R. Diazoluminomelanin: A Synthetic Luminescent Biopolymer. Free Radical Research Communications 8: 115-121 (1990).
3. Kiel, J.L., O'Brien, G.J., Simmons, D.M., and Erwin, D.N. Diazoluminomelanin: A Synthetic Electron and Nonradiative Transfer Biopolymer. In Charge and Field Effects in Biosystems-2, (M.J. Allen, S.F. Cleary, and F.M. Hawkridge, eds.), Plenum Press, New York, pp. 293-300 (1989).
4. Kiel, J.L., and O'Brien, G.J. (AF Inv 18,422) Luminescent Polymer. U.S. Patent 5,003,050 (issued 26 March 1991).
5. J. L. Kiel, J. E. Parker, Eric A. Holwitt, and H. A. Schwertner; Biosynthesis of Diazomelanin and Diazoluminomelanin, Patent Number 5,856,108; Jan 5, 1999.

KEYWORDS: Bioagents, Sensor

AF00-094 TITLE: Vision Corrective Wraparound Spectacles for Laser Eye Protection (LEP)

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop and demonstrate technology to grind vision corrective prescriptions into LEP spectacle lenses for full wraparound configuration.

DESCRIPTION: The USAF has a requirement for laser eye protection (LEP) that provides full field-of-view protection, i.e., prevents laser light from even reflecting into the eye from angles greater than 90o off the forward visual axis, and that is also capable of being ground with optical prescriptions to correct myopia. We are currently investigating wraparound spectacles as a potential solution for this requirement. While it is possible to grind prescription corrections into large base curve optical blanks, such as those that would be used for wraparound spectacles, the resulting lens has an unacceptable level of aberration and distortion, particularly in the periphery. The problem is further complicated by the materials and manufacturing methods used to produce LEP based upon new reflective coating technologies known as dielectric stacks, rugates, and holograms. Currently, these coatings are applied to the external surface of an optical lens blank made from polycarbonate or CR-39 plastics and then, for holograms and dielectric stacks, a protective cap is applied creating a laminated structure. To date, shear forces accompanying the grinding of prescription corrections into the lens blank cause either damage to the reflective coating or separation of the cap and base. If successful, the desired technology will: (1) provide at least an eight diopter correction for ocular refractive errors in the central visual field using polycarbonate and/or CR-39 plastic lens blanks; (2) produce these corrective lenses while meeting current industry standards for aberrations and distortion in commercially available eyewear; (3) not cause base/cap delamination or damage to laser reflective optical lens coatings; and, (4) produce lenses complying with ANSI Standard Z87.1 for protective eyewear.

PHASE I: Perform a technology feasibility assessment and deliver, if determined to be feasible, a description of the conceptual solution and a technology/technologies development proposal.

PHASE II: Execute the technology development plan proposed in Phase I and demonstrate the solution by delivering six lenses each with ground prescriptions of two, four, six and eight diopter of myopic correction that also meet the four criteria set forth in the Description.

PHASE III DUAL USE APPLICATIONS: In addition to a significant military market for LEP (aviators and ground troops), possible commercial markets for this type of eyewear (laser protective or not) include the general public, commercial and private aviation, occupational/industrial safety, academia, and the entertainment and health care industries.

REFERENCES:

1. ANSI Standard Z136.1. American national standard for the safe use of lasers. Section 4.6.2, American National Standards Institute, Inc., New York. 1993.

2. ANSI Standard Z87.1 American national standard for occupational and education eye and face protection. American National Standards Institute, Inc., New York. 1993.

3. "Introduction to rugate filter technology." Johnson, Walter E. and Crane, Robert L. in Inhomogeneous and Quasi-Inhomogeneous Optical Coatings, SPIE Proceedings Vol. 2046, pp 88-108; Dobrowolski, Jerzy A. and Verly, Pierre G., Eds (1993).

4. "Graded period rugates." Rahmlow, Thomas D. and Tirri, Bruce A. in Inhomogeneous and Quasi-Inhomogeneous Optical Coatings, SPIE Proceedings Vol. 2046, pp 147-153; Dobrowolski, Jerzy A. and Verly, Pierre G., Eds (1993).

5. "Laser-protective technologies and their impact on low-light level visual performance." Sheehy, James B. and Morway, Phyllis E. in Laser-Inflicted Eye Injuries: Epidemiology, Prevention, and Treatment, SPIE Proceedings Vol. 2674, pp 208-218, Stuck, Bruce E. and Belkin, Michael, Eds. (1996).

6. "Rugate and discrete hybrid filter designs." Rahmlow, Thomas D. and Lazo-Wasem, Jeanne E. in Optical Thin Films V: New Developments, SPIE Proceedings Vol. 3133, pp 25-35, Hall, Randolph L., Ed. (1997).

KEYWORDS: Laser eye protection, Wraparound eyewear, Myopic correction

AF00-095 TITLE: Remote Thermographer

TECHNOLOGY AREAS: Biomedical, Sensors/Electronics/Battlespace, Human Systems

OBJECTIVE: Remotely acquire accurate temperature measurements for various climactic conditions.

DESCRIPTION: A requirement exists for accurate measurement of the thermal signatures of various objects in the battlefield including temperature measurements of inaccessible personnel. This physiological characteristic is vital for evaluating the physical well being of the warfighter. Some battlefield and other emergency situations require that vital physiological parameters be measurable when direct contact is not possible. Remote heart and respiration rate monitors have been developed but accurate determination of temperature is also needed. Solutions need to be found to compensate for the difficulties inherent in acquiring remote temperature measurements, such as variations in ambient conditions such as temperature, humidity, background noise, etc.

PHASE I: Create innovative approach to accurately acquire temperature measurements of human subjects that are at least a few meters from the device. Also demonstrate means to compensate for variations in environmental variations, including extreme ambient temperatures.

PHASE II: Optimize the Phase I design, produce, evaluate, and deliver a full-scale prototype so that more accurate temperature measurements (+ 1 oC) can be made at larger distances.

PHASE III DUAL USE APPLICATIONS: Commercial applications of these technologies are possible in the area of civilian search and rescue activities, the monitoring of environmental conditions associated with such things as industrial air and water quality, and meteorological data gathering.

REFERENCES:

1. Choi, J. K., Miki, K., Sagawa, S., and Shiraki, K. Evaluation of mean skin temperature formulas by infrared thermography. Int J Biometeorol 1997 Nov 41:2 68-75

2. Ring, E. F. Quantitative thermal imaging. Clin Phys Physiol Meas 1990 11 Suppl A 87-95

3. Barnes, R. B. Determination of body temperature by infrared emission. J Appl Physiol 1967 Jun 22:6 1143-6

4. http://www.brooks.af.mil/AFRL/HED/hedr/hedr.home

KEYWORDS: Temperature sensing, Thermography, Remote thermal sensor, Vital signs monitor

AF00-097 TITLE: Human Performance Model for High G

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop a PC-based model of the human that characterizes task performance as a function of increasing G.

DESCRIPTION: Current performance models do not take into account the effect of extreme conditions on the human, such as the high, sustained G environment. The assessment of performance during taxing flight maneuvers has been traditionally compromised by the inability to provide a realistic environment to the subject. While individuals have been exposed to various acceleration time profiles and physiological and performance metrics have been recorded, the assessments have generally been open loop. Where closed loop performance has been studied, the exposure environment has not been close to the critical tasks required in a dynamic flight environment. This effort will seek to establish a set of critical tasks that have face validity and feedback control that will operate within the existing dynamic flight simulation capability of either AFRL centrifuge, as well as a model for predicting pilot performance in a high G flight environment.

PHASE I: Existing models for pilot performance under high sustained G will be evaluated for their relevance to an overall performance model. Products will include a final report and an approach for Phase II model development and validation.

PHASE II: The actual model will be developed and demonstrated on a PC. The final output of the model will be in terms of criteria that operators (pilots, operations personnel) understand--slower reaction, or percent loss of accuracy with a specific distribution of performance around the average. Exit criteria will include verification of validation of the model and the ability for the model to reliably reproduce results that are comparable to documented results of previous studies. If the model can accurately reproduce results from previous studies, where parameters such as G protection criteria, maximum G exposure, and difficulty of the performance task can be entered and monitored, then the model will have met validation criteria. In general, the model is considered complete when it can predict results of studies and then compare favorably with those results when the study is completed. Products will include (1) an interactive program to assess mishaps where sustained acceleration is considered a casual effect, and (2) an interactive program to predict pilot performance based on G protection provided, maximum G and G exposure duration, and the cognitive demands on the pilot. Both of these programs will be a part of the overall Acceleration Performance model that will be accessible in a workstation.

PHASE III DUAL USE APPLICATIONS: A model of human performance in the high sustained G environment may be adaptable to other extreme environments, such as extreme cold, heat, or altitude. In addition, these types of models will be applicable to a broad range of high workload vocations including driving trains, firefighting, and commercial flying.

REFERENCES:

1. O'Donnell, R., Cardenas, R., Eddy, D. Assessing the Performance Impact of G-Forces: Design of the Acceleration-Performance Assessment Simulation System (A-PASS). AL/CF-TR-1996-0093. AD # ADA320232

2. Chelette, T., Albery, W., Esken, L., and Tripp, L. (Sep 98) Female Performance at High G: Results of Simulated Flight after 24 hours of Sleep Deprivation, Aviation Space and Environmental Medicine, Vol. 69, No 9

KEYWORDS: Extreme Environments, Performance Model, Human Operator Model, High Sustained Acceleration, Maneuvering Acceleration, Dynamic Flight Simulation, Performance Measurement, Reaction Time, Percent Accuracy, G Protection, G Exposure

AF00-098 TITLE: Enhancing the Usability of Computer Generated Forces

TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Develop technology to enhance the usability of computer generated forces and behavioral representation (CGF& BR) in joint synthetic battlespace exercises.

DESCRIPTION: The government seeks innovative proposals to enhance the usability of computer generated forces and behavioral representation (CGF & BR) in joint synthetic battlespace (JSB) exercises. We are interested in technology to improve the ease of developing, employing, modifying, and maintaining such models. Proposals should improve the usability of CGF& BR throughout an exercise's lifecycle. A successful project will address one or more of the following goals. Reduction in: 1) the manpower required to develop, employ, modify or maintain a CGF& BR; 2) the time required to develop, employ, or modify a CGF& BR; 3) the training required to employ, modify or maintain a CGF& BR; and 4) the errors associated with developing, employing, modifying or maintaining a CGF& BR. The government is interested in proposals that address CGF & BR models used in campaign level simulations, simulation-based acquisition models, and distributed mission training.

PHASE I: Develop and document a concept for improving the usability of CGF &BR in JSB exercises. The plan should include a concept of operations for the proposed tool, the projected payoff, and a commercialization strategy.

PHASE II: Phase 2 will result in a prototype technique/tool, a field test to demonstrate the feasibility and payoff, a cost/benefit analysis, associated documentation, and a commercialization plan.

PHASE III DUAL USE APPLICATIONS: This technology can be used to improve the usability and fidelity of most any commercial simulation application that involves human interaction and human representation, such as training simulations, entertainment simulations, product development, and others.

REFERENCES: Modeling Human and Organizational Behavior: Application to Military Simulations. R. Pew & A. Mavor. National Academy Press. 1998.

KEYWORDS: modeling and simulation; joint synthetic battlespace; wargames; computer-generated force

AF00-099 Title: Aircraft Prognostics: Identifying Imminent Failures in Aircraft and System Components

TECHNOLOGY AREAS: Air Platform, Human Systems, Weapons

OBJECTIVE: Develop a capability to predict failure of aircraft and system components before they occur, and be able to display this information to maintenance mechanics in an easy to use format, so that repairs may be made proactively.

DESCRIPTION: The AF needs better ways to more efficiently manage its spare parts so that the right part is available at the right place, at the right time. Efficient management of parts requires the ability to predict what parts will be required and when they will be required. Technologies exist for predicting requirements on a fleet wide basis, however, provisioning and distribution of spares and the management of maintenance operations could be greatly enhanced by the capability to predict when specific components on an aircraft are about to fail. This would permit repairs to be made before a component actually fails, and would reduce the risk that aircraft about to deploy will have components fail en route or shortly after arrival (reducing spares requirements at the deployment site).

This prognostics program would have many benefits for the Air Force. The ability to predict failures in advance will reduce mission aborts due to system failures, reduce aircraft accidents, provide more cost-effective management of spares, and reduce the deployment footprint, by ensuring that only those components likely to fail are deployed. More parts would be available when required and the parts would be at the right location at the time that the old part needs to be replaced.

Innovative approaches are needed to perform prognostics for all aircraft systems, including electrical, mechanical, propulsion, and avionics. Technologies may address one or more types of systems. In addition to providing analyses that identify components that are about to fail, the technical approaches must include methods of extracting and presenting the information for use by maintenance managers and technicians in determining when to replace the component and by logisticians responsible for ensuring that the necessary parts are available. It is essential that information be presented in an easy to interpret and use format and meets all of the user's information requirements.

PHASE I: Phase I will define requirements, and develop a proposed approach for predicting failures, including identification of potential prediction variables, display techniques, identification of data sources, and recommendations for development of failure prediction algorithms.

PHASE II: Phase II will develop a prototype suite and demonstrate the concept on an aircraft system or subsystem.

PHASE III DUAL USE COMMERCIALIZATION POTENTIAL: This product would have major benefits for the commercial airline industry. An effective capability for predicting failures could reduce incidents of in-flight failures and flight cancellations due to component failure.

REFERENCES:

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2. G. Smith, J.B. Schroeder, S.Navarro,. Haldeman, "Development of an Integrated Diagnostic Strategy to Support Autonomic Logistics" Proc. of Air Force Logistics Symposium, March 1997
3. G. Smith, J.B. Schroeder, B. Masquelier, "Logistics for the Joint Strike Fighter, It Ain't Business As Usual," Proc. of 1998 Society of Logistics Engineers Symposium, August 1998
4. R Cowan, W Winer, "Integrated Diagnostics", February 1997, DTIC ADA324130, Georgia Institute of Technology Atlanta, GA Office of Naval Research/XB Contract #N00014-95-1-0539

KEYWORDS: Integrated Diagnostics, Prognostics, Failure Prediction, Predictive Maintenance, Sensor-Based Systems

AF00-100 TITLE: Force Protection Training Technology

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Conduct research to develop and validate strategies, methods and technologies to improve the effectiveness of team training and mission performance while deploying for specific contingencies.

DESCRIPTION: A potential problem arises when units of teams prepare for activities and missions without adequate advanced organizers or clear training and operational objectives. With the advent of advanced multimedia- and simulation-based training systems, there is a significant opportunity to develop and implement instructional strategies and mission objectives-based within high fidelity training modules that can be utilized at a home base, en route to theater, and in-theater. If the training content can be delivered to the point-of-need and is compatible with a variety of delivery systems and technologies, it can potentially improve mission performance significantly. Moreover, reducing the training support footprint by developing modules once and to reusing them to meet different training and mission objectives is a significant goal. Furthermore, these modules might incorporate a reachback capability to permit on-line interactions with content experts when needed in the field. It may even be feasible to provide coaching or guidance during a training event to enhance team member skill and proficiency for future performance. In addition, high fidelity environments can provide near-real time data for assessing the impact of different strategies and methods on actual mission execution and performance. There are a number of key research issues to be addressed. The first issue is related to an exploration of what constitutes an appropriate instructional strategy or strategies for a given operational content domain and objectives. The second issue is related to how to apply identified strategies within a training capability in a way that impacts the underlying competencies of mission personnel and their ability to execute the mission. A third issue is related to developing valid and reliable metrics to assess the impact of the strategies on mission performance. The fourth issue is related to examining the extent to which training content modules can be housed in a virtual library for use in different domains with similar objectives. Finally, this topic will develop proof-of-concept training content and will demonstrate the feasibility of delivery on multiple COTS computer hardware platforms and across multiple domains for similar objectives. It will also develop data integration and scoring methods to facilitate review for evaluation and remediation. Results will be of considerable relevance to both military and non-military clients for situations where near real-time training and multi-person integrated performance is required.

PHASE I: Phase I activities will result in proof-of-concept training development, modularization and delivery software tools. Phase I will also demonstrate the feasibility of distributing content just-in-time training during preparation for mission performance. The demonstration will be accomplished in a cross-training deployable environment and a civilian content domain. Phase I proposals must include a detailed market survey activity and letters of interest/commitment from potential commercial partners must be obtained for Phase II consideration.

PHASE II: This phase will fully develop, apply, test, refine, and validate the methods and technologies necessary to develop and distributed high-fidelity training content modules in a variety of delivery models and technologies. It will also refine and validate instructional approaches and architectures that generalize to cross-training to inter-discipline teams and variety of military and civilian operational systems (such as a medical disaster). As an additional activity in Phase II, an elaborated capability to efficiently develop and distribute training modules across operational contexts and potentially across mission objectives will be tested. Proposals should assume that the software will run in a platform independent environment.

PHASE III DUAL USE APPLICATIONS: The effort provides a unique capability to apply advanced distributed learning concepts to efficiently develop, deploy and evaluate modularized high-fidelity training. The results from this effort are of considerable interest to the Private Sector. The costs associated with developing and redeveloping training software are significant. The capability to systematically assess training requirements and occupational needs and to rapidly link needs to training modules has considerable practical value. In addition, the opportunity to develop a library of reusable training modules that permits identification of existing content to meet new requirements is unique and has not been demonstrated on a scale that makes it economical to reuse training content instead of developing new content. The benefits from such a capability to Government and Private Sector agencies include enhanced targeting training and performance support to reduce operator and maintainer time-to-proficiency, reduced error-rates, and reduced on-the-job training needs.

REFERENCES: Kraiger, K., Ford, J.K., & Salas. E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation. Journal of Applied Psychology, 78, 311-328.

Other Resources:
1. Force Protection Unit Advisor Course-Provides instruction for antiterrorism planning.
http://www.mcclellan.army.mil/usamps/dot/aletd/page24.htm
2. European Command Training and Equipment requirements for Force Protection: Antiterrorism measures, mine awareness training, explosive device instruction, medical threat, host country cultural aspects, rules of engagement, and use of deadly force. Also included are; NBC defense survival skills proficiency, weapons qualifications, medical training (endemic diseases, poisonous animals, environmental injuries, combat stress, sleep discipline and personal/dental hygiene).
http://www.eucom.mil/hq/escm/tng.htm
3. Transforming US Forces of the Future - Course topics include; Joint Vision 2010, information superiority, full-dimensional protection, focused logistics, counter proliferation, force protection and combating terrorism.
http://www.defenselink.mil/pubs/qdr/sec7.html
4. US Forces-Force Planning: Small scale contingency operations, major theater war, overseas presence, counter proliferation activities, force protection and combating terrorism.
http://www.dtic.mil/execsec/adr98/chap2.html
5. 7th Battalion, 95th regiment - Mission of Training battalion; mobilize and deploy to proponent schools, anti-terrorism and force protection
6. http://www.hallpage.com/f4bdc/f805/7bnps.shtml

KEYWORDS: Force protection, contingency training, inter-discipline teams, advanced distributed learning, just-in-time training, mission performance, multimedia instruction, performance support systems, program evaluation, simulation, training

AF00-104 TITLE: <u>Real Time Integrated Planner/Player (RIPP)</u>

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Airborne Warning and Control System (AWACS) - Electronic Systems Center (ESC/AW)

OBJECTIVE: Develop/demonstrate simulation, analysis, and visualization technologies to collectively address a broad range of sensor-decision maker-shooter issues.

DESCRIPTION: The contractor shall research, develop and demonstrate innovative integrated constructive and virtual simulation technologies which provide an effective and measurable means to thoroughly investigate a broad range of sensor to decision maker to shooter information issues. Issues shall include how to best accomplish: 1) integrated in-time and coordinated sensor, decision maker and shooter/weapons system operations, 2) the generation and distribution of real time information (exp. threat data, imagery, etc.) and tasking feeds/distributions, 3) the accomplishment of real-time damage assessment, 4) flexible adaptive planning and coordination (exp. AOC response to platform mission re-planning, re-targeting, re-tasking), 5) full theater exploitation of integrated RTIC/RTOC 6) real-time multi-source fusion and display in the shooter cockpit, AOC, flying airborne command post, and other support facilities, 7) consolidated (i.e., shooter/AOC) response to time critical targets, and 8)optimized C4ISR exploitation. "Appropriate fidelity" functional models/simulations shall be developed and/or utilized for platforms (airborne, spaceborne, and ground-based) and associated platform sensors (EO, IR, RF, etc.) and will be functionally integrated to address full spectrum sensor to decision maker to shooter issues. Other features of the consolidated system-level modeling and simulation capability will include: 1)"tunable" off-board and on-board sensor characteristics (exp. SAR resolution) to allow determination of overall system performance versus cost for selected grades of sensors, 2) Visualization of the simulation scene, mission profile, platform and AOC functions, selected simulation parameters and weapon system performance, and 3) Data collection and analysis, and configuration control. Maximum use of commercial-off-the-shelf desktop, workstations, and distributed simulation technologies/facilities shall be employed to provide a virtual engineering development environment so that integrated information concepts can be evaluated in a realistic operational combat-like environment in a cost effective fashion.

PHASE I: The desired products of Phase I are: 1) identification of the enabling real-time or non-real-time technologies for sensor to decision maker to shooter modeling and simulation, 2) accomplishment of specific experiments to verify critical aspects of the defined concepts, 3) development of a system specification, implementation approach, and demonstration plan. The contractor shall also document the potential for a Phase II follow-on effort.

PHASE II: The contractor shall accomplish a detailed design, develop the prototype technology, and perform a demonstration of the developed technology. The contractor shall also detail his plan for his Phase III effort.

PHASE III DUAL USE APPLICATIONS: The desired product of Phase III is a robust M&S capability for use in defense and commercial information and sensor technology development. M&S is an enabling technology and a change in the way of doing business that will have major implications for the commercial and defense sector. The commercial marketplace is presently making greater use of generic simulation techniques, simulation infrastructure, and off-the-shelf components for applications in financial industries, manufacturing, industrial process control, biotechnology, healthcare, communication, and information systems. The aircraft and automotive industries have demonstrated the success of integrated computer assisted design with supporting modeling and simulation to bring products to market quickly. Advances in software and computer technology are making virtual prototyping possible and affordable for the small to medium business. Software development itself is a manpower intensive endeavor. Requirements definition remains a problem area where the user is unable to verbalize what he/she wants in detail. Virtual prototyping of software requirements and modeling of the software is a future growth area in which simulation is used to review completeness of software requirements and functionality.

KEYWORDS: Modeling and Simulation, Collaborative Virtual Prototyping, Real-Time Simulation

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3) WL-TR-92-1119, The Integrated Test Bed (ITB) System Integration Project, September 1992
4) SSTZ00001B, System Specification for the Integration Test Bed (ITB) Facility, March 1993
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6) ESAI Report -- expected to be available in September 1999.

KEYWORDS: Modeling and Simulation, Collaborative Virtual Prototyping, Real-Time Simulation

AF00-105 TITLE: Domain-Portable Shallow Ontology Builder

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Intelligence, Surveillance and Reconnaissance (ISR) Integration System Program Office (SPO) - Electronic Systems Center (ESC/SR)

OBJECTIVE: Develop innovative domain-portable ontology builder to transform voluminous shallow information, extracted from text, into knowledge.

DESCRIPTION: Intelligence analysts need to exploit large volumes of free text in order to find information relevant to their topics of interest, and to gain situation awareness (knowledge) on them. Information Extraction (IE) technology is one step towards solving this problem. IE enables analysis and visualization (A & V) of free text by automatically extracting useful information from text and putting it into a structured form that A & V tools can use. The current state-of-the-art of IE is Shallow Extraction of relatively simple information like Named Entities (people, facilities, locations, dates, times, money, etc.) and Shallow Events. Shallow Events are events at a low level of text understanding. The shallow event's action corresponds to the clause's verb, with its associated location, start date, end date, and category. The Named Entities associated with the event (clause) are also known, although their role in the event may not be known. Please note that the definition of shallow events is still evolving and is interpreted differently by various IE researchers; the proposed solution needs to take this into account. The problem with IE is that it only gets us so far in the Cognitive Hierarchy, transforming voluminous data (text) into voluminous information. In order for analysts to gain situation awareness, they need to be able to transform this voluminous information into knowledge. This requires the use of ontologies, or some other form of knowledge representation, specifically designed to use the output of Shallow IE systems. Such ontologies should be capable of specifying the set of entities and concepts (including states, attributes, situations, events, etc.) being modeled or represented and the relationships that hold among them. Hierarchical structures (taxonomies) are typically used to organize the entities and concepts. The functionality of an ontological representation capability or tool typically includes creation and editing of entities, concepts, relationships; inference mechanisms; and search and retrieval mechanisms. Since analysts' domains of interest change, they need the capability to build new ontologies to capture their knowledge as they do their analyses and gain insight into the new domain; and since the world is dynamic, analysts need the capability to extend and modify existing ontologies, as well. It is also desirable that the ontology building capability be interoperable with other ontologies to the extent possible, to exploit the specialized knowledge they model. In short, the ontology-building capability needs to be robust, flexible, maintainable, domain-portable, and support knowledge sharing/reuse. This capability would enable timely situation awareness, help preserve corporate knowledge (e.g., senior analysts' domain knowledge), and facilitate training new analysts on these domains.

PHASE I: Perform preliminary research to determine the best approach to develop the ontology building capability described above. Develop preliminary software to assess concept feasibility.

PHASE II: Use the knowledge gained in Phase I as the basis for developing a full-scale Domain-Portable Shallow Ontology Builder.

PHASE III DUAL USE APPLICATIONS: An Ontology Builder would be valuable to organizations that exploit free-text to gain information and knowledge on a situation or topic of interest. This includes information analysts in the DoD, law enforcement community, research communities, and the financial world (e.g., competitive intelligence, market analysis, and stock analysis).

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2) "IJCAI Workshop on Ontologies and Problem-Solving Methods: Lessons Learned and Future Trends", http://www.swi.psy.uva.nl/usr/richard/workshops/ijcai99/home.html

KEYWORDS: Knowledge Representation, Ontology, Ontology Design, Information Extraction

AF00-106 TITLE: <u>Operational Level Inter-Modal Lift Planner</u>

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Intelligence, Surveillance and Reconnaissance (ISR) Integration System Program Office (SPO) - Electronic Systems Center (ESC/SR)

OBJECTIVE: Develop a system to plan, analyze, trade-off, and optimize air/land/sea inter-modal lift for SOF missions or logistics planning.

DESCRIPTION: Current SOF systems provide detailed "execution level" planning tools that help warfighters plan, analyze, rehearse, and execute SOF missions. These systems, however, lack automated tools to support "operational level" planning and coordination of air/land/sea resources. These same tools will have application to logistics planners who must make trade-offs between air, sea, and ground transportation options. This SBIR will provide a capability to help warfighters plan, analyze, trade-off, and optimize "operational level" inter-modal lift. It will use mission timing, detection risk, asset availability, and resource utilization as evaluation criteria. The warfighter will develop initial plans, and then iterate the process to: Capture and organize mission "objectives" and "task set"; define linkages and dependencies between tasks; input enemy sensor order of battle, and path constraints (e.g. terrain, no-fly zone, weather); select air/land/sea lift resources, "way-points" and "legs"; evaluate critical paths and optimize; recommend optimized Courses of Actions (COAs) for Commander's approval; and monitor "operational level" mission execution and re-plan, as necessary. AFRL encourages concepts that: 1) Run on an IBM PC Windows NT system, with a long-term plan of migrating to a Defense Information Infrastructure Common Operating Environment (DII COE) compliant environment; 2) Leverage existing products where appropriate; 3) Offer tabular, graphical, and map-based analysis/visualization; 4) Promote collaborative planning; and 5) Interface/integrate with existing DoD products and databases.

PHASE I: Develop initial concept. Perform analysis on concept feasibility. Prototype and demonstrate initial concept. Deliver report on initial concept performance - include user feedback and identify risk areas.

PHASE II: Extend concept. Integrate extended concept with USSOCOM CONOPS and/or mission applications. Demonstrate extended concept. Deliver report on extended concept performance - include user feedback and new risk areas.

PHASE III DUAL USE APPLICATIONS: Resulting technology will be applicable to any government or commercial industry that must move equipment over large distances using various types of vehicles (e.g., transportation management).

KEYWORDS: Optimization, Logistics, Planning, Intermodal Lift, Special Operations, Transportation Management

AF00-107 TITLE: Automated Multi-Level Security Digital Information Transfer Using Watermarking Technologies

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Investigate digital watermarking technologies for automated information transfer in a Multi-Security Level (MSL) environment.

DESCRIPTION: The U.S. military and the business community require the real-time ability to obtain and transmit information, based on need-to-know, with authenticity, confidentiality, and integrity across systems and networks at various levels of sensitivity, while protecting that information in storage, during processing, and in transit. MSL solutions, such as bi-directional high assurance guards, deliver much of this capability already. The portion of the problem set which has not been solved is the ability to accomplish the above transfer requirements in near real-time for complex data types. For fixed format information, solutions have already been developed and made ready for operational fielding. In fact, for complex data types such as imagery, filters which automatically examine the metadata for product classification have been developed, approved, and fielded. However, DOD MSL certifiers and accreditors have determined that metadata inspection is not sufficient. They require human inspection for all digital products being transferred across MSL boundaries. This means that in spite of many advancements in high assurance guards, digital product transfer from high-to-low still requires a "man-in-the-loop". The only process accredited for transferring, for example, secret image products (including image thumbnails) from a TS/SCI network to a Secret network is to use a high assurance guard that requires a human to manually open the image itself within a image viewer, ensure it is labeled "Secret" directly on the image, and enter confirmation of this into a verification screen. A similar shortfall exists for video products. Video purposely exploited for use in collateral environments must be manually reviewed by a MSL analyst before being streamed to the low side domain. This process severely hampers the ability to provide near real-time intelligence information to the warfighter. The integration of secure, key-dependent digital watermarking technologies, which have recently matured enough to be operationally demonstrable, into an accredited MSL guard has a very real potential to supply the last missing link in this information exchange challenge. The latest generation of digital watermarking algorithms contain the necessary robustness with respect to JPEG/MPEG compression, cropping, filtering, blurring, and uniform noise, to be used in the military's MSL environment. This effort will investigate and prototype the integration of digital watermarking technologies with both DOD approved and commercially available MSL guards. The selected guard(s) must have a modular architecture which separates the information inspection application from the actual boundary device application. The transfer of information between these applications should be based on Public Key Infrastructure technologies. The information inspection application architecture must be well suited for the integration of an algorithm which inspects the classification of the digital product via the watermark as part of the verification and validation pipeline process. This process determines if a product can be transferred to the destination sensitivity level. Successful demonstration of this capability will be a significant milestone in the military and commercial endeavor to exchange a growing assortment of information types between environments of different sensitivity levels.

PHASE I: Perform a detailed analysis of the readiness of digital watermarking algorithms for digital media to be integrated into a MSL guard for accredited automated transfer of low-side releasable products from a high-side network to a low-side network. This analysis should consider all network combinations practical within the DOD and industry. Digital media should include, but are not restricted to, digital imagery, digital video, and digital audio. Demonstrate a working prototype using a MSL guard provided by the government.

PHASE II: Develop a user interface for configuring, according to the data types, the run-time operation of the digital watermarking algorithms within a commercially available MSL guard. Generate a complete set of documentation to support certification and accreditation testing of the integrated prototype product. Investigate and integrate content authentication techniques to supplement the MD5 digital seal to ensure product integrity. Demonstrate the working prototype via a realistic business-oriented scenario.

PHASE III DUAL USE APPLICATIONS: Develop a certified and accredited product suite which can be integrated with one or more US Intelligence Community approved MSL guards. Install and support the accreditation of the integrated product at a DOD site requiring automated digital media transfer between a Top Secret and Secret network. Also install and support the certification of a commercially available integrated product in a business environment. With the increasing use of the Internet to promote the dissemination of information, there are numerous instances when an entity may want to restrict and control the release of sensitive information from an Intranet environment to the public domain Internet. This entity may want to protect its information regardless of whether it is a picture, a video, or a digital audio product. For example, a business enterprise may want to disseminate important marketing data, but may also wish to restrict the distribution of proprietary information to preserve its commercial viability. Law enforcement agencies may wish to share collected evidence with collaborating agencies, but may want to withhold public disclosure prior to the completion of the investigation. A distributor in the entertainment industry may wish to promote its new movie on the Internet, but may want to ensure that scenes of adult nature are not available to minors. A government office may wish to respect the Freedom of Information Act, but may want to ensure that sensitive or classified material is never released to the public.

KEYWORDS: Multi-Security Level (MSL), Digital Watermarking, Automated Imagery Transfer, Video Authentication Techniques, High Assurance Guards, Information Integrity

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3) Fridrich, J., "Methods for Detecting Changes in Digital Images", Proc. of the 6th IEEE International Workshop on Intelligent Signal Processing and Communication Systems (ISPACS '98), Melbourne, Australia, 4-6 Nov 1998.
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KEYWORDS: Multi-Security Level (MSL), Digital Watermarking, Automated Imagery Transfer, Video Authentication Techniques, High Assurance Guards, Information Integrity

AF00-108 TITLE: Security Management and Protection for Large-Scale Information Systems

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Intelligence, Surveillance and Reconnaissance (ISR) Integration System Program Office (SPO) - Electronic Systems Center (ESC/SR)

OBJECTIVE: The objective of this effort is to develop security management and protection mechanisms for large-scale computer networks and information systems. The security management techniques include technologies for intruder deterrence, intrusion detection, and recovery. The security protection techniques include technologies for boundary protection, internal misuse control, and dynamic vulnerability assessment.

DESCRIPTION: Security management and protection in large-scale information systems is a daunting task. Currently there are a number of tools that address different parts of the security management and protection problem. The tools that exist today are stovepiped, the outputs are not integrated or fused into a common operational picture of the cyberspace environment, and they have very poor user interfaces. It is necessary to have the ability to provide security management and protection of mission-critical information systems on an all-day, every-day basis. Defensive Information Warfare (DIW) analysts need real-time knowledge about what is happening on their networks and information systems. They need to know in real-time that an intrusion has occurred and to not only contain the intrusion but to understand from a forensics standpoint what happened. This SBIR will address the design and development of an architecture that enables security management and protection tools to be integrated in a cohesive manner and provides modern user interface capabilities. The foundation of the integrated system is an information integration infrastructure that allows different types of tools to be easily ported to it. In addition, the infrastructure will have the capability that allows outputs from different tools to be fused into a common operational picture of the cyberspace. The tools that are hosted on the infrastructure will address intruder deterrence, intrusion detection, information recovery, boundary protection, internal misuse control, and dynamic vulnerability assessment. The security management and protection system will provide support for advanced analysis techniques. Heuristic or knowledge-based methods are required to provide the capability to adapt to emerging network technologies, reduce data analysis efforts, reduce error and false alarm rates, and provide automated response to intrusions. This system will also provide the DIW analyst the capability to perform security management of networks at different security levels thus addressing the difficult multilevel security problem.

PHASE I: Investigate the feasibility of using COTS/GOTS technologies for building the security management and protection system. Investigate the feasibility of using COTS software for the information integration infrastructure. Design the system architecture.

PHASE II: Develop a prototype and demonstrate an integrated security management and protection system.

PHASE III DUAL USE APPLICATIONS: Security protection and management is needed throughout the Government (both the military and civilian sectors). Additionally, potential commercial applications exist in all aspects of business and industry where electronic commerce is becoming pervasive.

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KEYWORDS: Defensive Information Warfare, Information Protection, Information Security

AF00-109 TITLE: DoD Information Exchange Using XML

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Intelligence, Surveillance and Reconnaissance (ISR) Integration System Program Office (SPO) - Electronic Systems Center (ESC/SR)

OBJECTIVE: Develop and demonstrate XML encoded text and binary message formats of converting United States Message Text Format (USMTF) message types.

DESCRIPTION: The commercial world is developing a standard for Internet data exchange, known as the Extensible Markup Language (XML), based on the power of Standard Generalized Markup Language (SGML). This semi-structured data format allows communities of interest to define their own Document Type Definitions (DTDs) for specifying the valid structure of messages, in particular problem domains. The DoD could greatly benefit from the ability to use Commercial-Off-The-Shelf (COTS) tools for authoring, validating, parsing, and processing XML documents and messages, if more of its data conformed to this emerging standard. This proposal is to develop and demonstrate syntax and methods for converting USMTF formatted data into equivalent XML encodings.

PHASE I: Investigate the set of available tools for creating and parsing both USMTF and XML that could be leveraged in this format conversion effort. Understand the objectives of the USMTF program, and the commercial trends and standards efforts including World Wide Web Consortium's (W3C) Document Object Model (DOM), and XML itself.

PHASE II: Build a prototype conversion tool using available message parsing/formatting tools and class libraries. Define the specific DTDs for all of the USMTF message types. Use commercial XML-based tools to show the added value of having DoD messages in industry standard forms. Evaluate the effects of such a conversion on message size, human readability, and ease of database population.

PHASE III DUAL USE APPLICATIONS: The commercial world will benefit from the information systems technology upgrades resulting from this research.

KEYWORDS: United States Message Text Format, Extensible Markup Language, Document Object Model, Standard Generalized Markup Language

AF00-110 TITLE: Component-Based Data Fusion Architectures

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Intelligence, Surveillance and Reconnaissance (ISR) Integration System Program Office (SPO) - Electronic Systems Center (ESC/SR)

OBJECTIVE: Develop standards-based component frameworks for data fusion.

DESCRIPTION: Combining data from multiple sources into a single coherent "picture" is a fundamental challenge to Intelligence, Surveillance, and Reconnaissance (ISR) missions. As the commercial world adopts distributed object-oriented "component" software architectures such as CORBA and Enterprise JavaBeans, there is a need to design new systems using a component approach. Applications such as data fusion need to be built to leverage the commercial developments, but provide frameworks for extension that take into account the special needs of their class of problems. This proposal is to develop a component-based framework for data fusion that provides the necessary infrastructure to leverage COTS technology in these areas, while creating a plug-in receptacle interface for specific data sensors and sources.

PHASE I: Understand the commercial distributed object computing standards, including CORBA v3, Sun's Enterprise JavaBeans, and Microsoft's COM+. Develop a generic data model supporting information fusion for physical battlefield entities and their temporal, spatial and other attributed characteristics. Include data mediation for physical measured quantity units conversion and general mechanisms for representing uncertainty.

PHASE II: Develop a component software framework for allowing domain specific data conversion, comparison, and fusion components to interact. Define the common services needed for supporting such a framework, and develop several example data aggregation, summarization, and fusion components to demonstrate the utility of the component software approach.

PHASE III DUAL USE APPLICATIONS: The commercial world will benefit from the upgrades in standards-based component frameworks for data fusion resulting from this research.

KEYWORDS: Fusion, Software Components, Java Beans, DCOM

AF00-111 TITLE: Rapid Knowledge Base Development Using Intelligent Agents

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Defense Information Infrastructure Air Force System Program Office (SPO) - Electronic Systems Center (ESC/DI)

OBJECTIVE: Investigate and develop techniques/tools for rapidly designing, developing, and accessing large-scale data/knowledge bases using dynamic and adaptive agents. The goal is to rapidly produce massive knowledge base(s) consisting of innovative memory mechanisms, high performance agent supported architecture innovations and layers of data/information/knowledge capable of coordinating, cooperating, and negotiating to provide just-in-time information and services.

DESCRIPTION: Investigate high performance agent mechanisms to enhance rapid knowledge development for massive high performance information data/knowledge bases. The growing diversity of different types of data is generating a problem because of the massive size of modern data/knowledge bases. Increased use of video, fax, graphics, images, voice, and textual data make these data types readily available, in different forms, to users. Advanced computational models need to address processing of data at very high speeds. Advanced data structures could provide innovative ways to both rapidly develop and re-develop various forms of data/knowledge. Intelligent agents to coordinate various forms of raw data, including restructuring and re-use, to discover information and to leverage new computational paradigms available in emerging high performance computing technology need to be investigated. Optical computing agent oriented techniques for interconnection and processing could provide breakthroughs in unique tools for secure knowledge development. Graphical tools and machine learning techniques using agents for knowledge development provide an opportunity for both adaptable and scalable innovations. Mobile computing designs, integrated with agent technology, offer real potential for incorporating new and reusable knowledge sources within local domains. Research innovations in these areas supporting rapid knowledge development will help provide ways data should be dynamically structured and stored for efficient retrieval as well as provide adaptable transformation techniques to structure knowledge which can be managed more efficiently so that information can be rapidly filtered, manipulated and summarized. Mechanisms to be investigated include (1) intelligent information rich hyperprogram web agents, (2) advanced adaptable memory design/configurations, (3) electro/optical special purpose architecture enhancements, (4) agent-based mobile hand-held computational mechanisms for seamless access, and (3) evolvable and revolutionary data/knowledge base configurations which can rapidly add new knowledge. Challenges include unique use of techniques based on adaptive data architectures, learning mechanisms, and dynamic databases integrated with intelligent agents to rapidly develop knowledge.

PHASE I: Phase I will investigate development of techniques for rapidly designing, developing, and integrating large-scale active knowledge bases using dynamic and adaptive intelligent agents.

PHASE II: Phase II will demonstrate a rapid data/knowledge base development for very large knowledge bases in appropriate scalable information processing domains/platforms.

PHASE III DUAL USE APPLICATIONS: Phase III will test and evaluate tool(s) for rapid knowledge base development and commercialize results of Phase I and II. Rapid accessibility to integrated systems and information increases choices for consumers in both civilian and defense applications. This technology could have a major impact on applications that require integrated decision making and timely and accurate information such as planning/scheduling systems, autonomous vehicles, aircraft operation, hospital life support systems, decision support systems and personal military command and control.

KEYWORDS: Intelligent Systems, Software, Adaptive Computers, Knowledge Base, Dynamic Data Base, Agent-Based Tools

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AF00-112 TITLE: Improved Command and Control Modeling and Simulation

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Modeling and Simulation System Program Office (SPO) - Electronic Systems Center (ESC/CXS)

OBJECTIVE: Develop improved modeling and simulation (M&S) capabilities to support and analyze current and emerging Command and Control needs.

DESCRIPTION: The Air Force Command and Control architecture and operational cycle is evolving from a set of stove-piped systems and a discrete ATO (Air Tasking Order) cycle to a set of networked systems and a continuous ATO cycle. This evolution suggests the need for improved modeling and simulation tools to support military worth analysis, operations analysis, mission planning, resource allocation studies, etc. Several issues arise when considering these areas where improvement is required. One is the characterization of multi-sensor fusion and sensor cross-cueing. Current M&S tools do not adequately estimate the "integrated" detection/classification capability of various sensors working in tandem. Another issue is the importance of timely Battle Damage Assessment (BDA), and the current lack of ability to model dynamic re-tasking of assets to effectively do BDA. With the development of new sensors, there is a need for a systematic target database (ranged over azimuth and elevation) to properly represent the effects of a specific sensor against a particular target in a clutter environment. Still another issue, which must be addressed in the models, is the Processing, Exploitation, and Dissemination (PED) of information. Advanced information management techniques will be at the heart of solving the PEDs problem associated with the anticipated network of existing and new sensors. Current models do a poor job in representing PEDs capabilities, and they are likely to be strained beyond credibility in the near future. The issues addressed above are representative of those which must be addressed, but they do not make up the complete list. In addition to providing the modeling and simulation community with improved capabilities, the new developments must be compatible with the DoD standard High Level Architecture (HLA).

PHASE I: Phase I activity shall include (among other issues): 1) An evaluation of current and planned operational concepts of operations to determine the elements which must be addressed in the tool, 2) Develop a modeling approach which addresses the Command and Control modeling and simulation need, 3) Demonstrate the feasibility of the approach, and 4) Determine requirements for full development in Phase II.

PHASE II: Phase II activity shall include (among other issues): 1) Develop and validate a full-scale model based on the approach defined in Phase I, and 2) Demonstrate that the model is HLA compliant by integrating it into an existing federation.

PHASE III DUAL USE APPLICATIONS: The improved modeling and simulation capabilities are not only applicable to the DoD. These would benefit the intelligence agencies, civilian and federal law-enforcement agencies, NASA, and any member of the scientific community who needs to process and disseminate sensor data related to Space, the atmosphere or the Earth.

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KEYWORDS: Command and Control, Modeling and Simulation, Sensor Fusion, Sensor Cross-Cueing, Battle Damage Assessment, Processing, Exploitation, and Dissemination, HLA

AF00-113 TITLE: A Robust Integrated Framework for Plan Generation and Execution

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Modeling and Simulation System Program Office (SPO) - Electronic Systems Center (ESC/CXS)

OBJECTIVE: Develop innovative technology approaches for the integrated generation and execution of plans in coalition environments.

DESCRIPTION: The development of coalition campaign plans (e.g., air, logistics, information ops) is a very labor intensive process, requiring a great deal of manual information gathering, and analysis. The process of plan development becomes even more uncertain when members of the planning staff are from other countries whose assets capabilities are not known, or whose culture does not allow certain missions to be carried out. Such differences can negatively impact the pace of plan generation as well the entire planning process. Current planning systems are primarily authoring systems in which the user still manually builds the plan, but much of the "book keeping" is done via an information system. Coalition planning is usually carried out ad hoc across multiple stove piped systems and then integrated together manually. The objective of this topic is to develop an intelligent planning and execution framework, utilizing software agents and plan templates which can generate a plan quickly, share a common plan perspective amongst coalition members, check for possible conflicts amongst coalition partners, offer solutions to these conflicts, and react/replan accordingly to changes in the world state. All solutions must be DII COE compliant and based on COTS products.

PHASE I: Develop initial framework concept. Perform analysis on concept feasibility. Prototype and demonstrate initial concept. Deliver report on initial concept performance - include user feedback and identify risk areas.

PHASE II: Extend concept. Integrate extended concept with a coalition air, logistics, or information CONOPS and/or mission applications. Demonstrate extended concept. Deliver report on extended concept performance - include user feedback and new risk areas.

PHASE III DUAL USE APPLICATIONS: The ability to automatically generate and monitor execution of plans for large-scale, multi-national organizations would have widespread applicability in both the military and commercial sectors, e.g., global transportation/delivery industries, communications providers, etc.

KEY WORDS: Intelligent Software Agents, Planning Templates, Execution Monitoring, Coalition Operations

REFERENCES:

1) "Is George Bernard Shaw Still Right? Lessons from Coalition Operations", Buster McCrabb, International Workshop on Knowledge-based Planning for Coalition Operations

2) "Coalition Information Operations", Larry Wentz, International Workshop on Knowledge-based Planning for Coalition Operations

3) "Lessons from Bosnia", Larry Wentz, CCRP Press

AF00-115 TITLE: Satellite Communications Systems Simulation

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Modeling and Simulation System Program Office (SPO) - Electronic Systems Center (ESC/CXS)

OBJECTIVE: Develop a Satellite Communications Toolkit to be used in a communications planning tool environment and integrated with other simulation and planning technologies.

DESCRIPTION: Satellite communication (SATCOM) is playing an increasingly important role in the military communications infrastructure. SATCOM is no longer a separate asset, but is quickly becoming an integrated component of communications at all levels, including mobile services, personal communications, reach back, inter- and intra- theater communications, and both high- and low-speed data services over both short and long distances. As SATCOM becomes a part of the integrated communications infrastructure, or global grid, it will become increasingly important to provide planners with adequate tools that can help determine the proper "mix" of satellite, wireless, and wired communication assets for meeting given requirements of an operational scenario. This hybrid combination of various communication assets must be simulated as a whole and tuned to meet requirements before deployment. The toolkit that will be developed under this effort to perform this task must be able to treat the overall communication system as a single entity, providing seamless integration of models and performance measures. Furthermore, the tool must provide tradeoff and multi-scenario analysis capabilities that can predict performance changes caused by equipment failures and/or dropped links, for example. The tool must also be capable of determining the effects of multiple, simultaneous failures. The toolkit to be developed under this effort will be based on commercially available platforms and simulation frameworks. It will be easy to use and provide graphical user interface (GIU) tools that include animation capabilities, interactive link break/restore functionality, the ability to quickly add new traffic profiles to the simulation, real-time simulation modes, statistical output of both instantaneous and aggregate results, and error-checking routines. Access to external dynamically linked libraries (DLL) should be provided, but programming skills should not be necessary for performing most standard analyses.

PHASE I: Create the system-level design for the satellite communication system toolkit such that it is implemented on commercially available products such as Satellite Toolkitâ (Analytical Graphics, Inc.), COMNET IIIÔ (CACI Products Company), and/or NetCrackerâ Professional (NetCracker Technology). Goals, features, methodology, algorithms, software/hardware requirements, and user guidelines should be defined.

PHASE II: Implement the satellite communication system toolkit on a released version of an available product identified in Phase I. Demonstrate, validate, and provide samples/examples of SATCOM and hybrid systems. Provide all necessary documentation.

PHASE III DUAL USE APPLICATIONS: The resulting tool will be useful to military as well as commercial planners. Military planners will be able to rapidly plan the right "mix" of communication assets to be deployed and integrated in a given theater of operations. Within the fixed base environment, military planners will be able to plan and design the integration of various communications resources, both terrestrial and otherwise, in order to obtain the best performance and/or most efficient solution. Commercial providers will use the tool to plan redesign/optimization of existing infrastructure.

KEYWORDS: Communication, Simulation, Satellite, Network, Terrestrial, Performance Analysis, Failure Analysis, Planning Tool

AF00-116 TITLE: Advanced C2 Process Modeling and Requirements Analysis Technology

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Modeling and Simulation System Program Office (SPO) - Electronic Systems Center (ESC/CXS)

OBJECTIVE: Develop technologies for product/process modeling of integrated operational and system command and control architectures.

DESCRIPTION: The contractor shall research, develop and demonstrate innovative technologies supporting the specification and static analysis of integrated operational and system command and control architectures, and engineering methodologies for the spiral development and value analysis of command and control weapon system acquisitions. The innovative technologies should consider token-based architecture specification; enable the integration and visualization of data flow, control flow, and state transition information; specify and visualize each operational thread supported by the operational/system architecture; address resources (human, equipment, and computer) required to perform activities specified by each operational thread; and identify constraints imposed by operational and/or system requirements. Technologies should address entity relationship or object relationship data model schema specifying the syntax and semantics of all information referenced in the integrated operational/system architecture. Graph analysis metrics of the modeled system includes reachability, reversibility, absence of deadlocks, liveness, boundedness and mutual exclusion. Innovative business engineering technologies should be designed to enable the user to construct, annotate, retrieve, edit and store, in a data base repository, project requirements documents, proposed system architecture/design documents, underlying process/data models, proposed project management plan, and underlying work flow models throughout a spiral development of command and control systems. In order to identify system design and implementation risk factors and risk mitigation strategies for the weapon system, the project management workflow model must be highly correlated with the weapon system developer's architecture and design. Key supported metrics should include precision, evolvability, scalability, testability, formality, executability, tolerance, clarity, analyzability, and cost effectiveness. Maximum use of commercial-off-the-shelf desktops or workstations shall be employed. The resulting technology should be platform independent to support a substantial number of users. Graphical output should be as HTML pages, VRML worlds, and graphics metafile images for documents and slides. Any resulting graphical system should be designed to have the look and feel of a commercial graphical editor, where the user constructs, annotates, retrieves, edits and manipulates graphical objects that correspond to entities in a database to specify the integrated operational/system architecture. The system architecture should be open to support interfaces to other simulation and modeling tools.

PHASE I: Phase I activity shall include: 1) Specification of an innovative architecture modeling methodology and/or model-based, business engineering technologies used for the cost effectiveness evaluation of command and control system acquisitions, 2) developing a system architecture and design concepts, and 3) proof of concept demonstration.

PHASE II: The contractor shall accomplish a detailed design, develop, and demonstrate the system for command and control applications using the Collaborative Enterprise Environment (CEE) that is being developed by the Air Force Research Laboratory. The contractor shall also detail the plan for Phase III effort.

PHASE III DUAL USE APPLICATIONS: The desired product of Phase III is a robust, off-the-shelf modeling system or federation of systems for use in defense and commercial automated information system development applications and discrete manufacturing applications. The end product will directly support the command and control component of the AFRL CEE.

REFERENCES:
1) "Put a Virtual Prototype on Your Desktop", Program Manager Magazine, 94-99, September-October 1997.
2) "Air Force Modeling and Simulation Trends", Program Manager Magazine, September-October 1997.
3) "A Collaborative Engineering Environment for 21st Century Avionics", 1998 IEEE Aerospace Conference Proceedings, March 1998.

KEYWORDS: Modeling and Simulation, Business Engineering, Affordability, Process Models, Product Models, Collaborative Environment, Command and Control, System Architecture

AF00-117 TITLE: Expert Interface for Network Design and Configuration

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Combat Air Forces Command and Control System Program Office (SPO) - Electronic Systems Center (ESC/AC)

OBJECTIVE: Develop an Expert Interface (EI) for a network simulation engine that provides for automated communications network design, planning, configuration, and simulation.

DESCRIPTION: The ability to design a communications network that can handle the transmission of mission critical data, in a timely manner, is crucial to the deployment of the warfighter. Artificial intelligence (AI) or a rules-based methodology that responds to user requirements must be designed and created to provide automated configuration and design as well as designer decision aid. The EI should: (1) provide a knowledge base (long-term memory), (2) use 'working memory' (short term memory), (3) be application and user driven, (4) be very intuitive and easy to use, (5) include animation for instant visual analysis, (6) provide speech capability, (7) provide a way to create new network components, and (8) come with a database of known devices. The major goal of helping the designer design a communications network should also include ease of use so that the designer does not have to be an 'expert' to get quick results and fast answers. The system would be driven by requirements that reflect the usage of the network, for instance the communications traffic on the network would need to be defined as well as the end points or nodes. Other requirements could include the use of certain equipment, network cost, or network performance. The EI would then create the optimal configuration based on the requirements. The EI would provide an interactive session with the designer, asking questions where more information is needed - and making recommendations with each question. The interface should not require programming or simulation skills. The designer should have a working knowledge of communications networks.

PHASE I: Create the design for an EI to be implemented on a commercially available simulation product. Goals, features, methodology, algorithms, and how to use the toolkit should be identified.

PHASE II: Implement the EI on a released version of a commercially available simulation product. Provide documentation needed to run the Expert. Work with actual examples that can include exercises and joint communications networks.

PHASE III DUAL USE APPLICATIONS: The commercial industry needs a tool that enables them to determine a network design based on the network utilization, cost, and performance. With an animated interface, the commercial user can demonstrate in real time the benefits and risks of several proposed communications systems.

REFERENCES: Russell, Stuart J., Norvig, Peter, "Artificial Intelligence: A Modern Approach", Prentice Hall Series in Artificial Intelligence, 1995

KEYWORDS: Network Management, Network Configuration, Expert Systems, Artificial Intelligence, Auto Configuration

AF00-118 TITLE: Operational Impact Estimation Toolkit

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Modeling and Simulation System Program Office (SPO) - Electronic Systems Center (ESC/CXS)

OBJECTIVE: Develop a tool suite that provides the ability to assess the potential operational impacts of discovered system software weaknesses as well as the lifecycle cost and operational impacts of proposed changes in the functionality and/or components of a software system before any implementation decisions are made.

DESCRIPTION: The role of the Air Force Operational Test and Evaluation Center (AFOTEC) is to plan, execute, and report independent operational test and evaluations (OT&Es). In support of OT&E on software intensive systems such as those in the C4I domain, HQ AFOTEC uses several codified reviews to evaluate software suitability and effectiveness. Referred to as "Vol. Reviews," these reviews cover such topics as software support life cycle processes (Vol.2), maintainability (Vol.3), usability (Vol.4), support resources (Vol.5), maturity (Vol.6), reliability (Vol.7), and operational assessment (Vol. 8). Although these reviews provide information useful to AFOTEC Detachment Commanders in their assessment of weapon systems, these reviews could be enhanced by automation supporting the assessment of the operational impact of software weaknesses. For example, assessment of the operational impacts of low maintainability scores for software modules is not currently supported through automated means. In an attempt to identify areas for improvement in ways in which software suitability and effectiveness is measured, HQ AFOTEC chartered a Tiger Team in late FY98. This Tiger Team gathered inputs from AFOTEC Detachments and Operating Locations to include suggested improvements to the current software evaluation process and the identification of additional desired capability for software OT&E. Several respondents to the Tiger Team survey identified a requirement for a tool suite supporting traceability of operational scenarios to mission requirements down to source code and back, including an ability to assess potential operational impacts of discovered system software weaknesses, and estimate the lifecycle cost and operational impacts of proposed changes in the functionality and/or components of a software system before any implementation decisions are made. These capabilities are especially important due to the uncertainty of how change propagates through a system that operates within a system of systems (such as combat support and command and control systems). It is envisioned that such a tool suite will make use of several complementary technologies including scenario, requirements tracing/hypermedia, and program slicing technologies as follows. Scenario Technologies: Capture operational scenarios for weapon systems (that is, how a weapon system is expected to be used in various missions). Capture operational test scenarios and tie them to test resource requirements and to operational scenarios. Support scenario-based reuse where portions of various scenarios can be combined to define new scenarios. Support scenario-based traceability between operational and test scenarios to include the identification of operational scenario elements addresses by a given test. Requirements Tracing/Hypermedia Technologies: Support hyperlinks between scenarios, requirements, specifications, and other support documentation and software source code and back. Such traceability would support our need to be able to determine how software weaknesses are related to mission critical elements, and will help us identify which source code modules implement mission critical operations. The latter element may help reviewers focus AFOTEC Vol Reviews on those elements that have the potential for significantly affecting mission effectiveness. Automated support for requirements capture, to include automated support for transformation from paper-based requirements documents to hyper-linked requirements documents. Support capture of test data in such an environment. Program Slicing Technologies: Support investigation of error propagation. Support investigation of maintainability propagation. For example, modifying a package to make use of additional message types/formats may be infeasible even if the package itself is relatively easy to maintain if the overall communication package used to route and process these messages is not maintainable. Support test case maintenance and selection based on proposed software modifications. Such a tool suite should have an ability to use tools based on the above technologies in either isolated or integrated modes, and should be, to the maximum extent practical, compliant with the Defense Information Infrastructure (DII) Common Operating Environment (COE).

PHASE I: Investigate the technology areas cited above and develop a prototype implementation of the envisioned Operational Impact Estimation Toolkit.

PHASE II: Apply the prototype to an Air Force Operational Test and Evaluation (OT&E) problem and assess/implement appropriate enhancements to the toolkit based on the results of its application.

PHASE III DUAL USE APPLICATIONS: Operational Impact Estimation tools and techniques would equally apply to the commercial sector in such areas as aviation and satellite communications industries.

REFERENCES:

1) Evolutionary Design of Complex Software (EDCS) - http://www.if.afrl.af.mil/programs/edcs/

2) Defense Information Infrastructure (DII) Common Operating Environment (COE) - http://spider.osfl.disa.mil/dii/

KEYWORDS: Operational Scenarios, Impact Analysis, Program Slicing, Requirements Traceability, Hypermedia

AF00-119 TITLE: Multi-Disciplinary and Multi-Sensor Integrated Display Development

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Airborne Warning and Control System (AWACS) - Electronic Systems Center (ESC/AW)

OBJECTIVE: Develop new display concepts that facilitate presentation of multi-disciplinary data and on-board & off-board multi-sensor data on mission displays for C4I systems operators.

DESCRIPTION: There is an ever-increasing volume of information available to C4I system operators from a variety of on-board and off-board sensor systems. The data provided may be real-time, near-real-time, or non-real-time data. Operators from multiple disciplines (e.g. tactical C2, Strategic surveillance, EW, etc.) need a common set of display formats that will present multi-disciplinary and multi-sensor data in easily understandable and useable form so that C4I operators can fulfill their roles as decision makers, rather than human data integrators. The display formats must present an integrated picture of multiple sensor data, and be adaptable to a variety of different types of display system hardware. A common display concept is vital to the multi-disciplinary aspect of this system. Interfaces to the various sensor systems are necessary to include their data on a common set of displays. The display formats should be capable of allowing multi-disciplinary operators to use multiple types of hardware with little or no additional training. The display formats should be capable of presenting data and contacts in an effective and efficient manner. A concept for using multi-sensor data fusion for evaluating contact identification with an associated level of probability is central to the development effort. Consideration should be given to the ability to overlay multiple data types (at the contact or data level) effectively and to the presentation of logical guides to orient the operator to the scenario quickly. Development of automation type tools to help operators manage and follow multiple data types on the display is vital.

PHASE I: Formulate a display design concept, including display formats, automated and manual data drill-down concepts, operator-machine interface concepts (to include pointing devices) data source analysis, connectivity, target identification evaluation concepts, and data integration concepts.

PHASE II: Prototype the proposed display concepts on a commercial workstation similar in nature to C4I system workstations, using simulated data and stored sensor data. Integrate a broad selection of pointing devices for testing. Include sufficient functionality to clearly demonstrate the integration of data presentation from multiple sensor systems and demonstrate operability.

PHASE III DUAL USE APPLICATIONS: Implement fully the proposed multi-sensor display system in a combat system test-bed or development facility, including connectivity to real data from multiple sensors. Demonstrate the data integration and operability features in a realistic environment of real time multi-sensor data inputs.

KEYWORDS: Multi-Sensor Fusion, Real-Time, Near-Real-Time, Non-Real-Time, Common Display Formats, Automation Type Tools

REFERENCES:
1) Locker, E., AWACS System Program Office, Private Communication, April 1999
2) Alford, M. (et. al.), Proceedings of the Second International Society of Information Fusion, v. 1,2 p. vii., FUSION '99, 6-8 July 1999
3) Ibid., Fusion for Fault Detection and Diagnosis, v.2, p. 935.

AF00-120 TITLE: Wavelet Modulation Techniques for Digital Communications

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Evaluate wavelet modulation methods for channel performance and feasibility/practicality of implementation in military communication systems.

DESCRIPTION: Two primary concerns in communications system design are the efficiency and reliability of the information transmission. The demand for bandwidth-efficient modulations, and the ever-more-harsh channel scenarios encountered in modern systems makes these concerns more critical, motivating a reassessment of current source and channel coding approaches. Several generic channel environments and system user requirements are challenging current communication technologies. One scenario involves multi-user systems with time-varying fading channels, such as encountered in battlefield situations using digital mobile radios. In other cases, noisy channels of unknown time duration and bandwidth are present, such as occurs for point-to-point and multiple access users, covert and LPI (Low Probability of Intercept) communications, and systems that broadcast to a number of receivers of different front-end bandwidths and processing rates. A third example is found in UHF (Ultra High Frequency) and EHF (Extremely High Frequency) satellite communications systems and wireless local area networks, wherein channels with severe intersymbol and narrowband interference are commonplace. Until recently, both source and channel coding were based on classical Fourier techniques. An alternative scheme is wavelet modulation, which has been used in a variety of real-world applications such as image and data compression, remote sensing, seismic analysis, and medical imaging. In addition, wire-based wavelet modulation has shown great success in applications such as Asymmetric Digital Subscriber Loops (ADSLs) and Hybrid Fiber-Coaxial Networks (HFCNs), the former exhibiting 8 Mb/s data throughput on ordinary telephone lines, while the latter showing 10 Mb/s with full RFI (radio frequency interference) noise immunity. Wavelet modulation technology, and the engineering flexibility afforded by wavelet modulation techniques, may significantly enhance the performance of new wireless RF (Radio Frequency) systems.

PHASE I: Phase I shall include the following tasks: Investigate current baseband WMSs (Wavelet Modulation Systems)-for example, ADSLs and HFCNs-with respect to design procedures, CAE (Computer Aided Engineering), hardware implementation, and performance benefits. Migrate acquired knowledge base to the RF regime, considering both amplitude and phase modulation approaches, to arrive at a RF WMS design methodology. Specify relevant channel scenarios (upon consultation with customer representatives) and apply design procedure, identifying important system trades, assessing performance benefits, and evaluating hardware implementation/integration feasibility. Develop a plan for the operational prototype development/demonstration of a representative-and mutually agreed upon by the Air Force-candidate WMS in Phase II.

PHASE II: Fabricate and check out the WMS operational demo identified in Phase I and conduct initial tests to verify/validate design procedures, CAE tools, and performance benefits. Under the supervision of the Air Force, conduct a field over-the-air laboratory test (with full documentation of test parameters and outcomes) of the WMS.

PHASE III DUAL USE APPLICATIONS: Because of the inherently generic nature of wavelet modulation techniques (they can be thought of as a generalization of all current uncoded modulation approaches), the results of this effort could easily be transitioned to a wide variety of commercial wireless communications applications, ranging from personal communications systems to future High Definition Television broadcast services.

REFERENCES:

1) G. M. Wornell, "Emerging Applications of Multirate Signal Processing and Wavelets in Digital Communications," Proc. IEEE, Vol. 84, 586-603, Apr. 1996.

2) S. D. Sandberg and M. A. Tzannes, "Overlapped Discrete Multitone Modulation for High Speed Copper Wire Communications," IEEE Journal on Selected Areas in Communications, Vol. 13, 1571-1585, Dec. 1995.

3) A.R. Lindsey, "Wavelet Packet Modulation for Orthogonally Multiplexed Communication," IEEE Transactions on Signal Processing, Vol. 45, pp. 1336-1339, May 1997.

KEYWORDS: Satellite Communications, Bandwidth Efficient Modulations, Wavelets, Signaling Design, Robust Channels, Battlefield Theater Communications

AF00-121 TITLE: Voice Authenticated Wireless Communication

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a secure method of communication utilizing commercial satellite systems.

DESCRIPTION: With the extension of MSS (Mobile Satellite Service) to include STS (Satellite Telephone Service) the concept of utilizing commercial satellite systems (for example: Iridium, GlobalStar, ICO, Ellipso and Constellation) for private/secure commercial/government voice quality communication becomes a very real potential. To bring this potential to reality, the need exists to develop voice authentication/scrambling/unscrambling algorithms and translate the algorithms into cost effective miniaturized circuitry capable of being installed in hand held satellite telephones. The next step is to demonstrate the algorithms/circuitry over MSS and wireless communication systems and evaluate interoperability with existing cellular and SATCOM (satellite communications) systems. The final step is to investigate the effect of geolocation on the operability of the authentication algorithms.

PHASE I: Develop basic cost effective voice authentication/scrambling/unscrambling algorithms for MSS/STS systems. Design/fabricate breadboard circuitry and demonstrate/evaluate the baseline MSS/STS algorithms based system interoperability with existing SATCOM and wireless systems.

PHASE II: Finalize algorithm/circuit design. Design/construct prototype production hand set circuitry. Install circuitry in commercial hand sets. Test system in stressed demonstrations and for deployed operational, beyond line of sight (BLOS) extension of private communications. Investigate the effect on (mutually agreed) geolocation sites as a part of the system authentication. Devise/demonstrate specific algorithms to optimize various geolocation/stressed situations. Explain metrics used to determine which algorithm performs better in a given situation.

PHASE III DUAL USE APPLICATIONS: Voice authentication can be utilized for commercial and government private or secure communication. Techniques developed from this contract can be used to qualitatively evaluate interoperability between DoD systems and commercial MSS and wireless communication systems.

REFERENCES:

1) A. Vaisnys, J. Berner, "Secure Voice for Mobile Satellite Applications," NASA, Washington, DC, 1990, 6p. NTIS: N92-24190/0.

2) H. S. Cruickshank, "A Security System for Satellite Networks," Fifth International Conference on Satellite Systems for Mobile Communications and Navigation (Conf. Publ. No. 424) p. 187-90, IEE, London, UK 1996.

3) A. M. Odlyzko, " Public Key Cryptography," AT&T Technical Journal, vol. 73, no. 5, p.17-23, Sep-Oct 1994.

KEYWORDS: Satellite Telephone, Mobile Satellite, Speaker Verification, Wireless Communication

AF00-122 TITLE: Hyper-Spectral Sensor Resolution Enhancement Techniques (RET)

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Reconnaissance System Program Office (SPO) - Aeronautical Systems Center (ASC/RA)

OBJECTIVE: Design and develop techniques for resolution enhancement of overhead digital imagery and video.

DESCRIPTION: Process data collected at different instances in time and space to deliver data that is significantly more robust and revealing. Potential solutions can address all available sources of overhead reconnaissance imagery and video: satellites, aircraft, and Unmanned Aerial Vehicles (UAV). Sensor types can include: multi-spectral and hyper-spectral imagery, electro-optical imagery, infrared (IR) imagery, synthetic aperture radar (SAR) imagery, video sequences and video frames. Data from the various sensors each has unique resolution and properties. These differences can be exploited to provide data products with super-resolution and/or useful composite views of targets or scenes of interest. Proofs-of-concept can utilize commercial imagery. Commercial satellite imagery is becoming a key information source to enable Air Force operations. It can meet requirements that go unfulfilled due to gaps in national imagery coverage. An example problem scenario is a collection of data from reconnaissance satellite(s), gathered during a chosen time span, being processed to provide products that can be exploited to provide greater battlefield awareness in less time. Industry has accomplished much related work for the private sector that could be leveraged for defense purposes. Existing capabilities for imagery enhancement can logically be extended to exploiting video. The role of UAV's is also becoming more prevalent in Air Force operations, with the utility for such platforms filtering down to ever-lower echelons. With this advancement of UAV technology comes the challenge of effectively exploiting the large amounts of data that is collected. A typical UAV has a high resolution video camera with long-range telephoto zoom lens, a forward-looking IR sensor package for night operations (or a SAR sensor), and a laser rangefinder/designator. The UAV platform may or may not be stabilized, or have data from a Global Positioning System (GPS) or Inertial Navigation System (INS) readily available. The UAV makes multiple passes over an area or object while the cameras pan and zoom. Development can include robust techniques for automatic registration of imagery, video frames, video sequences, and video mosaics. This enhancement can be obtained from any combination of same-platform, same-sensor, cross-platform, and cross-sensor techniques. A by-product of the resolution enhancement is likely to be data reduction enabling more efficient transmission, processing, and storage of data, and lessening the human involvement necessary for analysis and interpretation.

PHASE I: Develop overall system design and specifications for hyper-spectral sensor resolution enhancement techniques. Develop and demonstrate proof-of-concept software that demonstrates feasibility of approaches and solutions.

PHASE II: Develop and demonstrate a prototype system. Conduct testing to prove feasibility with representative data under realistic conditions.

PHASE III DUAL USE APPLICATIONS: Innovations in this technology area would readily prove useful in any number military and civilian applications: reconnaissance, surveillance, peacekeeping, land use, law enforcement, environmental, regulatory, etc.

REFERENCES:
1) "Fusion of Hyperspectral Imagery", NASA Technical Reports, 01 Jan 1998, Boeing North American Inc.
2) "Perceptual-Based Image Fusion for Hyperspectral Data", IEEE Transactions on Geoscience and Remote Sensing, 01 Jul 1997, AFIT - Wilson, Rogers, Kabrisky
3) "Resolution Enhancement of Multispectral Image Data to Improve Classification Accuracy", Photogrammetric Engineering and Remote Sensing, 01 Jan 93, Rochester Inst. Of Technology - Munechika, Warnick, Salvaggio, Schott

KEYWORDS: Remote Sensing, Imagery, Spectral Imaging, Electro-Optical, Infrared, Radar

AF00-123 TITLE: Smart Data Processing for Radar, Multispectral, & Hyperspectral Sensors

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Reconnaissance System Program Office (SPO) - Aeronautical Systems Center (ASC/RA)

OBJECTIVE: Build an intelligent image correlator that allows for discrimination and identification of object materials from radar and hyperspectral scenes.

DESCRIPTION: The amount of information that can be derived from a suite of various imagery products can significantly enhance the quality, detail, reliability and confidence of analysis. The objective of this effort will focus on correlation of the informational content of these various data sets so that only objects of interest will be further interrogated. Hyperspectral imagery can entail hundreds of narrow spectral bands. The proper selection of which bands to isolate for object/target detection or identification should not only depend on spectral properties of object/target materials, but also on the spatial and temporal aspects of these materials as well. The concept would be to develop signatures of items of interest and maintain these in a database for use as required by operational forces. Correlation of features, radiance, and signatures from multi-imagery sources (IR, Radar, HSI, MSI, etc) pertaining to a particular event will enhance an analyst's ability to identify objects/targets and events not possible with single imagery products. The objective is to propose image processing correlation techniques capable of multiple-sensor "smart systems" that can enhance identification and provide location coordinates for sensor-to-shooter systems. In essence, these techniques should use data synergy, correlation, and distillation while incorporating smart use of MASINT technology and utilizing an actively accrued dynamic repository of spectral signatures. This initiative addresses requirements to detect, locate, and identify difficult/protected CCD targets. The challenge is to be able to visualize various types of datasets in either a fused or overlaid viewspace or in a smartly managed contiguous screen set-up, allowing for linked images and dynamic overlays which refrain from altering the original "raw" datasets. The need to automatically run specific algorithms tailored for real-time display of specific spectral bands, based on the automatic processing of spatial and temporal datasets, could further enhance the Battlespace Analyst's decision-making capabilities through the confirmation of suspected situations or detected targets. Thus, the correlation of various MASINT sources could be used to drive confidence levels.

PHASE I: Develop overall system design that includes the specification of tailored decision-based algorithms for multi-imagery correlation to facilitate the development of a continuously accrued or dynamic repository of spectral signatures, and the demonstrated feasibility of a phase II prototype.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility of discrimination and ID of target materials from radar, multispectral, and hyperspectral scenes through the use of data synergy, correlation, and distillation.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and commercial applications where multiple data types are needed to derive a final assessment. For example, real-time tracking of hazardous pollutants after a large explosion; or geologic mining of remotely placed minerals; or detecting targets under modern camouflage, concealment and deception (CCD) techniques.

KEYWORDS: Multi-Imagery Correlation, Synergy, Decision-Based Algorithms, Hyperspectral, Radar, Multispectral, MASINT, Target Detection

AF00-124 TITLE: Dynamic Architecture Signal Processor Technology

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Reconnaissance System Program Office (SPO) - Aeronautical Systems Center (ASC/RA)

OBJECTIVE: To process Radio Frequency Signal Intelligence (RFINT), Radar and Optical data streams on reconfigurable computers (RCs).

DESCRIPTION: RCs have been demonstrated to offer a high performance to cost benefit for applications such as those listed in the objective. Because this hardware can be reconfigured in system, it also offers advantages in size over non-reconfigurable commercial processors since one RC can be reconfigured to support algorithm processing for multiple sensors. This technology also has several key advantages over high performance custom implementations since unlike custom hardware solutions RCs can be "reprogrammed" just like static Random Access Memory (SRAM) can be written to. This key technology feature adds a level of flexibility never before attainable for high-performance signal processing systems which are size/weight/power or SWAP constrained. However, there are barriers to extensive military application of RCs. Mapping algorithms onto fine-grained Field Programmable Gate Array (FPGA) based RCs or newer generation coarse-grained RCs, in an optimal manner that provides high-performance and good resource utilization, is very challenging and time consuming. This mapping requires the combined skills of a hardware designer, a software programmer, a system level designer, and an FPGA designer. The use of higher order language compilers as well as visual programming technology are now plausible front-end design entry points for RC, but no commercial tool is in place. Debugging tools for RC programs are virtually nonexistent. Compilation tools for coarse-grained RCs are not commercially available. The feasibility of automatic design partitioning and FPGA floorplanning has been demonstrated, but there are no commercial vendors for this technology. RC programming and design tools are not seamlessly integrated into one design environment. Rugged, standard bus RC hardware for military equipment is not available. RCs are still finding their way into operational systems despite these barriers and the associated premium that must be paid to surmount them in the form of manually developed programs and custom processor boards. This topic is soliciting research and development of commercial products that will remove the barriers to widespread use of RC in military systems which require signal processing equipment. The benefits of this program would be a lower SWAP and cost for a multi-sensor platform, a much higher degree of system flexibility, as well as reduced system life cycle cost. This effort could directly impact the MARS and UAV programs by developing key enabling technology.

PHASE I: Develop a program concept as related to the topic description and perform technology feasibility demonstrations. Develop a high-level plan for a follow-on Phase II program.

PHASE II: Develop prototypes for technology concepts demonstrated in Phase I and further demonstrate technology feasibility by performing application mapping for at least one algorithm as described in the program objective.

PHASE III DUAL USE APPLICATIONS: The prototypes developed in the Phase II effort will be commercialized and made available to the public. Any RC hardware and/or software tools developed under this topic will be inherently dual use. This is because the same methods used to design electronics for military systems are applicable to commercial systems.

KEYWORDS: Digital Signal Processing (DSP), Adaptive Computing Systems (ACS), Computer Aided Engineering (CAD), Field Programmable Gate Arrays (FPGAs), Reconfigurable Computing (RC)

AF00-125 TITLE: Airborne JTIDS Net Controller

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Reconnaissance System Program Office (SPO) - Aeronautical Systems Center (ASC/RA)

OBJECTIVE: Design and simulate a multi-net, dynamic JTIDS (Link 16) network and manage the network from the ground by linking to an on-station High Altitude Endurance (HAE) Unmanned Aerial Vehicle (UAV) for robust communications to allied aircraft.

DESCRIPTION: DoD C3I Tactical Data Link Policy, dated 18 Oct 94 designated Link 16 "...as the DoD primary tactical data link for all services...". Link 16 has begun to proliferate throughout the services and is becoming a large operational system. The benefits and utilization of Link 16 to increase mission effectiveness are just beginning to be discovered. Current Link 16 operations utilize a small portion of the theoretical capabilities of the data link. Link 16 utilizes several communications techniques that allow for multiple "networks". The multiple networks are often depicted as "stacked rings" where each ring is called a net. Current Link 16 operations only utilize two nets (or rings) out of 128 total possible. As Link 16 proliferates, utilization of the data link will increase. Multiple net operations (greater than two nets) will be required to meet the increased utilization of the data link. Advancements are needed in multiple net operations. Furthermore, a substantial amount of preplanning and mission planning is required to design a Link 16 network. In today's dynamic battlefield environment, flexible and real-time Link 16 operation is and will be required. Often, the assets required to established and maintain a Link 16 network (AWACS, JSTARS) are not on station. When Link 16 control assets are not available or on station, establishment and management of a Link 16 network from the ground via a HAE UAV is desired. This has the benefit of reducing operating costs (network up even if "heavy" aircraft such as AWACS are not on station) while increasing flexibility of Link 16 operations. Advancements are needed in Link 16 control and management. Areas of interest include reduced mission planning time and assets, dynamic network management, real-time network establishment and increased throughput.

PHASE I: Develop overall multi-network (more than two nets) Link 16 operations and real-time control on a HAE UAV from ground units.

PHASE II: Develop and demonstrate multi-network Link 16 operations and real-time control. Conduct simulations and actual RF testing.

PHASE III DUAL USE APPLICATIONS: Commercial airlines have requirements for data link communications. Air Traffic Control (ATC) is evolving into Air Traffic Management (ATM) where increased application of data links will play an essential role. The Services are responding to this evolution via the Global Air Traffic Management (GATM) initiative. Technologies and techniques for information systems developed and demonstrated under this effort could be applied to the commercial airline industry and play a role in the services response to GATM.

REFERENCES: "Tactical Digital Information Link (TADIL) J Range Extension (JRE)," Proceedings, MILCOM '97.

KEYWORDS: Link 16 (JTIDS, MIDS), Multi-Net, GATM

AF00-126 TITLE: Innovative Information Technologies

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop innovative information technologies for enhancing the performance, availability, and affordability of C4I systems and subsystems.

DESCRIPTION: Proposals may address any aspect of Information pervasive technologies not specifically covered by other SBIR topics. Areas of interest include, but are not limited to, innovative concepts and technologies in: Global Awareness, Dynamic Planning and Execution, and Global Information Exchange.

1. Global Awareness

Global Awareness entails the affordable operational capability, from local to global level, for all pertinent personnel to understand militarily relevant situations on a consistent basis with the precision needed to accomplish the mission. Specific areas of interest include:

- Information Exploitation
  - -- Image/Video/Text
  - -- Signals
- Information Fusion
  - -- Algorithms or families of algorithms to perform information fusion must be developed and refined to make the fusion process more efficient and accurate. Algorithms are sought which can adapt to new patterns in the data or environmental situations, as well as provide feedback to the data collection process.
- Global Information Base: This is defined as a distributed, heterogeneous data/information management system which stores Global Awareness information, and provides information services to Dynamic Planning and Execution operations.

2. Dynamic Planning and Execution

This thrust concentrates on the aerospace commander's ability to rapidly acquire and exploit superior, consistent knowledge of the battlespace through a worldwide distributed decision-making infrastructure of virtual battlestaffs and intelligent information specialists. Specific areas of interest include:

- -- Configurable Aerospace Command Center
- -- Time Critical C2
- -- Real-Time Sensor-to-Shooter Operations
- -- Targeting
- Joint/Combined Coalition C2: There is a critical need for the capability and enabling decision-making infrastructure needed to achieve dynamic synchronization of large-scale missions and resources from components and coalition forces. This area will seek to develop new command and control technology enabling a future coalition planning staff to take into

consideration the differing influences of all members of a coalition force; including differing military Rules Of Engagement (ROE), force structures, authority roles, capabilities, doctrine, and culture.

- Collaboration/Simulation/Visualization: This technology will provide planners and decision makers with the ability to view, understand, and analyze the vast amounts of information available from C4ISR systems. Collaborating teams require a common, shared context data environment where the visualization of the data is tailored to the application domain and the user preference. Specific modeling and simulation capabilities will assist in both proactive and reactive assessment.

3. Global Information Exchange

Global Information Exchange is the ability to interconnect all members of the Air Force via a netted communication and information system, available anywhere, at any time, and for any task or mission. Specific areas of interest include:

- Global Communications: The technical goals center on wireless information exchange systems and technologies that interconnect remotely separated command and control systems and users, providing high quality, timely, secure, and low probability of exploitation communications to air, land, and space. The required capabilities provide line-of-sight and beyond-line-of-sight connectivity spanning the frequency ranges "from DC to light," in point-to-point, broadcast, or networked modes.

-- Multiband/Multifunction Communication Systems
-- Robust Tactical/Mobile/Wireless Networks
-- RF Communications Systems

- Defensive Information Warfare (DIW): DIW is concerned with the defense of friendly information systems and signatures and ensuring the authorized use of the information spectrum. This technology seeks to protect against corruption, exploitation, and destruction of friendly information systems; ensure confidentiality, integrity, and availability of systems; integrate actions (offense, defense, and mitigation) to ensure an uninterrupted flow of information for weapons employment and sustainment.

-- Information Systems Protection
-- Attack Detection
-- Computer Forensics
-- Secure Computing

PHASE I: Provide a report describing the proposed concept in detail and show its viability and feasibility.

PHASE II: Fabricate and demonstrate a prototype device, subsystem, or software program.

PHASE III DUAL USE APPLICATIONS: Many Information Technologies have substantial dual-use potential and will impact competitiveness and performance of the commercial sector as well as the military sector. All solutions proposed must have potential for use/application in the commercial as well as military sector, and potential commercial applications must be discussed in the proposal.

KEYWORDS: Information Technology, Command and Control, Communications, Computers, Intelligence, Global Awareness, Dynamic Planning and Execution, Global Information Exchange

AF00-127 TITLE: Intermediate-Level Event Extraction for Temporal and Spatial Analysis and Visualization

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop domain-portable, intermediate-level event extraction to automate event analysis and visualization from voluminous free-form text.

DESCRIPTION: AF Intelligence organizations suffer from textual "data overload"; analysts are inundated with free-form text messages, documents, and Open Source texts. This can negatively impact the timeliness and quality of Intelligence assessments, and that of the decisions based upon them. Ideally, analysis of voluminous text should be a more automated and conceptually oriented process. Analysts would prefer to perform temporal and spatial analysis of events visually on timelines and maps. This would improve the timeliness and quality of Intelligence products, and that of the decisions that depend on them. Progress has been made in recent years in domain-portable event extraction; e.g., AFRL's "Intelligence Analyst Associate (IAA) Build 2" performs domain-independent extraction of "shallow events" from free-form text. While this is believed to be the state-of-the-art for domain-independent event extraction, there is still much room for progress and innovation; e.g., IAA's shallow events are clause constituents, where the "event" corresponds to the verb. This represents a fairly low level of text understanding. Analysts need more conceptually meaningful event information at a high level of accuracy. In addition, focused research and development needs to be conducted in high accuracy temporal and spatial Information Extraction (IE). This is essential to achieving reliable temporal and spatial visualization of events. Furthermore, these capabilities must be flexible enough to support dynamically changing temporal and spatial areas of interest; e.g., some analysts may be interested in spatial analysis of events in Kosovo, others in events in North Korea. These capabilities must also be flexible enough to support varied levels of granularity; e.g., temporal analysis may be for large-scale events occurring over many years, or for smaller-scale events that occur over hours or minutes. Defining what "intermediate-level" event information consists of is up to the proposer. Likewise, the proposed approach to domain-portable, intermediate-level event extraction is open for definition (e.g., domain-independent extraction of events of higher complexity vs extraction of "generic" events applicable to multiple domains, like "procurement events").

PHASE I: Perform research to determine the best approach to developing a capability meeting the above description. Develop preliminary software to assess concept feasibility.

PHASE II: Use the knowledge gained in Phase I as the basis for developing a full-scale capability for domain-portable event extraction from voluminous free-form text.

PHASE III DUAL USE APPLICATIONS: Domain-portable event extraction would be valuable to anyone that exploits free-form text to gain useful information. This includes information analysts in law enforcement, the DoD, research communities and in the financial world (e.g., competitive intelligence, market analysis, and stock analysis).

KEYWORDS: Natural Language Understanding, Natural Language Processing, Information Extraction

AF00-128 TITLE: Attack Assessment Tools for Information Warfare

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this program is the development of a toolkit comprised of computer analytic techniques for information warfare attack assessment. This work will focus on the detailed organization, evaluation and in-depth analysis of data related to unauthorized access and use of computers, computer networks, and information systems.

DESCRIPTION: Classic computer forensics has focused on the process of evidence extraction from computer media. In the information age, our focus must be widened to include real-time, on-line attack assessment and recovery as well as traditional off-line forensic analysis. Information warfare attack assessment includes analysis of a wide spectrum of data (e.g. intrusion detection, firewall logs, audit trails, network management information), location, and identification of clues indicating malicious activity and assessment of the damage resulting from an information attack. Attack assessment traces the source and path of an attack and determines its impact on the information system. The traditional tools available to computer forensic examiners are inadequate to deal with today's networked, distributed environments. Information warfare attack assessment is especially difficult when the pertinent information has been intentionally or maliciously hidden, destroyed, or modified for the purpose of eluding discovery.

PHASE I: Design and prototype techniques that address deficiencies in networked computer system attack assessment. Specific technology areas to be investigated include: rapid discovery, analysis, and tracking of potentially malicious activity, integration of data from various supporting data sources and attack verification, and impact assessment. The products of this phase should be a toolkit framework and proof of concept demonstration.

PHASE II: Build and test the toolkit specified in Phase I.

PHASE III DUAL USE APPLICATIONS: The Air Force needs attack assessment tools in order to maintain its complex, large-scale information systems and networks in an operational status in spite of successful penetrations by adversaries. As a result of the current movement to electronic commerce environments, business, and industry require reliable attack assessment tools to mitigate the effects of the increased exposure and vulnerability of their information assets to malicious attack from the outside as well as misuse by insiders. Business needs this technology to identify the full impact and possible source (i.e. what, where and who) of criminal activities. Also, this ability will help maintain customer confidence in business' ability to quickly correct any corrupted information and to return to the status quo ante.

REFERENCES: Joint Pub 3-13 "Joint Doctrine for Information Operations" , 9 October 1998.

KEYWORDS: Defensive Information Warfare, Information Protection, Information Security, Information Attack Assessment

AF00-130 TITLE: Dynamic Effects Based Command and Control

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop and demonstrate a new generation of planning and assessment technologies and tools enabling aerospace commanders to determine and create the desired operational effects at the right place at the right time. An effects-based approach for planning will provide AEFs the flexibility to adapt to changing situations and threats and allow tomorrow's commanders to dynamically assess what is happening across the battlespace, determine what measures will create the desired effect, and then command near-real time employment of forces to execute those measures.

DESCRIPTION: Today's dynamic and ever-changing battlespace demands an effects-based model that is predicated on a comprehensive, coherent, and integrated C2 system of organizations, processes, and technical means that ensures unity of effort. Aerospace power has the potential to create effects concurrently at all levels of war and throughout the entire depth and breadth of the theater. The inherent flexibility of aerospace power makes it possible to employ the whole weight of available airpower against selected areas in turn; such concentrated use of an aerospace force is a battle-winning factor of the first importance. Central to this vision is an integrated information infrastructure that sparks shared situational awareness and joint strategy and campaign plan development, thus providing future commanders the ability to determine what effects will best achieve operational objectives, and to systematically link those effects to actions taken across the battlespace. Determining the ends, ways, and means that encompass the operational strategy, and identifying appropriate mechanisms that will reflect its efficacy, mandates a seamless link between command, strategy, and assessment functions. Tasks and measures of merit (MOMs) must focus on delivering a measurable effect via certain key indicators, or "mechanisms." In addition, MOMs must not only describe the desired effect, but also provide the necessary qualifiers regarding the degree of the effect, the intended duration, and necessary constraints imposed on creating the effect. In essence, effects-based operations demand effects-based analysis that continually determines the efficacy of the aerospace strategy in terms of achieving the desired tactical, operational or strategic effects, and recommends improvements to the aerospace strategy or suggests phase changes or branch development/initiation to the aerospace commander.

PHASE I: Perform preliminary investigation of innovative new technologies and tools that are capable of realizing a strategy-to-task approach to aerospace maneuver warfare exploiting a link between command, strategy, and assessment functions. Cost, benefit, risk, portability for use of effects based operation planning and other related technical concerns shall be addressed.

PHASE II: Develop and demonstrate prototype effects-based integrated command, strategy and assessment decision support tool(s) on both an AEF and a Chemical/Biological operational scenario. Metrics such as time to complete task, completeness of the result, end to end connectivity, strategy development impact, level of uncertainty and others shall be documented showing increased capability over existing systems and capabilities.

PHASE III DUAL USE APPLICATIONS: In both the civilian and military environment, the effects of actions could have extreme positive or negative impacts on finance, manpower, market share, or winning the war. Technologies and tools developed under this program will have a dramatic impact on corporations and military commands as 2nd and 3rd level effects of proposed actions can be determined based on a proposed decision.

REFERENCES: Effects-Based Operations: The Road Ahead, Major John Sims, 8 Apr 99. Available upon request.

KEYWORDS: Effects Based Operations, Command and Control, Planning, Execution Monitoring, Near-Real Time, Uncertainty, Knowledge Based Software, Coalition Forces

AF00-131 TITLE: Distributed Collaborative Environment Technology

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop technologies that support cross-discipline collaboration including dynamic planning, engineering, simulation, mission rehearsal, and analysis.

DESCRIPTION: The contractor shall research, develop, and demonstrate innovative collaborative technologies that support the overall concepts of the AFRL Collaborative Enterprise Environment (CEE). Technologies developed shall be consistent with the Joint Technical Architecture and Defense Information Infrastructure and support interoperability of distributed collaborative environments such as collaborative planning systems, mission rehearsal systems, distributed logistics, command and control, and collaborative engineering, simulation based acquisition, and distributed collaborative simulation. Special emphasis is placed on innovative approaches to show the impact of technology on affordability of weapon systems. Collaborative technologies offer the opportunity to develop consistent, shared plans and consistent battlespace pictures, conduct split operations and perform distributed, collaborative, fully interactive mission rehearsal and training. Maximum use of commercial-off-the-shelf desktop, workstations, web-based, and distributed information and simulation technologies shall be employed to provide a virtual development and operational environment so that integrated information concepts can be evaluated in a realistic combat-like scenario. Research from this effort shall play a critical role in the rapid cost effective spiral development of information and weapon systems. Technologies developed shall provide characterizations, performance data, life-cycle cost information to assess mission benefits, generate designs and implementations, and/or generate affordability, cost of function, and measure of effectiveness estimates. The following technical areas are of major concern: product and process modeling, innovative affordability and cost modeling, multi-level security, human collaboration tools, workflow management, web-based simulation, and advanced distributed visualization.

PHASE I: The desired products of Phase I are: 1) identification of the enabling collaborative environment technologies, 2) conduct of specific simulation experiments to verify critical aspects of the defined concepts, and 3) development of a system specification, implementation approach, and demonstration plan. The contractor shall also document the potential for a Phase II follow-on effort.

PHASE II: The contractor shall accomplish a detailed design, develop the prototype technology, and demonstrate the proposed technology in the appropriate Information Directorate simulation facility. The contractor shall also detail his plan for his Phase III effort.

PHASE III DUAL USE APPLICATIONS: The desired product of Phase III is a robust collaborative environment/collaborative simulation capability for use in defense and commercial information and sensor technology development. Collaboration is a crucial enabling technology for the 21st century and a change in the way of doing business that will have major implications for the commercial and defense sector. The commercial marketplace is presently making greater use of product and process modeling, generic simulation techniques, simulation infrastructure, and off-the-shelf components for applications in financial industries, manufacturing, industrial process control, biotechnology, healthcare, communication, and information systems. The aircraft and automotive industries have demonstrated the success of integrated computer assisted design with supporting modeling and simulation to bring products to market quickly. Advances in software and computer technology are making virtual prototyping possible and affordable for the small to medium business. Software development itself is a manpower intensive endeavor. Requirements definition remains a problem area where the user is unable to verbalize what he/she wants in detail. Virtual prototyping of software requirements and modeling of the software is a future growth area in which simulation is used to review completeness of software requirements and functionality.

REFERENCES:

1) "Put a Virtual Prototype on Your Desktop," Program Manager Magazine, 94-99, September-October 1997.
2) "Air Force Modeling and Simulation Trends," Program Manager Magazine, September-October 1997.
3) "A Collaborative Engineering Environment For 21st Century Avionics," 1998 IEEE Aerospace Conference Proceedings, March 1998.

KEYWORDS: Modeling and Simulation, Collaboration, Collaborative Environment, Virtual Prototype, Cost Models, Product Data Model, Visualization, Collaborative Engineering

AF00-132 TITLE: Database Accelerating Reconfigurable Computer

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To develop database acceleration co-processors based on reconfigurable computing technology.

DESCRIPTION: Advanced command and control systems heavily utilize database technology. The need to quickly receive the information derived from these databases is also on the rise. There is a need to achieve a step function in performance of database systems without greatly increasing their cost. Reconfigurable computers have been demonstrated to offer a high performance to cost benefit for many data intensive applications. Reconfigurable computers are an emerging class of digital processors that are built with commercial Field Programmable Gate Array (FPGA) components. By their nature reconfigurable computers can have their hardware logic "re-wired" repeatedly while in the system in order to optimally perform a specific task. Reconfigurable computers can be co-processors that reside in a host system and off-load time critical functions from the host processor. Conventional computers can compare either 4 characters or 8 characters at a time depending on whether they have 32-bit or 64-bit internal data paths. Assuming that the reconfigurable computing system is architected to receive the data quickly enough, it conceivably can compare a hundred characters at a time. Conventional computers must also use software to perform sort functions. With a reconfigurable computer these functions can be implemented in hardware for faster performance. This research seeks a solution to the requirement for high performance database services by taking advantage of the low-cost and high-performance characteristics of reconfigurable computers.

PHASE I: The preliminary design of the reconfigurable computer hardware and application software products will be performed. The functionality and interfaces will be completely specified. The expected performance improvements will be estimated.

PHASE II: The detailed design of the hardware and software products will be constructed, evaluated, and demonstrated. Reference manuals and user guides will be developed.

PHASE III DUAL USE APPLICATIONS: The database acceleration product(s) will be readied for market and tested by potential commercial and military customers. Production, marketing, and support plans will be developed and the products will be offered to users. No differences are anticipated between the requirements of commercial and military products.

KEYWORDS: Database Acceleration, Reconfigurable Computer, Reconfigurable Computing, Database Searching, Database Sorting, Field Programmable Gate Array

AF00-133 TITLE: Data Intensive System Implementation for Battlespace Awareness

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To implement selected battlespace awareness algorithms on Data Intensive Systems.

DESCRIPTION: The battlespace awareness problem involves looking for significant activity over a broad area. There is generally little prior detailed information about the area, but sensors can be targeted over the area for repeated surveillance. In order to detect and identify military targets, one first has to identify locations in which a likely target has been imaged. Physical sources such as small structures, abandoned vehicles, foliage etc. are a persistent source of false alarms. Object level change detection (OLCD) attempts to reduce the false alarms by using a historical database. By maintaining a "map" of the location of false alarms one can eliminate them in future looks. Database transactions support the primary functions of OLCD which include detection and segmentation, feature extraction and discrimination, registration association and change detection and feature prediction from target models. These features require a large processor to memory bandwidth and computational horsepower. The mission of the Data Intensive Systems (DIS) program is to develop a new memory architecture for computing systems that allows applications to manage the placement and flow of their data as well as allowing them to manipulate data in the memory subsystem itself. The focus is to greatly improve the memory to processor bandwidth bottleneck and could include placing the processing hardware directly in the memory itself.

PHASE I: Evaluate candidate battlespace awareness algorithms for key bottlenecks that could be improved through the use of data intensive computing architectures. This will also include an evaluation of emerging DIS architectures to determine which "flavor" of DIS architectures will provide the most performance gain.

PHASE II: Develop and demonstrate a prototype DIS based architecture which implements the battlespace awareness algorithms chosen in Phase I demonstrating their performance.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian applications where image detection and identification are necessary - for example in military target identification or cancer tumor identification.

KEYWORDS: Data Intensive Systems, Processor-in-Memory, Dynamic Database, Image Detection/Recognition

AF00-139 TITLE: Durable Coatings for Carbon-Carbon Development & Demonstration

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop and demonstrate survivable and repairable high temperature oxidation-resistant coatings for carbon-carbon (C-C).

DESCRIPTION: C-C offers a lightweight alternative to many high temperature metallic alloys, ceramics, and active/inactive thermal protection systems. Despite its benefits, C-C is vulnerable to oxidation above 750oF. Past efforts have developed coating and inhibition systems that have demonstrated oxidation protection to over 2500oF, but none of the efforts have demonstrated reliable performance nor addressed supportability issues such as life cycle costs or reparability. These issues will be important to future military hypersonic systems such as the Space Operational Vehicle and the Common Aero Vehicle. The proposed topic will build from the previous efforts while considering new systems that have been derived since these efforts ended. Established coating/inhibition systems will be evaluated to assess their high temperature capability (2000o+F) as well as their commercial availability. New innovative high temperature coating systems will be investigated and evaluated on their high temperature oxidation performance, ease of deposition, commercial scale-up capability, and likelihood for technology transfer. Subsequently, each coating system will be evaluated for ease of repair in a depot-level or field-level environment without cumbersome and intensive support equipment. From the compiled coatings list and the operational requirements, a test plan that combines compatible coating system constituents with the appropriate repair methodology will be created that will demonstrate the capabilities of at least two coating/repair designs applied to a minimum of two commercially available C-C substrates. The results will be evaluated and summarized, and a commercialization report will be prepared. A government panel made up of representatives from the Air Force, Navy, and NASA will assess the technical results and the military/ commercial viability of the coating systems throughout the effort.

PHASE I: The objective of Phase I will be to evaluate the five most leading coating system candidates for coating system make-up, deposition method, environment use, vendor availability, and reparability. The specific data required to evaluate the system for durability and survivability will be determined and the information obtained from the coating vendor and/or generated using the appropriate test methods. A military and commercial application will be determined, the design requirements identified, and the coatings assessed against the design requirements.

PHASE II: Phase II will take the data generated in Phase I and match coating capabilities with the operational environment of the military and commercial applications. A minimum of two coatings per application will be evaluated on multiple substrates, and any refinement of the coating system or deposition methodology will be made. In addition, the optimized coating system will be evaluated for durability of repairs as well as reparability in a depot-level or field-level environment. To conclude Phase II, subcomponent test specimens supplied by the military and commercial partners will be coated and tested, then subsequently damaged, repaired, and tested to demonstrate the success of the effort. A final report summarizing the findings and a commercialization report will be written.

PHASE III DUAL USE APPLICATIONS: Military and civil reusable launch vehicles and reentry systems for space, military and civil aircraft turbine engines, airborne laser heat exchangers, directed energy protection schemes, pistons for internal combustion engines, and incinerators for waste disposal.

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KEYWORDS: carbon-carbon, oxidation protection, coatings, inhibitors, thermal protection materials, supportability

AF00-141 TITLE: Processing of Inflatable Parabolic Reflectors from Polymeric Thin Films

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop polymer processing methods to produce net-shape parabolic reflectors for deployable optics applications.

DESCRIPTION: AFRL has demonstrated the feasibility of a mirror concept which employs reflective (i.e., metal coated) polymeric films as parabolic reflectors for optical imaging telescopes in which the film is opposed by a clear polymer film and the structure then inflated to a parabolic shape. In such a structure, the seam boundary is held planar by use of a rigidized torus or an otherwise stiff (yet deployable) precision ring. This polymer-based mirror should be stowable to an effective diameter no larger than 20% of the size of the deployed mirror. While high quality polymeric reflectors are now commercially available, AFRL studies have shown that the use of mechanically isotropic films of uniform thickness intrinsically suffer from shape aberrations which cannot be corrected with state-of-the-art adaptive optics. The purpose of this SBIR topic is to develop polymer processing techniques for the production of uniformly thin films (5 - 100 microns +/- 1%) which are parabolic in shape with a relatively small focal number (f # < 2), such that deployment by inflation will unfold the packaged film to yield the optically satisfactory shape. The films should possess a uniformly glossy surface with surface roughness less than 5.0 nm. In addition, the processing of a polymeric torus to be deployed with a rigidation material, along with active control, should be conceived and developed to satisfy stringent planarity (<100 nm) and circularity requirements. This effort should focus on the processing of both the reflector and torus, not on the development of a new polymer; however, material selection should consider stability in low earth orbit (atomic oxygen, ultraviolet, thermal cycling), resistance to creasing incurred on polymer film packaging, and resistance to creep deformation. Consideration must also be given to the ability to scale the proposed processing methods to large diameters (D > 8 meters).

PHASE I: The contractor should conceive processing schemes for both the parabolic reflector and the polymeric torus. Relevant fluid mechanics and heat transfer calculations should be performed to develop working models for the processes, with particular attention given to the influence of processing variables and polymer fluid properties on the resulting shapes. Methods for characterizing the perfection of the reflector's parabolic shape and the torus planarity and circularity should be designed and demonstrated on a prototype parabolic reflector with a diameter no larger than 25 cm and no smaller than 10 cm. The potential synergistic effects of future types of adaptive optics (e.g., phase conjugation with 4-wave mixing) will be explored and evaluated.

PHASE II: Based on the results of Phase I research, the contractor should further develop the reflector and torus processing methods to be implemented for the production of a mirror with a diameter of 1 meter. The process model should be modified, as needed, to account for scale-up issues. Material selection should be conducted based on design factors detailed in the project description and characterization of the processed reflector shape should be performed. The process should be altered, with guidance from the process model and characterization results, to yield the desired precision.

PHASE III DUAL USE APPLICATIONS: The processing of large, deployable mirrors will have significant military and commercial applications. These include surveillance, communications, target designation, imaging through clouds, space-based laser satellite characterization system, remote sensing, wind profiling, target illumination, nighttime imaging, assessing soil conditions and vegetation types, camouflage detection, detection of cruise missiles, ballistic missile defense, ground-based laser relay mirror, and space-based counterforce.

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KEYWORDS: polymers, membranes, polymeric thin films, membrane mirrors, membrane optics, parabolic films, inflatable mirrors

AF00-142 TITLE: Durability of Bonded Joints for Low Cost and LO Repair of High Performance Composite Structures

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: To develop engineering models to predict the durability of adhesively bonded composite structures and LO structural repairs subjected to realistic service environments.

DESCRIPTION: The use of adhesively bonded polymer matrix composite structures has lead to dramatic reductions in assembly cost as well as significantly lighter weight designs over traditional bolted joint assembly methods. Advanced composites are viewed as system enabling in many weight critical applications. In addition, the repair of highly loaded structures, as seen on the B-2, F-22, and V-22, for example, requires the use of adhesively bonded scarf joints for repair to maintain a flush surface contour to meet LO requirements. These critical applications require the ability to predict the long-term lifetime durability of the bonded joint under realistic service conditions. Realistic service conditions include cyclic moisture, cyclic temperature, as well as cyclic mechanical loading. Currently, knowledge of their lifetime performance in the demanding service environments is limited, and no rational comprehensive approaches exist to evaluate materials for performance in their service environments over the expected lifetimes of the systems. Research under this topic area should develop and validate an engineering model that incorporates the appropriately coupled transport, chemical kinetics, and boundary conditions relevant to the coupled problem of oxidative and hydrolytic degradation in high temperature organic matrix composites. In addition, these effects must be coupled to models for predicting the initiation and progression of matrix microcracking, interfacial debonding, and the corresponding loss of mechanical properties.

PHASE I: Approach and procedure for modeling service lifetime of high temperature adhesively bonded composite joints under coupled oxidative and hygrothermal environment must be demonstrated and validated.

PHASE II: Refine modeling procedure and software into a transitionable product. Selection of two candidate material systems and perform extensive environmental aging to validate the models.

PHASE III DUAL USE APPLICATIONS: Future civil aircraft and spacecraft will require substantial use of adhesively bonded composite structure with a high degree of confidence. This level of confidence can only be achieved by the development of rational, comprehensive, and validated models to predict bond degradation.

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KEYWORDS: composites, adhesives, repair, environmental, modeling, degradation, oxidation, hygrothermal, hydrolysis

AF00-143 TITLE: Novel Durable Polymer Based LO Hardcoats for Canopy Exteriors Using Benign Processing Techniques

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design, synthesize, and develop novel durable polymer-based hardcoats to be processed in monolayer film by state-of-the-art methods for aircraft canopy LO characteristics.

DESCRIPTION: Current aircraft canopy coating systems are composed of multiple layers of various materials compositions and thickness. The inherent problem with the concept of "one material, one application" is the materials mismatches in properties, such as refractive index, optical transmission, coloration, coefficient of thermal expansion (CTE), thermal stability, and mechanical strength. An additional problem is encountered in the concept when factoring in the acoustic and radar cross-sectional reductions of stealth along with personal protective design concepts. The state-of-the-art methods by which some of these coatings are applied to very large doubly curved surfaces are very exacting processes in order to control layer thickness and are very cost prohibitive for future aircraft and retrofits. Organic polymer-based hardcoating systems may provide a more compatible system with the substrate plastics because organic polymers are more similar to the substrate plastics in chemical composition or can be tailored by the addition of functional chemical groups or by copolymer compositions to be more like the substrate. Various atomic bonding schemes are also employed with organic polymers to promote adhesion. Organic polymers are amenable to "alloying" with other dissimilar materials through chemical miscibility, such as photochromic dyes and the like. A processing advantage of using polymer-based hardcoats is the design flexibility to allow for some of the more recently described deposition techniques under very benign processing conditions while controlling film thickness. Some monolayer films have been shown to be mechanically robust to the extent that vigorous mechanical forces have been unable to dislodge the films from the substrate. What is sought in this technical effort is an organic polymer hardcoat material that is multifunctional in purpose, i.e., environmentally and thermally durable but also of low radio frequency cross-section, which is applied in controlled thickness by a cost effective, novel coating process.

PHASE I: The goal of the Phase I effort is the preparation of novel aromatic or heteroaromatic polymers as monoliths or alloys as monolayer (one molecule thick) films whose deposition will result in a coating profile on a flat bisphenol A polycarbonate substrate coupon. The ability to prepare the monolayer by an accepted low temperature coating method, such as sol-gel, Langmuir-Blodgett, or other flowcoating or dipcoating technique, will greatly reduce the costs of processing the final polymer composition and will accelerate the technical transition of the candidate composition. Methods for test of the proposed system shall include determination of the coating profile on the substrate; basic spectroscopic and chemical analysis; full thermal analysis with long-term thermal aging in air, 2-D, and 3-D CTE; molecular weight determination; solution viscosity; appropriate ASTM hardness tests, adhesion tests, abrasion tests, and solvent crazing under tensile load. A key element of the Phase I effort shall be the delivery of 12 replicate coupons on 4 in. sq. x ¼-½ in. thick polycarbonate with the coating applied at Month 5-6 of the technical effort for further testing at AFRL. The final key element of the successful Phase I program will be the proof of concept of the composition by successful completion of the following ASTM transparency tests: refractive index, luminous transmittance, yellowness index, and haze at both room temperature and near the glass transition on the free-standing films (if available) and the laminate, and falling dart impact on the laminate alone. Preliminary acceptance of the coating using accelerated aging techniques shall comply with a minimum equivalent 1530 flight hours simulation and meet hardness criteria near the current values for state-of-the-art materials. Deliverables for this portion of the effort include the coupons enumerated above and data.

PHASE II: In Phase II of the effort the technical work shall require the acquisition and fabrication of larger and more complex shaped specimens with a double curvature employing the technology demonstrated as proof of concept in Phase I. Reproducible scale-up of the candidate composition shall be required to a minimum of one to five pounds. Basic chemico-physical, thermomechanical, and optical property evaluations of the materials shall continue to prove reproducibility of process. Accelerated wear techniques, such as QUV and rain erosion for 6100 flight hours simulation and the previously cited optical, abrasion, and adhesion tests, shall be accomplished. It is understood that optical quality of the monolayers may not be an issue if true monolayers are obtained. Compatibility with substrates other than polycarbonate shall be required as demonstration in this phase to show breadth of process utility. Acoustic and radio frequency test profiles will be provided by the government project engineer in this phase of the technical effort. Potential offerors must include qualification of their facility and personnel to DoD 5200, 5220, and 5230 security directives for this phase of the effort. Deliverables for this portion of the effort include data and two double curvature demonstration articles of the full laminate.

PHASE III DUAL USE APPLICATIONS: Many commercial industries have similar harsh degradative environment reliability concerns. Several of these industries are (1) solar cells, (2) commercial aerospace, and (3) military aircraft and military personnel vehicles. Many of the transparent products of these applications require durable exterior hardcoats that have good optical properties and long lifetimes with resistance to solvents, electromagnetic radiation, and scratching.

REFERENCES:

1. WL-TR-94-4083, "Conference on Aerospace Transparent Materials and Enclosures, Volume I-II," Sam Marolo, ed., pp. 18-237, 880-952, March 1994 (unclassified, unlimited).

2. (a) R. Stonier, SAMPE J. 1991, 27 (4) 9.

   (b) R. Stonier, SAMPE J. 1991, 27 (5) 9.

3. G. Decher, Science 1997, 277 1232.1.

KEYWORDS: aircraft transparencies, coatings, thin films, hardcoats, topcoats, radar, monolayer, flowcoat

AF00-144 TITLE: Detection of Flaws Under Thermal Barrier Coatings Repairs

TECHNOLOGY AREAS: Materials/Processes, Biomedical

OBJECTIVE: (Should not exceed 15 words): The objective of this topic is to provide the aerospace component manufacturers with a methodology to detect and quantify flaws, e.g., cracks, under highly attenuative coatings. This would be a new nondestructive inspection (NDI) capability for coated materials.

DESCRIPTION: (Should not exceed 500 words; preferably keep under 300 words): There are many situations where cracks and other defects must be detected under coatings. This situation occurs on airframes where the paint is often stripped before surface breaking cracks and corrosion can be detected. For turbine blades the problem of detecting cracks under Many other types of coatings, e.g., thermal barrier coatings (TBC), are even more difficult because the coating is porous and therefore highly attenuative . The presence of porosity scatters ultrasound and soaks up so much penetrant to render both of these often used techniques useless. Radiographic techniques are also difficult to apply because there are insignificant differences between the porous coating and the defects that must be detected. It is for this reason that a new and novel method of detection of cracks under coatings on turbine blades is sought. Of course, eddy current methods could be used to effect here, but changes in both lift-off and conductivity of the substrate limit their usefulness to the situations where the coating is stripped from the structure before this inspection method can be reliably used.

PHASE I: (Describe desired end product. Expectation should be specific. Describe task and/or results which can reasonably be accomplished within the established SBIR cost and time constraints (Phase I - $100K/9 mos.). Require Proof-of-Concept Demonstration.) During this phase of the program the proof of the concept should be demonstrated on laboratory specimens approaching the configuration of actual aerospace components, e.g. turbine or compressor blades.

PHASE II: : (Describe expected work to be accomplished.. Expectation should be specific. Describe task and/or results which can reasonably be accomplished within the established SBIR cost and time constraints (Phase II - $750K/24 mos.). Require Proof-of-Concept Demonstration.) During this phase of the program most of the engineering aspects of the new capability should be developed. Additionally, testing of actual blades showing direct evidence of the viability of the methodology. Finally, the definition of the exact engineering parameters for a production piece of equipment must be worked out and a prototype piece of equipment constructed and tested.

PHASE III DUAL USE APPLICATIONS: (Must contain a strong, concise description of it's Dual Use/Commercialization Potential. Briefly list the DoD/commercial areas which have requirements for this particular technology; what end application is envisioned and what sort of benefits are anticipated.) An example of a dual use application for this technology would be in the inspection of the thermal barrier coating (TBC) on turbine blades of land based gas used for power generation. The next generation of these turbines will depend on the thermal barrier coating to meet the service life requirements. Coating conditions that need to be detected included the following conditions: 1) detection of oxidation beneath the bond coat. 2) bonding of the TBC to the bond coat. 3) thickness of the TBC. If it is too thin, then local oxidation will occur and shorten the blade life. If the TBC is too thick, then it may crack because the thermal strain between the TBC and the bond coat may be too much for the TBC to sustain and severe cracking can occur. Please note the TBC may contain intentional longitudinal cracks to limit cracking due to this expansion mismatch. Areas of interest include the platform radius where the blade transitions from the airfoil to the base. During this phase of the program a piece of equipment installed on a production line and data acquired demonstrating the economic utility of this new methodology. Additionally, sufficient data should be collected to validate the reliability of the process in a production environment.

REFERENCES:
Ultrasonic Testing of Materials, Third Edition, J. Krautkramer and H. Krautkramer, 1983, Springer-Verlag, New York
Radiological Imaging, H. H. Barrett & W. Swindell, Vol I & II, 1981, Academic Press, New York, NY.
The Nondestructive Testing Handbooks, Second Edition; Vol. 3, Radiography and Radiation Testing, Ed. L. E. Bryant; Vol. 4, Electromagnetic Testing, Ed. M. L. Mester; Vol. 5, Acoustic Emission, Ed. R. K. Miller; Vol. 7, Ultrasonic Testing, Ed.s A. S. Birks & R. E. Green, Jr.; Vol. 9, Special Nondestructive Testing Methods, Ed. R. K. Stanley; American Society for Nondestructive Testing, Columbus, OH.

KEYWORDS: Nondestructive evaluation (NDE), Nondestructive inspection (NDI), Coatings, Multilayer coating, Corrosion, Oxidation

AF00-145 TITLE: NDI for Diffusion Bonded Components

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective of this topic is to provide the jet engine manufacturers with a methodology to guarantee minimum properties of diffusion bonded components through a new nondestructive inspection (NDI) capability.

DESCRIPTION: Currently, there are no NDI methods of guaranteeing the bond integrity of bonded components. Ultrasonic methods have been tried but they can not detect the difference between two surfaces in intimate contact and those with good bonds. Therefore, a new approach is sought that places the bond under a local proof test and at the same time examines it for fracture. Methods are sought that will permit the implementation of such a concept. Methods that are non contact have obvious advantages as well a those which are based on existing technologies. Existing methodologies not common to the NDI community should be explored before examining those classically investigate and known to be of minimal value - see the references below for several NDI techniques that fit this latter category. The advantage associated with modification of existing technologies are the reduced cost to bring them to operational levels and enhanced probability of success. If an approach is found that will load a joint to a substantial fraction of its ultimate load bearing abilities, then its operational reliability is substantially enhanced. If the bond is broken during such a test and that fracture is detected, then a part with marginal or unacceptable properties can be eliminated from those acceptable components.

PHASE I: During this phase of the program the proof of the concept should be demonstrated on laboratory specimens approaching the configuration of actual aerospace components, e.g. turbine or compressor blades.

PHASE II: During this phase of the program most of the engineering aspects of the new capability should be developed. Additionally, testing of actual blades showing direct evidence of the viability of the methodology. Finally, the definition of the exact engineering parameters for a production piece of equipment must be worked out and a prototype piece of equipment constructed and tested.

PHASE III DUAL USE APPLICATIONS: An example of a dual use application for this technology would be in the inspection of the diffusion bond in hollow core titanium turbine blades of land based gas used for power generation. The next generation of industrial gas turbine steam generators very likely will depend on titanium blades tot meet the erosion requirements of the back ends where the steam has condensed to water. Hollow titanium blades have obvious advantages but are not currently used for a variety of reasons; one being the lack of ability to adequately inspect the diffusion bond line for life limiting flaws and metallurgical conditions. Without an adequate inspection capability, then continued used of solid metal blades will be required with the obvious deficit to performance and increased cost of operation. During this phase of the program a piece of equipment installed on a production line and data acquired demonstrating the economic utility of this new methodology. Additionally, sufficient data should be collected to validate the reliability of the process in a production environment.

REFERENCES:
"Acceptance Criteria for Nondestructive Evaluation of Adhesively Bonded Structures," E. Segal & S. Kenig, Materials Evaluation, Vol. 47, No. 8, p. 921-927, 1989.
"Bonded Joints and Nondestructive Testing - 1," D. J. Hagemier, Nondestructive Testing, Vol. 4, No. 12, p. 401-406, 1971.
"Bonded Joints and Nondestructive Testing - 2," D. J. Hagemier, ibid, Vol. 5, No. 2, p. 38-47, 1972.
"Nondestructive Testing of Bonded Metal-to-Metal Joints," D. J. Hagemier, ibid, Vol. 5, No. 6, p. 144-153, 1972.
"Evaluation of Sonic Methods for Inspecting Adhesive Bonded Honeycomb Structures, I. R. Kraska & H. W. Kamm, Air Force Materials Laboratory Technical Report, AFML-TR-69-283, 1970.
"Detection of Unbonds in Multi-Layered Fuselage Sections with the Bondascope 2100," R. Bosco, Applications Report #521, NDT Instruments, Inc., Huntington Beach, CA.
"Ultrasonic Study of Adhesive Bond Quality of a Steel-to-Rubber Interface by Using Quadrature Phase Detection Techniques," A. C. Smith & H. Yang, Materials Evaluation, Vol. 47, No. 12, p. 1396-1400, 1989.

KEYWORDS: Turbine engines, Nondestructive testing, Bonding

AF00-146 TITLE: Turbine Engine Airfoil Thermal Barrier Coating Reliability Enhancement

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop robust thermal barrier coatings for turbine blades that reduce the occurrence of early coating failures and increase the meantime between inspections.

DESCRIPTION: Coatings are used as both oxidation and thermal barrier coatings on airfoils in gas turbine engines. Thermal barrier coating (TBC) systems consist of a metallic bondcoat applied to a Ni-based superalloy substrate on top of which a ceramic coating, commonly yttria-stabilized zirconia (YSZ), is applied by either plasma spray or electron beam-physical vapor deposition processes. Since the YSZ coating is transparent to oxygen and thus does not protect the substrate, the bondcoat must be resistant to both thermomechanical fatigue and oxidation [1]. The oxidation of the bondcoat is a primary failure mechanism of TBCs and a weak link for improving coating lifetimes [2]. New approaches are requested to develop and characterize bondcoat systems that yield improved lifetimes for thermal barrier coatings.

PHASE I: This program will focus on critical issues, which when successfully addressed, will provide proof of concept. Proposal should demonstrate reasonable expectation that proof of principle can be obtained within Phase I.

PHASE II: This program will be structured to develop and refine those feasible concepts to the point where performance is physically demonstrated (burner rig or engine test) on a scale (coupon or representative airfoil) to permit an evaluation of the ultimate application potential to meet Air Force needs.

PHASE III DUAL USE APPLICATIONS: The developed approaches would have broad commercial applicability due to the large number of commercial engines that currently incorporate thermal barrier coatings.

REFERENCES:

1. B. A. Pint, et al., "Substrate and bond coat compositions: factors affecting alumina scale adhesion," Materials Science and Engineering, A245 (1998) pp. 201-211.

2. A. M. Freborg, et al., "Modeling oxidation induced stressed in thermal barrier coatings," Materials Science and Engineering A245 (1998) pp. 182-190.

KEYWORDS: Thermal Barrier Coatings, Bondcoat, Oxidation

AF00-147 TITLE: Boron Based Ceramic Matrix Composites for Aircraft Brake Friction Materials

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and characterize boron based ceramic matrix composites as high performance aircraft brake friction materials.

DESCRIPTION: Carbon-carbon composites (C/C) are the state-of-the-art friction material for aircraft brakes. C/C is expensive to produce and suffers from a relatively low friction coefficient, a high variability in friction coefficient as a function of temperature, moisture content, and pressure, susceptibility to oxidation at the use temperature, generation of a nuisance dust (through brake wear), and degradation from fluids commonly used on and around the aircraft. Ceramic matrix composites (CMCs) offer an alternative to C/C which may ameliorate many of these deficiencies. [1-3]. Silicon based CMCs (i.e., SiC, Si-O-C) have been the primary focus of attention to date, but boron based CMCs, such as those based on boron nitride (BN), appear to also be viable candidates [4].

PHASE I: Survey the composites community for candidate boron based CMCs and select one or more materials which would be suitable for an aircraft brake. Selection criteria should include consideration of material cost and scalability of fabrication technique, as well as performance and maintainability issues. Fabricate coupons and subject them to a battery of mechanical and friction tests. Assess the test results, identify material and process refinements, and identify the most promising candidate.

PHASE II: Optimize the processing and performance of the chosen boron based CMC through fabrication and testing (mechanical and friction) of coupons in an iterative fashion. Demonstrate material performance through fabrication and dynamometer testing of a generic aircraft sized rotor/stator pair [~12" diameter] at energy levels typical of a modern military aircraft. Develop scaleup and marketing plans.

PHASE III DUAL USE APPLICATIONS: The resulting advanced friction materials will be directly applicable to the large commercial aircraft brake market, where improved performance will result in reduced cost per landing.

REFERENCES:

1. W. Krenkel, "CMC Materials for High Performance Brakes," Proceedings of the ISATA Conference on Supercars, Aachen, 1994.

2. W. Krenkel and R. Renz, "C/C-SiC Components for High Performance Applications," Proceedings of the European Conference on Composite Materials (ECCM), Naples, 1998.

3. A. Ibott, "The China Syndrome," FastBikes Magazine, Nov. 1996.

4. C. G. Cofer, A. W. Saak, and .J Economy, "Carbon/Boron Nitride Composites: An Alternative to Carbon/Carbon," Cer. Eng. Sci. Proc., Vol. 16, 5, p 663-671 (1995).

KEYWORDS: Aircraft Brakes, Ceramic Matrix Composites (CMCs), Friction Materials, Boron based CMCs, Process Development

AF00-148 TITLE: Improved Life Prediction of Turbine Engine Components

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop improved fracture-mechanics based tools for predicting fatigue lives under service conditions for gas turbine engine materials.

DESCRIPTION: Gas-turbine engine structural materials, such as titanium and nickel-base superalloys, are subjected to a complex spectrum consisting of numerous temperature and load excursions, depending upon the mission. Fatigue damage processes under engine operating conditions can be very complex, involving effects of loading frequency and stress ratio, creep, environment, and the interactions of these variables. [Ref 1,2] Presently, components are life managed based on TACs (total accumulated cycles) or TECs (total equivalent cycles), which represents a rough form of cycle counting, wherein a number or fraction of an "equivalent cycle" is assessed for certain throttle excursions. At the completion of a flight the number of TECs is added to the running total for a particular engine, and the components are life managed based on that number compared to the predicted (or design) life - also given in TECs. Due to the inexact application of "equivalent cycles" in accounting for the wide envelope of potential effects and interactions, numerous safety factors have evolved in fatigue predictions to minimize the effect on safety of flight. This has led to the possibility of an overly conservative life estimate for components. Significant advances in a variety of computational and materials technologies now offer the possibility for much improved accounting of the actual service mission on the nucleation and growth of cracks, and innovative prediction tools are required to account for the actual mission conditions experienced by turbine engine rotating hardware. Ultimately, these tools need to take into account the effects of thermomechanical loading, dwell times, load-interaction effects, etc. on the growth of initial damage and small cracks, transition from small to large cracks, and the growth of microstructurally large cracks.

PHASE I: Develop fracture-mechanics based algorithm(s) to predict or assess the useful fatigue life as a function of the key variable(s), i.e. temperature, load, frequency, hold time, environment, etc. Establish the feasibility with available data, or generate laboratory data to demonstrate the utility of the algorithm(s).

PHASE II: Further development of fracture-mechanics based analytical technique(s). Demonstration of the utility of the technique on laboratory and/or subelement tests under mission-like load and temperature spectra. Delivery of software code, developed under the SBIR contract, would be for evaluation purposes by AFRL and/or ASC in subcomponent, component, and/or engine validation testing. Additional distribution of software would occur only as a result of separate contractual agreements. All computer codes should be PC compatible with Windows NT.

PHASE III DUAL USE APPLICATIONS: The fracture-mechanics based algorithm(s) and software codes developed to predict or assess the useful fatigue life of engine structural materials should be applicable to a wide variety of commercial applications including, but not limited to, commercial aircraft (engines and airframes), land based turbines, automotive and other transportation vehicles, and any industrial applications where fatigue and/or thermomechanical fatigue is the primary failure mechanism. All computer codes should be PC compatible with Windows NT.

REFERENCES:

1. Nicholas, T. and Larsen, J. M., "Life Prediction for Turbine Engine Components," Fatigue: Environment and Temperature Effects, Plenium Press, New York, New York, Editors J. J. Burke and V. Weiss, pp.353-375, 1983.

2. Larsen, J. M. and Nicholas, T., "Cumulative-Damage Modeling of Fatigue Crack Growth in Turbine Engine Materials,"Engr. Frac. Mech., Vol. 22, No. 4, pp. 713-730, 1985.

3. Larsen, J. M., et. al., "An Assessment of the Role of Near-Threshold Crack Growth in High-Cycle Fatigue Life Prediction of Aerospace Titanium Alloys Under Turbine Engine Spectra," Int. J. of Frac., Vol. 80, pp. 237-255, 1996.

4. Nicholas, T. and Zuiker, J. R., "On the Use of the Goodman Diagram for High-Cycle Fatigue Design," Int. J. of Frac., Vol. 80, pp. 219-235, 1996.

KEYWORDS: Fatigue, Thermomechanical fatigue, Fracture Mechanics, Crack propagation, Small cracks, Mission spectrum, Creep, Environment, Titanium, Nickel-base superalloy

AF00-149 TITLE: Durability of Turbine Engine Materials

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Life extension of turbine engine components through the demonstration of material durability and life management improvements.

DESCRIPTION: The inability of some key fielded, turbine-engine components to meet or exceed their original design life is of increasing concern and expense to the Air Force. For major, fracture-critical components, reduced lives can result from inadequate nondestructive evaluation (NDE) capabilities, inadequate understanding of the material response to the engine operating environment, unanticipated or premature wear-out modes, or excessive conservatism in the life management system. It is postulated that a large fraction of these costly parts could be safely used well beyond their predicted LCF "design" life through the application of appropriate life-extension technologies. These technologies include improvements in NDE techniques and procedures, more accurate and robust fracture-mechanics models, innovative repair or refurbishment processes, and better understanding of initial surface finish and residual stress conditions. For fan blades and hot-section components high cycle fatigue, foreign object damage (FOD), hot corrosion, oxidation, and creep are major causes of decreasing, useful component life. Improvements in control, mitigation, and understanding of the damage modes are crucial steps required to maximize the useful economic life of components, without increasing the risk of failure. In addition, advanced materials, material-coating schemes, and material processes, which may be candidates to replace existing practice, must demonstrate improved durability, or increased resistance to the active damage mode.

PHASE I: Demonstrate the potential for service life extension and quantify the associated improvements in life cycle cost or cost savings. Proof of concept shall be demonstrated through initial formulation, bench- or coupon-level testing and evaluation in support of an advanced model, material, coating, surface treatment, process, or NDE technique. A specific engine component, or components, and the degree of life extension or increased capability should be individually addressed.

PHASE II: Demonstrate the feasibility to scale the technology. This could be accomplished through sub-element or full-scale testing in support of models or advanced materials and processes. For improved NDE techniques, material processes and surface treatments, optimization and scale-up are required to establish feasibility for manufacture and widespread use. The degree of life extension, when applied to specific components, should be demonstrated under realistic test conditions.

PHASE III DUAL USE APPLICATIONS: The technology developed should be applicable to a wide variety of commercial applications, including, but not limited to, commercial aircraft, land-based turbines, and automotive and other transportation vehicles.

REFERENCES:
1. Larsen, J. M. and Nicholas, T., "Cumulative-Damage Modeling of Fatigue Crack Growth in Turbine Engine Materials," Engr. Frac. Mech., Vol. 22, No. 4, pp. 713-730, 1985.
2. McDowell, D. L., "Basic Issues in the Mechanics of High Cycle Metal Fatigue," Int. J. of Frac., Vol. 80, pp. 103-145, 1996.
3. A.M. Freborg, et al., "Modeling oxidation induced stresses in thermal barrier coatings," Materials Science and Engineering, A245, pp. 182-190, 1998.
4. S. L. Semiatin and T. R. Bieler, "Microstructural Evolution during the Hot Working of Superalloys," JOM, Vol. 55, No. 1, p. 13, 1999.
5. Harris, J. A., Engine Component Retirement for Cause, AFRL-TR-87-4069,1987.
6. Berens, A. P., "Analysis of the RFC/NDE System Performance Evaluation Experiments," Review of Progress in Quantitative Nondestructive Evaluation 6, D. O. Thompson and D. E. Chimenti, eds., Plenum Press, New York, 1987.
7. Keller, S., et al., "Performance Experience and Reliability of Retirement for Cause (RFC) Inspection Systems," RTO-MP-10, NATO Research and Technology Organization, Neuily-Sur Seine Cedex, France, November 1998.

KEYWORDS: Durability, Materials, Processing, Nondestructive evaluation (NDE), Modeling, Life management, Life extension, Damage Modes, Turbine Engines

AF00-150 TITLE: Titanium Processing for Low Cost Airframe and Engine Components

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The development of lower cost titanium metal and processing techniques that will significantly reduce the cost of airframe and engine components.

DESCRIPTION: The cost of titanium sponge is the largest single raw material contribution to the cost of titanium forgings and castings (25% and 17%, respectively). The use of titanium in the F-22 is approximately 40% by weight in the airframe and in the F119 engine. In comparison, there is only 15% aluminum in the airframe and 4% in the engine. Since the cost of titanium is close to seven times that of aluminum, methods to reduce the cost of titanium can lead to significant cost reductions in the unit cost of the F-22. New approaches are requested to develop techniques that reduce the cost of titanium sponge or a comparable sponge substitute [1]. In addition, new approaches are requested which investigate the feasibility of near-net-shape processing using titanium powder [2]. The powder-based technologies must demonstrate final material properties comparable to cast/wrought titanium components at a lower cost.

PHASE I: This Phase I effort will focus on techniques that will reduce the cost of titanium sponge or a comparable sponge substitute. Near-net-shape processing techniques that significantly reduce the manufacturing cost of titanium components shall also be investigated. Proposals should demonstrate reasonable expectation that new approaches and techniques will lead to lower cost titanium airframe and engine components that demonstrate materials properties superior to or equal to current cast/wrought components.

PHASE II: This Phase II effort will refine those new techniques developed in Phase I and demonstrate comparable mechanical properties and lower cost manufacturing to current titanium aerospace components. Raw material production concepts and near-net-shape techniques will be demonstrated by the manufacture of prototype aerospace component(s). Mechanical properties of the finished prototype components shall be tested. A cost analysis shall be conducted to verify the cost savings projected in phase I.

PHASE III DUAL USE APPLICATIONS: The developed approaches should have broad commercial applicability due to the large number of commercial airframes and engines that are fabricated from titanium. Potential customers shall be identified. Benefits of the new technology to the customer base shall be established, and the cost of implementing the technology into the customer base shall be determined.

REFERENCES:
1. A. D. Hartman, et al., "Producing Lower-Cost Titanium for Automotive Applications," JOM, Vol. 50, No. 9, pp. 16-19.
2. F. H. Froes, "The Production of Low-Cost Titanium Powders," JOM, Vol. 50, No. 9, pp. 41-43.

KEYWORDS: Titanium Sponge, Powder Processing, Near Net Shape Processing, Forgings, Castings, Airframe Components, Engine Components

AF00-151 TITLE: The Control Stick of the 21st Century "C21"

TECHNOLOGY AREAS: Air Platform, Information Systems, Materials/Processes

OBJECTIVE: Design and develop the control stick of the future while considering the requirements to potentially retrofit the CS21 stick technology into aircraft currently in development and production.

DESCRIPTION: This is a requirement of the F-22 System Program Office for the re-design and re-engineering of the stick used by the pilot to control the aircraft. The size and complexity of the current stick technology must be drastically reduced in order to provide more functionality and improved human factors considerations. The switch bodies are huge which causes the stick and throttle grips to be very large. More functionality is needed at the pilot's fingertips in order to improve the pilot's performance during flight and war fighting. The current stick technology user friendliness and other human factors also leave a lot to be desired. The offeror must develop a comprehensive set of CS21 user needs, supporting technical engineering requirements to resolve the issues of the user, and provide a new and innovative solution to the aerospace industry.

The offeror must consider establishing a CS21 design team that is composed of the required knowledge and skills, including component suppliers. The offeror should consider using a process such as Integrated Product and Process Development (IPPD) to ensure completeness, consistency, quality, and cost control of their CS21 strategy. The offeror should develop an interface with the F-22 and JSF SPO engineers for the CS21 technology development to ensure that the prime contractors, major subcontractors, and their suppliers participate appropriately. The offeror should use modern CAD and simulation and modeling technologies to demonstrate recommended CS21 concepts as early as possible in Phase I to enable confidence in the Phase II proposal potential. These CS21 demonstrations should depict how the war fighter's needs and the technical engineering requirements will be satisfied.

PHASE I: This phase will define the requirements, prototype designs, and simulation models demonstrating CS21 conceptual physical and functional profiles, operations, and interactive interfaces in a war fighter's simulated environment. The offeror will use a carefully selected Technical Review Board (TRB) of subject matter expert users, potential developers, and suppliers of CS21 technologies for project over site.

PHASE II: Phase II will convert the selected CS21 conceptual design into a physical product using a systems engineering approach to satisfy CS21 requirements and specifications from the IPPD and TRB evaluations. The offeror will develop and productize the CS21, commercialize it, and work with the SPO and prime contractors to install and validate CS21 technology in hardware. The CS21 engineering designs and analysis, simulation models, and data will be installed in the AFPMO Product Affordability Realization Testbed (PART) facility for possible prototyping and for demonstrating the CS21 to potential users and developers.

PHASE III DUAL USE APPLICATIONS: The models, methodologies, techniques, and resulting technologies will be used to convey the CS21 project results to companies developing commercial and military systems.

REFERENCES: TIB/B94-04983, Application of Active Side Arm Controllers in Helicopters, Knorr, R.; Melz, C.; Faulkner, A.; Obermayer, M., Eurocopter Deutschland GmbH, Ottobrunn (DE), 1992.

KEYWORDS: Functional Capabilities, Control Stick, Re-design

AF00-153 TITLE: Development of Improved Mold Facecoat Technology

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop a lower cost, more robust, and more detectable facecoat system for the titanium investment casting industry.

DESCRIPTION: Titanium investment castings have gained wide usage in aerospace propulsion systems to reduce cost. The investment casting process offers the ability to make complex parts of one piece construction, thus eliminating the expensive fabrication of parts from multiple pieces. Recently, the F-22 has made use of titanium investment castings for large critical airframe structure. Significant cost savings will be realized through the successful use of titanium investment castings in future military and commercial airframe structure. Unfortunately, the F-22 has experienced significant processing related issues with their castings that can be attributed to the mold facecoat system.

The investment casting process involves making a mold by systematically pouring ceramic slurries over a wax "copy" (referred to a "wax") of the part to be cast. The wax is then melted out of the ceramic mold and the ceramic mold is cured during a "wax burnout" process. The metal is then poured into the ceramic mold. The first ceramic slurry poured over a wax is the facecoat system. This facecoat system is selected to reduce the reactions with liquid titanium as the titanium is pored into the mold and the metals cools. If great care is not taken during the fabrication of the ceramic mold, the mold can be stressed and weakened thus increasing the possibility of ceramic inclusions contaminating the titanium casting. X-ray techniques are employed to detect ceramic inclusion in titanium castings. Unfortunately, the delectability of the ceramic inclusion material in titanium castings is not good enough to take full advantage of the benefits that titanium investment castings offer.

PHASE I: This phase I effort will focus on titanium investment casting facecoat materials and/or mold systems that are cheaper, more robust, and more detectable via non-destructive inspection than current state-of-the-art mold systems. Proposals should demonstrate that the offeror has experience in the development of facecoat materials for investment casting. However, the facecoat "system" need not be limited to the facecoat alone. Cost effective materials, material systems and/or techniques shall be identified which can, decrease the chance of foreign inclusions ending up in titanium investment castings and increase the chance of detecting them if they do end up in the casting. Robust mold systems that show a very low chance of ever ending up in a final casting should also be considered. Proposals should demonstrate reasonable expectation that new approaches and techniques will lead to robust, highly detectable (if applicable), and cost effective mold systems. Demonstration will require association with a casting house of the offeror's choice.

PHASE II: This phase II effort will refine those new materials, systems, and techniques developed in phase I and demonstrate the robustness and delectability of the new materials and/or systems. Prototype molds shall be fabricated. Test shall be developed and conducted which can evaluate the robustness (strength) of the mold materials and/or systems. The ability of the new mold materials and/or systems to withstand the typical manufacturing process of an F-22 side-of-body "like" casting shall be determined. Prototype titanium castings shall be poured and inspected by non-destructive inspection (NDI). NDI results shall be compared to destructive test and used to. develop probability of detection (POD) curves for mold materials in titanium, or demonstrate that the mold material does not end up in the casting. A cost analysis of the new mold technology shall be conducted and reported.

PHASE III DUAL USE APPLICATIONS: The developed approaches should have broad commercial applicability due to the large number of commercial airframes and engines that are fabricated from titanium. Potential customers shall be identified. Benefits of the new technology to the customer base shall be established, and the cost of implementing the technology into the customer base shall be determined.

REFERENCES: Air Force Contract F33615-95-2-5555, Engine Supplier Base Initiative

KEYWORDS: Titanium , Investment casting, Lost wax process, Ceramic mold, Slurry, Facecoat, Alpha case

AF00-154 TITLE: Advanced Adaptive Optical Coating Process Technologies

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design adaptively controlled optical coating processes to either infer or enable direct measurements of optical properties.

DESCRIPTION: In order to produce state-of-the-art, low stress, low absorption, environmentally stable optical coatings, all material parameters must be well characterized and controlled during the deposition process. Dielectric molecules are characterized to first order by the molecular electric polarizability while molecules of a birefringent material will have a permanent electric dipole moment. Other molecules may have higher moments, quadrupole, etc., for both the polarizability and the permanent moments. Magnetic materials have the corresponding quantities for the magnetic field. Conductive materials have free electrons and therefore non-zero electrical conductivity. In the general case, a material has all of these properties. Knowledge of these parameters is necessary for all constituent species of molecules to be modeled and controlled during processing. In addition, the arrangement of molecules as well as the interaction of different species will induce stresses and strains in the molecules, which in turn induces permanent dipole moments and therefore stress birefringence. Additionally, the properties are a function of temperature and pressure. The goal of this SBIR topic is to design and develop technologies for an advanced adaptive process to monitor and control the above discussed properties during the deposition of optical coatings. One current deposition process of choice is reactive dc Magnetron sputtering to deposit dual wavelength optical coatings with very high reflectance which are also dense, with very low absorption (~10 ppm) and scatter (surface roughness ~1 nm), and promise long-term stability and durability in a space environment. We believe this process can easily be adapted to ultra lightweight materials to produce rapid, low cost, uncooled mirrors for space optical applications, as well as environmentally stable/durable coatings for leading edge aircraft applications. However, in order to satisfy the stringent material property specifications for all optical applications, particularly those of high aspect ratio optics, extremely close control of source profiles and deposition parameters must be maintained. Continual evaluation of deposition parameters, and more to the point, coating performance, during deposition, would ensure specified performance from the finished product, essentially without the need for witness samples.

PHASE I: Demonstrate the feasibility of an advanced processing technology (e.g., integrating gas cluster ion processing with a compatible deposition process and/or use in situ monitoring of relevant material parameters via evanescent microwaves as the basis for tuning through the gas cluster ions). The objective of Phase I is to demonstrate improvements in the quality and uniformity of optical coating properties across a range of optical coating materials to include interfaces, i.e., inter-layer and film-to-substrate. The primary candidate materials for this investigation would be titanium dioxide (TiO2), tantalum pentoxide (Ta2O5), and Silicon dioxide (SiO2). Titanium dioxide has a broad spectral range of transparency (0.4 mm to 8.0mm), and a high refractive index. Previous investigations indicate that good quality films of this material can be grown using IAD.1,2 It has also been demonstrated that the stress of evaporated TiO2 and SiO2 films can be altered by IAD.1,2 Tantalum dioxide has a lower refractive index than TiO2, but is transparent in the ultraviolet spectral region and has extremely good resistance to radiation damage. SiO2 is the most durable low index material available, and has good resistance to radiation damage. Characterization of the films on various substrate materials will be necessary. Although stress caused by different thermal expansion coefficients is usually of secondary importance, in some cases it may be significant. Of more importance would be the adhesion of the film structure to the substrate. This may differ depending on the substrate, and some investigation of adhesion related to surface preparation prior to coating may be useful.

PHASE II: Develop an advanced optical coating process prototype to enable near real-time monitoring and control of deposited single-layer, multi-layer, and/or gradient films relative to optical properties, electro-magnetic conductivities, and morphology (grain size, orientation, roughness, etc.) for both defense and commercial applications. Thin face-sheet mirror materials should be first investigated to demonstrate the prototype's ability to monitor and control adhesion and stress.

PHASE III DUAL USE APPLICATIONS: With the increasing need for lighter-weight optics, large investments are being made in lightweight mirror and membrane materials, including deployment techniques, but not in the durable high-performance optical coatings necessary for their implementation. A high reflectivity, low absorption, low stress optical coating is key to enabling highly efficient operations. Such lightweight high reflector membranes not only would serve to increase operational efficiency for space and airborne applications, but as well to reduce the cost of deployment to operational altitude. Low stress coatings in particular could provide the key to enabling thin materials and facesheets to be used in any optical application. Of particular interest is the need for a process which has the potential to produce rapid, low cost, uncooled mirrors for space optical applications; and this potential is tremendous. Studies such as AFRL's Lasers and Space Optical Systems indicate that such large lightweight space optics are the enabling technologies to answer warfighter requirements, as well as those of commercial applications such as laser communication, including lighter-weight mirrors for crosslink and large apertures for down and up links. With such large apertures, far-reaching technologies such as optical imaging through clouds could be realized, opening the full military realm to laser applications, including covert communications. Eventually, even directed energy type applications may also benefit, including the Next Generation Space Based Laser. In any of these applications, launch weight savings alone would be phenomenal, not to mention the capability produced by having this large optic in space.

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KEYWORDS: Thin Film Optical Coatings, Adaptive Control Technologies, Environmentally Stable Optical Coatings

AF00-155 TITLE: Guided Wave Electro-Optic Materials

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

OBJECTIVE: Develop new electro-optic materials with superior properties as compared to those presently available.

DESCRIPTION: Guided-wave electro-optic technology is required for optical communication between satellites and for highly-dense data handling on satellites. It offers high bandwidths for data transfer exceeding 100 gigabits per second, significantly reduced susceptibility from electro-magnetic pulse interference, reduced radar cross-section, reduced e-m noise generation, and a high tolerance against space radiation effects. However, the current state-of-the-art material, lithium niobate, is limited in a number of respects, including high modulation voltage, large device size, an inability to directly integrate with electronics, instability problems (temporal and thermal), piezoelectric ringing, a large dielectric constant, a moderately large index of refraction, and sensitivity to various forms of ionizing radiation. Currently, polymeric films (including both self-assembled organics and electro-optic poled polymers) appear to offer the best compromise of properties based on both the present state of materials development and the potential for improvement. The objective of this effort is to develop polymeric thin films with enhanced electro-optic (EO) coefficients of at least 50 pm/V at a wavelength of 1550 nm. Besides the enhanced EO coefficients, additional characteristics of the films must include processibility, thermal stability (125C depoling temperature), temporal stability, and suitability for low-loss optical waveguides (<1dB/cm). Materials suitable for operation at a variety of wavelengths will be considered, but the greatest Air Force interest is at 1550 nm. Nonlinear optical devices may be fabricated only as a minor part of a materials effort to evaluate and demonstrate the properties of the material(s).

PHASE I: The objective is to demonstrate a new material, the feasibility of a proposed new growth technique, improved functionality of a material through innovative processing techniques, or improved materials properties resulting from either growth or processing advancements.

PHASE II: The objective is to further develop the proposed material and / or the relevant processes to fully demonstrate the materials properties and usefulness for commercial and military applications. Establish all necessary manufacturing processes for commercialization of a product.

PHASE III DUAL USE APPLICATIONS: Materials technology is fundamental to all applications, military and commercial. Examples of commercial applications are optical switches for cable TV, optical phase shifters for phased array radar, optical interconnects for electronic packages, and switching networks for communications.

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KEYWORDS: electro-optic materials, nonlinear optical materials, NLO materials, optical communications

AF00-156 TITLE: Materials for Superlattice Infrared Detectors

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

OBJECTIVE: Research and development of innovative epitaxial growth techniques for III-V superlattice materials with controlled mixed anion interfaces.

DESCRIPTION: The Air Force requires new, very long wavelength infrared (VLWIR) detectors with increased operating temperature, >40K in VLWIR, and improved detectivity for space based applications. These detectors will be required to operate at wavelengths beyond 16 micrometers. The presently available detectors are based on extrinsic silicon. Due to excessive dark current, the operating temperature of these detectors is below 20K. Detectors with increased operating temperatures with equivalent or better detectivity will have significantly reduced launch costs due to reductions in the weight of the cryocooler. The principle alternatives to extrinsic silicon at present are compound semiconductor superlattices based on group III antimonides and arsenides. So far, detector structures fabricated from InGaSb/InAs and InAsSb/InAs superlattices have not been demonstrated beyond 12 micrometers, and are Shockley-Read noise limited due to defects in the materials. This task seeks to develop improved and innovative epitaxial growth techniques for growing superlattices based on mixed anion interfaces such as InGaSb/InAs. The key areas to be addressed are the interface purity, abruptness and smoothness between the thin InGaSb and InAs layers. Examination of these parameters on the scale of a few Å's is required. Also, the controlled repeatability of the superlattice layer thicknesses and compositions over 1-2 micrometers of material growth should be examined. Both molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD) will be considered as well as other novel growth techniques. Growth on novel substrates is encouraged.

PHASE I: Phase I will address process development and growth of simple heterointerfaces along with the minimum characterization to demonstrate improved interfaces. A deliverable of a representative test sample to the government is encouraged.

PHASE II: Phase II will optimize the growth process demonstrated in Phase I with more extensive characterization. Modeling of the growth process is appropriate. Growth and evaluation of superlattice structures suitable for VLWIR detectors will be used to demonstrate the success of the program. Delivery of test materials to the government for evaluation is encouraged.

PHASE III DUAL USE APPLICATIONS: Structures based on mixed anion heterointerfaces have applications in a wide variety of electronic and opto-electronic areas. In particular, room temperature operating infrared detectors based on III-V semiconductor superlattices or multiple quantum wells are of interest to the automotive and aviation industries, among others. Microwave transistors based on mixed anion heterointerfaces have applications in many commercial areas such as cellular phones, and direct broadcast satellite television. The technical product from this effort is expected to be high quality, antimonide based epitaxial materials. The commercial product can either be wafers of these materials designed to user needs, or devices fabricated from these materials.

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KEYWORDS: Infrared, Materials, Superlattice, Semiconductor, Epitaxy, Hetero-interfaces

AF00-157 TITLE: Growth of Semi-Insulating Silicon Carbide (SiC)

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

OBJECTIVE: Develop innovative bulk growth processes for semi-insulating silicon carbide for microwave and RF applications.

DESCRIPTION: Air Force Tactical RADARs and other RF systems currently employing vacuum tube technology have inherent shortcomings including lifetime reliability issues due to overall fragility and cathode burnout, size and weight issues and rigid cooling requirements. It is desired to replace vacuum tube technology in these systems with high power solid state electronics affording reduced space and weight requirements, less stringent cooling needs and greater reliability. Conventional semiconductors such as bulk silicon and gallium arsenide cannot meet these requirements. Semi-insulating silicon carbide has many unique properties such as wide band gap, high breakdown field and high resistivity, which make it attractive for high performance, high temperature and power microwave operation. This task seeks to develop improved and innovative approaches for the growth of semi-insulating bulk silicon carbide. Innovative techniques to obtain semiinsulating behavior will be addressed. The focus of this effort will be on the 4H-SiC polytype with secondary interest in 6H-SIC. Other polytypes or amorphous SiC compounds will not be considered. Hybrid materials combined with SiC will also not be considered.

PHASE I: Phase I will address process development and initial testing to show proof of concept. Phase I goals shall include confirmed growth of semi-insulating bulk silicon carbide with overall resistivity greater than 1017 ohm-cm. Modeling studies of growth processes or materials properties are appropriate. A deliverable of a representative test sample to the government is encouraged.

PHASE II: Phase II will develop the advanced growth processes and techniques to demonstrate the potential application. Phase II goals shall reflect state-of-the-art parameters for semi-insulating bulk growth including but not limited to total resistivity variation of 10% or less over the total wafer diameter and entire boule length. Minimum wafer size and boule length output as a result of the Phase II effort shall be at least 2-inch in diameter with minimum boule length of 1 inch. Other goals include bulk micropipe defects less than 50 per square centimeter. Deliverables of test materials to the government for evaluation are encouraged.

PHASE III DUAL USE APPLICATIONS: Microwave devices made from SiC will exhibit high power, high frequency operation (e.g., 20 watts in X-band at room temperature) with higher package density and reduced cooling subsystem requirements. In addition to military application in tactical RADARS, commercial application of semi-insulating silicon carbide includes @ and HDTV transmitters for the broadcast industry and tube technology replacement in airport surveillance and tracking RADARS. The development of semi-insulating bulk SiC will be required to successfully commercialize these high frequency, high temperature and power devices.

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KEYWORDS: Semi-Insulating Silicon Carbide, Materials, Crystal Growth, High Power Microwave

AF00-158 TITLE: Development of Liquid Crystal Materials for Directed Energy Control

TECHNOLOGY AREAS: Materials/Processes, Biomedical, Sensors/Electronics/Battlespace

OBJECTIVE: Develop new liquid crystal technology (materials and/or processing) with enhanced performance and utility for energy control, switching, and redirection.

DESCRIPTION: Liquid crystal materials are pervasive through commercial based applications ranging from simple twisted nematic-based devices to more complicated display architectures. They are also used in a number of commercial imaging, shuttering, novelty, and entertainment applications. Most of these devices take advantage of the switchable anisotropic optical properties of the LC fluid. The objective of this topic is to improve upon and exploit inherent LC properties for their application in state-of-the-art energy control, switching, and redirection applications. Some examples of appropriate research areas are: new materials with switchable grey scale properties including fast ferroelectric compounds; new switchable polarization materials and schemes with improved contrast and speed; novel passive thin films for compensator and out-of-band filtering applications; new approaches and materials to enhance current switchable and tunable filter materials properties; and approaches to increase contrast in existing architectures. Proposals submitted to this topic should focus on the materials and processing necessary to improve device performance; they should not be device demonstrations.

PHASE I: The offeror will demonstrate proof-of-principle with respect to new materials or processing schemes. The offeror will demonstrate applicability and discuss the issues to be addressed during Phase II.

PHASE II: The offeror will optimize the approach demonstrated in Phase I and will design and characterize the improved article to demonstrate advancement with respect to state-of-the-art technology.

PHASE III DUAL USE APPLICATIONS: Because liquid crystals are pervasive in the commercial sector, improvements to particular materials and/or processes will have wide scale applicability in numerous markets including display, entertainment, and research areas.

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KEYWORDS: Energy control, Liquid crystals, Nematic liquid crystals, Switching speed, Contrast ratio

AF00-159 TITLE: <u>Bulk Growth of Aluminum Nitride for Space and Propulsion Applications</u>

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: The objective is to grow 2 inch diameter single crystal Aluminum Nitride substrates.

DESCRIPTION: Wide energy bandgap aluminum gallium nitride (AlGaN) has potential in high temperature, radiation hardened, and ultra-violet (UV) wavelength applications. However, there is no suitable substrate available. It is not practical to have GaN as a substrate due to the extremely high pressures needed to grow the material by conventional Czechrolski techniques. Therefore, alternative substrate materials, such as sapphire which has a large lattice mismatch of 14% to GaN and others, have been used. The large mismatch causes a large amount of dislocation defects (108-1010 cm-2) in the epitaxially grown GaN. These defects reduce device yield and reliability. Silicon carbide (SiC) and zinc oxide (ZnO) have smaller lattice mismatches to GaN, but are not of the same elemental constituents, which also results in high defect densities. ZnO has the additional problem that it thermally degrades at temperatures where GaN is grown epitaxially. A potential substrate that has not been looked at seriously is bulk grown aluminum nitride (AlN). The lattice constant mismatch is small (about 2%) to that of GaN and even smaller to that of AlGaN. It has the same crystal structure and is thermally stable at high temperatures. In addition, nitrogen is a common element in both GaN and AlN. Therefore, the use of such a substrate may be extremely valuable in high temperature electronics for propulsion applications, space electronics where radiation hardening is imperative, and UV solid state emitters and detectors for missile defense, optical communications and data storage.

PHASE I: The first phase of this effort will consist of the development of a single crystal AlN boule growth of a hexagonal crystal structure. The boule can be grown by any method that produces a 1-inch or larger round AlN wafer for delivery at the end of Phase I.

PHASE II: The second phase will be to extend the knowledge gained in Phase I and develop the capability to grow single crystal 2-inch AlN boules with low dislocation densities (<106 cm-2), no twin defects and a resistivity of greater than 107 ohm-cm. As an indication of progress, two 2-inch round wafers will be delivered with at least a single side polished for material characterization, halfway through the program. A final delivery will be made at the end of the contract with six 2-inch round single crystal AlN wafers with at least one side polished from the same best effort boule. Two of the wafers will be from each of the two ends and the final two will be from the middle of the boule. Also, the remains of that boule will be delivered.

PHASE III DUAL USE APPLICATIONS: Two inch AlN substrates will be made available to the public and may be extremely valuable for uses in high temperature electronics for propulsion applications, space where radiation hardening is imperative in satellite communications, and in UV solid state emitters and detectors for missile defense, optical communications and data storage. There is great commercialization potential for data storage and optical communications with wide bandgap materials.

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KEYWORDS: Crystal growth, Substrate, Aluminum Nitride

AF00-160 TITLE: Qualifying Light, High-Performance Materials for Airborne and Space-Based Laser Systems

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop a rapid materials-selection strategy and demonstrate efficacy on critical high-energy laser components.

DESCRIPTION: The Airborne Laser (ABL) Weapon System, based on the chemical-oxygen-iodine-laser (COIL) concept, represents a major advancement in weapon system technology. The development and acquisition of traditional Air Force weapon systems has required the expertise of many engineering disciplines but not typically chemical process engineering, as does the ABL. The unique chemistry of a COIL presents new challenges in chemical processing, material handling, process material selection, logistics, and safety.

Airborne and space-based chemical laser systems require lightweight, high-performance materials to achieve system performance objectives. The chemicals used in chemically driven laser systems are incompatible with many materials used in the chemical processing industry. In addition, materials that have been used for ground-based chemical laser systems pose extreme weight penalties for aircraft and space applications. Conventional material evaluation techniques require long test periods and are very labor intensive. A rapid, high-confidence evaluation technique is required to predict material performance for critical laser system equipment in a compressed time frame.

PHASE I: Comprehensive materials testing and evaluation strategy involving the use of sub-scale process elements representative of full-scale operational equipment intended for use on high-energy chemical laser systems. Chemical exposure duration of as much as 3000 hours is required with intermittent material assessment. Strategy (Phase I) should include: (1) material selection, fabrication, and identification (government and contractor specified), (2) performance evaluation criteria, (3) material performance data correlated to system design (size, weight, process fluid interactions) and operation (reliability, availability, maintainability) and (4) material performance data correlated to equipment service decisions (MC , NMC , MC with waiver).

PHASE II: Demonstrate rapid material qualification on selected process materials for Chemical-Oxygen-Iodine-Laser (COIL) system. Provide equipment failure modes, assessment techniques for full-scale system evaluation, and mean-time-between-failure for system critical components. Demonstration (Phase II) should include: (1) identification and qualification of materials and material suppliers, (2) sub-scale component fabrication, (3) test configuration and chemical exposure, and (4) post-exposure material inspection, analysis, and qualification. The strategy and demonstration should be an iterative process based on statistical experimental design that will result in the greatest amount of information in the shortest amount of time. Materials should be selected that will result in decision alternatives; i.e., plan B, C, etc., should any selected material fail to meet performance criteria. Process materials must be suitable for use in systems exposed to basic-hydrogen peroxide, chlorine gas, chlorine liquid, hydrogen peroxide (70-wt. %), and ammonia (anhydrous). Specific conditions will be provided upon request.

PHASE III DUAL USE APPLICATIONS: The procedures and methods developed in this effort will compress significantly the development time for advanced chemical-based weapon systems by reducing the time for selecting and qualifying new materials and new material applications. Air Force weapon systems of the future require new methods and tools for managing programmatic and technical risk such as the one specified herein. In addition, developments in this area will be of value in other process industries, such as production of polymeric materials and manufacturing that requires rapid prototyping.

REFERENCES: Oxygen-Iodine Supersonic Technology Program, Area I Supersonic Laser, Subsystem Design Analysis Report, October 13, 1983, Unclassified, TRW Space and Technology Group, Redondo Beach, CA 90278, Contract Number F29601-82-C-0083.

KEYWORDS: chemical oxygen iodine laser, COIL, basic hydrogen peroxide, BHP, chemical decomposition

AF00-161 TITLE: Fuel Processor for Air Expeditionary Force Deployable Fuel Cells Power Generator

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

OBJECTIVE: Develop a highly efficient, lightweight, and small size multi-fuel processor for more reliable fuel cells power generators.

DESCRIPTION: The rapid evolution of fuel cell technology as a replacement for conventional electric power generators has provided a gateway to future efficient and reliable power generating systems using hydrogen as primary fuel. The major drawback to the use of fuel cells as electric generators for deployed forces is the inability to effectively use battlefield fuels (diesel and JP-8) as the primary energy source. The ability to reform battlefield fuels to highly enriched hydrogen gas would allow the use of fuel cells in place of conventional diesel engine powered generators. This would result in a reliable electric generation system with higher efficiency, lower emissions, and lower noise signature. Because of these potential advantages, the objective of this effort is to develop an efficient fuel processor to reform diesel/JP-8 fuels to a high purity hydrogen gas stream for Air Expeditionary Force (AEF) applications. Existing fuel processing can be categorized into stream reforming and partial oxidation technologies with processes to purify the enriched hydrogen gas from sulfur and carbon monoxide. Both technologies yield heavier and bigger units with longer start-up time to compete with diesel engine powered generators. A new concept is sought to develop a lightweight, small size, and quick start-up time fuel processor unit suitable for deployable electric generators.

PHASE I: Develop a conceptual design for a small size, mobile, and highly efficient multi-fuel processor for fuel cells power generator. The conceptual design shall be presented in a technical report and will include details on recommended equipment design and construction, expected performance and durability, total expected weight and size, energy conversion efficiency, and unit cost.

PHASE II: A prototype unit will be constructed based on Phase I recommendations. A demonstrated performance through a single integrated system will be conducted, validated, and presented in a Phase II technical report with further development or commercialization recommendations.

PHASE III DUAL USE APPLICATIONS: A successful, efficient, lightweight, and small size diesel/JP-8 fuel processor with over 85% reforming efficiency will have a multitude of commercial airline facility-emergency power applications, in addition to DoD's use of this technology as a deployable military power generator in a Bare Base scenario. Portable and backup generators are very much in demand during natural disasters (hurricanes, floods, earthquakes, etc.) by emergency response teams.

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KEYWORDS: Logistic Fuel Reformer, Fuel Processor, Fuel Cell

AF00-162 TITLE: Nondestructive Characterization of Titanium Castings and Weldments

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Identify reliable, cost-effective technology for detection and characterization of large titanium casting and weldment defects.

DESCRIPTION: Advancements in airframe structural design and the drive towards greater performance have lead to the incorporation of large complex titanium castings and weldments within new advanced Air Force weapons systems. The design margins of such structures allow for the tolerance of only very small defects. Reliable and accurate flaw detection and sizing is critical in ensuring the structural integrity of the airframe. Defects of greatest concern are subsurface defects such as alpha stabilized inclusions, shell inclusions, porosity, shrinks, and voids within castings, and lack-of-fusion, porosity, and inclusions in titanium casting weld repairs, and titanium electron beam welds. The coarse grain structure of titanium, in particular beta-annealed titanium castings, significantly increases the difficulty in accurate flaw characterization through thick structure. In addition, the move toward large complex castings and electron-beam welded structures significantly increases the difficulty in inspection access. Currently applied methodologies such as delta-scan, shear-wave, longitudinal-wave ultrasonics, and film radiography have proven unreliable in accurately detecting, locating, and sizing such defects within manufacturing environment. Technologies such as phased-array ultrasonics, used extensively in medical imagery, have begun to demonstrate application in industrial inspections were greater flexibility is required for the inspection of complex geometries. This solicitation requests the development and application of phased array ultrasonics, or other NDI imaging technologies, which provide significant improvement in signal-to-noise, signal interpretation, defect characterization, and application flexibility than currently applied technologies. The system, at the end of Phase II, should provide a demonstrable, low-cost system to detect and characterizing defects in titanium castings and weldments, and explore the application of the technology to other Air Force inspection challenges.

PHASE I: Research and develop entire sensor and image acquisition system concept. Develop approach for accurate signal characterization (i.e. defect sizing and location). Build proof-of-concept hardware, software and sensor for the inspection of both titanium weld repairs and titanium electron beam weldments. Demonstrate and define system capability and limitations.

PHASE II: Develop system prototype incorporating data acquisition into a user friendly interface. Data acquisition hardware and operating systems should be PC and Windows 95 based. Sensor and imaging system shall demonstrate full capability for detect detection and characterize of weld defects in both titanium electron-beam weldments and titanium casting TIG weld repairs. Defect hardware can be provided, in part, by the Government. Perform "capability study" to determine inspection sensitivity and reliability. In addition, other applications should be explored such as inspection of steel and aluminum weldments and casting, crack detection in aluminum airframe structures, composite structure inspection, and detection of shell inclusions in titanium castings.

PHASE III DUAL USE APPLICATIONS: Potential applications include inspection metallic or composite structures in aircraft, naval vessels, automobiles, rail systems, or building structures. This technology may have additional application to corrosion detection and characterization in aircraft, ship, and oil pipeline structures. Potential customers include aerospace, nuclear, marine, automotive, and rail industries, FAA, DOD, and the DOE.

REFERENCES:

1. Weld Imperfections, Proceedings of a Symposium at Lockheed Palo Alto Research Laboratory, A.R. Pfluger, R. E. Lewis, Addison-Wesley Publishing Company, Reading Massachusetts, 1968.
2. Ultrasonic Testing, Nondestructive Testing Handbook, Vol. 7, Second Edition, A.S. Birks, R.E. Green, American Society for Nondestructive Testing, Inc., Columbus, Ohio, 1991.
3. ASM Handbook, Nondestructive Evaluation and Quality Control, Vol. 17, J.R. Davis, S.R. Lampman, ASM International, 1994.
4. Phased -Array Techniques and Manipulators: An Advanced Modular Approach for Inspection of Boiling Water Reactor Vessels, J.C. Grigsby, M. Dalichow, E.R. Fischer and W. Rathgeb, Materials Evaluation, Vol. 50, No. 5, May 1992, p 605.
5. Ultrasonic Identification of Weld Discontinuities, R. Wappel, Materials Evaluation, Vol. 43, No. 9, Aug. 1985, p 1060.
6. Tomography, Non-contact Ultrasonic Reflection, J.K. Hu, D.A. Hutchins, J. Ungar, Q.L. Zhang, and D.K. Mak, Vol. 47, No. 6, June 1989, p 736.

KEYWORDS: Titanium castings, Titanium weldments, Nondestructive Inspection, Phase Array Ultrasonics

AF00-163 TITLE: Aircraft Battle Damage Repair (ABDR) of Substructural Core Repair

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop the capability to repair and replace substructural core to aircraft that have been damaged in an ABDR environment.

DESCRIPTION: The US Air Force has established an ABDR program whose primary purpose is to restore sufficient strength and serviceability to a damaged aircraft that will permit the aircraft to fly additional operational sorties within time to contribute to the outcome of an ongoing battle. Therefore, repairs of this nature need to be rapidly accomplished, with little special materials and equipment, restoring full strength while often disregarding normal fatigue and corrosion issues. Repair of substructural core materials poses a concern due to the wide variety of core materials in service, the skill required for machine replacement plugs of core, and the difficulties of bonding these replacement plugs in place. This program investigates two-part "foam-in-place" materials and develops procedures for repair of substructural core on-aircraft.

PHASE I: The contractor shall investigate two-part "foam-in-place" materials for potential repair of substructural core. The contractor shall test these materials for capability to fill component cavities, structural strength, temperature limitations, shelf life, and time required to mix and cure.

PHASE II: The contractor shall develop procedures for replacing core in battle damaged aircraft components. These procedures shall be simple to perform on a variety of component configurations including upward and downward facing openings. The contractor shall demonstrate repair of a representative US Air Force aircraft component with damaged core and validate through structural tests.

PHASE III DUAL USE APPLICATIONS: The process developed would be beneficial for repair and manufacturing of commercial aircraft.

REFERENCES:

1. Sanders, A.L., Stewart, G.G., Regnery, A.M., Rapid Repair of Battle Damaged Aircraft Structure, AFWAL-TR-84-3034, May 1985.

2. Snyder, David L., Battle Damage Repairs Applied to Ballistically Damaged F-15 Horizontal Stabilators and Vertical Stabilizers, JLF-TR-88-9, July 1990.
3. Carter, Douglas W., Validation of F-15 Horizontal Stabilator Battle Damage Repairs, WRDC-TR-91-3003, February 1991.

KEYWORDS: Repair, Substructure, Honeycomb Core

AF00-165 TITLE: Directed Electromagnetic Radiation Energy Curing of High Temperature Repair Adhesives

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Achieve uniform curing of high temperature capable adhesives, on-aircraft, via electromagnetic radiation energy.

DESCRIPTION: Bismaleimide (BMI) composites are constituting more of the structure of advanced fighters due to the high temperature requirements of these aircraft, however, the ability to repair these materials far lags manufacturing capabilities. A major cause of this is due to the necessity to postcure BMI adhesives to temperatures exceeding 400°F, for long durations, in order to achieve the required elevated temperature properties. For on-aircraft repair, this long hot soak is intolerable as is it can potentially damage the surrounding structure, the substructure (i.e., exceeds the degradation temperature of many fuel sealants), as well as pose a safety risk (i.e., exceeds the flash point of aviation fuel). An alternative to the utilization of heat as the primary curing mechanism for high temperature adhesives (>350°F) is therefore needed. This alternative mechanism should have the capability of achieving uniform curing across the bondline despite thermally complex structures and also uniform curing of bondlines in deep core repair.

PHASE I: The contractor shall demonstrate the capability to cure an adhesive bondline, uniformly, with electromagnetic radiation energy so as to achieve adequate elevated temperature properties. The contractor shall demonstrate, at a laboratory scale, adhesive properties which are comparable to autoclave cured BMI adhesives.

PHASE II: The contractor shall optimize curing mechanisms, energy disbursement methods, spacing, energy source, wavelength and intensity. The contractor shall optimize to achieve high strength bondlines. The contractor shall demonstrate proof-of-concept on a large component (one-foot repair area within deep core) to include evaluated temperature (i.e., "hot/wet") repair properties.

PHASE III DUAL USE APPLICATIONS: Commercial airframe and engine manufactures are being driven to higher operating temperatures for their material systems in the pursuit of efficiency and performance. This is and will continue to necessitate the use of higher temperature capable materials such as BMIs (e.g. for engines BMIs are being used in thrust reversers and acoustic damping plates of commercial engines). As with the military systems, there exists no current capabilities for repairing these structures, on-aircraft, due to the temperature restrictions imposed by substructure, subsystems, and the flashpoint of jet fuel. Directing electromagnetic radiation into the bond area could potentially overcome these temperature restrictions.

REFERENCE: Sennett, Michael S. and Wentworth, Stanley E., Evaluation of Resins Cured by Ultraviolet Radiation and in Conjunction with Fiber Optic Systems for use in the Field Repair of Composite Materials, MTL-TR-87-15, March 1987.

KEYWORDS: Repair, Adhesive, Processing

AF00-166 TITLE: Low Observable Maintainability

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop technologies, compatible with aircraft low observable requirements, which allows quick and easy removal and replacement of access panels and doors without degradation of aircraft signature.

DESCRIPTION: The US Air Force has relied heavily on low observable (LO) technologies in recent aircraft designs to perform critical deep theater missions. Although, these technologies have proven very effective against the latest air defense systems in recent conflicts, maintenance of these LO aircraft is the number 1 concern for Air Combat Command. One of the leading causes of LO aircraft downtime is the removal and replacement of LO treatments around access panels and doors. LO treatments, such and tapes and caulks, are applied to conductively bridge the gap between panels and the aircraft structure. Furthermore, fastener heads are covered to fulfill conductivity and smoothness requirements. Removal of these LO treatments before panel removal is very time consuming and risk damage to the panels and aircraft structure. Also, replacement of the LO treatments is even more time consuming due tedious processing steps of the materials including long cure times.

PHASE I: The contractor shall investigate technologies that allow quick and easy access through aircraft panels and doors without degradation of aircraft signature. The contractor shall investigate innovative "in place" seals and fastening methods which completely eliminates the current practice of removing and replacing LO treatments. Furthermore, the contractor shall investigate methods to reduce procedural and material cure times of LO treatments. The contractor shall propose feasibility of investigated methods for signature tests.

PHASE II: The contractor shall develop the most promising solutions investigated during Phase I. These methods shall be compatible to current maintenance skill level and have minimal impact to support equipment available in the field. The contractor shall measure signature loss of developed methods and compare to existing methods.

PHASE III DUAL USE APPLICATIONS: Commercial aircraft utilize conductive sealants around panels and door for lightning strike and EMI protection. Gaining access through the panels or doors for maintenance purposes requires removal and replacement of these conductive sealants. This causes long and costly maintenance downtimes of the aircraft due to the tedious processes and required cure of the material. Technology developed under this program would alleviate or completely eliminate these maintenance processes.

REFERENCES: Yamashita, G., Structural Battle Damage Repair for Low Observable Aircraft, AFRL-VA-WP-TR-1998-3006/7, December 1997.

KEYWORDS: Low Observable, Maintenance, Repair

AF00-167 TITLE: Protective Hard Film Coatings and Solid Lubricants

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop coatings and coating techniques to control friction and wear in moving mechanical assemblies in air and space vehicles.

DESCRIPTION: Recent advances in the design, deposition, and processing of inorganic materials allow fabrication of hybrid composite coatings that are both hard and lubricious. New chemical and microstructural designs, to the nanometer scale, even permit oxides to perform as solid lubricants. These engineered hard films and solid lubricants offer the advantage of improved performance and lower systems weight in rotating and dynamic components for turbine engines, flight control actuators, and spacecraft mechanisms. Control of fretting and galling, as for example between blade roots and disk slots in turbine engine fan and compressor sections, is also of interest. This program would research and develop innovative coatings, coating compositions, and coating processes for specific applications. Additional high payoff topical areas such as micro-electromechanical systems (MEMS), quasicrystals, adaptive materials, and lubricious oxides could be explored.

PHASE I: Develop a viable coating composition and deposition technique to address the key elements of the research and development areas described above .

PHASE II: Follow-on efforts in Phase II will further develop and optimize the materials, coatings, deposition technique, and/or complete lubrication systems using the approaches established in Phase I.

PHASE III DUAL USE APPLICATIONS: The materials and technology developed under this program would have numerous dual use applications. The commercial aircraft and spacecraft industries will benefit because the technology developed will be directly applicable to their needs for reduced size and weight and increased life and performance. Any industry in which miniaturization is important, or that uses sensors in a critical application may also benefit.

REFERENCES:
1. "Microelectromechanical Systems: Advanced Materials and Fabrication Methods," NMAB-483, National Academy Press, Washington D.C. 1997.
2. "Recent Developments in the Design, Deposition, and Processing of Hard Coatings," J. Vac. Sci. and Tech. A, 16(3) (1998), 1890-1900.
3. "Advanced Solid Lubricant Coatings for Aerospace Systems," AGARD-CP-589, (1996).

KEYWORDS: Coatings, Lubrication, Hard, Friction, Wear, Tribology, MEMS, Solid Lubricant, Bearings, Engines, Fasteners, Space lubrication, Gyros, Slip Rings, Gimbals, Gears

AF00-168 TITLE: Computational Fluid Mechanics Models for the Processing of Superalloys and Aerospace Titanium Alloys

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop Computational Fluid Dynamics (CFD) based process metallurgy models for the production of nickel-based superalloys and aerospace titanium alloys.

DESCRIPTION: The production of clean, fully dense, homogeneous castings of superalloys and aerospace titanium alloys via remelting, refining and solidification is crucial to the production of defect-free components using these materials. Quality problems occurring during these steps can potentially lead to the catastrophic failure of critical components during service[1]. In addition, these steps often constitute a significant portion of the ingot cost to component manufacturers. These operations represent a complex interaction of electromagnetic, heat transfer, fluid flow, mass transfer and chemical reaction processes. Computational Fluid Dynamics (CFD) models of processing operations such as electroslag remelting, vacuum induction melting, vacuum arc remelting, and cold-hearth melting, are needed in order to develop process improvements by computing realistic descriptions of the melting process so that solidification defects, (e.g., macrosegregation in nickel-based alloys, and impurities, such as hard-alpha inclusions in titanium alloys), can be eliminated from the ingot. Reduction or elimination of these defects is anticipated to significantly increase the useful life and reliability of cast-wrought components fabricated from these ingots. Furthermore, process optimization using these models will reduce the cost of the ingots to component manufacturers [2].

PHASE I: This program will focus on the development and subscale validation of a model that demonstrates a fundamental understanding of the processing operation. Proposal should demonstrate reasonable expectation that this proof of principle can be obtained within Phase I. Proposal must incorporate interaction with the primary aerospace metals processing industry.

PHASE II: This program will be structured to develop and refine the model to the point where performance is physically demonstrated on an industrial scale. The model will provide quantitative information of the affects of changes in process parameters to permit an evaluation of the ultimate application potential to meet Air Force needs.

PHASE III DUAL USE APPLICATIONS: The developed approaches would have broad commercial applicability due to the large number of commercial airframes and engines that are fabricated from titanium and nickel-based superalloys.

REFERENCES:
1. J. A. Van Den Avyle, et al., "Reducing Defects in Remelting Processes for High-Performance Alloys," JOM, Vol. 50, No. 3, p. 22.
2. D. K. Melgaard, et al., "Controlling Remelting Processes for Superalloys and Aerospace Ti Alloys," JOM, Vol. 50, No. 3, pp. 13.

KEYWORDS: Computational Fluid Mechanics Models, Processing of Ni-based Superalloys and aerospace Ti alloys, Remelting and solidification

AF00-172 TITLE: In-situ Monitoring of Bondline Integrity for Adhesive Bonded Repairs

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an in situ sensor capable of monitoring the integrity of a bondline in a repair.

DESCRIPTION: As the USAF aircraft fleet continues to age, the major sustainment issues for metallic structures are cracking (due to fatigue) and corrosion. Adhesive-bonded repairs, primarily using composite patch materials, can play an important role in keeping the aging aircraft operationally ready by stopping or retarding fatigue cracks and by restoring strength to structure thinned by corrosion.

Bonded repairs have several distinct advantages over traditional mechanically-fastened repairs. The most significant of which is the transfer of structural loads in an efficient manner without load concentration points created by rivets or bolts. Bonded repairs are also generally more aerodynamic, lighter and less expensive than mechanically fastened repairs. In many cases, bonded repairs are the only economically viable alternative to component replacement. For these reasons, bonded repair technology has been utilized in a number of applications within the USAF (and elsewhere), primarily to repair fatigue cracked structures.

Despite the advantages of bonded repairs, there is still reluctance among many aircraft maintainers to consider them as a permanent structural repair. Although testing can demonstrate that a given repair design (if properly implemented) will resolve a structural problem, there are currently no nondestructive techniques available for determining either the initial bondline quality or the long-term environmental durability of a proposed repair. Because of these limitations in bonded repair, the USAF's engineering authority requires a "fail-safe" approach for repair-bonding on safety-of-flight structure. With this approach, fatigue cracks must be nondestructively inspected using the inspection interval required for an unrepaired defect (i.e., one-half the time necessary for the unrepaired crack to grow to critical length). As these inspections are costly and time consuming, bonded repair is not considered an economically viable option for cracks approaching critical length. If a means or a technique can be found which can monitor the integrity of a bondline in a repair, this may obviate the need for the "fail-safe" approach thus increasing the use of bonded-repair technology and concomitantly increasing operational readiness while decreasing life-cycle cost.

PHASE I: At the completion of this phase, the contractor shall demonstrate the feasibility of an in-situ sensor for monitoring, nondestructively, the integrity of a bondline in a composite patch (both conductive & nonconductive) applied to cracked 2024-T3 aluminum substructure. The sensor should be able to verify that the initial bond is adequate for the repair and/or detect the beginning stages of deterioration in the bondline (initially of adequate quality) due to exposure to the environment.

PHASE II: The contractor shall optimize the in situ sensor for the verification of the initial integrity of the bondline and/or the on-set of bondline degradation due to environmental exposure. The contractor shall demonstrate proof-of-concept on a cracked 2024-T3 aluminum structure repaired with a composite patch bonded to the metal surface following state-of-the-art Air Force procedures for repairing metallic structures. The sensor must be capable of operating under typical aircraft conditions and must not degrade the bondline due to its presence. Data acquisition should be able to be performed with at most, off-the-shelf portable computers.

PHASE III DUAL USE APPLICATIONS: An in situ sensor, with the above mentioned capabilities, would benefit the commercial aircraft industry through increased confidence and subsequent increased use of bonded-repair technology in the maintenance of their aging aircraft

REFERENCES:
1. USAF 1994 Scientific Advisory Broad Summer Study on Life Extension and Capability Enhancement of Existing Air Force Aircraft.
2. Committee on Aging of U.S. Air Force Aircraft, National Research Council, Aging of U.S. Air Force Aircraft, Final Report, National Academy Press, 1997.
3. G.D. Davis and D.K. Shaffer, "Durability of Adhesive Joints," Handbook of Adhesive Technology, K.L. Mittal and A. Pizzi, eds., Marcel Dekker, New York, 1997.

KEYWORDS: Adhesive Bonding, Bondline Integrity, In-situ Monitoring

AF00-173 TITLE: Munition Effectiveness Modeling & Technology Integration Research

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Research new munition component technologies; provide research tools to assess weapon lethality, effectiveness, and utility.

DESCRIPTION: The Assessment and Demonstrations Division is seeking new and innovative ideas in areas that include highly-agile air-to-air missile concepts, air-to-surface munition concepts, such as unitary penetrators, dispensers, submunitions, and projectiles. Technologies under consideration include aerodynamic shaping, advanced structural/material designs, innovative flight controls which can be integrated into future space delivery platforms and unmanned flight vehicles. Other key areas of interest include technologies for time-critical target defeat, bomb-damage identification, and counterweapons of mass destruction. Modeling and simulation tools of interest include high-fidelity physics-based codes for warhead design and penetration analysis, engineering-level tools for weapon/target interaction analysis, and analysis tools for theater-level modeling. New concept and innovative tools are sought for assessments/evaluations, the prediction of functional relationship of fire and/or blast effects on fixed structures, and dispersion of chemical/biological neutralization agents in a high-temperature environment. Commercial dual-use applications for innovative flight vehicle technologies could improve air vehicle performance, as would air foil products, i.e., wind turbines, turbomachinery, etc. Simulations of effects would reduce test costs and provide greater capability for safety officials and insurance underwriters to assess associated hazards. Improved simulation models could benefit commercial building demolition, safety-related assessments, auto safety research, explosives research, mining, drilling, and a wide range of product analysis and evaluation activities.

PHASE I: Determine the scientific or technological merit and feasibility of the innovative concept. Merit and feasibility must be clearly demonstrated during this phase. A technical evaluation of the concept or methodology, a demonstration of proof of principle, or a thorough description of the technical approach, alternative approaches, and risk factors may be appropriate.

PHASE II: Produce well defined deliverable technology demonstrator hardware or simulation/model capability.

PHASE III DUAL USE APPLICATIONS: Each proposal submitted under this general topic should have an associated commercial application stated in the Phase I proposal. Specific application should be determined and planned during Phase I. Phase II proposals should contain a complete commercialization plan. For instance, innovative and low cost munition flight vehicle technologies could be used in the general aviation area. Simulations of munitions effects will reduce test costs and could provide safety officials and insurance underwriters a more accurate tool to assess industrial hazards. Improved simulation models using advanced analytical methodologies would be of value to a wide variety of commercial interests for analysis of operations effectiveness or process performance. General commercial applications include building demolition, mining and drilling operations, safety assessments, auto safety research, explosives research, and a wide range of industrial production analyses.

REFERENCES: http://www.munitions.eglin.af.mil/public/weapflgt.html

KEYWORDS: airframe, flight control, simulation, warhead effects, target penetration modeling, weapon lethality

AF00-174 TITLE: Guidance Research

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop innovative concepts in guidance technologies for air deliverable autonomous munitions

DESCRIPTION: The Advanced Guidance Division of the Air Force Research Laboratory Armament Directorate seeks new and innovative ideas/concepts in areas related to closed loop guidance, navigation and control of autonomous munitions. Topics of primary interest in navigation include very small, low cost inertial measurement units (IMUs), Global Positioning System (GPS) guidance, jam resistant GPS, and transfer alignment. Topics of interest in guidance technology include innovative approaches for integrating the guidance law, target state estimation, and autopilot functions. Topics of interest related to seekers include electrooptical, millimeter-wave, and radio-frequency seeker technology and the components and signal processing systems used in such seekers for autonomous guided munitions. This includes, but is not limited to, sources, detectors, polarization-sensing elements and systems, modulators (both single element and pixelated), pattern recognition and processing systems, and basic material and device development for accomplishing all of these; polarization-sensing elements and systems for studies of the utility of such systems for target characterization and discrimination; developing algorithms for use within autonomous target acquisition (ATA) applications; innovative signal and image processing algorithms used, for example, in synthetic aperture radar (SAR), millimeter-wave (MMW), imaging infrared (IIR), and laser radar (LADAR), needed to autonomously detect and recognize target signatures embedded in backgrounds; operations/functions associated with the ATA process involving noise elimination, detection, segmentation, feature extraction, classification (e.g., truck vs. tank), and identification (e.g., tank A vs. tank B); utilization of Image Algebra in the development of non-proprietary ATA algorithms. Algorithms capable of processing/fusing multi-sensor data are of particular interest. Key research areas include signal and image processing, pattern recognition/classification, image understanding, artificial neural networks, fuzzy logic, superresolution, knowledge- and model-based vision, and data fusion. Of particular interest are cutting edge methods for the design of closed loop guidance and control systems for munitions with numerous MEMS-based sensors and control actuators; both biomimetic and mathematics-based approaches are of interest. Topics of interest related to modeling and evaluation include synthetic target signature generation and scene projection technology for hardware-in-the-loop applications. Concepts must have a good dual use/commercialization potential.

PHASE I: During Phase I, the offeror shall determine the technological or scientific merit and the feasibility of the innovative concept.

PHASE II: The Phase II effort is expected to produce a well defined deliverable product or process.

PHASE III DUAL USE APPLICATIONS: Each proposal submitted under this general topic should have an associated dual-use commercial application of the planned technology. The commercial application should be formulated during Phase I. Phase II will require a complete commercialization plan.

KEYWORDS: LADAR, seekers, jam-resistant GPS, artificial neural networks, guidance of autonomous munitions, algorithms for autonomous target acquisition (ATA), MEMS

AF00-175 TITLE: Ordnance Research

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Identify, develop, and demonstrate commercial components having application to air deliverable munitions.

DESCRIPTION: New and innovative ideas/concepts are needed in the area of air delivered, non-nuclear munitions that have a dual use/commercialization potential. Military products include bombs; penetrators; submunitions; warheads; projectiles; fuzes (including safe and arm devices); explosives/energetic materials; time delayed, polymer binders for shock survivable explosives; solid state inertial components; exterior ballistics; test technology; modeling and simulation resources and techniques; and conventional weapon environmental demilitarization and disposal techniques. Examples of desired research are target detection sensors for deeply buried targets; warhead initiation; self-forging fragment warheads; shaped charges; reactive fragment warheads; hard-target weapon/penetration technology; energetic materials; and low velocity deep earth penetrators. Concepts and methodologies for defeating and neutralizing chemical and biological agents during production, storage, and employment in weapons of mass destruction are desired. Technologies for denying enemy access to weapons of mass destruction are also of interest. Rapid solid-state reaction, combustion and detonation process models for metallic particle systems are of interest. These models should include energy extraction rate, theoretical descriptions of initiation, and kinetics of reaction. Process models shared also account for the physical processes unique to metallic particle energetic systems. Metallic particle sizes of interest are 10-100 nanometers. Models developed should provide insight into the impact of parameterization of particle size, surface area, and heat conduction rate as related to initiation and reaction behavior.

PHASE I: Determine the technological or scientific merit and feasibility of the concept.

PHASE II: Provide a deliverable product or process.

PHASE III DUAL USE APPLICATIONS: A wide range of commercial products could be produced from this research. Typical products include propellants, initiators, gas generators, high strength and high strain rate materials, low cost sensors/detectors, and environmentally compatible recycling processes for energetic materials. Each proposal submitted under this topic should have an associated dual-use commercial application. Phase II will require a complete commercialization plan.

REFERENCES:
1. Progress in Astronautics and Aeronautics: An American Institution, by Martin Summerfield, Volume 21, Academic Press, 1963.
2. Dynamic Aspects of Detonation: Progress in Astronautics and Aeronautics, Volume 153, Book Publication of AIAA.

KEYWORDS: Fuzes, Target Detection, Warheads, Chemical neutralization, Hard Target, Defeat Agent Defeat, Explosives, Safe and arm, Counterproliferation

AF00-176 TITLE: Laser Research for Imaging LADAR Seekers

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Investigate new pulsed lasers for use with focal plane array based imaging LADAR receivers

DESCRIPTION: We are interested in proposals that would pursue research into new pulsed lasers for use with focal plane array (FPA) laser radar (LADAR) architectures. Such lasers are characterized by very high pulse energies and low pulse repetition frequency (PRF). Of particular interest are proposals for lasers with: 10 Hz - 2 kHz PRFs; greater than 10 megawatt peak power; short pulse widths (full-width half-maximum in the neighborhood of 15 nanoseconds); and, lasing at wavelengths in the near to mid-IR atmospheric windows (between 1 - 5 micron output). The Munitions Directorate of the Air Force Research Laboratory has been involved in the research and development of LADAR seeker technologies suitable for air-to-surface munitions. Increasing emphasis is being placed on the use of two dimensional detector arrays to gather single pulse range and intensity imagery. The military and commercial advantages of FPA based LADAR include increased frame rates, wide instantaneous field of view, and elimination of mechanical scanning mechanisms leading to reduced cost and increased maintainability. We are primarily interested in high efficiency, low-cost, compact, heat-sinked, air-cooled or thermo-electrically cooled laser designs. For munition applications, proposals are encouraged to address low-cost thermal management techniques that allow stable lasing for up to 30 minutes before shutdown. In addition, designs good for only a few shots (less than 5) are also of interest.

PHASE I: Phase I of this project should investigate the performance of the proposed laser through detailed modeling and experimentation to demonstrate critical elements of the design. The investigation results would be incorporated into a detailed prototype laser design to be reported at the end of Phase I.

PHASE II: Phase II of this project would involve the construction and delivery of a prototype laser based upon the design investigated in Phase I.

PHASE III DUAL USE APPLICATIONS: A wide range of commercial and military applications exist for new pulsed, high-power IR lasers including medical applications, manufacturing processes, and remote sensing. Commercial LADAR applications include geographic surveying (e.g. tree height, mine surveying, tunnel profiling), industrial monitoring applications (e.g. saw positioning, quality control in steel manufacturing, conveyor belt loading), and collision avoidance sensors for transportation systems. Military LADAR applications include seekers for autonomous munition guidance, sensors for surveillance and reconnaissance, and precision targeting systems.

REFERENCES:
1. J. T. Sackos, R. O. Nellums, S. M. Lebien, C. F. Diegert, J. W. Grantham, T. C. Monson, "A Low-Cost, High-Resolution, Video-Rate Imaging Optical Radar", SPIE Proceedings, Vol. 3380, pp. 327-342, 1998.
2. C. G. Bachman, "Laser Radar Systems and Techniques", Artech House, Boston, 1979.
3. A. Jelalian, "Laser Radar Systems", Artech House, Boston, 1992.
4. Verdeyen, Joseph T., "Laser Electronics, Third Edition", Prentice-Hall, Englewood Cliffs NJ, 1995.
5. Shen, Y. R., "The Principles of Non-Linear Optics", John Wiley & Sons, New York, 1984.

KEYWORDS: Laser, Laser Radar, LADAR, Munitions, Imaging, Laser Ranging

AF00-177 TITLE: Innovative Imaging LADAR Techniques for Munition Seekers

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop new techniques for imaging laser radars

DESCRIPTION: The goal of this topic is to develop laser radar (LADAR) systems that promise a substantial performance improvement and/or cost reduction over current LADAR systems. Low-cost, medium-range (1-4 km) imaging LADARs with range resolutions less than 1 foot are needed. Current long-range LADAR systems rely on one of two basic schemes to find the distance to an object: pulsed direct detection, which measures the photon time-of-flight; or coherent mixing of an intensity modulated output and/or return. New LADAR systems or new techniques for range measurement which result in improved performance and/or reduced cost are solicited. Proposals should address research into a new technique or system architecture expected to result in improved LADAR performance or reduced system cost. System designs that improve performance or reduce cost by implementing new LADAR components other than lasers or optical detectors, e.g. optical scanners, transmit and receive optics, and ranging electronics, are of interest. Of primary interest are techniques to improve signal-to-noise ratio for laser ranging. Techniques that lend themselves to implementation in compact packages are of great interest. Furthermore, techniques that can be used at near-IR to mid-IR wavelengths, allowing more eyesafe operation of LADAR systems, are of great interest. Exploration of multi-spectral LADAR systems is encouraged. Proposed systems and techniques should be capable of implementation in small packages at low cost appropriate for use on autonomously guided airdropped munitions. Proposed schemes should be appropriate for implementation in a laboratory breadboard setup.

PHASE I: Phase I of this project should investigate the performance of the proposed component or technique through modeling, construction, and experimentation with critical elements of the proposed design. The investigation results will be incorporated into a detailed prototype component or LADAR system design to be reported at the end of Phase I.

PHASE II: Phase II of this project would involve the construction and delivery of a prototype component or LADAR system based upon the design developed in Phase I.

PHASE III DUAL USE APPLICATIONS: Advances in LADAR systems and components can result in new system capabilities appropriate for a variety of uses in the military and commercial sectors. Potential commercial uses of LADAR systems include remote sensing applications for environmental monitoring, security systems, geographic surveying (e.g. tree height, mine surveying, tunnel profiling), industrial monitoring applications (e.g. saw positioning, quality control in steel manufacturing, conveyor belt load volumes), and collision avoidance sensors for transportation systems. Potential military uses include munition seekers, airborne reconnaissance and surveillance, and targeting systems. Advances in individual LADAR components may result in a wide variety of commercial and military applications, depending upon the particular component and the nature of the advance. Lasers, optical detectors, and optical scanners have many uses in a wide range of commercial and military systems.

REFERENCES:
1. A. Jelalian, "Laser Radar Systems," Artech House, Boston, 1992.
2. Fox, Clifton S. (ed.), "The Infrared & Electro-Optical Systems Handbook", Volume 6: "Active Electro-Optical Systems", SPIE Optical Engineering Press, Bellingham WA, 1993.

3. J. T. Sackos, R. O. Nellums, S. M. Lebien, C. F. Diegert, J. W. Grantham, and T. C. Monson, "A Low-Cost, High-Resolution, Video-Rate Imaging Optical Radar", SPIE Proceedings, Vol. 3380, pp. 327-342, 1998.
4. C. G. Bachman, "Laser Radar Systems and Techniques", Artech House, Boston, 1979.

KEYWORDS: laser radar, LADAR, laser ranging, direct detection, coherent laser radar, laser applications, optical scanners, optical detectors

AF00-178 TITLE: Shock Mitigating Technology

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop technologies capable of mitigating/attenuating the high shock loads associated with high-speed impact.

DESCRIPTION: Active decision making fuzing, which monitors impact deceleration, has been demonstrated for penetrating warheads with impact velocities up to 2200 ft/sec. Future weapons are postulated to obtain impact velocities up to 6000 ft/sec. The resultant impact loads imposed on the sensitive electronics, accelerometer, and power supply are unknown. Past experience with very high (hundreds of kilo-"g") explosively induced shock loads indicate that some type of shock mitigation must be employed to assure electronic survivability. The shock mitigation techniques employed in the past suffer various shortcomings; i.e., modulus change with temperature, susceptibility to off-axis loads, excessive volume, etc. Designs, fabrication techniques, and material compositions are sought that will provide mechanical filtering and energy absorption while allowing acceleration monitoring of rigid body motion.

PHASE I: Phase I of this program should investigate by analysis and laboratory test, methods and materials applicable for mechanical filtering and/or energy absorption of very short duration, high G shock. Designs can be considered for filtering internal to the fuze package (e.g., circuit boards and/or components) and/or designs for isolating the entire fuze. Typical fuzes range in volume from 9 to 20 cubic inches with weights from one to five pounds. Long duration loads (multiple millisecond) can be in the 30 to 100Kg range with loads greater than 200Kg at higher frequencies.

PHASE II: Phase II of this program will involve the detailed design, fabrication and field test of one or more of the concepts. These tests should include a simulated fuze containing an accelerometer and onboard data recorder. Tests should include high speed impact and/or explosively induced shock.

PHASE III DUAL USE APPLICATIONS: This technology has direct applicability to mitigating shock in high-speed crash survivability and aircraft inflight data recorder survivability.

REFERENCES:
1. Alcone, J. A., "Analysis of the Inverting Tube Energy Absorber", Shock and Vibration Bulleting (1970)
2. Bateman, V. I., R. G. Bell, & N. T. Davie, "Evaluation of Shock Isolation Techniques for a Piezoresistive Accelerometer", Proceedings of the 60th Shock and Vibration Symposium, David Taylor Research Center, Portsmouth, VA (1989)

KEYWORDS: Energy Dissipation, Shock Mitigation, Shock Attenuation, Shock Isolation, Shock Absorbing, Energy Absorbing

AF00-179 TITLE: Recrystallization of Nitramines

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop processes to desensitize RDX and HMX explosives by eliminating microvoids/defects within the crystals.

DESCRIPTION: It is hypothesized that defects in the crystalline structure increase the sensitivity of explosives to shock initiation, since voids provide interaction sites or foci for the deposition of shock energy. Hot spots are created by the shock-induced collapse of voids, and may lead to detonation. AFRL is interested in the development of processes that produce void-free nitramines or reduce the number and/or size of voids in nitramines. Small voids should be more difficult to collapse and would release less energy during the collapse. A lower void concentration should result in less energy deposition per unit volume. The proposed process should be environmentally friendly and cost-effective.

PHASE I: This project should include development of a process to create void-free nitramines, and identification of analytical techniques for measuring the product quality (i.e., void detection and quantification).

PHASE II: Should include the production of nitramines using the processes developed in Phase I and a comparative analysis of void-free nitramines with conventional nitramines, particularly in the measurement of shock sensitivity.

PHASE III DUAL USE APPLICATIONS: The recrystallization processes used by U.S. producers have resulted in nitramines containing a large number of defects; this has led the DoD to consider foreign sources that have the capability to produce defect-free nitramines via proprietary processes. There is a need for a reliable U.S. market source for defect-free nitramines. The commercial application for this product can be found in the mining and demolition industries. Desensitized nitramines could be used to make improved, safer explosive boosters.

REFERENCES: V.J. Krukonis, M.P. Coffey, and P.M. Gallagher, "Exploratory Development on a New Process to Produce Improved RDX Crystals: Supercritical Fluid Anti-Solvent Recrystallization," U.S. Army Ballistic Research Laboratory, January 1989.

KEYWORDS: Recrystallization, Nitramine, Crystal, Defect, Void, Sensitivity, Energetic Materials, Explosives, HMX, RDX

AF00-180 TITLE: <u>High-Frequency Motion Simulation for Hardware-In-The-Loop Testing</u>

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop a high-bandwidth simulator for the deterministic representation of missile airframe dynamics, either as a stand alone test system or as an integral part of a conventional flight motion simulator.

DESCRIPTION: Advanced interceptor systems using reaction jets for divert and attitude control can induce very high frequency dynamic motion. This motion can be in the form of airframe rigid body response or vibration. With increasing accuracy requirements for defensive missiles, the impact of high-frequency sensor line-of-sight errors on missile closed-loop guidance is a critical testing issue. The most advanced flight motion simulators currently available have bandwidths of 60 to 100 Hz. This limited level of response can be shown to introduce artifacts into hardware-in-the-loop simulations in the form of modified control system duty cycle and can lead to questionable test results. Past efforts to develop high bandwidth systems have concentrated on magnetic bearing approaches that have never reached maturity due to control system complexity, cost, and limited performance.

A method is desired to deterministically simulate motion at frequencies ranging from 0 to 1000 Hertz. Stand-alone devices specifically designed to test missile sensor packages, as well as high-frequency inner gimbal approaches to augment traditional flight motion simulators are of interest. In order to achieve the accurate representation of motion at these high frequencies, significant risks must be overcome. Actuators typically have bandwidths much lower than 1000Hz due to structural and fluidic resonance inherent in their design. Actuators with sufficient force and displacement capability to stimulate missile sensor payloads do not generally exist in sizes compatible with the desire for a flight motion simulator inner gimbal. Design of an integrating structure and test article mounting structure with a resonance outside the desired control bandwidth is extremely difficult. The design of a feed-forward control scheme that can account for the effect of resonance within the control bandwidth are difficult to implement and result in a non-robust point design. Dynamic coupling between the simulated degrees of freedom can result in degraded accuracy. Following are the anticipated products of this program.

PHASE I: Define a high frequency motion simulator conceptual design that can accurately represent low amplitude airframe dynamics (0-1000 Hz). A demonstration of key components is desired. Concept control, accuracy, limitations, and system interface requirements should be defined.

PHASE II: Develop and demonstrate a hardware prototype of the simulator concept.

PHASE III DUAL USE APPLICATIONS: This system could be used in characterization of a broad range of sensors in severe dynamic environments. Examples include sensors used in missile guidance systems and closed-loop pointing/tracking systems operating on dynamic platforms. This system would provide a means for the deterministic representation of the severe environments associated with automobiles, aircraft, and launch vehicle operation. Deterministic duplication of launch vehicle environments for closed-loop demonstration of active control systems could potentially result in great cost savings to commercial launch operations.

REFERENCES: J.M.Carter, K.E.Willis, "History of flight motion simulators used for hardware-in-the-loop testing of missile systems," SPIE Proceedings Volume 3368, 13-15 April 1998.

KEYWORDS: flight motion simulator, hardware-in-the-loop, structural vibration.

AF00-181 TITLE: Real Time Bomb Damage Indication (BDI) Sensors and Processing Algorithms

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Identify critical data needs and develop munition borne sensors and associated algorithms for real time bomb damage indication.

DESCRIPTION: The advent of smart munitions enhances the probability of a successful air to ground engagement. However, the real-time, efficient assignment of the minimum amount of ordnance per target remains elusive. The development of munition borne BDI capability is a step toward addressing this deficiency. Technological improvements in areas such as seekers, fuzes, cameras, data fusion and telemetry may provide a means to generate pertinent BDI data and provide it directly to the user or to a real-time BDI algorithm. Wherever possible, we are interested in making maximum use of seeker and fuze sensors which are already part of the munition. However, we are also interested in investigating new low-cost sensors which could be incorporated into the munition and/or deployed off-board by the munition prior to impact. One of the more critical elements of on board munition BDI capability is a raw data processing algorithm that quickly determines the likelihood of a designated target having been destroyed by a given munition, based on sensor information either on board or deployed off board by the munition. Processing must be sufficiently fast to support target reassignment for remaining munitions as part of the strike package. Future concepts envisioned might include autonomous target reassignment by the BDI algorithm. In order to support this, the algorithm should be capable of establishing priorities for retargeting of remaining, in-flight ordnance. The goals of this effort are: 1) to analyze, develop, and test inexpensive sensor concepts 2) determine a prioritized list of sensor data from which a minimum data requirements set can be established, and 3) develop algorithms capable of using this data to provide real-time bomb damage indication.

PHASE I: Phase I should develop a concept for the munition-borne sensor and determine a prioritized list of sensor data from which a minimum data requirements set can be established for algorithm development. The concept should include, but not necessarily be limited to, consideration of the information content for the proposed sensor, cost considerations, how the sensor could be integrated into a munition, and an operations concept for using the munition-borne sensor.

PHASE II: Phase II would involve fabrication and test of the munition-borne sensor. Test concept need not include an all-up round test, but should be sufficient in scope to demonstrate the feasibility and utility of the overall concept. Phase II would also involve the development and validation of the real-time bomb damage indication algorithms. Although the algorithms may initially be deployed off board using telemetry inputs, the long term vision is to enable on board deployment with real time target reassignment for remaining munitions.

PHASE III DUAL USE APPLICATIONS: Potential military applications for this Real Time Bomb Damage Indication (BDI) Sensors and Processing Algorithms include integration with current munitions for enhanced, all-weather BDI capability. In addition, the sensor/algorithm may be applied to advanced seeker concepts for autonomous operations. Real-time battle damage sensors and processing algorithms will have many commercial applications as well. One example is remote sensing of hazardous environments or use on covert operations. The sensor/algorithm can be used to determine change from a known state that can provide real time information and aid in autonomous surveillance.

REFERENCES:

1. Meade, Tony E., BDA, The Road to Victory, Military Intelligence, 1 Apr 98
2. Dickenson, Glenn, Battle Damage Assessment, Military Intelligence, 1 Oct 97
3. McCain, John J., BDA Analysis, Using Automation to Speed the Process, Military Intelligence, 1 Jul 94

KEYWORDS: Battle Damage Assessment, Bomb Damage Indication, Information Processing Algorithms, Algorithms, Munition Sensors, BDA, BDI

AF00-183 TITLE: Powered Submunition Communication Architecture

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop a low cost wireless network technology that will enable multiple munitions to communicate

DESCRIPTION: In the near future, a new class of low cost autonomous miniature munitions will become a vital part of the Air Force weapons inventory. One of the distinguishing features of miniature munitions is their ability to be deployed in large numbers against threats that are either mobile, relocatable or difficult to distinguish by high altitude reconnaissance. In concepts currently being developed, such as Low Cost Autonomous Attack System (LOCAAS) and cruise missile programs such as Tomahawk Land Air Missile (TLAM), Conventional Air Launched Cruise Missile (CALCM), and Joint Air to Surface Standoff Missile (JASSM), the deployed munitions independently search for and attack a target. Clearly the performance of groups of miniature munitions could be dramatically improved by permitting communication and cooperation between the individual munitions. This topic seeks technologies that will enable a wireless communications network to be established between a group of miniature munitions. Technical challenges/design goals include the following. (1) The added cost of the networking hardware must be very low as these munitions must remain inexpensive. (2) The network must be autonomous and self generating; that is, no mission planning involving human interaction should be required before or during the mission to establish a network. (3) The network should be designed to be functional during a midcourse guidance phase where the distance between munitions and their individual orientations may be constantly changing. As such, the network must be robust to channel fades, antenna nulls, near-far effects, and jamming. (4) The network should be capable of supporting up to 100 munitions flying over a broad range of altitudes within a realistic 1000 km2 battlefield. (5) The network must be robust to weather and smoke. (6) Ideally, the data from any single munition should be reachable from any other munition on the battlefield, however, less complete networks should also be explored. (7) The data relayed from each munition is assumed to be digital, consisting of munition and target state information of moderate bandwidth. (8) The link must be covert so that transmissions can not practically be intercepted.

PHASE I: Establish link requirements, survey and trade protocol, modulation, channel assignment, and transmitter and antenna technologies appropriate to requirements.

PHASE II: Design and build prototype transmitter and antenna hardware. Demonstrate design goals.

PHASE III DUAL USE APPLICATIONS: This network technology is obviously relevant to autonomous munitions but is also extendable to broader autonomous battlefield concepts that include manned and unmanned aircraft and satellites. Satisfaction of cost goals strongly recommends commercial networking and transmission technologies be used to the maximum extent. Other applications include autonomous robot manufacturing cells and emergency rescue/response in remote regions with no communications services.

REFERENCES: J. Sharony, "An architecture for mobile radio networks with dynamically changing topology using virtual subnets," Mobile Networks and Applications 1, pages 75-86, (1996).

KEYWORDS: Networks, munitions, wireless, self-generating, adaptive, autonomous, low cost

AF00-184 TITLE: Recycling/Recovery of Energetic Materials and Polymer Binders

TECHNOLOGY AREAS: Chemical/Biological Defense, Weapons

OBJECTIVE: Develop processes to recover nitramines from explosive formulations, particularly plastic-bonded explosives.

DESCRIPTION: The need to recover and recycle energetic materials is driven by two factors--increasingly strict environmental legislation, and reduced life cycle cost for munitions. Traditional methods for disposal of excess or obsolete explosives, such as open burning / open detonation (OB/OD), are being challenged by Federal and state environmental regulatory agencies. And, large price increases for HMX and RDX have occurred in recent years as nitramine production capabilities have transitioned from a government-owned, contractor-operated (GOCO) activity to the private sector. Recovery of nitramines from excess or obsolete explosives would reduce the pollution burden and should be less expensive than the combined costs of new material production and disposal. Environmental impact and life cycle costs may be reduced by: (1) incorporating recovered energetic materials in new formulations, (2) developing new energetic formulations that are easily demilled, or (3) developing cost efficient recovery technologies for existing explosive formulations. It is the third option that is of most interest in this solicitation. The proposed process should be environmentally friendly and cost-effective. Common explosive binder systems of interest include hydroxyterminated polybutadiene (HTPB), acrylate, polypropylene glycol (PPG), or Viton.

PHASE I: Phase I of this project should investigate process development for binder degradation and extraction.

PHASE II: Phase II should investigate process efficiency and product characterization.

PHASE III DUAL USE APPLICATIONS: This technology would have two product lines, energetic materials and polymer feedstocks. The primary customer for the recovered nitramines would be the military with excess going to commercial explosive and rocket propulsion markets. The polymer feedstocks would be sold to the chemical commodity market. Since the process requires the chemical decomposition of the polymer binder, it would have commercial applications in the plastics/polymers industries. For example, the recycling of automotive plastics would reduce landfill expenses and produce commodity chemicals.

REFERENCES: D.F. Hartline and A.F. Spencer, "Separation and Recovery of HMX from Octol", Proceedings of Energetic Materials Conference, pp. 240-244, Fullerton CA, 29 March - 1 April, 1998.

KEYWORDS: Recycling, Recovery, Demilitarization, Plastics Explosives, Energetic Materials, Binder Polymer

AF00-185 TITLE: Miniature Munition Control Actuation

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Miniature Munition Capability

OBJECTIVE: Design, construct, and test an adaptive material control actuator for miniature munitions.

DESCRIPTION: Adaptive materials exhibit the unique characteristic of "remembering" their shape upon application of an electric current, magnetic field, etc. This characteristic has led to their use in industry for a variety of applications. A new application of these materials could be for flight control actuation of munition control surfaces. Conventional electro-mechanical actuators are expensive components of an overall weapon system. Adaptive or smart material actuators could reduce this expense by at least an order of magnitude (from $5000 to $500). Furthermore, with an increased emphasis on miniature or even micro munitions, smart material control actuation could be crucial as they could be much smaller than conventional electro-mechanical actuators. Miniature munitions currently under technology development are on the order of 30 inches long, 19 inches wide and 13 inches high. A penetrator version is 72 inches long and 6 inches in diameter. Current small electro-mechanical actuators are difficult to house in the small volume available in these miniature munitions, and are challenged to provided the actuator performance needed. The focus of this effort is to explore the possibilities of flight control actuation for miniature munitions using smart materials. The goal is a low-cost, highly compact control actuation device. The challenge is the development of a smart material actuator that will provide the control performance and response that is equal to or better than today's conventional actuators.

PHASE I: Phase I of this effort will investigate the range of smart materials that have potential application to flight control. Evaluation of their performance to meet the miniature munition control requirements will be made. Selection of preferred designs will be made for development and test in Phase II.

PHASE II: Phase II will involve the construction of one or more smart material control actuation devices. Integration of the devices into a miniature munitions flight control system will be accomplished. Hardware-in-the-loop testing will be performed to evaluate the performance of the design in realistic flight scenarios.

PHASE III DUAL USE APPLICATIONS: Smart materials are already making their mark in the commercial market. This project can further benefit their application in other commercial areas, such as general aviation, as well as in influencing the current market through the miniaturization of components. In aviation, smart materials can be used not only for control actuation, but also to affect the airflow over wings, and reduce drag or delay stall.

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1. A. Seifert, "Use of Piezoelectric Actuators for Airfoil Separation Control", AIAA Journal, Aug 1998, Vol. 36, Number 8
2. K.B. Lim, "Effective Selection of Piezoceramic Actuators for an Experimental Wing", Journal of Guidance, Control, and Dynamics, Sep 1998, Vol. 2, Number 5
3. J. Ball, "A Comparison of Shaped Piezoelectric Actuators for Divergence Control", Sep 1995, Vol. 5, Number 5

KEYWORDS: Adaptive Materials, Control Actuators, Smart Structures, Flight Control, Shape Memory Alloys, Piezoelectric Material

AF00-186 TITLE: Real Time Kinematic (RTK) Carrier Phase GPS from Start-up to Impact

TECHNOLOGY AREAS: Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Miniature Munition Capability

OBJECTIVE: Develop a tightly coupled GPS/INS RTK approach that can deliver a decimeter accuracy navigation solutions.

DESCRIPTION: Navigation error is a significant contributor to the overall weapon CEP (circular error probable) and may become the dominant contributor as target location error and guidance errors drop below 3 meters and 1 meter, respectively. Current civilian GPS applications, specifically precision farming, use real-time kinematic GPS solutions to generate navigation accuracy measured in centimeters. Unfortunately, these solutions depend on an additional GPS receiver, at a known location, to remove several important obstacles to resolving the integer ambiguity problem. One approach for the use of RTK in tactical munition navigation is to use the onboard weapon GPS/INS and a wide-laning technique to overcome the ambiguity resolution hurdle. However, additional errors in the GPS system complicate the problem. The ephemeris errors of the GPS satellites and ionospheric propagation delays can obscure the integer ambiguity resolution. In theory, these problems may be solvable by propagating the position estimate forward to the next GPS update using the inertial navigation system (INS) inputs to the Kalman filter and then estimating the pseudorange errors based on that a priori knowledge of position. The practicality of this approach remains to be demonstrated and is expected to be accomplished in the following manner.

PHASE I: Develop a system design that eliminates the need for a separate GPS receiver for carrier cycle integer ambiguity resolution by making use of the onboard inertial information. Demonstrate the resulting system design via simulation.

PHASE II: Design a breadboard system that demonstrates the basic technique via testing on the Mobile Test Vehicle.

PHASE III DUAL USE APPLICATIONS: High accuracy remote surveying, automated precision unmanned vehicles, cooperative robot manufacturing cells.

KEYWORDS: Kinematic GPS, Navigation, Inertial Navigation, Munition

AF00-187 TITLE: Complementary Ladar/Millimeter-Wave Seeker (CLAMS)

TECHNOLOGY AREAS: Weapons

OBJECTIVE: To determine whether a munition-size package of complementary MMW and LADAR sensors is feasible

DESCRIPTION: Advances in the development of Solid state LADAR seekers and their associated 3-D autonomous target acquisition algorithms coupled with advances in GPS/Inertial guidance systems are bringing about the long sought era of very smart if not brilliant weapons. These advances are being followed almost certainly by countermeasures. It has long been acknowledged that the best counter-counter measure is to complement a given sensor technology with another, one whose operational characteristics are widely separated from the first. This usually takes the form of operation in a different portion of the frequency spectrum. Although a large variety of possible combinations of two or more sensors and means to combine them exists, this investigation should focus on a millimeter-wave imager as the complementary sensor. Millimeter-wave (MMW) offers adverse-weather and poor-visibility conditions wide-field-of-view cueing for the LADAR. If the MMW sensor is passive, it can also provide a degree of covertness for the smart munition. Finally, under the worst of conditions, it offers the potential to operate in a stand-alone attack mode. The purpose of this effort is to determine whether a munition size package of MMW and LADAR sensors is feasible, whether an active or passive MMW complement is better, whether MMW imaging is a necessity, and whether such a package is affordable.

PHASE I: Investigate the potential for hybrids of LADAR and active MMW or LADAR and passive MMW sensors to improve the operational limitations of stand-alone LADAR seekers. Mission scenarios are those that can be viewed on the AFRL/MN Web site at <http://www.mn.afrl.af.mil>. Various sensor configurations such as shared or common aperture, conformal antenna, etc., should be explored. Modes of operation such as Simultaneous, Either-Or, Handoff, etc., and associated algorithmic complexity should be evaluated. A preliminary cost estimate for the various configurations should also be provided. Viable approaches should be determined and risks associated with each identified. A preferred approach should be selected and a preliminary design prepared.

PHASE II: Develop a detailed design, prove this design employing Government furnished sensors in a near co-boresighted configuration and through realistic simulations of approved operational scenarios. Produce a detailed estimate for unit production cost for the integrated, detailed, hybrid-sensor design.

PHASE III DUAL USE APPLICATIONS: A compact, light weight, affordable hybrid LADAR/MMW sensor has potential applications for light-aircraft adverse weather landing guidance, for base, post, and yard surveillance and intrusion detection, for lake, river, canal, inland waterway navigation, and a myriad of like applications. The commercial potential for such a hybrid sensor would appear to be enormous.

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1. Smith R.M., et al., "Passive Millimeter Wave Imaging," IRIS Passive Sensors Symposium, Albuquerque, NM, March 1994.
2. Browne, Jack, "MM Waves Aid Commercial Applications," Microwaves & RF, Vol. 31, No. 7, pp 113-1116, July 1992
3. "Ten Kilometer Imaging Solid State LADAR Demonstration," Apr-95, IRIS Active Optical Systems

KEYWORDS: Smart Munitions, Seekers, Millimeter-wave, Active MMW Seeker, Passive MMW Seeker, solid-state LADAR, Hybrid Seeker, Dual Mode Seeker

AF00-188 TITLE: Optical Detector Research for Imaging LADAR Seekers

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop room temperature infrared optical detectors for use in laser radar systems

DESCRIPTION: This topic pursues the development of low-cost, near to mid-IR optical detectors (peak spectral response between 1 - 5 microns) for use in laser radar systems. We are ultimately interested in low-cost, scalable, two-dimensional detector array concepts. Of interest are projects that explore either new materials for room temperature operation, or, new manufacturing techniques for existing materials that might result in fewer defects or lower cost. Current room temperature mid-IR detectors are high-cost, high-defect items (relative to Silicon detectors). Both fast response (nanosecond rise time) array designs and implementations of integrating, CCD-like arrays (with frame readout rates greater than 10 Hz) are of interest. Integrating designs that allow fast (MHz) gain modulation are highly desirable. Array proposals of at least 32 x 32 elements are of interest, but architecture concepts that can be scaled (e.g. to 512 x 512) in a cost-effective manner are desired. The Munitions Directorate of the Air Force Research Laboratory is placing increasing emphasis on the use of two dimensional detector arrays to gather single pulse range and intensity imagery. The military and commercial advantages of FPA based LADAR include increased frame rates, wide instantaneous field of view, and elimination of mechanical scanning mechanisms leading to reduced cost and increased maintainability. Detectors that can be thermo-electrically cooled to improve performance are of interest. Proposals should include at least a conceptual implementation of their detector in an imaging LADAR system. Such systems should be capable of range resolution on the order of 1 foot or less.

PHASE I: Phase I of this project should investigate the performance of the proposed detector through detailed modeling and experimentation to demonstrate critical elements of the design. The investigation results would be incorporated into a detailed prototype detector design to be reported at the end of Phase I.

PHASE II: Phase II of this project would involve the construction and delivery of a prototype detector based upon the design investigated in Phase I.

PHASE III DUAL USE APPLICATIONS: A wide range of commercial and military applications exist for new room-temperature near to mid-IR optical detectors including medical applications, manufacturing processes, and remote sensing. Commercial LADAR applications include geographic surveying (e.g. tree height, mine surveying, tunnel profiling), industrial monitoring applications (e.g. saw positioning, quality control in steel manufacturing, conveyor belt loading), and collision avoidance sensors for transportation systems. Military LADAR applications include seekers for autonomous munition guidance, sensors for surveillance and reconnaissance, and precision targeting systems.

REFERENCES:

1. J. T. Sackos, R. O. Nellums, S. M. Lebien, C. F. Diegert, J. W. Grantham, T. C. Monson, "A Low-Cost, High-Resolution, Video-Rate Imaging Optical Radar," SPIE Proceedings, Vol. 3380, pp. 327-342, 1998.
2. C. G. Bachman, "Laser Radar Systems and Techniques," Artech House, Boston, 1979.
3. A. Jelalian, "Laser Radar Systems," Artech House, Boston, 1992.
4. W. L. Wolfe, G. J. Zissis, "The Infrared Handbook," Environmental Research Institute of Michigan, Ann Arbor MI, 1989.

KEYWORDS: Optical detectors, infrared, electro-optic devices, focal plane array, laser, laser Radar, LADAR

AF00-189 TITLE: Doped Nanoparticulate Silicon Fabrication and Blending

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop new semiconductor devices based upon doped silicon nanoparticles uniformly dispersed in a polymer matrix

DESCRIPTION: Ball milling of bulk crystalline semiconductor grade silicon is tedious and inefficient, generally resulting in submicron particles of approximately 300 to 500 nm average size. This is an order of magnitude too large for synthesis of useful layer structures required for optoelectronic device fabrication. Development of semiconductor devices based upon nanoparticulate silicon would be aided by a more direct means of making considerably smaller (50 to 100nm) particles of silicon of fixed doping concentration ("p-type" boron or "n-type" phosphorus doping at a controlled level within the range of 10 to 1000 ppm). In addition, techniques must be developed for blending and consolidating the tiny silicon particles with polymers for fabrication of thin film devices. Passive infrared (from 8 to 14 micron wavelength) detectors for military and commercial applications would be the primary result of this work. Military air target fuzing would be greatly enhanced by this type of passive proximity detection, especially with regard to all-weather capability.

PHASE I: Phase I of this effort would involve demonstration of a viable method for fabrication of doped silicon nanoparticles. Techniques for surface stabilization and consolidation of the silicon nanoparticles with adequate electronic coupling must also be demonstrated using a polymer matrix that facilitates thin film processing and assessment of semiconductor behavior.

PHASE II: The Phase II effort would focus upon development of passive infrared detectors and conformal detector arrays of potential use for all-weather air target proximity fuzing.

PHASE III DUAL USE APPLICATIONS: DUAL USE COMMERCIALIZATION POTENTIAL: There are numerous applications for infrared detectors, including telecommunications, heat detection for security systems, night vision or surveillance systems, fog vision systems, thermometers, pyrometers, temperature controllers, cameras for nondestructive evaluation or process control/monitoring systems, and remote control systems.

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1. T. F. Tadros, Advances in Colloid and Interface Science 46(1993)1.
2. Nanotechnology: Products for the Material World, BMDO Office of Technology Applications, National Technology Transfer Center, Article #1402.
3. DTIC REFERENCES: ADA283314 – Synthesis and Consolidation of Nanoparticles

KEYWORDS: nanoparticle, nanocomposite, doped silicon, polymer dispersion, proximity fuze, passive infrared detector

AF00-190 TITLE: Real Time Failure Prediction Sensor

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Determine the feasibility of failure sensing during impact with reactive decision making.

DESCRIPTION: On-target effectiveness of penetrating weapons has been improved by utilizing accelerometers to monitor axial rigid body position within the target and detonate the warhead at the optimum point. However, in a number of cases, the penetrator will fail due to ricochet, tail slap, or high bending loads. In the majority of cases high angular rates (hundreds of radians/sec) and/or accelerations (hundreds of kiloradians/sec2) are present. In the past, case failure sensors have been implemented using break wires, but these techniques are not applicable for concrete penetrating weapons due to case yielding (i.e., bending, ovaling, etc.,) without failure.

PHASE I: Phase I of this program will include analysis of the proposed sensor(s) performance during penetrator impact and penetration. Laboratory test shall be conducted to demonstrate the sensor's applicable performance characteristics. The effort will also result in a Phase II test plan to demonstrate the sensor (and any associated circuitry) effectiveness during target penetration.

PHASE II: This phase will include the detailed design, fabrication and field test of the proposed sensing mechanism. It is envisioned that these tests would include concrete impacts up to 1000 ft/sec in a nominally 3.3 inch diameter projectile 24 inch in length. These tests can be conducted by the government with contractor-supplied penetrator and instrumentation.

PHASE III DUAL USE APPLICATIONS: The sensors and associated discriminating algorithms may be applied to automobile crash dummies to determine rotational rates or other injury causing environments. Sensor suites could be used to deploy multiple airbags from different directions depending upon the area of the vehicle impacted. Other applications include sensing/decision making for automated/robotic manufacturing, deep drilling operations and remote machine processes.

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3. Schwer, L.E. and J. Day, "A Computational Technique for Predicting Ricochet of Perforation of Steel Plates," Proceedings of the International Conference on Computational Engineering Science, Vol. 1, Chapter 6, Atlanta, Georgia, April 1988.

KEYWORDS: Bomb Impact, High Rotational Rate, Bomb Case Failure, Penetration Prediction, Ricochet, Concrete Penetration

AF00-195 TITLE: Aero Propulsion and Power Technology

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Explore innovative approaches for turbine and advanced propulsion systems and electrical power concepts for manned and unmanned applications.

DESCRIPTION: The Propulsion Directorate aggressively pursues major performance advances in all components of gas turbine engines under the Integrated High Performance Turbine Engine Technology (IHPTET) initiative. Technologies derived under this initiative have resulted in higher thrust to weight rations and improved efficiencies. The focus of this topic is to consider those aspects in the design of gas turbine engines and other prime propulsion concepts, electrical power systems and energy storage devices that could support manned and unmanned mission requirements. The innovative approaches may include, but are not limited to, the use of microelectromechanical (MEMS) and mesoscopic machine technology. Emphasis would be on affordability, reliability, and lightweight designs without compromising range and payload. New analysis techniques, innovative designs, hybrid propulsion systems and electrical power concepts to support manned and unmanned air vehicle (UAV) applications (especially long duration flights) are solicited.

PHASE I: Define the proposed concept and predict the performance of the proposed design. Explore the feasibility of a new concept or concepts, through analysis and/or small scale testing to demonstrate the merits of a flexible modular design that can meet various mission applications.

PHASE II: Provide detailed analytical derivations and prototypical device or hardware demonstrations.

PHASE III DUAL USE APPLICATIONS: UAVs can present an effective alternative for some civil sector missions, for example, meteorological data gathering, atmospheric sampling and surveillance. Forest Service mapping and fire spotting, agriculture and ranching support, coastal and border patrol and surveillance, and storm tracking and disaster assessment are some specific areas that may be exploited with UAVs.

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1. "FY97 Aero Propulsion & Power Technology Area", Headquarters Air Force Material Command, Directorate of Science & Technology, Wright-Patterson AFB OH, World Wide Web address: stbbs.wpafb.afmil/STBBS/info/taps/fy96/propulsn/final.doc
2. Air Force Research Laboratory Propulsion Directorate website address: http://www.afrl.af.mil/pr.html

KEYWORDS: High speed propulsion, turbine engines, scramjets, fuels, lubrication, power systems, MEMS, mesoscopic machines

AF00-196 TITLE: Advanced Life Determination of Turbine Engine Components

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Accurately determine individual gas turbine engine component life, real time, at any given time in service, operational role or environment.

DESCRIPTION: A good understanding of local operational environment for an engine component can greatly enhance our ability to accurately predict engine life. The solutions sought in this project must be practical to implement in an operational aircraft, and not just in an engine test cell environment.

Turbine engines are designed using the flight system's mission profile, a profile that often resembles 'worse case'. It is assumed that all aircraft will basically experience the same mission. History shows, however, that each aircraft is flown differently from the original mission, as well as from each other. Hence, the engine does not see exactly the same environment that it was predicted to see and useful life is often lost. In a fleet of engines, a component from one engine will experience different mechanical and thermal loads than that from another engine. This variability in cyclic loading leads to different levels of component life being used. Unique and innovative approaches are sought for obtaining a more accurate assessment of life used and remaining component life, for metal and/or composite components. Some example techniques that could apply include: (1) using advanced analysis methods that would provide improved accuracy in their life predictions, such as taking into account environmental effects in the analysis; (2) measuring the physical state of the component that may indicate the life used and life remaining, such as measuring its residual stress to determine how the diminishing effect will impact life; and/or (3) monitoring and modeling the environment that the component is being subjected to. Specific technical examples include taking into account environmental and operational effects in the component life prediction and measuring residual stress to determine how its diminishing effect will impact the life. Other innovative approaches are encouraged.

PHASE I: Identify an approach that will provide a capability for evaluating the life of a turbine engine component. Show feasibility and applicability of the approach, for a turbine engine environment, by performing preliminary investigations and proof-of-concept demonstrations.

PHASE II: Further develop the approach identified in Phase I to a prototype level. Validate/demonstrate the approach using a spin pit or rig test of a turbine engine component. Demonstrate the practicality of using the approach on an operational aircraft. Develop a technology transition path for implementing the approach.

PHASE III DUAL USE APPLICATIONS: An improved capability of determining component life will be useful for all military engines, as well as commercial flight engines. It could also be applied to land-based turbine engines that are used for generating power and transferring fluids in the water, fuel and oil industries.

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2. "Multiaxial Life Prediction System for Turbine Components," ASME Journal of Engineering for Gas Turbines and Power, 109,1; January 1987, pp. 107-114.
3. "Engine Health Monitoring System for Advanced Diagnostic Monitoring for Gas Turbine Engines," Roemer, M.J., Report Number: AD-A359658 AFRL-PR-WP-TR-1998-2120, February 1998, ADA 359-658.
4. "The Future Direction and Development of Engine Health Monitoring within the United States Air Force," Green, Andrew J., 1998 Technology Showcase JOAP International Condition Monitoring Conference, AD-A349 389, 24 April 1998.
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KEYWORDS: Turbine Engine Component, Structures, Component Life Prediction Analysis, Component Life Determination, Residual Stress Measurement, Environmental Effects on Component Life

AF00-197 TITLE: Process for Applying Fretting/Galling Material Resistant Film on Engine Compressor Disks

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: To develop antifretting and antigalling protective coatings and to develop the process for applying the coatings to the blade and disk interfacial surfaces.

DESCRIPTION: The fatigue life of the turbine engine compressor can be significantly reduced due to the occurrence of fretting or galling. This reduction in fatigue strength leads to shorter inspection intervals, to infant mortality part removal, and in some cases, to part and engine failure. Furthermore this type of fatigue reduction decreases aircraft reliability, decreases fleet readiness and increases operational expense. According to recent estimates, about one in six of all in-service mishaps can be linked to fretting, galling and associated mechanisms prevalent at the blade-disk interface. The phenomenon of fretting and galling, primarily, depends on the interaction of the contacting bodies. Protective coatings are currently in use but they need to be improved in order to reduce the operational costs associated with the blade-disk interface. Therefore, improved coatings are needed to reduce the material interaction of the mating surfaces and the associated operational expense.

PHASE I: Develop innovative coatings for Titanium based alloy to reduce the occurrence of fretting and galling. Perform adequate proof of concept that the coating significantly enhances the fretting and galling resistance.

PHASE II: The process for applying the coating to the blade-disk interfacial surfaces should be optimized in this effort. The end product should be a prototype system that can be used to coat the blade-disk interfacial surfaces.

PHASE III DUAL USE APPLICATIONS: The techniques developed to enhance fretting and galling resistance will be useful for a wide variety of commercial applications to include, but not limited to commercial aircraft engines, land-based turbine engines for electrical power generation and the automotive industry.

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1. Waterhouse, R.B. and Lindley, T.C., Fretting Fatigue, ESIS Publication No. 18, European Structural Integrity Society, Mechanical Engineering Publications Limited, London, 1984.
2. Calcaterra, J.R. and Mall, S., "Investigation of Small and Large Stress Amplitude Interaction on the Fretting Fatigue Behavior of Ti-6Al-4V, Proc. of 3rd National Turbine Engine High Cycle Fatigue Conference," HCF 98, San Antonio, Feb 2-5, 1998.

KEYWORDS: Fretting Fatigue, Galling, Low Cycle Fatigue, High Cycle Fatigue

AF00-198 TITLE: Data Fusion for Gas Turbine Engine Diagnostics and Predictive Diagnostics

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Joint Strike Fighter

OBJECTIVE: To integrate engine health monitoring data and create a total systems approach for engine diagnostics and prognostics.

DESCRIPTION: The key to producing more confident, real-time, on-wing diagnoses resides in the processing and validation of multisensory data. The abundance of carefully chosen sensory data on future aircraft engines will not maximize engine health awareness unless the data is processed and fused in the most optimal and meaningful way.
Current aeroengines give data from a range of sensors that, when processed, provide separate information on engine health; these may be vibration, oil condition, and typical engine-sensed parameters like temperature, pressure, fuel flow and pilot's power lever angle. This data is usually processed and read manually on landing but is seldom cross-referenced or trended to provide good engine health information. For example, a vibration signal may have been forewarned many hours earlier by an increase in oil debris, gas-path temperature and fuel flow.

This topic seeks to fuse data from engine and ac sensors, and allow for the addition of state-of-the art sensors, to provide best information on the health and performance of a gas turbine engine. This will validate the data sensed by one sensor, from data provided by one or several others, and increase the diagnostic and prognostic capabilities of health monitoring systems. This will provide a highly accurate tool for engine and fleet management, and provide a key for the Intelligent Engine in the VATE program.

Advance real-time sensory systems, such as non-contact tip vibration monitoring systems, on-line oil monitoring, inductive debris detection, and crack detection systems, need a Data Fusion Center to autonomously process and fuse the sensory data so that diagnostic assessments can be performed. The statistically confident engine fault diagnoses generated in the Data Fusion Center, coupled with component and engine fleet histories, and a priori engineering analyses, make for the accurate predictive diagnoses of impending faults. This is critical to enable the best Air Force fleet management decisions to be made to enhance safety and reliability, and ensure the optimum use of engines and airframes.

PHASE I: Design and develop innovative and effective concept(s) to fuse and integrate modern engine sensory data from a range of sensors and, in so doing, demonstrate that more effective diagnostic and predictive diagnostic information can be obtained. Perform adequate proof-of-concept demonstrations to show confidence for the success of a Phase II program.

PHASE II: Based on the initial designs and proof-of-concept demonstrations from Phase-I. Develop a full-scale data fusion system, with an open architecture, that allows for the addition of state-of-the-art sensing technologies to provide complete engine health management. Build a prototype system and demonstrate it on a demonstrator engine.

PHASE III DUAL USE APPLICATIONS: By optimizing the retrieval and processing of sensory data, data fusion technology has potential in virtually any real-time control or monitoring systems. It is the focus for Prognostic Health Management in JSF and will be a key technology in achieving the VATE goal to reduce maintenance costs by 67%. Also, it has the potential to increase time on wing and operational effectiveness, and reduce time to diagnose faults. The Data Fusion Center concept could also play a role in improving the performance of military surveillance or intelligence equipment where fast and confident situational diagnosis is vital. Once developed, the system described above would be highly sought by the commercial airlines to drive down support costs, while improving safety and heightening their competitive edge. Beyond the arena of gas turbines, robotic control systems, which rely on quick response and autonomous, decisive initiatives, would benefit greatly from commands generated from optimally useful combinations of multisensory information.

REFERENCES: Society of Automotive Engineers E32 Conference on Engine Condition Monitoring.

KEYWORDS: Data Fusion, Prognostics, Diagnostics, Predictive Diagnostics, Gas Turbine Engine Health Monitoring and Health Management

AF00-199 TITLE: Advanced Temperature and Composition Sample Instrumentation for High Fuel-Air Ratio Combustor Applications

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Joint Strike Fighter

OBJECTIVE: Development of innovative non-or minimally intrusive sensor designs for high performance aircraft gas turbine engine combustors.

DESCRIPTION: As high performance calls for higher combustor inlet and exit temperatures, advanced environmental and temperature sensors are needed to support the next generation of high temperature, military and commercial, low fuel consumption gas turbine engines. In order to optimize the combustion process, aerodynamic design, and cooling technology to achieve these goals, real-time accurate temperature sensing and chemical sensing of the combustor/turbine flowpath are required. Particular emphasis will be placed on temperature and chemical species sensing devices that can accurately survey gas-path flows at the high temperatures (up to 40000F) and high pressures (20 to 40 atm) of advanced gas turbine hot sections while tolerating increased temperatures and pressures of cooling flows. This technology will enhance current computational capabilities by increasing the extent of their experimental validation and will be an enabler technology for exceptional diagnostic capability requirements associated with the use of active combustion control.

PHASE I: Phase I will require the identification of innovative prototype sensor design concepts and a feasibility analysis for their design, fabrication and practical implementation.

PHASE II: Phase II work will be focused towards demonstrating design concepts. These design concepts shall be consistent with the practical features and environmental limitations of gas turbine engines. The information gained under Phase I will be used to design and fabricate a subscale test article, which exhibits the anticipated conditions in a modern gas turbine engine. A test plan shall be prepared identifying the testing and development work required to validate the concept identified. Testing shall demonstrate both the capability of the test article and the effectiveness of the proposed instrumentation system.

PHASE III DUAL USE APPLICATIONS: All commercial gas turbine engines require combustion systems. Demonstration of advanced temperature and environmental instrumentation concepts will provide great benefits in improving efficiency and performance by cooling and weight reduction, and extending hot section life, therefore, directly benefiting commercial gas turbine engines.

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2. "Advanced Instrumentation for Aero Engine Components: Conference Proceedings of the Propulsion and Energetics Panel Symposium," May 19-23, 1986, pp. 14-1-14-12.
3. "Gas Turbine Combustor Exit Temperature Measurement," Sullivan, John D.; Kendall, John E.; TR-91-11, AEDC, Final Report AUG 91.

KEYWORDS: Gas turbine combustor instrumentation, data reduction, gas path temperature sensor, high temperature measurements, test and evaluation

AF00-200 TITLE: Stochastic Modeling of Gas Turbine Engine Blade High Cycle Fatigue (HCF) Capacity

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Engine System Program Office (SPO)

OBJECTIVE: The objective of this task is to develop a stochastic model of the high cycle fatigue (HCF) "capacity" in Titanium gas turbine engine blades, and to develop the supporting material database.

DESCRIPTION: In developing a stochastic model to predict probability of HCF failure for a gas turbine engine blade, it is necessary to compare stochastic models of mission profile, aeromechanical loading, blade modal analysis, and material capability (other models may also be required). The primary factors that influence material capability include: fretting, foreign object damage (FOD), and the interaction between HCF and low cycle fatigue (LCF). The purpose of this research is to develop experimental and analytical approaches for probabilistically assessing the HCF capacity of Titanium gas turbine engine blades. It is essential that the new model is capable of including an initial damage state due to material defects and FOD. An effort is underway with the major US turbine engine manufacturers to develop a probabilistic framework for the prediction of gas turbine engine blade HCF life. It is envisioned that a stochastic model of blade HCF capacity could operate as a stand-alone code, or as a part of an overall HCF life prediction code.

PHASE I: Develop an approach for stochastic modeling of HCF capacity in Titanium gas turbine engine blades. Identify requirements for blade and specimen data necessary to support development and validation of the stochastic model.

PHASE II: Conduct blade testing to evaluate the influence of various controlling parameters on fatigue crack initiation/growth. Develop a stochastic model of the HCF capacity in Titanium gas turbine engine blades. Validate the model with at least two specific test cases.

PHASE III DUAL USE APPLICATIONS: Turbine engine HCF is a significant cause of blade failure in both military and commercial applications. HCF is of special concern in single engine fighter aircraft, resulting in significant losses. A probabilistic assessment of HCF capacity will aid designers in solving this critical problem.

REFERENCES: AFRL-PR-WP-TM-1998-2148, High Cycle Fatigue (HCF) Science and Technology Program—1998 Annual Report, Multiple Authors, January 1999, Section 2.0 – Materials Damage Tolerance Research, Section 4.0 – Component Analysis.

KEYWORDS: Gas Turbine Engines, High Cycle Fatigue, Foreign Object Damage, Fretting, Probabilistic, Stochastic Modeling

AF00-201 TITLE: Innovative Damping Concepts for Extreme Environments Capacity

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop damping concepts for structures subjected to high temperatures, centrifugal loading, and oxidizing environments.

DESCRIPTION: Although there are a number of relatively mature technologies associated with damping nonrotating structural components at temperatures below 500 degrees Fahrenheit, there is a critical need for damping concepts appropriate for static structure and rotating component applications that are subjected to high temperature vibratory loads and other extreme conditions. Existing polymeric viscoelastic damping materials are only effective over a narrow temperature range, and become susceptible to creep or material decomposition when exposed to elevated temperatures and/or when subjected to large steady state loads. For extreme environments, damping concepts using polymeric materials must include an innovative application scheme to address these problems. Alternative approaches to the use of polymeric viscoelastic materials may be identified for the damping concept, and damping treatments that are relatively insensitive to temperature would be very useful in many applications. An analytical model that can be used in the design of the damping treatment is required so that the damping design will not be based on an empirical "trial and error" approach. The damping treatments may be designed for specific extreme environment applications of interest to the Air Force, including engine nozzles, hypersonic vehicle structures or exhaust washed structures, and rotating components within air vehicle engines. One application of special interest is the damping of aircraft turbine engine blades, which supports research to reduce the effects of high cycle fatigue (HCF) in aircraft engines.

PHASE I: Demonstrate the feasibility of the damping concept, including its compatibility with elevated temperatures and sustained steady state loads. The feasibility study should include analytical studies of the concept that predict the level of damping to be seen in the component and an experimental evaluation of the effectiveness of the damping treatment in the defined environment.

PHASE II: The damping treatment must be fabricated and then tested to demonstrate its effectiveness in the application considered. The testing must effectively demonstrate the damper's durability in the environment for which it is designed. The Phase II program must also demonstrate that the treatment can provide effective damping without adding excessive weight, cost, or maintenance requirements and that the damping effectiveness can be accurately predicted in a structure.

PHASE III DUAL USE APPLICATIONS: There are several commercial markets for damping technologies that are capable of withstanding elevated temperatures and large steady state loading, including vibration isolation devices for heavy machinery. Damping concepts can also be used in the commercial aircraft and automotive industries to reduce undesirable vibration in vehicular structures and engines. Added damping reduces resonant response, which reduces requirements for maintenance and enables the development of lighter weight, higher performance turbine engines. Large turbines used in the power generation industry, which have realized benefits from lower temperature damping concepts, could also benefit from high temperature damping concepts.

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1. Jones, D.I.G., Lewis, T., and Michael, C., "Partial Coverage Air Film Damping of Cantilever Plates," 1997, J. Sound and Vibration 208 (5), pp 869-875.

KEYWORDS: Turbine Engine Components, Passive Damping, High Cycle Fatigue, High Temperature, Durability

AF00-202 TITLE: Smart Fuels for the Future Air and Space Force

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop "Smart" fuel additives that enhance the operation, performance, component durability and environmental compliance of current and advanced propulsion cycles as a function of the flight envelope.

DESCRIPTION: The Air Force Research Laboratory (AFRL) is developing future propulsion concepts that will enable operation of advanced weapon systems in both the atmosphere and space. In addition, AFRL is exploring ways of enhancing the performance, reliability, durability, environmental compliance and affordability of advanced weapons systems as well as legacy systems. The United States military consumes between 4 and 5 billion gallons of jet fuel per year which is one of the most expensive components of the operational and support budget of weapon systems. Logistically, a common kerosene base fuel used by both the military and commercial fleet is attractive for global operations, however, military aircraft fly a more demanding mission and require fuels that are better than the standard commercial fuels. The number two largest footprint item for the Air Expeditionary Force (AEF) is fuel. In addition to the weight and bulk of the product itself, equipment needed to clean, dispense, additize and test the fuel adds to the number of cargo aircraft loads needed to support a contingency. Increased utilization of commercial fuels enhanced at location with a new generation of "smart" additives could achieve deployment objectives and enhance the operation of our weapon systems. Development of these additives could lead to the simultaneous deployment of convention and trans-atmospheric vehicles from a single location anywhere in the world. The commercial industry has a long history of watching the military make the significant improvements in jet fuel technology and implementing them after the technical risk has been reduced to near zero. Environmental legislation and corporate earnings requirements are forcing the commercial industry re-think there requirements for enhanced fuels and may readily partner in the development and demonstration of these additives.

Conventional jets fuels such as JP-8 have been optimized based on performance, cost and availability and contain additives such as lubricity additives to extend pump life, antistatic additive to reduce static discharge, and fuel system icing inhibitor (FSII) to prevent water in fuel from freezing. Recently, the Air Force began fielding a new additive "+100" that increases the thermal stability of fuel by 100°F and has been demonstrated to reduce fuel system maintenance in the field. It is currently being used at 59 locations in over 2500 aircraft. As part of the research effort, it was identified that fuel additives technology could be developed that would significantly enhance propulsion system operations as a function of the flight envelope. "Smart" fuel additives will feature components which can be selectively "controlled" by temperature or shear, to react in the fuel system or combustor to enhance a specific property. For example, signatures could be reduced by reducing the amount of particulates generated by the combustor, altitude limits could be increased with additives that improve low temperature behavior, cold starts and high altitude relight limits could be improved with ignition enhancers and rocket performance could be enhanced with high energy additives. "Smart" fuel additives can potentially increase aircraft, helicopter, and unmanned air vehicle (UAV) system reliability, increase or extend aircraft service life, reduce time-phase interval inspections, and reduce vulnerability. Furthermore, the smart fuel concept can potentially increase infrastructure systems' reliability, maintainability and supportability, and increase aircraft ground support, supply, transportation, and test equipment interoperability, reliability and maintainability.

Initial goals for "Smart" fuel additives include a 50% reduction in particulates produced by turbine engines, 20 degree F reduction in fuel freezepoint (from –53°F), ignition enhancers that increase altitude relight envelop by 10,000 feet. In addition, additive mixtures ("cocktails") need to be developed that reduce the number of additives that need to be injected at the forward operating locations and would reduce the volume of additive needed by 50%. Pure additives may be difficult to mix and may react adversely when mixed in a concentrated state, thus additive cocktails must contain blending agents to minimize incompatibility. The desired additives should have all the functionality of the current (FSII, lubricity enhancer and static dissipater additive) as well as the new "smart" additives. Innovative, light weight, small physical size injection systems and advanced in-situ diagnostic techniques need to be developed to make it easy to deploy the additive cocktails. Goals for the injection equipment are that it fit in a suitcase size space (or smaller) and be easily transported and operated by a single person. Goals for the diagnostics include identification of basic fuel properties and quality and measurement capability for the additives in a small easily to use package.

This program requires the development innovative fuel additives (or an additive "cocktail" package) that react in the fuel system or the combustor to selectively enhance a specific property at discrete operational points. The desired additives should have all the functionality of the current packages (FSII, lubricity enhancer and static dissipater additive) as well as the new "smart" additives. Cocktails to make commercial fuels JP-8 and JP-8+100 should be developed as baselines. In addition, advanced additive injection techniques such as light weight "suitcase" size injectors with throw away bottles of additive, "fizzy" tablets, premixed additive balls, or heat (or shear) activated microcoatings of tablets could be explored to improve usability in the field and reduce the volume of material that would be needed. Finally, advanced field diagnostic techniques (requiring operation over conditions ranging from desert to arctic) are required for smart fuels. For example, a "smart nozzle" concept could be used to incorporate state-of-the-art diagnostics equipment into a single package that is attached to the single point refueling nozzle (or on the refueling truck) to test for key fuel properties as the fuel is dispensed. The technical risk is rated medium for this effort.

PHASE I: The Phase I goals are to identify suitable smart additives, additive "cocktail" mixes, advanced additive injection techniques and/or in-situ diagnostic concepts. The contractor shall demonstrate the feasibility of the technology, and quantify the payoffs for both military and commercial applications and conduct a cost benefit assessment to determine affordability. Size, weight and deployment footprint reductions shall be determined.

PHASE II: The goals of Phase II are to demonstrate a prototype of the technology (sample of new additive, sample of additive cocktail, additive injector (hardware) and/or in-situ diagnostic device), validate performance at true operating conditions, and refine cost/benefit predictions for both military and commercial applications. Size, weight and deployment footprint shall be compared to conventional systems.

PHASE III DUAL USE APPLICATIONS: All technologies developed under this topic have both military and commercial jet fuel applications due to the similarities of the jet fuels (i.e., JP-8 is commercial Jet A-1 fuel with a military additive package).

REFERENCE: Coordinating Research Council, "Handbook of Aviation Fuel Properties," CRC Report No. 530, 1983, ADA 132 106.

KEYWORDS: Smart fuels, smart nozzles, additive cocktails, fuel additives, emissions, sub-freezing properties

AF00-203 TITLE: <u>Turbine Burner for Near-Constant Temperature Cycle Gas Turbine Engine</u>

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop innovative strategies for an ultracompact turbine burner that can enable a near-constant engine cycle by combusting in between the high-and low-pressure turbines.

DESCRIPTION: The driver for this program is the need to enhance performance and reduce life-cycle cost for advanced air-breathing propulsion and power systems. The development of a revolutionary propulsion system that operates on a highly-efficient constant-temperature (CT) cycle instead of the constant-pressure cycle of today's engines is a high-payoff, high-risk approach to an enhanced performance low-cost gas turbine engine. An ultracompact combustion system, that efficiently adds heat between the turbine stages, is the key to a CT cycle aircraft or missile engine. Such a combustor is referred to in the literature as a turbine burner. Cycle analysis studies indicate that afterburner level thrust can be achieved with a non-afterburning, CT cycle engine without a large increase in specific fuel consumption (SFC). This topic seeks the development of an efficient, lightweight, ultracompact turbine burner that would enable the development of a CT cycle gas turbine engine for use in aircraft or missile systems. A turbine burner must be short and lightweight so as not to significantly increase the length/weight of the turbine, thereby nullifying performance gains. The combustion efficiency of the burner must be high so that almost all of the fuel is consumed. The pressure drop across the burner must be low so that the engine performance is not lost. Also, a turbine burner concept must take into account the fact that guide vanes are required to turn the flow before going into a rotor.

PHASE I: Conduct suitable studies to demonstrate that the proposed turbine burner concept has a reasonable chance of success. Conduct a preliminary design of the turbine burner

PHASE II: Design, fabricate, and test the turbine burner concept. Tests must be designed to demonstrate the validity of the turbine burner concept.

PHASE III DUAL USE APPLICATIONS: The development of an efficient, ultracompact turbine burner would stimulate the development of high thrust-to-weight ratio commercial aircraft engines but also more efficient engines for power generation. More work can be extracted from a CT cycle engine than for a Brayton cycle engine because it more closely simulates the Carnot cycle. However, CT cycle gas turbine engines currently have limited use in the power generation industry because of the lack of efficient turbine burners.

REFERENCES: AIAA-97-2701, J. Prop. & Pow, Vol 14, No. 6, 1998, "Selected Challenges in Jet and Rocket Engine Combustion Research," W.A. Sirignano, J.P. Delplanque, and F. Liu Department of Mechanical and Aerospace Engineering University of California, Irvine, CA.

KEYWORDS: Combustion, Turbine Burner, Constant Temperature Cycle Engine, Reheat Cycle

AF00-204 TITLE: Active Combustion Stability Control During Scramjet Altitude and Mach Number Transients

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a control strategy and instrumentation/actuation hardware that enables active control of combustion instabilities during scramjet transients such as engine cycle transitions, vehicle acceleration, and altitude changes.

DESCRIPTION: A scramjet engine is an open duct from inlet to exhaust nozzle. The shock system that is established upstream of the combustion section is a function of the flight Mach number, the vehicle angle of attack, the engine's internal geometry and the rate of heat release within the combustor. Perturbations in the heat release couple to movements in the shock system. Extreme changes can force the shock system out of the inlet and unstart the engine, or can cause regions of intense local heat flux and compromise the structure. Smaller changes in the heat release-shock structure system can reduce the combustion efficiency or blow out the flame. Operation of a scramjet as part of a combined cycle engine can be expected to exacerbate the challenge of maintaining stable combustion during a system transient. Fuel preparation, fuel injector placement, and igniter strength are the main control parameters available to manage combustion instabilities, especially in fixed geometry engines. Sensing temporal changes in the flow field and the attendant spatial changes in the shock structure, having the algorithms in place to know what action will counter the evolving flow changes, and having control over parameters that can implement the desired action, all at a time scale adequate to damp the instability, are crucial to managing the stable flight of a scramjet. This topic solicits development of control strategies for scramjet engines, especially for those with fixed geometry. Development of flight-weight instrumentation, control algorithms, and flow-control hardware are within the scope of this topic.

PHASE I: The effort under this program is expected to demonstrate a sensing and control strategy for managing transitions within a combusting, supersonic flow field. The demonstration is expected to be experimental on a bench-scale device.

PHASE II: The effort is expected to develop a sensing and control package for installation in an existing scramjet component test fixture and for demonstration of the control functions on hardware that is near full scale.

PHASE III DUAL USE APPLICATIONS: Active stability control of a combustion process has far ranging implications for both military and commercial applications. In combined cycle engine concepts, the transition from one cycle to the next is a source of flow instability that can lead to catastrophic failure of the system. In more conventional systems such as the gas turbine engine, active control over combustion instabilities enable operation of the engine with less stability margin which enhances performance. Further, combustion induced instabilities may drive component fatigue. These would be reduced or eliminated.

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KEYWORDS: Combustion, Control, Scramjet, Active Stability Control

AF00-205 TITLE: Oil and Material Compatibility for Improved Bearing and Gear Durability

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Joint Strike Fighter and F-22 Systems Program Office

OBJECTIVE: Develop material evaluation methodologies and compatibility solutions to enable large step improvements in bearing and gear capability.

DESCRIPTION: The gas turbine engine main-shaft bearings, power gear train and the associated lubricant are backbone elements of the propulsion and power systems which power USAF aircraft. Those machine elements and lubricants are also pervasive in commercial power systems. Improving the capability of those elements has fundamental potential to enable many capability and reliability improvements in the systems they support. Improved bearing performance capability, that can only be obtained through the use of new emerging candidate materials, is required in advanced USAF engines that are under development. Material compatibility problems have occurred in attempting to utilize some of these new materials. Those problems must be solved to enable fully successful designs. The Air Force is seeking the development of innovative design and testing processes and methodologies to enable selection and accurate evaluation of the tribological, material science, and chemistry properties that control the state-of-the-art capabilities of bearings and gears. In conjunction with these evaluation methodologies, the Air Force is seeking solutions to these compatibility problems that will allow large step increases in gear and bearing capabilities. Some gear and bearing capability improvements that are desired are (1) Maximized rolling element bearing DN capability. (DN refers to the product of bearing bore diameter and rotor speed. DN is usually expressed as the product of RPM and millimeters) (2) Maximized load-carrying capability of rolling element bearings either at low or high values of DN (3) Corrosion resistant bearings, gears and oils. This is a high pay-off area. If corrosion of these elements could be eliminated, large cost savings and durability improvements would result. (4) Increased operating temperature capability of gears, bearings, and oil.

PHASE I: Should identify and explain the major compatibility issues between advanced materials and lubricants limiting the advancement of durability and life of bearings and gears. An example is the degree of "reactivity" compatible with lubrication and corrosion resistance. A comprehensive technical approach should be identified to economically test the contact system for competitive surface or near-surface failure modes. Phase I should demonstrate, by way of simulation tests, the tradeoffs associated with conflicting requirements of lubricants, for high temperature or corrosion inhibition and materials tigue life, wear resistance or corrosion resistance.

PHASE II: Should prototype innovative design and testing processes and methodologies enabling large step increases in bearing and gear tribological performance. The technical approaches should utilize opportunities in oil formulation and/or surface engineering technologies. It is anticipated that the Phase II effort be conducted in conjunction with one or more supporting companies for material and lubricant technologies and at least one turbine engine manufacturer. The prototyping demonstration should be applied to emerging candidate material systems identified by the engine company(s) and should be evaluated for its potential to enable component insertion of new material systems enabling large step improvements.

PHASE III DUAL USE APPLICATIONS: Applications of the design and testing processes developed in this SBIR program would have wide application in Phase III. The specific design enhancements of gas turbine engine designs, developed by the engine companies using this technology, would be applied to both military and commercial jet engines. The resulting design and testing processes would be applicable to any commercial or military power train system in any application from Army tanks to Space systems.

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1. Johnson, Michael et al., "Thin Dense Chrome Bearing Insertion Program Pyrowear 675 and Cronidur wear testing" AFRL-PR-WP-TR-1998-2110, ADA 361 451.

2. Averbach, B.L., Bamberger, E.N., "Analysis of Bearing Incidents in Aircraft Gas Turbine Mainshaft Bearings" Tribology Transactions Volume 34(1991),2,241-247.

KEYWORDS: Tribology Bearings, Gears, Oil, Metallurgy, Chemistry, Material Science, Lubrication.

AF00-206 TITLE: Non-Intrusive, Flight-Weight Instrumentation of High-Speed, High-Temperature Flow Fields

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop robust, flight-weight instrumentation that can be used in conjunction with a process control system to monitor and/or control combusting flow in high-speed propulsion systems.

DESCRIPTION: Non-intrusive instrumentation has been extensively developed for research and ground testing of high-speed propulsion devices such as ramjets and scramjets. Laser Doppler velocimetry, planar imaging velocimetry, planar laser induced fluorescence, spectroscopy, and other non-invasive methods routinely measure gas velocity, species concentration and temperature in very harsh flow environments. The techniques have yielded wonderful insight into very complex processes. They have the potential to provide continuous, real-time assessments of the performance and structural health of practical, in-service combustion device. Developments in diode lasers and chip-based detectors may be sufficient to enable use of these laboratory techniques in a flight environment. However, identification of a parameter that can be measured with sufficient accuracy, and over a broad enough area of the engine flow-field to enable a near-instantaneous assessment of the state of the process, has yet to be accomplished. As an example, measurement of the OH radical is a good indicator of the extent of a reaction and the location of the flame front. However, measurement of OH through absorption spectroscopy is best performed with a small, intense column of laser light transiting the flow-field. The measurement can be made with adequate accuracy, but not over a broad enough area of the flow-field nor with sufficient speed to permit active engine control. Multiple line measurements of OH at a given engine station could be deconvolved to define the extent of reaction at the measurement plane. However, the deconvolution algorithm would take time and its accuracy would be diminished relative to the line measurement. The loss of speed and accuracy may make engine control impossible. Identifying what to measure and how to use it in order to assess structural integrity or to optimize system performance are of equal importance to the actual task of miniaturizing the diagnostic tool. This topic solicits development of non-intrusive, flight-weight instrumentation for propulsion applications, especially for ramjet and scramjet engine cycles. The only acceptable responses are those in which the development can be expected to lead to devices to measure parameters with sufficient precision and at time scales conducive to managing internal flows of an engine.

PHASE I: The phase I effort of this program is expected to identify the measurement strategy, the information processing approach, and one or more parameters that could be actuated to actively control a high speed, chemically reacting flow. The focus of the effort is on measurement strategy and must identify the specie(s) to be measured as well as the required precision of the measurement, required coverage of the flow field, and required speed. The Phase I effort is expected to define a development effort to prototype such an instrument for in-flight use.

PHASE II: The phase II effort of this program is expected to culminate in prototype testing of sensing instrumentation that can function in a high speed, high temperature flow and measure one or more parameters suitable for active process control. The prototype must be bench tested, addressing issues of effectiveness and packaging suitable for flight.

PHASE III DUAL USE APPLICATIONS: Non-intrusive instrumentation is routinely used in laboratory environments to evaluate performance. Such instrumentation also has the potential for process control. However, for such applications it requires miniaturization and durability in excess of current technology, and it must be integrated into a reliable and rapid measure-evaluate-actuate process. Potential applications are numerous in both military and commercial sectors. Propulsion systems, power generation, chemical processing are all areas that would benefit from such instrumentation.

REFERENCES:

1. "Diode-laser absorption sensor system for combustion monitoring and control applications," (1997) Mihalcea, R.M., Baer, D.S., and Hanson, R.K., AIAA Paper 97-3356, 35th Aerospace Sciences Meeting, Reno, NV

2. "Diode laser sensors for real-time control of pulsed combustion systems," (1998) Furlong, E.R., Mihalcea, R.M., Webber, M.E., Baer, D.S., Hanson, R.K., AIAA Paper 98-3949, 34th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Cleveland, OH, July 1998

3. "Diode-laser sensor system for closed-loop control of a 50-kW incinerator," (1997) Furlong, E.R., Mihalcea, R.M., Webber, M.E., Baer, D.S., Hanson, R.K., Parr, T.P., Proceedings Society of Photo-Optical Instrumentation Engineers (SPIE) Vol. 3172, p. 324-330.

4. "Advanced Diagnostic Techniques Development for Supersonic and Subsonic Combusting Flowfields," (1996) Goss, L.P., et al., Innovative Scientific Solutions, Inc., Final Report Contract F33615-96-C-2638, Report No. AD-A322830; WL-TR-96-2144; NIPS-97-22951.

KEYWORDS: Measurement, nonintrusive instrumentation, process diagnostic

AF00-207 TITLE: Air Film Bearing for Oil-Free Turbomachinery

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop affordable air film bearings with predictable performance for rotor support in midsize oil-free aerospace turbomachinery.

DESCRIPTION: Traditional rotor support for aerospace gas turbine engines and turbomachines for power units consists of rolling element bearings which are lubricated with a recirculating oil system. Advantages of this approach include high load capacity and well characterized, predictable performance. The recirculating lubrication system accounts for a substantial portion of the cost and weight of the turbomachine (typically 15% in a gas turbine engine). Additionally, this approach limits performance in advanced machines because extensive cooling is required to maintain bearing temperatures within the operating limits of conventional ester lubricants (400°F max), and friction and inertia forces within the rolling element bearings limit rotor speeds to less than 3 MDN (MDN = 106 x shaft diameter (mm) x rotational speed (rpm)). Other drawbacks include high maintenance and limited storability between uses.

Air film bearings present an attractive alternative approach to rotor support in some systems. They do not require a lubrication system, thus substantially reducing machine cost and weight. Operating temperature has been demonstrated to 1200°F. Rotor speeds are essentially unlimited, they are potentially maintenance free, and have unlimited storability. Air film bearings are currently in use in applications requiring relatively small rotors and loads, such as aircraft air cycle machines (ACMs). The application of air film bearings to larger machines has been limited by their low load and damping capacity, and limited scalability. Recent advances in these areas are making air film bearings feasible for midsize turbomachinery applications such as gas turbine engines for cruise missiles and Unmanned Air Vehicles (UAVs), and aerospace power units such as Integrated Power Units (IPUs) and integrated power/cooling packages. Another limiting factor is that traditional design methodologies are inconsistent in predicting performance, thereby requiring a semi-empirical development for each new application. This results in long lead-time and high cost in the final machine. Additionally, fabrication of some bearing designs can be labor intensive, with inconsistent performance in units produced within the same lot. These shortfalls must be overcome if air film bearings are to be viable and cost effective over the range of midsize turbomachine applications.

PHASE I: Define the range of required performance characteristics for rotor support in proposed midsize turbomachine applications (cruise missile engine, UAV engine, and power units). Define a proposed air film bearing concept and modeling approach. Through analysis and/or small scale testing, explore the feasibility and flexibility of the proposed bearing concept to satisfy the performance requirements over the range of target applications. Demonstrate the validity of the modeling approach through correlation with test data.

PHASE II: Develop prototype air film bearings and demonstrate performance at required end application operating conditions in demonstrator turbomachines. Correlate test data with predicted performance to refine and validate modeling methodology.

PHASE III DUAL USE APPLICATIONS: This technology has application in gas turbine engines for cruise missiles and UAVs, and turbomachines for aerospace power units. Potential commercial applications include turbochargers, air compressors, gas turbines, auxiliary power units, and gas turbine engines for general aviation aircraft.

REFERENCES:

1. "Advancements in the Performance of Aerodynamic Foil Journal Bearings: High Speed and Load Capability," Heshmat, H., ASME Paper No. 93-Trib-32, STLE/ASME Tribology Conference, New Orleans, LA., Oct 1993.
2. "A New Foil Bearing Concept," Scharrer, J., Hibbs, R., and Lindsey, T., final report for NASA contract NAS8-40536, 1995.
3. "Effects of Static Load on Dynamic Structural Properties in a Self-Acting Foil Journal Bearing," ASME Trans., J. of Vibration and Acoustics., Vol. 116, No. 3, pp. 257-262, July 1994.
4. "Foil Air/Gas Bearing Technology – An Overview," Agrawal, G.L., ASME Paper No. 97-GT-347, 1997.

KEYWORDS: Foil Bearings, Air Bearings, Air Film Bearings, Aerodynamic Foil Bearings, Gas Bearings, Oil-Free Bearings

AF00-208 TITLE: In-Flight Engine Start System (ASC-017D)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop techniques, devices and components for aerospace advanced power generation to support in-flight engine restarting and electrical power generation.

DESCRIPTION: In-fight power generation and engine starting systems are needed to provide power for propulsion engine start assist and increased payload power over the operational range of an aircraft, tailored to high altitude vehicles, including UAVs. Existing systems of interest do not have engine restart capability and exhibit less than 50% shaft to electrical conversion efficiency while being severely limited in electrical power generation growth potential for payload power. Present technologies and approaches cannot meet the stated needs. To minimize the weight and volume of the secondary power system, new and innovative solutions in electrical power generation/motoring technologies as well as conversion approaches are needed; emergency power for in-flight engine restarting, auxiliary power if needed, normal engine starting power, and 2x-3x increase in power generation capability are desirable. Since high altitude exacerbates any thermal control and propulsion engine/power generation coupling issues, achieving the goals inherently involves high risk. Current and planned systems use a variety of methods/components to provide secondary power, auxiliary power, emergency power, and/or in-flight engine starting capability; monopropellants, stored compressed air, fast starting jet fuel starters and auxiliary power units (APU's), and electrochemical energy storage for electrically driven accessories are examples. It is desirable that logistics support requirements of the secondary power system are minimized. Concepts are solicited that utilize the best characteristics of candidate technologies while introducing new technologies to produce a system, potentially a hybrid, which can provide full secondary power system functionality in a compact, lightweight, and low cost power unit. Crossover functionality to emerging directed energy weapon power requirements is also desirable. Any proposed technologies should be fully compatible with the current thrust to make power units fully self- sufficient, both electrically and from a thermal control standpoint. The suggested propulsion engine to be used for evaluating candidate technical approaches for in-flight start assist is the AE3007H series engine produced by the Rolls-Royce Allison company. The number (minimum goal of two desired) of successive in-flight propulsion engine restart attempts at high altitude (greater than 45000 ft altitude desired) should be evaluated for weight and volume impacts as well as operational impacts.

PHASE I: Develop a detailed technical definition of the problem, identify a proposed solution, and demonstrate key technologies enabling the use of that solution.

PHASE II: Concentrate on exploratory component development..

PHASE III: Hardware development and subsystem demonstrations.

PHASE III DUAL USE APPLICATIONS: These technologies may have application for all high speed motors, generators, actuators, and power electronics which may be used in future high power density electric/hybrid transportation vehicles (commercial air, high speed rail, and electric car), power generation, and manufacturing facilities.

REFERENCES:
1. "Integrated Power Unit For A More Electric Airplane", Colegrove, P.G., AIAA Paper 9'@-1 188, Feb. 16-19, 1993.
2. "More-Electric Integrated Power Unit Designed For Dual-Use", Klaass, R.M., McFadden, B.B., SAE Paper No. 94115, 1994.
3. "Integrated Power Unit - Advanced Development", Smith G., Halsey D., Hoffman E.. SAE Paper No. 981281,1998.
4. "High Temperature Generator Development," AFAPL TR 74 69, Robert Fear, et al., Westinghouse Electric Corporation, AD-786 046; NTIS, 5285 Port Royal Rd., Springfield, VA.

KEYWORDS: Power generation, motors, fault tolerant PM machines, switched reluctance machines, emergency power, engine starting

AF00-209 TITLE: Space Based Radar Thermal Control

TECHNOLOGY AREAS: Air Platform, Sensors/Electronics/Battlespace

OBJECTIVE: To develop techniques, devices and components for space based radar thermal control.

DESCRIPTION: Innovative thermal control concepts are sought for space based radar (SBR). Several SBR concepts require antennas of large area on a low earth orbit (LEO) platform. The possibility of large peak-to-peak temperature variation exists because operating windows lasting about 18 minutes may occur at anytime during an orbit (i.e., when the platform is at its high or low temperature extreme). Curvature of the antenna and temperature-induced out-of-phase conditions occur if the antenna does not remain flat and isothermal in a phased array system. These may be corrected via electronic calibration and steering means, but these approaches alone may not be sufficient or desired. Directly solving the problem (that is, controlling the thermal state of the antenna) is heavy, difficult, and practically infeasible with today's technology. Thus, it is desired to develop innovative thermal control technologies that mitigate peak-to-peak temperature fluctuation as well as to assure an isothermal antenna. Potential technologies include, but are not limited to, passive or active radar transparent coatings, integrated phase change thermal energy storage, and passive or active deployable heat transport systems. These technologies are not fully developed and their application in the space based radar involves a medium level of risk. Concepts that are integrated with the antenna structure and offer mass savings are of great interest. Successful offerors must demonstrate a basic knowledge of phased array radar systems and space craft thermal control issues. For the purpose of thermal control problem definition, a notional SBR platform would have a 6m x 44m antenna and a highly distributed power system with up to 15000 power converters integrated with the transmit/receive (T/R) modules. The SBR would be in a 500nm (~104 minute) orbit with two 18-minute operating periods, each occurring anytime during orbit and possibly back-to-back. The antenna would have a peak radiated power of 60kW and average radiated power of 15kW, (i.e., 25% duty cycle). A T/R module efficiency of 35% and a power conditioning component efficiency of 90% may be assumed. The goal is to control temperature variation across the antenna to less than 10°C.

PHASE I: Develop a detailed technical definition of the problem, identify proposed solutions, select the optimum solution, and demonstrate the key technologies enabling the use of that solution. Efforts devoted to modeling and simulation of the thermal control technologies in the space based radar application are also appropriate for Phase I.

PHASE II: Concentrate on development of prototype components and prototype subarray-scale demonstrations with a focus towards commercialization.

PHASE III DUAL USE APPLICATIONS: These technologies have application for commercial high power spacecraft and terrestrial radar or electronics cooling applications.

REFERENCES:
1. Cantafio, L.J., Editor, Space-Based Radar Handbook, Archtech House, Inc., Norwood, MA, 1989, 701 p.
2. Keener, D., Reinhardt, K., Mayberry, C., Radzykewycz, D., Donet, C., Marvin, D., and Hill, C., "Directions in US Air Force Space Power Technology for Global Virtual Presence," AIAA Paper 98-1021, presented at the 36th AIAA Aerospace Sciences Meeting & Exhibit, Reno, NV, Jan. 12-15,1998.
3. Eatock, B.C., "Progress in DND's Space-based Radar R/D Project," Proceedings of the Sixth CASI Conference on Astronautics, 1990.
4. Christensen, E.L., Skou, N., Dall, J., Woelders, K.W., Jorgensen, J.H., Granholm, J. and Madsen, S.N., "EMISAR - An Absolutely Calibrated Polarimetric L- and C-band SAR," IEEE Transactions on Geoscience and Remote Sensing, Vol. 36, No. 6, Nov. 1998, pp. 1852-1865.

5. Kutscheid, T. and Gilg, W., "Configuration of an Antenna Subpanel for a Spaceborne High Resolution X-Band SAR," Proceedings EUSAR '98 - European Conference on Synthetic Aperture Radar, Friedrichshafen, Germany, May 25-27, 1998, pp. 225-228.

KEYWORDS: Space based radar, spacecraft thermal control, phased array radar

AF00-210 TITLE: Drag and Thermal Load Reduction by Nonequilibrium Plasmas

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop nonequilibrium plasma model and validate results by experimental test of drag and or thermal load reduction under high speed flight conditions.

DESCRIPTION: The effect of nonequilibrium plasmas on high speed flights has recently been investigated in Russian, British, in the US laboratories and test centers. Measurements of shock attenuation, dispersion, and shock velocity increase have been reported which cannot entirely be explained by gas heating in a self-sustained discharge. Russian wind tunnel experiments have shown 20-30% drag reduction when a nonequilibrium plasma is injected in front of a projectile moving at Mach 6 in air as well as in inert monoatomic gases. Based on some of the preliminary experimental test results, it suggests that the understanding of the energy transfer mechanism in plasma-shock interactions may lead to a revolutionary high speed vehicle design. Injection of weakly ionized gas flow may be used to reduce skin friction, thermal loading, inlet and nozzle flow control, and enhance combustion efficiency for very high speed flights. The primary emphasis of the experimental and theoretical research should be to understand energy coupling mechanisms between the floe field energy and nonequilibrium plasma.

The experimental and/or theoretical results should be applied to permit scale-up of the test configuration, and/or to show the trade-off between the input electrical energy requirement for plasma generation, versus high speed engine performance enhancement, thermal load minimization and/or drag reduction.

PHASE I: Define the atmospheric boundary conditions where nonequilibrium plasma generation and injection may have significant impact on shock modification and high speed flow field modification. Design experimental /computer simulated test setup to demonstrate the effect.

PHASE II: Conduct test under well defined conditions to permit accurate theoretical model development for energy exchange mechanism between plasma and flow field. Also define optimum electrical configuration for plasma generation for any conceptual high speed aerospace vehicle.

PHASE III DUAL USE APPLICATIONS: Economical space access vehicle design for global telecommunication satellites.

REFERENCES:
1. "Drag Factor", Janes Defence Weekly, 17 July 1998.
2. 2nd Weakly Ionized Gases Workshop," Norfolk, April 24-25, 1998

KEYWORDS: Shock wave, nonequilibrium plasma, high speed flights.

AF00-211 TITLE: Directed Energy Weapon Power Generation and Pulsed Power Technology

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop electrical power generation and pulsed power conditioning for potential directed energy weapon systems concepts. Perform related analysis and simulation to understand system performance improvement with the new components.

DESCRIPTION: The Air Force seeks innovative concepts for electrical systems, electrical power generation and pulsed power conditioning for electrically powered directed energy weapon (DEW) concepts for potential air, space, and missile defense systems. The types of DEW systems considered in this program include high power microwaves devices, gas dynamic lasers, free electron lasers, and particle beams. The average power levels of these potential vehicle systems range from 100's kW up. The voltages in these systems range up to 100's kV for microwave and radio frequency based systems. High-voltage generator technologies that can be directly integrated with vehicle propulsion will be considered in this program. The magnetic technologies of interest include lightweight high temperature superconducting magnets with coated conductors, especially with yttrium-barium-copper oxide. Compact pulse power conditioning technologies of interest in this effort include high voltage pulsed power switches, pulse-forming network components, and solid-state pulse forming lines. Pulsed power components will need to produce microsecond pulses ranging from the kilovolt, megawatt level up to the megavolt, gigawatt peak level. All computer models of components and systems should be reduced ordered models to produce fast computations. All software developed in this program must be compatible with operating systems on personal computers.

PHASE I: Develop conceptual designs of components, perform preliminary tests of materials, develop analysis tools that predict system performance with new components.

PHASE II: Develop prototype components, develop analysis that predicts detailed performance of the system.

PHASE III DUAL USE APPLICATIONS: Software and component technologies will have potential commercial applications for high power and high voltage generators and power electronics used in utility power systems, and civilian space missions.

REFERENCES:
1. V. Fraishtadt, A. Kuranov, E. Sheikin, "Use of MHD Systems in Hypersonic Aircraft", Technical Physics, Vol 43 Number 11, November 1998, pp. 1309-1313.
2. H. Cohen, F. Lehr, T. Engel. Spear II: High Power Space Insulation, Texas Tech University Press, 1995.
3. B. Gamble, T. Keim, "A Superconducting Generator Design for Airborne Applications," Advances in Cryogenic Engineering, Vol 25, 1980, pg. 127.

KEYWORDS: Electric power, power generation, magnetohydrodynamics, superconducting generators

AF00-212 TITLE: Power Electronics and Conditioning for Electrical Actuation

TECHNOLOGY AREAS: Air Platform, Sensors/Electronics/Battlespace

OBJECTIVE: Reduce DC power requirements for flight control actuators

DESCRIPTION: As the amount of electric flight control actuation increases in future aerospace vehicles, increased electrical capacity is required. Innovative concepts are requested to reduce the DC power required by these actuators. Proposals should address the development of power electronic devices, controls and/or subsystem architectures for aerospace actuation systems that will result in more efficient operation. Candidate device, controls, and subsystem technologies should demonstrate advancements in efficiency and power density. Approaches that modulate power to various actuators working simultaneously will be considered. Other approaches including advanced switch modules, innovative controls and innovative motor designs that improve efficiency are desirable.

PHASE I: Goals include analyses and proof-of-concept experiments

PHASE II: Goals include detailed analytical deviations and prototypical devices, components, or hardware demonstrations.

PHASE III DUAL USE APPLICATIONS: Much of the technology is of direct interest to future commercial utilization by the automotive, portable electronics, power generation, and motor drive industry, where high power density, high current fault tolerant switching, and/or high reliability are required.

REFERENCES:
1. "An Electromechanical Actuator for a Transport Aircraft Spoiler Surface," Proceedings of the 32nd Intersociety Energy Conversion Engineering Conference, 1997 pg 694-698.
2. N. Mohan, T.M. Undeland, W.P. Robbins, "Power Electronics: Converters, Applications and Design," John Wiley & Sons; NY, NY, 1989.

KEYWORDS: Power conditioning, actuatory, power electronic devices

AF00-213 TITLE: Power Systems for MEMS and UAV Applications

TECHNOLOGY AREAS: Air Platform, Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: Develop lightweight, long duration electrochemical propulsive power and energy storage systems for MEMS and/or UAV flight platforms.

DESCRIPTION: This topic seeks proposals with innovative concepts related to electrochemically powered (batteries, fuel cells, and electrochemical capacitors) microelectromechanical systems (MEMS) and unmanned aerial vehicles (UAVs). There are many challenges for enabling MEMS for specific applications that will provide a benefit in cost, weight, manufacturing, reliability, etc. MEMS devices have had limited evolution from novel micro devices to specific applications. For the most part, the development of microsensors such as accelerometers, pressure sensors, chemical sensors, and the like have been the primary focus for transitioning this micro-technology to real world applications. One barrier to applying MEMS technologies in specific applications has been a lack of suitable micro-power systems. These systems could be composed of any devices capable of converting energy from the environment, such as solar energy, thermal energy, or the energy of motion, to electrical energy. Then, some means of storing and conditioning that energy is needed, such as microscopic batteries, fuel cells, and/or electrochemical capacitors. UAVs are primarily powered by internal combustion engines. To enhance UAV endurance and survivability, electrochemical power sources for prime power and energy storage are being sought. Electrochemical propulsive power and energy storage systems can provide lightweight, cost-effective, low-observable solutions to the power/energy storage needs for UAV platforms. The power requirements can range from several watts for MEMS to tens/hundred of kilowatts for large high-altitude long-endurance (HALE) reconnaissance/directed energy weapons platforms. The mission times range from several hours/days for primary power applications, to months/years for solar regenerative applications. Rechargeable energy storage capacities greater than 300 watt-hours/kilogram are desired. Electrochemical propulsive power weight goals are mission dependent, however, doubling the energy density compared to existing propulsion systems is the desired goal.

PHASE I: Define the proposed concept, predict the performance of the proposed design, and through analysis and sub-scale testing, demonstrate that the proposed design can meet the desired weight goal for the MEMS/UAV mission application.

PHASE II: Provide an operable prototype component or system that is completely suitable for the intended application. The prime consideration must be deliverable hardware and a clear demonstration of a manufacturable device, component or system that improves the existing technology either through exceptionally high performance, significantly reduced cost, or improved robustness.

PHASE III DUAL USE APPLICATIONS: Electrochemical batteries, fuel cells, and capacitors for MEMS/UAVs would be utilized in civilian MEMS/UAVs, electric vehicles, and various other portable power applications.

REFERENCES:

1. P. B. Koenenman, I.J. Busch-Vishniac, and K.L. Wood, Feasibility of Micro Power Supplies for MEMS, Journal of Microelectromechanical Systems, Vol. 6, No. 4, Dec. 1997.

2. S.F. Brown, The Eternal Airplane, Popular Science Magazine, p70, Apr 94.

KEYWORDS: UAV, power, energy storage, electrochemical, battery, fuel cell, capacitor, ultracapacitor

AF00-214 TITLE: High Speed Power Generation Technology for Aerospace Vehicles

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop technologies in support of high speed electrical machinery for application in space power systems and oil-free integrated power units for aircraft.

DESCRIPTION: Electrical machines are needed that operate at high speeds (45-70 kRPM) and high power levels (up to 300 kW) for aircraft and spacecraft applications. Typical aircraft applications are integrated power units (i.e., turbomachinery with shaft-mounted electrical machines); these are generally switched reluctance machines (SRMs) due to their mechanically robust rotor. Typical spacecraft applications are expected to be the energy input/output mechanism for flywheel-based power systems for space-based radar, space-based laser, space station, or other missions. Proposals are solicited which address these technology areas. Examples of areas of interest include but are not limited to the following. For aircraft applications, foil thrust and journal bearings for integrated power units and integrated power/cooling packages are of primary interest, particularly design and analysis approaches which allow accurate prediction of dynamic performance. Oil-free auxiliary bearings for magnetic bearing systems and hybrid bearing configurations for this class of machine are also of interest. For space-based flywheel systems, high speed machines are of interest, particularly those which can compensate for voltage variation with speed, which offer extremely low heat rejection rates (i.e., very high efficiency), and which can physically be integrated with a magnetically-suspended flywheel. Common to all applications are control approaches to integrate the magnetic bearing with the electrical machine, thus eliminating one magnetic bearing or providing additional rotor system stability by active control of electrical machine flux. Related areas of interest are approaches to understanding interactions between the SRM and the rotor (estimation and measurement) and pulse-testing techniques applicable to health monitoring of SRM/rotor systems.

PHASE I: Develop a detailed technical definition of the problem or opportunity, identify a proposed solution, and demonstrate key technologies which enable the use of that solution. Correlate any experimental data from technology demonstrations with analytical predictions.

PHASE II: Develop prototype components, conduct subsystem demonstrations, and fabricate hardware suitable for incorporation into system technology demonstrations if appropriate. Correlate test data with results from models or simulations in order to demonstrate clear understanding of any technology development.

PHASE III DUAL USE APPLICATIONS: These technologies have application for all high speed machines which may be used in future aircraft, spacecraft, hybrid or electric vehicles, and stand-alone or backup/uninterruptible power supplies for utilities or critical facilities.

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1. "Integrated Power Unit For A More Electric Airplane," Colegrove, P.G., AIAA Paper 93-1188, Feb. 16-19, 1993.
2. "More-Electric Integrated Power Unit Designed For Dual-Use," Klaass, R.M., McFadden, B.B., SAE Paper No. 94115, 1994.
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5. "A New Foil Bearing Concept," Scharrer, J., Hibbs, R., and Lindsey, T., final report for NASA contract NAS8-40536, 1995.

KEYWORDS: Power generation, motors, fault tolerant PM machines, switched reluctance machines, emergency power, engine starting

AF00-215 TITLE: Propulsion and Power Systems Commercial Design Philosophies and Practices

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Evaluate current commercial design philosophies and industrial practices for aerospace propulsion and electrical power systems and compare with those used in similar military systems. The evaluation will identify opportunities to incorporate best commercial practices into military products; this would reduce manufacturing and assembly costs as well as expedite production of modular propulsion or power systems.

DESCRIPTION: Modular assembly, which would allow cost effective production with minimum production times, is typically not designed into military propulsion and power systems. For example, the production rate of the F-22 is 3 aircraft per month (approximately 7 days per aircraft). Unfortunately, the aircraft and its major component systems (engines, structures, etc.) are built using a sequential assembly approach that can require many months to complete the work in many assembly stations. This results in excessive tooling costs, due to the many jigs and fixtures needed to support the multiple aircraft and major components being assembled at any one time. Also, operator teaming and use is ineffective due to the months required to produce a final product and the fact that each operator is not involved in the production of every system. Excessive assembly time can be further affected by delays due to turnover in trained personnel, sick leave and holiday schedules. Another significant problem with a system's lengthy production time is the lost opportunity to incorporate design and process improvement ideas; this then results in significant wasted resources if these improvements can only be incorporated through retrofit. This research topic addresses the resolution of this problem by identifying commercial best-practices; it is recognized that some risk is involved due to the difficulty associated with identifying key process parameters and obtaining accurate raw data upon which evaluations can be based.

PHASE I: Defuse the technical roadblocks to parallel production and modular assembly of propulsion and power systems as used in modern fighter aircraft. Perform research on adapting current commercial design philosophies and practices for propulsion and power systems from several commercial sectors (i.e., aircraft, automotive, farm equipment, etc.) in order to determine common factors and processes and to identify application areas in military systems. If appropriate, develop a modular design to incorporate best commercial practices and designs into the production of fighter aircraft propulsion and power systems. The goal is to design and model a system that could be produced in balanced manufacturing stations. For the F-22 example, each station should have a cycle time of 7 manufacturing days. Additionally, parallel operations should be maximized and series operations minimized in order to achieve the shortest lead-time possible for a complete system or subsystem.

PHASE II: Estimate production times and manufacturing costs associated with assembly and production, and compare these with existing norms in the military propulsion and power systems industry for demonstration hardware and modules using a modular design. Extrapolate the model to include other aircraft components (structures, avionics, etc.). Identify propulsion and electrical power and other aircraft systems hardware and modules to demonstrate the modular design approach, incorporating the commercial designs and best commercial practices. Estimate implementation costs and payback factors associated with changing existing manufacturing and production processes and procedures and select candidate system or systems for implementation in Phase III.

PHASE III DUAL USE APPLICATIONS: The technologies being developed would have application in the production processes of both military and commercial aerospace systems. In particular, efficiencies introduced would result in more cost-effective processes that would more readily support incorporation of improved technologies.

REFERENCES: US Navy Best Commercial Practices Program and Reports 2. DoD Manufacturing Technology Program and Reports

KEYWORDS: electric power, power generation, manufacturing technology, jet engines, avionics, aircraft structures

AF00-219 TITLE: Advanced Rocket Propulsion Technologies

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop innovative components, manufacturing and processing techniques, and integration technologies aimed at doubling existing rocket propulsion capabilities by the year 2010.

DESCRIPTION: There is a critical need for novel, innovative approaches to develop technologies which can double existing rocket propulsion capabilities by the year 2010, and for bold, new, nonconventional aerospace propulsion-related technologies which will revolutionize aerospace propulsion in the next century. These revolutionary concepts, based on sound scientific and engineering principles, are essential in order to increase performance and mission capability which either maintaining or decreasing existing life-cycle costs. The proposed solutions shall emphasize "dual use technologies" that clearly offer civilian/commercial as well as military applications. Proposals emphasizing "spin-on technology transfer" from the civilian/commercial sector to military applications will receive additional consideration.

Our technological goals include: (1) Improve specific impulse and mass fraction for boost and orbit transfer, spacecraft, and tactical missile propulsion. (2) Reduce the stage failure rate as well as hardware and support costs for boost and orbit transfer propulsion. (3) Improve the thrust-to-weight ratio for liquid rocket engines. (4) Improve the total impulse to wet mass ratio for electrostatic and electromagnetic satellite propulsion systems. (5) Improve density impulse of monopropellants for satellite propulsion systems. (6) Improve the delivered energy of tactical missile propulsion systems. In the conduct of rocket propulsion research we strive to reduce environmental hazards from propellant ingredients and processing, propulsion exhaust, and rocket motors while either maintaining or surpassing current propulsion efficiency.

Improvements in the operability, reliability, maintainability, and affordability of space launch applications, for example, might include development of novel systems which can be launched with short lead times for relatively low life-cycle costs. An example of such a concept may include the design and development of a rocket-based combined cycle (RBCC) engine. Such systems would need to demonstrate high reliability and maintainability levels.

Subsets of advanced rocket technologies would have lengthy shredouts of potential research subjects but are not stated here in detail. These technologies might include innovative combustion and plume diagnostics (i.e., application of electro-optical devices and sensors), performance predictions, modeling of exhaust plume radiation and combustion characterization, propellant and component service life prediction technologies, and environmental contamination.

Additionally, bold, new advanced propulsion and related technological concepts and products for space activities are solicited for development. These topics include revolutionary concepts in very advanced fuels and oxidizers, metastable high energy nuclear states, nanotechnology products and techniques applied to rocket propulsion, enigmatic energy devices, and field propulsion thrusters. Research in these advanced rocket propulsion topics are included and structured to provide a maximum of innovative flexibility while yielding promising commercial applications/dual-use technology applications for prospective investigators.

Proposals also submitted for any other Department of Defense FY98 Small Business Innovative Research (SBIR) topic shall not be considered for this topic.

PHASE I: Further develop the concept and perform analyses required to establish the feasibility of the proposed approach.

PHASE II: Complete the Phase I design and develop a demonstrator or prototype. Document the R&D and develop a technology transition and/or insertion plan for future systems and commercial ventures.

PHASE III DUAL USE APPLICATIONS: DUAL USE COMMERCIALIZATION POTENTIAL: Advanced rocket propulsion technologies will transition to new, higher performing and/or lower cost U.S. military and commercial rocket engines and motors or advanced propulsion systems. This will enable the U.S. aerospace industry to increase global market share for space launch opportunities by reducing the life-cycle cost and increasing the efficiency of inserting payloads in orbit. Advanced rocket propulsion technologies also serve the commercial sector by enhancing our ability to remanufacture components to maintain and monitor the health of the U.S. ballistic missile fleet.

REFERENCES: "Selected Bibliographies, Handbooks, Manuals, and Reviews," CPIA SB-94, Nov 1994.

KEYWORDS: rocket plume, rocket engine, rocket propellants, advanced propulsion, satellite propulsion, boost and orbit transfer

AF00-220 TITLE: High Temperature Catalyst for Nontoxic Monopropellant Applications

TECHNOLOGY AREAS: Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: ICBM Stage IV / Ballistic Missile Defense Organization (BMDO) Interceptor Program

OBJECTIVE: Develop an ignition system for nontoxic monopropellants that will survive higher combustion temperatures than current catalyst bed systems

DESCRIPTION: Hydrazine is currently the monopropellant of choice for spacecraft maneuvering engines and gas generator applications. The high vapor toxicity and vapor pressure of hydrazine presents a challenge in such applications. As a result, new monopropellants are under development which pose no vapor toxicity hazard. One approach favored by industry and DoD is the use of energetic ionic compounds to replace hydrazine. However, a difficulty encountered with monopropellants containing a high concentration of energetic salts is that the combustion temperature is significantly higher than that of hydrazine. These high temperatures, up to 2500 K, render present catalytic ignition sources unusable. A technical need exists for a highly reliable ignition method with very low weight. Such an ignition method would accelerate the development and use of new high performance monopropellants for spacecraft attitude control systems and main propulsion systems. Also, such combustion systems would be useful in gas generator and emergency power applications.

PHASE I: Research catalyst support media that can withstand the higher operating temperatures of energetic salt monopropellants. Prepare and test actual catalyst pellets, in a catalyst bed, under actual temperatures and flow conditions as produced by energetic salt propellants. The flow media initially may be inert gas, but must be followed by actual propellants.

PHASE II: Refine and perfect manufacturing processes for production of the final catalyst, and demonstrate the process full scale. Also, perform full-scale firings of propulsion systems (in cooperation with the government) using the new catalyst

PHASE III DUAL USE APPLICATIONS: Gas generators and turbine systems using such nontoxic propellants promise to be useful for commercial and military aircraft applications. Depending on propellant cost and availability, commercialization could extend to public and private transportation as well.

REFERENCES:

1. Cort, Robert, Hurlbert, E., et al., Non-toxic On-orbit Propulsion for Advanced Space Vehicle Applications, AIAA Paper 95-2974, July 1995.
2. Walls, T. T., Dillinger, R. B. et al., Performance and Safety Aspects of Monopropellant and Non-toxic Bipropellant Liquid Divert/ACS Propulsion for Navy Theater Ballistic Missile Defense Applications, AIAA Paper 93-2634, June 1993.
3. Eberstein and I. Glassman, "Consideration of Hydrazine Decomposition," pp. 351-365, Liquid Rockets and Propellants, L.E. Bollinger, M. Goldsmith and A.W. Lemmon, Editors, Progress in Astronautics and Rocketry Series, Academic Press, 1960.
4. Hurlbert, E., Applewhite, J., et al., "Nontoxic Orbital Maneuvering and Reaction Control Systems for Reusable Spacecraft," Journal of Propulsion and Power pp. 676-687, Vol. 14, No. 5, Sept-Oct 1998.

KEYWORDS: catalyst, high temperature, ignition, energetic, monopropellant, propulsion

AF00-221 TITLE: Microthruster Attitude Control System (ACS) for Laser Lightcraft

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop and demonstrate small-scale propulsion components for a flight-weight ACS system to be used in vertical flights of subscale Laser Lightcraft vehicles.

DESCRIPTION: The "Lightcraft" concept is a laser propelled, trans-atmospheric vehicle concept developed in the late 1980's designed to reduce, by several orders-of-magnitude or more, the production and launch costs for sensor satellites. This novel launch system will employ a megawatt-class ground-based laser to transmit power directly to an advanced, hypersonic/combined-cycle laser engine that will propel a 1.4-meter diameter nanosatellite (1-10 kg), with a mass fraction of 0.5, to low earth orbit. The Lightcraft is a concept in which the laser propulsion engine and satellite hardware are intimately shared. The electronics and payload are packaged in the forebody section. The tankage for a working fluid is packaged into the center and aft portions of the vehicle. The forebody aeroshell acts as an external compression surface during the airbreathing mode. The afterbody has a dual function as a primary receptive optic for the laser beam and as a plug nozzle during the rocket mode. The primary thrust structure is the annular shroud, which serves as both inlet and impulsive thrust surface during the airbreathing mode. In the rocket mode, the annular inlet is closed, and the afterbody and shroud combine to form the rocket thrust chamber.

The goal of the Lightcraft Technology Demonstrator program is to demonstrate technology readiness by placing a one or two kilogram functional nanosatellite in low earth orbit by the second quarter of 2005.

PHASE I: The results of the upcoming report on Dynamics and Control of Laser Lightcraft Vehicles1 will be used to design a flight-weight attitude control system for the Laser Lightcraft. The system components could include, but not necessarily be limited to, microthrusters, propellant feed system, tankage, and electronic control system. Unique and/or innovative approaches to accomplish this task are essential to minimize weight under the anticipated dynamic stresses and thermal loads. The analysis should predict performance parameters and physical characteristics of the subcomponents and the overall system. Compatibility with the current Laser Lightcraft (family) design features and operating characteristics must be maintained. Cost analysis for the entire ACS system will be used to predict and minimize cost during manufacture, installation, and operation.

PHASE II: The goal of this phase will be to completely develop and demonstrate a flight-weight microthruster attitude control system that meets Laser Lightcraft requirements. The proof-of-concept demonstration will come from vertical flight experiments on Laser Lightcraft to significant altitudes where turbulent atmospheric conditions will require precise attitude control. The design from Phase I will be fabricated, tested, and demonstrated under flight conditions. Design iterations will be accomplished based on test data, and analyses will be reviewed and updated to correspond with measured performance and other results.

PHASE III DUAL USE APPLICATIONS: If successful, microthruster attitude control systems will be applicable to trans-atmospheric, laser propelled space launch systems for both military and civil nanosatellites, as well as other very small satellite systems.

REFERENCES:
1. Bielawa, R.L., "Dynamics and Control Analysis of Laser Lightcraft Vehicles," AFRL-PR-ED-TR-99-?, AFRL Propulsion Directorate, Edwards AFB CA, to be published in 1999.
2. Myrabo, L.N. et al., "Transatmospheric Laser Propulsion," Final Technical Report, prepared under Contract No. 2073803 for Lawrence Livermore National Laboratory and the SDIO Laser Propulsion Program, 30 Jun 89.

KEYWORDS: lightcraft, laser propelled vehicle, dual mode, pulsed detonation engine, transatmospheric, single-state-to-orbit, micropropulsion

AF00-222 TITLE: <u>Lightweight, High-Temperature Thermoplastic Case and Motor Insulation for Solid Rocket Motors</u>

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop a new high temperature thermoplastic insulation for solid rocket motors that dramatically increases the high temperature limit and reduces the weight of the insulative material. The polymer should be easily processed and relatively inexpensive to address the cost requirements of the IHPRPT program (see goals in Description section).

DESCRIPTION: Near and long-term material goals for solid rocket motors (SRM's) include replacement of composite and thermoset case and motor insulation with inexpensive, high-temperature polymers that are easily processed (e.g., injection molded, co-extruded). Unfortunately, many high-performance polymers are incapable of withstanding the severe temperatures and/or erosion environment required for SRM insulation. Under the Department of Defense's Integrated High-Payoff Rocket Propulsion Technology (IHPRPT) initiative, dramatic decreases in weight and processing of insulation, along with increased use temperature, is required. For case insulation this amount to a 50°C increase in high-end use temperature, and a 50% reduction in the weight of the material. For rocket motors, reduced ablation of the protective char layer formed upon incineration of the insulation is required. A 50% reduction in ablation would amount to a 44% decrease in insulation weight, and a 6-7% payload increase. For both systems, combining the low-cost, toughness, and processibility of organic polymers with the high-temperature/oxidation resistance properties of inorganic polymers offers an attractive solution to these problems. A variety of hybrid polymer systems are available, and the proposal should address how the combination of properties required will be achieved. An innovative proposal would also include how to combine the dramatically different requirements for case and motor insulation into one polymeric system.

PHASE I: Identify and synthesize candidates for SRM insulation. Tests for use-temperature, decomposition temperature, decomposition products, tensile strength, and small-scale processibility should be performed. Then samples should be classified as being acceptable for case insulation, rocket insulation, or both. Sufficient testing should be done to demonstrate the viability of the candidate materials for their specific application.

PHASE II: Scale-up the selected insulation candidates and conduct intensive thermal and rocket motor tests. Equally important, the ease of processing of the material should be demonstrated, with processing parameters supplied.

PHASE III DUAL USE APPLICATIONS: The resulting high-performance insulation would have great potential for use in aircraft, automotive, electronic, and household appliances/furniture where higher use temperatures are required.

REFERENCES:
1. Jensen, G.E., editor; Netzer, David W. Journal Prog. Astron. And Aeron. Vol. 170, 1996
2. Wu, H.; Xu, J; Liu, Y; Heiden, P.J. Applied Polymer Science, Vol. 72, 1999, pp. 543-552
3. Khan, M.B.; Polymer-Plastics Technology and Engineering, Vol. 35, 1995, 719, pp. 187-206
4. Kuznetsov, G.V.; Rudzinskaya, N.V. Mechanics of Composite Materials, Vol. 33, 1997, pp. 275-281

KEYWORDS: insulation, thermoplastic, lightweight rockets, casing, temperature

AF00-223 TITLE: Rapid Prototyping of High Temperature Ceramic and/or Metal Liquid Rocket Engine (LRE) Combustion via Low Pressure Spray

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Design and fabricate selected liquid rocket engine (LRE) combustion components, such as injectors, thrust chambers, and nozzles or inserts. The resulting components will be fabricated from advanced materials that will survive in an oxidizing environment about 2400 deg C using state-of-the-art Low Pressure Plasma Spray (LPPS) techniques.

DESCRIPTION: Low pressure Plasma Spray (LPPS) techniques are attractive alternatives to current state of practice fabrication methods for Liquid Rocket Engine (LRE) components. Successful application of LPPS techniques to LRE components will allow low-cost near-net shape production of articles such as thrust chambers, injectors, nozzles, inserts, etc. However, the material systems needed to operate in an oxidizing environment above 2400 deg C and the property requirements of the fabricated components, present unique challenges to LPPS. To meet the stringent thermal and mechanical requirements of the LRE environment, the sprayed refractory metal or ceramic must be of near theoretical density and largely stress-free. The LPPS parameters required in the production of complex LRE components meeting these two criteria, for material systems of interest to the rocket propulsion community, are largely unknown.

PHASE I: Perform appropriate analysis and design an appropriate LRE component(s) that takes advantage of the LPPS process and the properties of the materials outlined above. Show ability to manufacture the chosen materials by fabricating test coupons and delivering a single hot-fire test specimen.

PHASE II: Develop, fabricate and upscale component(s) using LPPS technology. Model the thermal spray process in terms of its various parameters.

PHASE III DUAL USE APPLICATIONS: The use of ceramic, refractory metal, and cermet materials have huge industrial potential in the auto, aircraft, medical, and general materials industries. They are, generally, strong, lightweight, and heat resistant. They are however, very expensive. Exploitation of these rapid processing techniques will decrease the cost (by >50%) and manufacturing time (by >90%) of these materials, making them attractive for applications such as automotive engines and aircraft brakes.

REFERENCES: T.N. McKechnie, F.R. Zimmerman and M.A. Bryant, "Vacuum Plasma Spray Applications on Liquid Fuel Rocket Engines," AIAA 92-3527S

KEYWORDS: Low Pressure Plasma, ceramics, metals, oxidation protection, thermal barrier

AF00-224 TITLE: Extraction of Rocket Propellant Physical Properties Via Computed Tomography

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Determine a method for extracting propellant material properties from CT data

DESCRIPTION: The Air Force has invested heavily in Computed Tomography (CT) systems to help maintain its missile fleet. Currently, CT data is used to determine the structural integrity of a motor by detecting any critical flaws during the inspection. Use of non-invasive techniques allows good motors to be returned to the fleet rather than destroyed during testing, saving money and increasing the reliability of the assets. Critical flaws are only one failure mode possible in missiles, however. Rocket motor propellant physical properties (elastic properties, fracture properties, etc) change with time and storage environment and can be the root cause of failure as well.

Currently, the Air Force does not have a reliable, non-invasive technique for determining propellant material properties. Assets must be destroyed, tested, and the results applied in a statistical fashion to the remaining assets. Computed Tomography should be able to non-invasively measure material properties, although how accurately and to what extent has not been fully established. Successful determination of material properties using this technique would allow good motors to be returned to the fleet without the time and cost of destruction and testing.

PHASE I: Determine the feasibility of measuring a propellant's CT signature as a function of mechanical properties and strain. Demonstrate feasibility by comparing CT-gathered data of propellant samples to property data gathered by standard mechanical tests.

PHASE II: Demonstrate reliability of the technique by calculating material properties for a full-scale asset and compare to mechanical (destructive) testing results for that asset.

PHASE III DUAL USE APPLICATIONS: Computed Tomography will decrease the need for destructive testing of military rocket motor assets to determine material properties. The same technology is applicable to industrial materials such as polymers and composites and would decrease industry's need for destructive testing and associated costs.

REFERENCES:
1. Standard Guide for Computed Tomography (CT) Imaging. AS'I'M E-144 1
2. Standard Practice for Computed Tomography (Cry) Examination. ASTM E-1570.
3. Standard Test Method for Measurement of CT System Performance. ASTM E1695.

KEYWORDS: Computed Tomography (CT), Material Properties, Energetic Materials, Propellant, Solid Rocket Motor (SRM), ICB

AF00-225 TITLE: Advanced Materials and Cooling Schemes for Rocket Engine Combustion Chambers

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Identify and demonstrate materials for rocket engine combustion chamber applications with higher heat transfer or higher temperature capability; identify and design cooling schemes for rocket engine combustion chamber applications in a hydrogen/oxygen combustion environment

DESCRIPTION: Current regeneratively cooled rocket engine combustion chambers are relying heavily on copper alloys as a chamber material in contact with the combustion products. Copper offers good heat transfer properties and to some extent reduces the low cycle fatigue seen in the Space Shuttle Main Engines. Future rocket engines will need to operate at higher chamber pressures and temperatures to increase their performance while reducing any losses. In order to accomplish this, better cooling schemes such as transpiration cooling, or better materials with higher temperature capability or heat transfer are necessary. For example, transpiration cooling a rocket engine reduces the chamber wall temperature and potentially extends the life of the chamber while reducing the needed coolant flow. A reduced cooling flow requirement also reduces the pressure requirements on the turbopumps. In another example, for expander cycle engines to further increase their performance, complex cooling schemes or higher heat transfer materials must be developed. Such materials will allow higher-performing, longer-life, reusable chambers. This research and development effort addresses the need to develop high performance rocket engine combustion chambers employing an advanced cooling scheme such as transpiration cooling or higher heat transfer/temperature capable materials that can be cooled using cryogenic hydrogen. This chamber needs to operate at higher pressures and heat loads in a hydrogen/oxygen combustion environment.

PHASE I: Consult with rocket engine, launch vehicle and aerospace vehicle manufacturers to identify material properties, cooling scheme requirements, and manufacturing techniques available for hydrogen/oxygen combustion chambers. b) Identify potential materials, cooling schemes, and manufacturing techniques allowing higher performing combustion chambers. Identify the processes required to prove these schemes are acceptable in this application. c) Formulate several conceptual designs incorporating the cooling scheme for either a 50,000 to 80,000 lb cryogenically cooled engine or as a component for a planned system. d) From among the various conceptual designs select and justify the component with the greatest performance advantage for further development. e) Initiate a preliminary design and test plan for this cooling scheme.

PHASE II:

a) Finalize the design and test plan.
b) Manufacture prototype hardware.
c) Conduct testing in a simulant fluid or actual rocket propellant using test plan to prove the validity of the material or cooling scheme and design.
d) Review results of testing and consult with rocket engine, launch vehicle and aerospace vehicle manufacturers and users.
e) Identify any prototype modifications needed to meet established requirements.
f) Modify design and/or material system as required.
g) Re-accomplish testing as required and create manufacturing plan.

PHASE III DUAL USE APPLICATIONS: The commercial aerospace industry to include aircraft, combined cycle vehicles, and launch vehicles would have widespread use of such a material. Any industry requiring cooling of a surface would greatly benefit from such cooling schemes. Higher heat transfer materials can be applied to several industrial applications such as refrigeration, automotive, and electronics.

REFERENCES:
1. Sutton, George P. Rocket Propulsion Elements: An Introduction to the Engineering of Rockets. 5th Edition, New York: John Wiley & Sons, 1986.
2. Andrus, J.S. and R.G. Bordeau. "Thrust Chamber Material Technology Program," NASA-CR-187207, Aug 86.
3. Kazaroff, J.M. and A.J. Pavili. "Advanced Tube Bundle Rocket Thrust Chamber," Journal of Propulsion and Power, Vol. 8, No. 4, Jul-Aug 1992, pp. 786-791.
4. Popp, M. and G. Schmidt. "Rocket Engine Combustion Chamber Design Concepts for Enhanced Life," AIAA-96-3303, July 1996.

KEYWORDS: rocket, cooling, low cost, high performance, combustion chamber, rocket engine

AF00-226 TITLE: Micro-Newton Thrust Measurement System

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a system to accurately measure thrust performance of propulsion systems for micro-satellites.

DESCRIPTION: The technological challenge is to mitigate thermal effects (drift) on micro-Newton thrust measurement systems. This would result in a thrust measurement system that can measure micro-Newton thrust with micro-Newton to sub-micro-Newton resolution. The micro-satellite propulsion systems will be operated in a space simulation chamber. All controls and recording devices will be external to the chamber and at atmospheric pressure. The system must operate without impacting propulsion system performance. It must be capable of measuring both continuous and single pulses. The measurement system must be able to mount/support the entire propulsion system mass (< 25 kg). The measurement system must have provisions for supplying the propulsion system with two (2) separate gaseous propellant feed lines, 2 pairs of high voltage dc power feeds, 10 low voltage dc instrumentation channels. The sensing apparatus must be able to withstand ultra high vacuum, highly energetic plasmas, and high EMI environments. All chamber feedthroughs must use standard conflat flanges

PHASE I: Demonstrate the feasibility of a micro-Newton thrust stand with the indicated resolution

PHASE II: Demonstrate a completely functional micro-Newton thrust stand. Must include all equipment necessary for calibration, measuring, and recording (via personal computer) thrust.

PHASE III DUAL USE APPLICATIONS: The military uses of this work would be to analyze performance of developing micro-satellite propulsion systems. Commercial uses would also be along the same lines of analyzing developing micro-satellite propulsion systems.

REFERENCES:
1. T.W. Haag, "PPT Thrust Stand," 31st Joint Propulsion Conference and Exhibit, San Diego, California, July 1995, AIAA 95-2917
2. Edward A. Cubbin, et. al., "Laser Interferometry for Pulsed Plasma Thruster Performance Measurements," 24th International Electric Propulsion Conference, Moscow, Russia, September 1995, IEPC-95-195.

KEYWORDS: micro-newton, performance, continuous, pulsed, propulsion

AF00-227 TITLE: Fluid System Nonvolatile Residue Test Process

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center - Launch Programs

OBJECTIVE: Develop a method for testing fluid systems in place (liquid or gaseous interfacing systems) for both hydrocarbon and fluorocarbon residues.

DESCRIPTION: Liquid oxygen and high pressure gaseous oxygen systems in any application are sensitive to contamination by hydrocarbon deposits. Such contamination can easily result in explosion and fires. In the Air Force, many launch vehicles use liquid oxygen as a rocket oxidizer, and hydrocarbon contamination can be catastrophic. At the same time, such systems, as well as interfacing gas systems, use fluorocarbon lubricants such as Krytox as a "LOX (Liquid Oxygen) compatible" lubricant for valves, regulators etc. Though chemically compatible, this material accumulates in the system and can cause clogging and sticking of orifices and mechanisms - especially at cryogenic temperatures. Hence contamination concerns encompass both types of materials. The traditional means of detecting and quantifying these materials has been by solvent rinse of systems with CFC-113 (which readily dissolves both hydrocarbons and fluorocarbons) followed by gravimetric analysis of the rinse. CFC-113 was found to be a Class 1 Ozone-Depleting Substance under the Clean Air Act, and its manufacture by the Montreal Protocol nations was banned after 1995. At this point, no other single solvent has been found which dissolves both types of contaminant and has the other properties needed for nonvolatile residue (NVR) testing. Some progress has been made in finding a dual-solvent combination which may be usable, but a fully developed and demonstrated/proven procedure for using them separately or together is needed. In addition to the solvency requirements, candidate materials must have vapor pressures suitable for low temperature evaporation processes, and be reasonably safe to handle from fire and toxicity standpoints. It should be noted that a completely different alternate technology to the solvent rinse approach is acceptable and even encouraged. The basic requirement is for confident verification of cleanliness of a system to Level A per MIL-STD-1246C.

PHASE I: Phase I shall include investigating potential single/dual solvents for the subject purpose, and performing tests to determine surface contaminant pickup efficiency and gravimetric analysis effectivity. Develop and demonstrate the effectivity of selected solvent(s) in as a field inspection process. Downselect Phase II candidate solvents

PHASE II: Phase II shall select a final solvent(s) and develop a complete procedure for use, along the lines of an ASTM Test Procedure. The procedure shall also be demonstrated successfully on a fluid system with known contaminant levels, either laboratory fabricated or in a field installation.

PHASE III DUAL USE APPLICATIONS: A practical contamination-measuring technique of this type has a large number of potential military and commercial applications, wherever liquid oxygen or high pressure oxygen gas are handled. This would include aircraft systems, submarines, hospitals, welding gas handlers, and air reduction plants.

REFERENCES:

1. Arnold, G. S., Uht, J. C., Nonvolatile Residue Solvent Replacement, Aerospace Report No. TR-95(5448)-1, 1 March 1995, The Aerospace Corporation. Contact Aerospace Corp. Reports Distribution at 310/336-7260.
2. The Development of Methodologies and Solvent Systems to Replace CFC-113 in the Validation of Large-Scale Spacecraft Hardware, NASA-CR-202520, C.A. Clausen, Univ. of Central Florida, Oct. 1996.
3. Beeson, Harold L. and Hornung, Steven, Development of CFC-free Cleaning Processes at the NASA White Sands Test Facility, CPIA Conference Paper, Allied-Signal Tech Services, Las Cruces NM, July 1995.

KEYWORDS: nonvolatile residue, ozone-depleting substance, freon 113, liquid oxygen, hydrocarbon/fluorocarbon solvents, gravimetric analysis

AF00-228 TITLE: Low Cost, High Performance Rocket Motor Technology

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop and demonstrate an innovative new technology for manufacturing next generation rocket motors in a more reliable, safe, cost efficient, and environmentally acceptable manner, while maintaining high performance (>245 lbf-sec/lbm). The payoffs should include reducing manufacturing costs by >50%, increasing mass fraction by 4%, the potential of reducing case weight by 25% and insulation by up to 50%, while reducing hazards.

DESCRIPTION: The Air Force Research Laboratory (AFRL) Motor Branch is seeking to develop and demonstrate an innovative new technology for manufacturing next generation rocket motors in a more reliable, safe, cost efficient, and environmentally acceptable manner, while maintaining high performance (>245 lbf-sec/lbm). The payoffs should include reducing manufacturing costs by >50%, increasing mass fraction by 4%, the potential of reducing case weight by 25% and insulation by up to 50%, while reducing hazards and. The problem with manufacturing high performance rocket motors is that many of the steps are very labor intensive and time consuming, such as assembling and preparing the case mandrel prior to winding the composite case. After the case is cured, the tooling must be disassembled and removed. Once the case is finished, it must be insulated, which often involves laying up the insulation by hand. Then the core tooling must be assembled and prepped before casting then disassembled after propellant cure. It is analogous to building a ship in a bottle only significantly more hazardous when the propellant is added. Past manufacturing method improvements such as winding the composite case over the propellant grain have shown benefits in time and cost savings, as have alternative solid propellant approaches such as Thermal Plastic Elastomer (TPE) propellants and liquid oxidizer/solid binder solution propellants.

PHASE I: Demonstrate the feasibility of an innovative new technology for manufacturing next generation solid rocket motors in a more reliable, safe, cost efficient, and environmentally acceptable manner, while maintaining high performance. Trade and manufacturing studies should show the cost and hazards reduction and mass fraction payoffs. To be considered successful, a subscale solid propellant motor manufactured with the new technology shall demonstrate an Isp of >245 lbf-sec/lbm under standard conditions in a test firing.

PHASE II: Implement the demonstrated approach in manufacturing a larger motor. Perform longer duration motor firings. Perform modeling and trade studies for applications into current DoD systems.

PHASE III DUAL USE APPLICATIONS: Aside from wide-spread DoD applications in missile propulsion and gas generators, high performance, low cost rocket motors would have even wider possibilities for space boosters, satellite propulsion, gas generators and air bag inflators.

REFRENCES:

1. Sutton, G. P., Rocket Propulsion Elements, John Wiley & Sons Inc, New York.
2. http://www.munitions.eglin.af.mil/public/weapflgt.html

KEYWORDS: Low Cost Solid Rocket Motor Manufacture, High Performance Low Cost Solid Rocket Propellant, Low Cost Solid Propellant, Optimized Rocket Motor Manufacture, Reduced Hazards Solid Rocket Propellant, Reduced Hazards Solid Rocket Motor

AF00-229 TITLE: <u>Micro Propulsion Technology Development</u>

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop and validate innovative thrusters, propulsion system components, and/or test capability required for the development and deployment of microsatellite propulsion systems

DESCRIPTION: Many future Air Force and NASA missions will rely on maneuverable microsatellites to increase capability while reducing both launch and fabrication costs. These microsatellites will operate either alone or in fleets to perform such missions as on-orbit satellite servicing, space-based radar, or direct measurements in high-risk areas such as planetary rings. The microsatellites are extremely mass, volume and power limited. For the near-term missions supported by this solicitation, propulsion development is sought for microsatellites with total mass below 100 kg in support of the Air Force TechSat21 flight. Full realization of microsatellite capability is expected to require satellites below 25 kg and 25 W. Therefore, proposed technologies and systems should be able to address both regimes.

The microsatellite missions have requirements for both high thrust maneuvers and high specific impulse maneuvers. For example, high thrust is needed to quickly form a space-based radar formation. Once formed high specific impulse propulsion is required to perform stationkeeping within the propellant mass restrictions. To address this need, the proposed propulsion system may use chemical, solar-thermal, solar-electric, tethers or other novel methods of creating thrust. The objective of this effort is to radically push the technological envelope in the field of micropropulsion. Propulsion system components may include novel propellant storage and feed devices, improved intermediate energy storage for the Pulsed Plasma Thrusters, miniaturized power processing units, etc. For a proposed component, a comparison should be provided between what is currently available and what is proposed, in terms of mass, cost, power requirements, and efficiency. Improved test capabilities that may be proposed include methods for accurately assessing the performance of the micropropulsion devices, with an accuracy comparable to that presently achieved at higher power levels.

For Phase I efforts, a strong emphasis should be placed on the validation of the design that is expected to provide the stated performance enhancements; experimental and theoretical methods can be considered. Government and commercial test and evaluation facilities may be utilized; documentation of efforts to secure these facilities should be provided. Based on the results of these tests, performance should be estimated and improvements quantified.

PHASE I: Develop and validate innovative micropropulsion concepts, components and/or testing capability suitable for supporting satellites with total mass below 100 kg. The proposed concept should also be valid for a microsatellite mass down to the 25 kg or less level. The primary interest is the impact of the developed concept on the propulsion system mass, power requirement, cost and reliability. For a developed testing capability, the primary interest is the impact on the propulsion system developmental costs and time. During Phase I a working bench-top prototype system should be fabricated and tested. Measurements should be made that enable a viable assessment of the impact of developed concept on micropropulsion.

PHASE II: Apply the results of Phase I to the design, fabrication, experimental validation, and optimization of the micropropulsion concept. The design process is expected to be iterative with the best overall design prototype being reproduced and delivered to the Air Force at the end of the Phase II period. For a micropropulsion thruster or system component, the final product at the end of Phase II should be flight-like with a minimal amount of engineering required prior to thermal, vibration, and vacuum testing and spacecraft integration. For a proposed testing capability development, the final product should be a turn-key unit suitable for commercialization

PHASE III DUAL USE APPLICATIONS: Dual use commercialization would occur through the development and validation of flight quality micropropulsion systems for microsatellite and space experiment applications. The development of microsatellites, and their propulsion systems, is one avenue for greatly reducing satellite launch and fabrication costs. The higher performance thrusters will result in greater mission capability including both satellite life and maneuverability, which are areas of interest to government and commercial customers. Both mission capability and profitability will increase through the introduction of these thrusters into the marketplace. The outlook for commercialization therefore appears very strong.

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4. Forward, R.L., and Hoyt, R.P., "Application of the Terminator Tether Electrodynamic Drag Technology the Deorbit of Constellation Spacecraft," AIAA Paper 98-3491, June 1998.
5. Burton, R.L., and Turchi, P.J., "Pulsed Plasma Thruster," J. Propulsion and Power, Vol. 14, No. 5, 1998, pp. 716-735.

KEYWORDS: micro propulsion, electric propulsion, tethers, solar-thermal, chemical propulsion, microsatellites, propulsion, satellites

AF00-230 TITLE: Health Monitoring of Rocket Motors Using Embedded Miniature Sensor Technology

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and implement a cost-effective method of monitoring aging of rocket motors in the field by using embedded sensor technology.

DESCRIPTION: Miniature sensors technology is expanding rapidly with potential use for service life assessment of solid rocket motors (SRMs). Current methods of service life assessment of SRMs require expensive destructive testing to determine existing chemical and mechanical states. Having the capability to determine physical states of SRMs nondestructively would decrease the number of aging propellant assets required for surveillance programs and reduce the costs associated with destructive characterization.

Embedded sensors would be in place for the entire service life of a solid rocket motor. As a result, the sensors must not harm or degrade the aging characteristics, storage life, or operation of the motor over long time periods. The materials in which the sensors would be embedded include solid propellants using any of the typical binders (PBAN, HTPB, CTPB, etc.), liners, insulators, and composite cases.

As aging of solid rocket motors is a complex phenomenon, many properties could be considered for measurement by embedded sensors. These include, but are not limited to, stress, strain, deformation, chemical concentrations, and diffusion in any or all of the above-mentioned materials or at interfaces between materials.

PHASE I: Demonstrate the feasibility of embedded miniature sensors to monitor physical properties and/or chemical state of a solid propellant analog motor.

PHASE II: Implement the demonstrated approach on a SRM. Conduct tests to demonstrate sensor performance. Determine if technology can be integrated into the rocket-based weapon system.

PHASE III DUAL USE APPLICATIONS: Microelectromechanical systems and miniature sensor technology are finding widespread industrial uses. Health monitoring devices used to assess the integrity of components nondestructively is much safer and provides quicker and less expensive evaluation methods.

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1. Fab Shi, Palghat Ramesh, Subrata Mukherjee, "Dynamic Analysis of Micro-Electro-Mechanical Systems," International Journal for Numerical Methods in Engineering, Vol. 39, 1996, pp. 4119-4139.

2. Scott, Marion W., Sandia Microsensor Technologies, Opportunities to Leverage Industrial R&D Resources with Sandia's Technology, Sandia National Laboratories, 1998.

KEYWORDS: microelectromechanical system (MEMS), service life, micro sensors, chemical sensors, solid rocket motor, health monitoring

AF00-231 TITLE: High Maneuverability, Small Chemical Propulsion Systems

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: Develop and validate innovative design concepts for micro-satellites propulsion systems

DESCRIPTION: High thrust small satellites currently utilize storable hypergolic propellant combinations with pressurized feed systems. Propulsion system requirements for this class of satellite are increasing due to large maneuvering requirements and more precision attitude control. Substantial improvements in propulsion system mass fraction are required to increase overall vehicle delta-V capability. The objective of this effort is to investigate alternate propulsion system concepts to increase propulsion system mass fraction. Proposed concepts must show promise for increased propulsion system mass fraction. Projects proposing enhancements to existing systems will also be considered. The propulsion system should be sized for vehicle mass of 20 kg to 50 kg. Main engine thrust levels up to 100 lbf and attitude control thrust levels of 5 lbf. Particular interest lies in reduced toxicity propellants, ignition systems of non-hypergolic propellants (monopropellants or bipropellants) and alternate propellant feed systems.

For Phase I efforts, a strong emphasis should be placed on the validation of the design that is expected to provide the stated performance enhancements; experimental and theoretical methods can be considered. Government and commercial test and evaluation facilities may be utilized; documentation of efforts to secure these facilities should be provided. Based on the results of these tests, vehicle performance should be estimated and improvements quantified.

PHASE I: Develop and validate innovative propulsion components for small satellite (20 kg to 50 kg) applications: primary interests are reduced toxicity propellants, increased propulsion system mass fraction, minimal impact on spacecraft volume, minimal spacecraft contamination, environmental compatibility, and reliability. The focus of the effort should be on space inspection and orbit maneuvering applications.

PHASE II: Apply the results of Phase I to the design, fabrication, experimental validation, and optimization of micro-satellite propulsion components. The design process is expected to be iterative with the best overall performance being reproduced and be deliverable at the end of the Phase II period.

PHASE III DUAL USE APPLICATIONS: Phase III military applications/commercial applications of this technology include maintenance or refueling of satellites to extend their lifetimes, retrieval or salvage of satellites, or removal of dead satellites.

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1. Hawkins, T.W., et al., "High Performance, Reduced Toxicity Monopropellant Development" JANNAF PDCS & SEPS Joint Meeting, April 21, 1998
2. Hawkins, T.W. et al., "Reduced Toxicity Monopropellant Development" JANNAF PDCS & SEPS Joint Meeting, April 29, 1999
3. Barnhart, D.A., et al., "XSS-10 Micro-Satellite Demonstration", AIAA Paper 98-5298, 1998.
4. Rockey, E.D., et al., "Development of a Pump Fed Monopropellant Hydrazine Bootstrap Pressurization System", Final Report AFRPL-TR-70-133, Air Force Rocket Propulsion Laboratory Research and Technology Division, Feb 1971

KEYWORDS: hypergolic propellants, microsatellites, monopropellants, reduced toxicity propellants, ignition systems, pumps, biopropellants

AF00-232 TITLE: Lightweight Low Cost Nozzle for Boost Engines

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Identify and demonstrate materials for lightweight nozzle can be manufactured for boost engines.

DESCRIPTION: To meet current boost-phase engine goals, lightweight low-cost rocket-nozzle concepts must be improved. The SBIR effort should identify materials and prove key design and fabrication parameters, which will allow a significant lead-in to a future laboratory or commercially funded program. The goal is a 45% weight reduction in nozzle weight relative to the Space Shuttle Main Engine (SSME) baseline nozzle (1395 lbs.).

PHASE I: a) Consult with rocket engine, launch vehicle, and aerospace vehicle manufacture to identify beneficial rocket nozzle integration concepts for current or planned vehicle propulsion systems. b) Identify the rocket nozzle performance requirements or desires for such systems. c) Formulate several lightweight, low manufacture cost nozzle conceptual designs, which support the identified requirements/desires. d) From among the conceptual designs, select and justify the rocket nozzle concept with the greatest overall (performance, weight, cost, operations, maintenance, etc.) benefit to the current or planned vehicle system. e) Initiate a preliminary design and test plan for this new design

PHASE II: a) Finalize the design and test plan. b) Manufacture prototype hardware. c) Conduct testing in a detailed simulation-using test plans to prove the validity of the material and design. d) Review results of testing and consult with rocket engine, launch vehicle and aerospace vehicle manufacturers and users. e) Identify any prototype modifications needed to meet established requirements/desires. f) Modify design as required. h) Re-accomplish testing as required and creates manufacturing plan

PHASE III DUAL USE APPLICATIONS: DUAL-USE APPLICATIONS: New rocket nozzle designs are in demand in both the civil and military launch vehicle markets. We recognize the technology advancements in cost, weight reduction, and performance improvement that need to be applied to today's space vehicles. One of the major drivers in weight, cost, and performance is the nozzle component. Improvements here will show significant payoff in launch vehicle cost, both commercially and military, across the board.

REFERENCES:

1) Batchelor, J.D., "Castable Carbon for Nozzle Applications," AFRPL-TR-66-11, Atlantic Research Corp, Alexandria, VA, Jan 1966. [AD: 369071]

2) Huzel, Dieter K, and Huang, David H., "Modern Engineering for Design of Liquid-Propellant Rocket Engines," AIAA Progress in Astronautics and Astronautics Series, Volume 147, pp 67 - 104, 1992.

3) Sutton, George P., "Rocket Propulsion Elements An Introduction to the Engineering of Rockets," Sixth Edition, pp 41-88 and pp 281-298, 1992.

4) NASA SP-8120, "Liquid Rocket Engine Nozzles," July 1976, Available through National Technical Services.

KEYWORDS: lightweight, nozzle, rocket engine, launch vehicle, boost engine

AF00-233 TITLE: High Purity Solvent Processing for Nonvolatile Residue Testing

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space and Missile Systems Center - Launch Programs

OBJECTIVE: A methodology for small-scale purification of solvents for nonvolatile residue (NVR) testing.

DESCRIPTION: Liquid oxygen and high-pressure gaseous oxygen systems (in any application) are sensitive to contamination by hydrocarbon deposits. Such contamination can easily result in explosion and fires. In the Air Force, many launch vehicles use liquid oxygen as a rocket oxidizer, and hydrocarbon contamination can be catastrophic. At the same time, such systems, as well as interfacing gas systems, use fluorocarbon lubricants such as Krytox as a "LOX (Liquid Oxygen) compatible" lubricant for valves, regulators, etc. Though chemically compatible, this material accumulates in the system and can cause clogging and sticking of orifices and mechanisms - especially at cryogenic temperatures. Hence contamination concerns encompass both types of materials. The traditional means of detecting and quantifying these materials has been by solvent rinse of systems with CFC-113 (which readily dissolves both hydrocarbons and fluorocarbons) followed by gravimetric analysis of the rinse. CFC-113 was found to be a Class 1 Ozone-Depleting Substance under the Clean Air Act, and its manufacture by the Montreal Protocol nations was banned after 1995. Some progress has been made in finding a dual-solvent combination that may be usable, but a source for the solvents with adequate purity is needed. Because of the very limited demand for such high purity solvents, they are not commercially available. Logically, any facility that uses the NVR (Nonvolatile Residue) test should be able to prepare the test solvent(s) from reagent-grade chemicals when and as needed in an economical manner. For purposes of this effort, the solvents will be (1) ethyl acetate, (2) cyclohexane and (3) AK225 (Asahi Chemical) and the purity requirement will be 1.0 mg/liter of NVR maximum, with a goal of 0.1 mg/l.

PHASE I: Develop and demonstrate a scalable preproduction method for purifying small amounts (1 to 10 gallons) of each solvent to the required purity on a repeatable basis. Equipment may be commercial, modified commercial, or new design, selected for ease of operation, cost effectiveness and repeatability.

PHASE II: Develop/document/demonstrate a cost effective production process for purification technique(s) and equipment for solvents 1 through 3 and others. Include data on purity verification and storage requirements to maintain purity and chemical stability.

PHASE III DUAL USE APPLICATIONS: A practical NVR test solvent preparation technique of this type has a large number of potential military and commercial applications, wherever liquid oxygen or high-pressure oxygen gas is handled. This would include aircraft systems, submarines, hospitals, welding gas handlers, and air reduction plants.

REFERENCES:

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2. The Development of Methodologies and Solvent Systems to Replace CFC-113 in the Validation of Large-Scale Spacecraft Hardware, NASA-CR-202520, C.A. Clausen, Univ. of Central Florida, Oct. 1996.
3. Beeson, Harold L., Hornung, Steven, Development of CFC-free Cleaning Processes at the NASA White Sands Test Facility, CPIA Conference Paper, Allied-Signal Tech Services, Las Cruces NM, July 1995.

KEYWORDS: nonvolatile residue, high purity, solvent, processing, hydrocarbon/fluorocarbon solvents, gravimetric analysis

AF00-235 TITLE: Kinematic Carrier Phase Tracking and Attitude Estimation with GPS in an Interference Environment

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Global Positioning System (GPS)

OBJECTIVE: Demonstrate GPS Attitude Determination and Kinematic Carrier Phase Tracking with a Controlled Reception Pattern Antenna/Electronics (CRPA) in an Interference Environment.

DESCRIPTION: The ability to: 1) perform carrier phase tracking and attitude determination with GPS (Global Positioning System) in a benign environment and 2) to use a phased array of antenna elements for spatial filtering of jammers by adjusting the gain and phase of each antenna element is well known in military GPS systems. As military and civil systems attempt to become more interference resistant and used for more precision applications, the need to perform carrier phase tracking and attitude determination in the presence of interference will become a requirement. A case in point is the planned use of Kinematic Carrier Phase Tracking for JPALS (Joint Precision Approach and Landing System) to obtain centimeter levels of accuracy. Carrier phase measurements from multiple antenna elements (e.g., Controlled Reception Pattern Antenna or CRPA) can also be used for attitude determination. However, after the phase adjustment of the signal by an anti-jam spatial filter (Antenna Electronics or AE), attitude determination presents a serious challenge. The very same carrier phase measurements needed for attitude estimation have been adjusted in gain/phase for jammer attenuation. The future trend in low-cost navigation systems is to go to MEMS (Micro-Electro-Mechanical Systems) IMUs. MEMS IMUs will require continuous calibration of their associated systematic errors. The continuous calibration process in a GPS/IMU navigation system normally relies on the dynamic coupling of the IMU (acceleration) errors into position and velocity errors for observability. This becomes more difficult during low acceleration dynamics, because the acceleration-sensitive errors in the IMU are not excited. Another observable that can be used to maintain calibration of the IMU is attitude knowledge. Additional measurements from low-power attitude sensors may be aided with GPS attitude to provide continuous attitude observables with which to maintain IMU calibration. This will permit the use of Ultra-tight GPS/IMU coupling with MEMS IMUs in a jammed environment, which has been proposed as one solution to anti-jam.

PHASE I: 1) Conduct a theoretical analysis of performing carrier phase tracking/GPS attitude estimation in the presence of jamming. 2) Define spatial/temporal/spectral processing that would be applied to the data from each element of a CRPA to establish a baseline 3) Define signal processing required to perform carrier phase tracking in the presence of jamming. 4) Combine carrier phase data with other aiding sensors to perform attitude determination in the presence of jamming.

PHASE II: Implement Phase 1 approach. Demonstrate/verify performance using realistic GPS and jammer signals in prototype hardware. The architecture of the Phase II system must be adaptable to an operational configuration.

PHASE III DUAL USE APPLICATIONS: The signal processing for this technology will have wide application in future, DoD and commercial precision applications.

REFERENCES:

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2. A Complete GPS/INS Integration Technique Using GPS Carrier Phase Measurements by Kim, Jee and Lee, PLANS '98 Proceedings pp. 526-533
3. The Enhancement of INS Alignment Using GPS Measurements by Park, Kim, Lee, Park, Jee and Oh, PLANS '98 Proceedings pp. 534-540

KEYWORDS: Carrier Phase Tracking, GPS Attitude Determination, GPS/IMU Navigation System, Spatial Filtering of Jammers, MEMS IMUs

AF00-237 TITLE: Ultraminiature Laser-Based Atomic Clocks (ULAC)

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Global Positioning System (GPS)

OBJECTIVE: Develop/Apply Ultraminiature Laser-Based Atomic Clocks to GPS Receivers.

DESCRIPTION: The use of GPS receivers under battlefield conditions can be restricted by: signal jamming; an obscured view of the sky which may prevent acquisition of enough satellites; and after loss of contact with a satellite, time for reacquisition may be too long. Placing an ultraminiature laser-based atomic clock (ULAC) on GPS receivers would mitigate all of the above conditions and allow for direct-Y code acquisition capability, resulting in a more reliable receiver which could be used in applications which push current technological boundaries. Y-code signal is the GPS P-code signal encrypted for Military, Special Operations and other classified DoD users. The development of a ULAC is to aid military acquiring Y-code directly, whereby, minimize military dependency on Coarse Acquisition (C/A) code. Atomic clocks suitable for use in GPS receivers for battlefield applications, such as smart weapons, portable receivers, etc., need to be very small, consume little power, have short warm-up time and high frequency accuracy. Innovative technology will be required to develop such devices. Microcomputer-controlled quartz-crystal oscillators (MCXO) are alternative small-size, low power clocks for the above applications, but they have frequency stability's lower than those achievable from miniature atomic clocks. Major ULAC issues to be corrected, prior to GPS application, include resolution of causes of long-term frequency instability and development of methods to minimize long-term frequency noise. Clock dynamics following turn-on (warm-up and accuracy issues) is an area in which little is known, and must be developed. Quantitative goals are a clock that uses 600Milliwatts or less in a -55 degrees Celsius to 60 degrees Celsius, has a volume of 40 Cubic Centimeters or less, and has a total variance no greater than 1.0 X 1.0 E -12 seconds for Tau greater than 1000 sec. and less than 90,000 sec. Production unit costs should be less than $900 for lots of 6000 or greater.

PHASE I: 1) Explore applicable analytic theory and physical component requirements to develop/apply Ultraminiature Laser-Based Atomic Clocks to GPS receivers. 2) Determine causes/remedial methods in reference to the constraints specified in "Description" above. 3) Down select a clock design from several candidate configurations. 4) Demonstrate basic clock functions by means of a breadboard demonstration unit.

PHASE II: Upon successful completion of phase I, finalize design and manufacture a prototype ULAC. Demonstrate the prototype clock to mutually (Air Force/contractor) agreed/configurations/specifications.

PHASE III DUAL USE APPLICATIONS: Ultraminiature Laser-Based Atomic Clocks can be used in both DoD and commercial aircraft, space vehicles and ground stations in the future. As the Radio Frequency (RF) communication spectrum gets more and more crowded with consumer-market wireless users, having very accurate time and frequency control available in devices such as cell phones, RF modems, smart pagers, etc., will allow much more efficient use of the RF spectrum (i.e., more users and more varied applications). That has a much wider market impact than direct -Y acquisition.

REFERENCES:
1. P.J.Chantry, B. R. McAvoy, J. M. Zomp and I. Liberman, "Towards a miniature laser-pumped cesium cell frequency standard," Proceedings of the 1992 IEEE Frequency Control Symposium, pp. 114-122 (IEEE Press, 1992).
2. G. Mileti, J. Deng, F. L. Walls, D. A. Jennings and R. E. Drullinger, "Laser-pumped rubidium frequency standards: new analysis and progress," IEEE Journal of Quantum Electronics, Vol. 34, pp. 233-237, 1998.

KEYWORDS: GPS Receivers, Direct Y Code, Frequency Instability, Ultraminiature Laser-based Atomic Clock, Quartz-crystal Oscillators (MCXO), Long Term Frequency Noise

AF00-238 TITLE: Automatic Cartographic Data Translation and Registration

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Global Air Traffic Management (GATM) System Program Office (SPO)

OBJECTIVE: Develop a capability that uses data from national assets to develop instrument approach/departure procedures for tactical and special mission operations.

DESCRIPTION: The need exists to provide a near real-time capability to develop instrument approach and departure procedures for tactical and special missions, where little or no current mapping or imagery data exists. The capability, to collect imagery and mapping data required to develop instrument approach and departure procedures, exists today from national assets (e.g., Satellite Data, Joint STARS Data, Unmanned Aerial Vehicles Data, Etc); although the translation of this data into a usable format, to develop the instrument approach and departure procedures, does not exist. Algorithms need to be developed, that translate this data into the information necessary to develop the instrument approach and departure procedures.

PHASE I: Phase I activity shall include (among other issues): 1) A thorough review of the data required to prepare instrument approach and departure procedures to include resolution and accuracy requirements; 2) a review of current data collection assets that have the potential to collect the identified data within 24 hours; 3) and an approach on how to translate the data.

PHASE II: Phase II activity shall include (among other issues); 1) tradeoff analysis that identifies the value of the data versus the time to acquire the data 2) development of the algorithms 3) prototype demonstration of the capability.

PHASE III DUAL USE APPLICATIONS: Instrument approach and departure procedures are used in every airport throughout the world. This capability could be implemented in civil procedure development.

REFERENCES:
Multiple Database Integration and Update (MDBIU)
POC Jim McNeily, AFRL/IFEA (315) 330-2110
Email: mcneely#m#_Jim@irdpost.ird.rl.af.mil

KEYWORDS: Cartographic Data Translation and Registration, Instrume45, NT Approach and Departure Procedures, Mapping or Imagery Data from National Assets

AF00-239 TITLE: High Sensitivity LWIR and MMW Sensor Fusion on One Chip

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop a true sensor fusion array combining LWIR and MMW band passive imaging in a single focal plane array.

DESCRIPTION: There is a need for systems incorporating long wavelength infrared (LWIR) and millimeter wavelength (MMW) detection capability in the same focal plane array (FPA) chip. Both military and commercial sensor and surveillance systems currently face the limitations of size, weight and cost. The areas of commercial adverse-weather navigation/guidance and object recognition/identification, mid-course detection and discrimination, and space-based surveillance would benefit from sensors with high resolution, low power, reduced weight, robustness and lower cost. Though the technology is ready to provide such sensors, working hardware has not been achieved. Innovation is needed to achieve true sensor fusion, where the information from multiple bands is fused at the sensor, rather than combined further downstream in the data flow. Some performance needs include low thermal time constants, fast frame imaging rates around 1kHz, wide bandwidth, and in situ image processing and data multiplexing.

A focal plane array and processing electronics should be capable of a noise equivalent temperature difference < 0.05 °K for LWIR and < 0.5 °K for MMW detection. Atmospheric sensors should be capable of receiving images through clouds and turbulence, should deliver real-time images, and have outputs compatible with conventional multiplexing architectures. Space-based sensors, in addition, should have high data processing capability, and power and weight requirements lower than currently available configurations. Dual mode sensor fusion assemblies, as opposed to true sensor fusion configurations, will not meet this topic's requirements, because the dual sensor arrays have size, weight, and cost, which are too high.

PHASE I: The phase I activity shall include, but not be limited to, the design/fabrication/demonstration of a proof-of-concept sensor assembly. One potential sensor configuration (among others) might consist of a blocked-impurity-band-type detector, or bolometer, merged with a micromachined cavity waveguide thermal sensor and two band processing electronics. The bands most appropriate would be in the MMW and LWIR range.

PHASE II: Based on the developments in Phase I, the Phase II activity will design/fabricate/demonstrate a true sensor fusion assembly amenable to assembly-line production. For various applications, the FPA chip design shall be merged with multiplex signal processing architecture electronics allowing flexibility to address mutually (Air Force/contractor) agreed applications such as: 1) smart target vs. decoy identification; 2) fast-frame imaging in the LWIR and MMW bands; 3) filtering and imaging in the mid-wavelength infrared (MWIR) (3-5μm) range; 4) filtering and imaging in both LWIR and MWIR colors for discrimination and long range detection of selected objects independent of weather; 5) active and passive modes; 6) comparisons with stored reference images. Performance specifications, performance test data reports, and information on specialized test equipment shall be documented for the agreed applications.

PHASE III DUAL USE APPLICATIONS: The basic sensor fusion/processing arrays developed in Phase II, together with application specific versions, will significantly enhance air traffic control, vehicle traffic control, satellite-borne surveillance, and aircraft landing site stored image vs. pilot view operations.

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3. G. M Rebeiz, et al., "Monolithic Millimeter-Wave Two-Dimensional Horn Imaging Arrays," IEEE Transactions on Antennas and Propagation, Vol. 38, No. 9, pp. 1473 1482, Sep 1990.

KEYWORDS: Long Wavelength Infra-Red (LWIR), True Sensor Fusion, Micromachined Cavities, Millimeter, Wavelength (MMW), Fast Frame Imaging, Multiplexing Architectures

AF00-240 TITLE: Analog-to-Digital Converter Development

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Airborne Communication Node (ACN); Global Positioning System (GPS); and Military Satellite Communications (MILSATCOM)

OBJECTIVE: To investigate and comprehend the complex balance associated with assembling digital receivers for multi-platform applications.

DESCRIPTION: The manufacturing of receivers with more digital components is an effort to bring the digitization functions closer to the antenna portion of the receiver and reduce the number analog receiver components which tend to be temperature sensitive. This can result in a higher performance (dynamic range > 80 dB; bandwidth > 100 MHz) digital receiver that meets the demands evolving commercial and military applications. One example of this pertains to global positioning satellite (GPS) receivers, which must operate effectively against higher (120 dB) jamming-to-signal ratios (J/S). Another is the development of space-based communication and radar functions which minimally require the greater bandwidth mentioned above plus increased distributed processing capability (> 5 GOPS). A compact digital receiver will play a key role as the preliminary signal-processing hub integrated to the ground-based or space-based sensor.

Although efforts have made to reduce the size, weight and power of digital receivers on aircraft platforms, all of these factors need to be reduced by at least an order of magnitude for ground-based and space-based operations. An important aspect of a hand-held or space-based digital receiver is the reduction of power in the components, which comprise the digital receiver. This includes components such as RF filters and amplifiers, mixed-signal electronics, digital signal processing electronics, and associated power converters/conditioners. These electronics also must consider the aspect of being capable of reliable operation within unique environments for at least ten years. Initially, a trade-off study should look at the eventual demonstration of a digital receiver which dissipates less than 10 Watts of power and have all of its electronics operate from a single power supply with point of load power distribution designed into the digital receiver components. Emphasis needs to be placed on balancing the performance versus power aspects of the analog-to-digital converters (ADCs), which can dissipate up to 50% of the receiver's total power.

PHASE I: Complete tradestudy examining the assembly and packaging of the necessary components required to have a functional digital receiver operate within a ground and/or space environment at a power dissipation level of less than 10 Watts. Identify the commercial uses for such a digital receiver. Effort should concentrate on the development of a high performance (resolution > 12 bits, sample rate > 200 Msps), reduced power dissipation (< 3 Watts) ADC, as it often dictates the overall receiver design. Examination of advanced device technologies (e.g., SiGe HBT, GaAs CHFET, InP HBT, etc.) coupled to unique mixed-signal circuit architectures (e.g., sigma-delta, sub-ranging, pipeline-interleaving, etc.) is appropriate in order to achieve the necessary ADC operating specifications and drive a high performance digital receiver solution.

PHASE II: Assembly and test of a prototype digital receiver for either ground or space as determined through component and packaging tradestudy. Reliability data must be gathered with predictions as to the receiver lifetime and which components are most likely to fail under unique environment operation. Cost analysis of the digital receiver unit must demonstrate applicability to commercial and military platforms and should drive the necessity for continual improvement to the receiver's critical components.

PHASE III DUAL USE APPLICATIONS: Advancements to hand-held GPS units could provide more widespread insertion of navigation units into automobiles. Performance improvements to ADCs will always be of great interest to the cellular communications industry. Space satellite communications would benefit greatly from reduced power digital receivers with increased functionality and programmability. Encourages vendors of space qualified electronics to improve their specifications recognizing that increased bandwidth and data transmission in space is of future commercial need.

REFERENCES:
1. "Miniature Digital Receiver Technical Interchange Meeting Report", Air Force Contract F33615-95-2-1768, March 1998.
2. Robin Getz, "Single-Slope A-D Conversion for High-Resolution Measurements", Computer Design, V. 34 (Nov. 1995), pp. 112-114.

KEYWORDS: Digital GPS Receivers, RF (Radio Frequency), ASIC (Application Specific Integrated Circuit), ADCs (Analog-to-Digital Converters), J/S (Jamming-to-Signal Ratios), Space Qualified Electronic Component

AF00-241 TITLE: Improved Spacecraft Telemetry, Data Acquisition Systems

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: Develop a user-configurable analog signal processing/data conversion array to improve integration/reliability/radiation tolerance of spacecraft telemetry data acquisition systems.

DESCRIPTION: Acquisition of analog components suitable for spacecraft telemetry signal conditioning and data acquisition systems remains especially difficult for many satellite programs which must operate in either radiation-hardened or radiation-tolerant environments. Radiation-hardened analog component types, in many instances, cannot be found. Instead, in many cases commercially produced components are screened on a lot basis for radiation tolerance, and with appropriate mitigation techniques, can be used under certain program- specific circumstances. This approach is time consuming, expensive, risky, and yields program-specific, low-integration solutions to the general problem of spacecraft telemetry data acquisition systems. This development is intended to result in a modular, user- configurable analog signal conditioning and data conversion array with application to telemetry and potentially other satellite systems (possibly termed as a "Field Programmable Analog Array," FPAA). Just as the radiation-hardened Field Programmable Gate Array (FPGA) has solved certain satellite digital implementation issues, the FPAA seeks to solve analog implementation issues for satellite telemetry signal conditioning and data acquisition systems. Each module of the array has several analog components which can be internally connected together (or simply not used), as the user decides, after most or all circuit fabrication steps have been completed. Some components in the module may have user- selectable options (such as gain). The resulting circuits are not expected to be high-performing, but should be adequate for telemetry systems. The array modules inputs and outputs may be interconnected to each other within the array. The number of modules per array may be small, and the number of module types is expected to be few. The user configuration may be volatile, non-volatile, or mixed. Another product of this effort is a design environment, which allows the user to design the program-specific circuit within the array, accurately model its performance, and facilitate programming of the array.

PHASE I: Phase I activity shall include: 1) investigate current modular, user- configurable analog data acquisition components, 2) determine a set of requirements which would satisfy many spacecraft telemetry signal conditioning and data acquisition systems, 3) perform tradeoffs and define an appropriate architecture, 4) develop a plan to design, fabricate and characterize a prototype, 5) determine requirements for a Computer Aided Design (CAD) environment which predicts user-configured performance in a standard, widely useable output (i.e. Spice model), 6) develop a plan for the user to configure the array, with rapid turnaround and 7) provide breadboard demonstration of basic principles.

PHASE II: Develop, fabricate, characterize and deliver prototypes, including: 1) detailed design and simulation of the array architecture, 2) fabrication, test, and detailed characterization/demonstration of several array prototypes, 3) delivery of prototypes for customer, and user evaluation, 4) develop a user-environment to design, model, and define configuration of the array, which can interface with industry-standard tools, 5) develop a plan for the user to configure the array, and facilitate customer programming of prototypes for evaluation, 6) develop a plan to migrate the design to a radiation-hardened production facility.

PHASE III DUAL USE APPLICATIONS: The Array should be useful for the large number of commercial satellites planned for the near future. The Array (produced on regular, non-rad tolerant processing lines) would have broad applicability for manufacturing, automotive, and energy production industries.

REFERENCES:
1. Julio Faura, Chris Horton, et al., "A New Field Programmable System-on-a-chip for Mixed Signal Integration," European Design & Test Conference 1997, http://www.sidsa.es/fipsoc_r.htm.

2. Robert C. Moore, Spacecraft Command and Telemetry, In: Fundamentals of Space Systems (A94-34826 11-12), New York, Oxford University Press, p. 601-627, 1994.

KEYWORDS: Spacecraft Telemetry, Field Programmable Gate Array (FPGA), Circuit Fabrication, Program-Specific Circuit, Analog Components, Array Modules

AF00-242 TITLE: Low Power InP MMICs for Low Noise Receivers

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: To minimize the dc power consumption in phased array receive antennas by circuit design and device modifications.

DESCRIPTION: Phased array antennas provide multiple beam opportunities with agile scanning capability. Arrays for satellite receivers will contain several hundred elements to allow the formation of narrow beamwidths. These arrays will dissipate excessive power unless the dissipation per element is low. Unfortunately, low power dissipation is hard to maintain with stringent requirements on noise figure (NF) and intermodulation products (IP3). Paths to reduced power dissipation have included the use of indium phosphide (InP) technology with low drain voltage and series-connected devices that share drain current. These and other techniques such as feedback and use of hybrid technologies can be used to reduce dc power consumption while maintaining suitable NF and IP3 capabilities. The intent of this program is to explore the best approach to achieving minimum (phased array antenna element) power dissipation and demonstrate the level of performance that can be achieved in associated low noise amplifiers for satellite application at 44 GHz.

PHASE I: The first phase of this program will include a study of ways to reduce power consumption through innovations in circuit design and device modifications. This will lead to the establishment of dc power goals for Microwave Monolithic Integrated Circuit (MMIC) technology as a function of NF, gain, bandwidth, IP3 and frequency. Specific goals will be projected for a mutually agreed (Air Force/Contractor) receive array. Also, a plan and working relationship with a foundry will be developed to demonstrate the performance of circuit concepts at N4MIC level and to implement any proposed device modifications.

PHASE II: Based on the receive array selected in Phase 1, mask sets will be designed using foundry design rules, novel circuit concepts and simulations to produce low power, low noise MMIC performance at 44 GHz. Wafer lots will be fabricated and tested to demonstrate performance. Devices will be tested in Radio Frequency (RF) fixtures but a complete module design will not be required. Proposed device design innovations will be evaluated and introduced into the foundry process if found to be advantageous.

PHASE III DUAL USE APPLICATIONS: Phase III is the process of completing the development of a product to make it commercially available. Military applications account for less than a third of the present III-V semiconductor device market. Commercial applications include personal telecommunications systems, wireless local area network, automobile sensors, security systems, and intelligent highway systems.

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1. Lo, D. C. W., et al. "A High-Performance Monolithic Q-Band InP-Based HEMT Low-Noise Amplifier," IEEE Microwave and Guided Wave Letters, vol. 3, pp 299- 301, 1993.
2. Kobayashi, K. W., et al. "A 44 GHz InP-Based HBT Double-Balanced Amplifier with Novel Current Re-Use Biasing," in IEEE MTT-S Int. Microwave Symp. Dig., 1998.
3. Kobayashi, K. W., et al. "The Voltage-Dependent IP3 Performance of a 35-GHz InAlAs/InGaAs-InP HBT Amplifier," IEEE Microwave and Guided Wave Letters, vol. 7, pp 66-68, 1997.

KEYWORDS: Phased Array Antennas, Noise Figure (NF), Inter-nodulation Products (IP3), Microwave Monolithic Integrated Circuit (MMIC), Feedback, Hybrid Technologies

AF00-243 TITLE: Antenna Control Computer for TT&C Phased Array Antenna

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Air Force Satellite Control Network (AFSCN)

OBJECTIVE: Develop/demonstrate a low-cost processor and associated software that will provide antenna control for TT&C operations in satellite control.

DESCRIPTION: Phased array antenna offers improved performance over the existing parabolic dish antenna presently used in ground stations for satellite control. However, high phased array cost due to stringent tracking, telemetry and commanding (TT&C) requirements (hemispherical coverage, simultaneous transmit and receive, multiple beams, and high gain/noise temperature (G/T)) prevent it from adapting for satellite control application. There is no phased array control computer in existence today that can support control of phased array antenna for TT&C operation. The objective of this research is to develop a low cost array control processor and software for phased array antenna in support of satellite TT&C operations such as the Air Force Satellite Control Network (AFSCN). This antenna control computer should be capable of performing antenna monitoring, diagnostic, beam steering and scheduling, as well as other command and control functions. It should also be able to interface with ground station satellite operations control through a communication network and input/output units for operator interface. Successful development of a low cost array control processor will provide a key element in the implementation of an affordable, multi-beam, conformal phased array antenna for simultaneous multiple satellite control operations.

PHASE I: Phase I activity shall include: (1) develop general performance, software and data processing requirements for supporting TT&C operation; (2) identify and assess technical issues associated with the selection of different control approaches; (3) design candidate software and processor architectures which can provide a range of operating modes from minimal impact to the existing ground station to full utility of phased array antenna capabilities. Alternative control and beam scheduling concepts will be assessed in terms of their effectiveness, cost, portability and expandability. Rank candidate designs for Phase II selection and implementation.

PHASE II: Based on the results of Phase I, the contractor shall: (1) select two most promising software and processor designs for further trade-offs on throughput, coding complexity, cost, operational flexibility, etc.; (2) employ incremental software and hardware-in-the-loop simulation to predict the effectiveness of the two candidates for antenna control operations; (3) down-select to a single design and implement a control processor to interface with a simulated subarray of 64/128 elements; (4) test and evaluate the performance of processor and software against various operational scenarios; (5) analyze the feasibility and performance of integrating the antenna control computer into a full-scale conformal array for AFSCN satellite control operation; and (6) assess the required modifications of the existing AFSCN ground station elements and operations as a result of replacing existing dish antennas with phased array antennas.

PHASE III DUAL USE APPLICATIONS: The antenna control computer developed in this research is equally applicable to both commercial and military satellite control operations. Low-cost phased array antennas are capable of improving commercial satellite control network performance and reducing maintenance and operational cost.

REFERENCES:

1. Liu, S. F., Survey of Phased Array Antenna for AFSCN Application, May 1998. Available from S. F. Liu, The Aerospace Corp., P.O. Box 92957, M5/656, Los Angeles, CA 90009-2957; Telephone 310/336-7670, FAX: 310/336-0562

2. Tomasic, B., Analysis and Design Trade-Offs of Candidate Phased Array Architectures for AFSCN Application, Presentation to the Second AFSCN Phased Array Antenna Workshop, Hanscom AFB, 31 March – 1 April 1998. Available from Dr. B. Tomasic, Telephone 781/377-2055, FAX: 781/377-5040.

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7. The Air Force Satellite Control Network Capabilities Document, Aerospace Corporation TOR-96(1567)-2, September 1996. Contact Aerospace Corp. Reports Distribution at 310/336-7260; Address: ATTN: Reports Distribution, The Aerospace Corporation, P. O. Box 80966, M1199, Los Angeles, CA 90080-0966.

KEYWORDS: Satellite Control, Conformal Phased Array Antenna, Beam Scheduling, Beam Steering, Beamforming Computation, TT&C

AF00-244 TITLE: <u>Low Cost T/R Module for TT&C Phased Array Antenna</u>

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Air Force Satellite Control Network (AFSCN)

OBJECTIVE: Develop/demonstrate the feasibility of low-cost T/R modules to support tracking, telemetry and commanding (TT&C) operations in satellite control.

DESCRIPTION: Phased array antenna offers improved performance and reduced operational and maintenance cost over the existing parabolic dish antenna presently used in ground stations for satellite control. However, high phased array cost due to stringent TT&C requirements (hemispherical coverage, simultaneous transmit and receive, multiple beams, and high gain/noise temperature (G/T)) prevent it from adapting for satellite control application. An affordable active transmit/receive (T/R) module suitable for such application does not exist today. The objective of this research is to develop low cost T/R module technology for phased array antenna in support of satellite control operations, such as in the Air Force Satellite Control Network (AFSCN). Candidate modules will have dual-band (L and S), simultaneous transmit and receive, and switchable right-hand/left-hand (RH/LH) circular-polarization capabilities. This research will materially contribute to the implementation of an affordable, multi-beam, conformal phased array antenna for simultaneous multiple satellite control operations.

PHASE I: Phase I activity shall include: (1) develop module design requirements for supporting TT&C operation; (2) identify and assess technical issues that will impact the selection of constituent components and module architectures; (3) specify the required performance parameters of the T/R components such as phase shifter, power divider/combiner, power amplifier (PA), 90 deg hybrids, filter/limiter, variable attenuator, low noise amplifier (LNA), beamsteering controller, interface to beamforming network and array elements, power supply, etc.; and (4) design low cost (less than $100/module) candidate T/R modules. Component and module design concepts will be assessed in terms of their performance, cost, manufacturability, reliability and maintainability. The module must accommodate multi-layer RF beamforming network for two simultaneous independent, transmit and receive beams with full duplex operation. The module shall also be constructed as a line replacement unit to support hot maintenance requirement. Rank candidates for Phase II selection and fabrication.

PHASE II: Based on the results of Phase I, the contractor will: (1) select two most promising T/R module designs, (2) perform numerical simulation and refine design trade-offs on performance, packaging, cost, manufacturability, reliability, adaptability, etc.; (3) down-select to a single design and fabricate four T/R modules; (4) test individual T/R modules and compare the measured with simulated results; (5) develop efficient manufacturing process, test and quality control for large quantity production; and (6) perform realistic production cost and timeline analysis.

PHASE III DUAL USE APPLICATIONS: The T/R modules developed in this research are equally applicable to both commercial and military satellite control operations. Low-cost phased array antennas are capable of improving commercial satellite control network performance and reducing maintenance and operational cost.

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1. Liu, S. F., Survey of Phased Array Antenna for AFSCN Application, May 1998. Available from S. F. Liu, The Aerospace Corporation, P. O. Box 92957, M5/656, Los Angeles, CA 90009-2957; Telephone: 310/336-7670; FAX: 310/336-0562.
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3. Wu, T. K., "Phased Array Antenna for Tracking and Communication with LEO Satellites,"1996 IEEE International Symposium on Phased Array Technology, Boston, MA., Oct. 1996.
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6. Air Force Satellite Control Network Space/Ground Interface, Aerospace Corporation TOR-0059(6110-01)-3, Rev. I, March 1992. Contact Aerospace Corporation Reports Distribution at 310/336-7260; Address: ATTN: Reports Distribution, The Aerospace Corporation, P.O. Box 80966, M1199, Los Angeles, CA 90080-0966.
7. The Air Force Satellite Control Network Capabilities Document, Aerospace Corporation TOR-96(1567)-2, September 1996. Contact Aerospace Corporation Reports Distribution at 310/336-7260; Address: ATTN: Reports Distribution, The Aerospace Corporation, P.O. Box 80966, M1199, Los Angeles, CA 90080-0966.

KEYWORDS: Satellite Control, Conformal Phased Array Antenna, Simultaneous Transmit and Receive, Hemispherical Coverage, Active T/R Module, TT&C

AF00-245 TITLE: Affordable Beamforming Network for TT&C Phased Array Antenna

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Air Force Satellite Control Network (AFSCN)

OBJECTIVE: Develop/demonstrate feasibility of low-cost beamforming network for phased array antenna to support satellite TT&C operations.

DESCRIPTION: Phased array antenna offers improved performance and reduced operations and maintenance cost over the existing parabolic dish antenna presently used in ground stations for satellite control. However, high phased array cost due to stringent tracking, telemetry and commanding (TT&C) requirements (hemispherical coverage, simultaneous transmit and receive, multiple beams, and high gain/noise temperature (G/T)) prevent it from adapting for satellite control application. A low cost feed network that distributes radio frequency (RF) power to, and combines RF signals from individual transmit/receive (T/R) modules suitable for such application does not exist today. The objective of this research is to develop low-cost beamforming network technology for phased array antenna in support of satellite TT&C operations, such as in the Air Force Satellite Control Network (AFSCN). The feed network must accommodate two independent transmit and receive beams with full duplex operation. This research will materially contribute to the implementation of an affordable, multi-beam, conformal phased array antenna for simultaneous multiple satellite control operations.

PHASE I: Phase I activity shall include: (1) develop general performance and array feed/control network design requirements for supporting TT&C operation. The multilayer network must provide: RF beamforming (two transmit and two receive simultaneous beams), beamsteering and direct current (dc) power supply; (2) identify and assess technical issues associated with the selection of different RF/dc multilayer beamforming architectures and fabrication approaches; (3) design candidate network architectures using affordable technologies; and (4) assess candidate design concepts in terms of their performance (amplitude and phase errors, frequency bandwidth, isolation, loss, power handling, etc.), feasibility, manufacturability, reliability and cost. The network shall interface T/R modules/array elements and must accommodate real-time replacement of T/R modules to support hot maintenance requirement. Rank network candidates for Phase II development.

PHASE II: Based on the results of Phase I, the contractor shall: (1) select two most promising beamforming network designs; (2) perform numerical simulation and refine trade-offs on performance, manufacturability, reliability, cost, adaptability, etc.; (3) down-select to a single design and fabricate a complete network assembly capable of supporting a 64/128 planar subarray; (4) test the network and compare measured values with simulated results; (5) develop efficient manufacturing process, test and quality control for large quantity production; (6) perform realistic production cost and timeline analysis; and (7) assess the feasibility and cost of integrating the feed network into a full-scale conformal array (including distributed power supply) for AFSCN application.

PHASE III DUAL USE APPLICATIONS: The beamforming and control networks developed in this research are equally applicable to both commercial and military satellite control operations. A low-cost phased array antenna is capable of improving commercial satellite control network performance and reducing maintenance and operational cost.

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KEYWORDS: Satellite Control, Conformal Phased Array Antenna, Simultaneous Transmit and Receive, Hemispherical Coverage, Beamforming Network, TT&C

AF00-246 TITLE: Miniaturized Antenna Array for GPS Anti-Jam Applications

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Global Positioning System (GPS)

OBJECTIVE: Accurately determine individual gas turbine engine component life, real time, at any given time in service, operational role or environment.

DESCRIPTION: The Spatial filter or adaptive antenna nuller/beamformer is the most effective method of mitigating the effects of intentional and unintentional interference on the reception of GPS signals. These systems rely on an array antenna or Controlled Reception Pattern Antenna (CRPA), and an antenna controller or antenna electronics unit to create spatial nulls in the antenna pattern. These spatial nulls adapt to the changing environment around the air vehicle continuously placing reduced gain toward the interference sources and increasing gain toward the desired signal. Current CRPAs contain 4-7 antenna elements, with sizes ranging up to 14 inches in diameter. The large sizes of the arrays have prevented their use on several space-constrained platforms that could benefit from the capability provided by a CRPA antenna. The objective of this project is to develop a CRPA containing at least 7 elements in a maximum of 8-inch diameter footprint. The desired antenna should be capable of working with current antenna electronics (AE) units (AE/1A and GAS-1) and be compatible with conformal installations. Since antenna size is conventionally mandated by frequency of operation, this effort must go beyond conventional antenna techniques to research new methods and develop new techniques to create an antenna almost half it's normal size, while still maintaining antenna performance of a larger antenna. The ability to control the antenna pattern will provide the flexibility to negate GPS interference, regardless of direction, and the small antenna size will enable installation in a wide variety of military and commercial platforms.

PHASE I: Investigate technologies applicable to the size reduction of a seven element conformal array for use with current AE units. Model several candidate antennas using electromagnetic modeling software to determine the ability of the antenna to provide sufficient null depths, antenna patterns, VSWR and mutual coupling for use with the GPS system. Select a viable candidate based on performance and cost trades.

PHASE II: Fabricate a proof-of-concept breadboard antenna system based on the selected design that demonstrates all key performance and physical features. Conduct laboratory and/or antenna range testing to mutually (Air Force/contractor) agreed upon specifications to measure CRPA performance with and without an AE like unit.

PHASE III DUAL USE APPLICATIONS: As GPS receivers become standard equipment in many civilian applications, particularly in general and commercial aviation, the necessity to ensure high availability of the GPS signals under all operating conditions will increase dramatically. The susceptibility of GPS signals to even low level interference is well documented. The CRPA/AE is the only approach capable of defeating all interference sources. Development of a small, low cost CRPA/AE will have high commercial potential.

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KEYWORDS: Spatial Filter, Adaptive Antenna Nuller/Beamformer, Controlled Reception Pattern Antenna (CRPA), GPS Satellites, Antenna Controllers, Anti-Jam Applications

AF00-248 TITLE: Re-configurable Embedded Spacecraft Antenna

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Space Based Radar

OBJECTIVE: Develop and test the principles of embedding re-configurable RF transmitting and receiving framework in the structure of spacecraft.

DESCRIPTION: The ability to convert a part or all of the structure of the spacecraft into a single antenna or separate antennas will enhance the capability and survivability of space communication systems. One manifestation of this concept would be to design and incorporate Radio Frequency (RF) transmitting and receiving elements into the spacecraft frame and its various appendages. These elements can then be configured into an antenna, whose shape can be changed in real time to maximize its effectiveness depending on the position and attitude of the spacecraft. If proven feasible, such an antenna may be a weight and space saving replacement for the primary antenna. Alternatively, it could serve as a back up in case the primary fails. This concept will become more important as the footprints of satellites continue to shrink in the future. A project is needed to determine how to implement this concept to different types of spacecraft. The results of this program will benefit both military and commercial satellite systems.

PHASE I: Develop basic ideas of embedding RF transmitting and receiving elements in various spacecraft materials, components, and subsystems. Design and verify the technique to form an antenna and change its shape in real time. Model the efficiency of such antennas for several commonly used satellite types.

PHASE II: Design and build prototype structures to verify modeled predictions. Develop and test real-time re-configurable linkages between RF elements. Build and test real-time re-configurable antennas. Collect engineering and cost-benefit data needed to establish the feasibility and practicality of the concept.

PHASE III DUAL USE APPLICATIONS: The results of this project will provide extremely useful information to both military and commercial spacecraft designers. As the size of spacecraft continue to shrink, it is clear that the primary antenna systems are the least scalable of all subsystems. Substantial savings in weight and space will result if the frame could be used to replace the primary antenna on any spacecraft, military or commercial.

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KEYWORDS: Spacecraft Structure, Secondary Antenna, Spacecraft Attitude Related References, Embedded RF Transmitting/Receiving Elements, Omni-Directional Antenna, Embedded Re-configurable Antenna

AF00-249 TITLE: Digital Receiver Development for AWACS Electronic Support Measures

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Accelerate the development and availability of digital receiver modules.

DESCRIPTION: This topic seeks to leverage recent advances in digital receivers and high speed analog to digital converters for use in ESM systems. The emphasis is to produce a digital receiver module with a very small size and weight. The spurious free dynamic range requirement is a minimum of 80 dB. The receiver module will contain RF amplifiers and filters and have a tunable RF front end between 100 and 500 MHz and a bandwidth of at least 1 MHz. The incoming RF will need to be bandpass filtered and directly sampled with a very high speed analog to digital converter operating at or above 1 GHz. The digital receiver module will also contain a digital sampling and filtering section, so a connection can be made directly to a signal processing system.

PHASE I: Develop a detailed digital receiver design, prediction, and simulation demonstrating the performance listed in the description.

PHASE II: Construct a prototype of the Phase I design and compare measured performance to the Phase I design and simulation.

PHASE III DUAL USE APPLICATIONS: The development of digital receivers will improve performance and decrease costs for numerous consumer applications including land mobile radios, portable high definition television receivers, air traffic control communication receivers and other satellite receivers. The advancement of this technology will also have application in making consumer electronics more portable.

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2. CG204N16715-3; dated 10 June 1988, Program Performance Specification CPCEI 20N715A ESM Operational Computer Program for E-3 System Contract F1628-87-C-0030

KEYWORDS: Digital Receiver, RF, Radar, Signal Processing Systems, Electronic Support Measures, Small Size and Weight

AF00-250 TITLE: Recognition Algorithms for Combat Identification

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Intelligence Surveillance and Reconnaissance (ISR) Integration System Program Office (SPO)

OBJECTIVE: Develop and prove new data processing techniques to detect, recognize and identify targets of interest from sensor returns.

DESCRIPTION: The need to identify targets has never been greater than it is today. The advent of beyond visual range (BVR) weapons means visual identification of targets is no longer optimal—more reliable long-range combat identification (CID) information is required to support optimal employment of weapons. Unfortunately, CID technological developments have not historically received the priority necessary to keep pace with developments in many other technology areas. As a result, CID systems currently possess significantly less capability than the weapon systems they support. There are two major technological areas that need to be addressed in attempting to develop robust Combat Identification solutions for the warfighter. They are: (1) sensor system (hardware) development and techniques to provide target signature (phenomenological) data on air and surface targets at long range/all aspect and (2) data processing techniques (software) to exploit the data and yield a high confidence, unambiguous identification of the target. This SBIR topic addresses the second of these two areas. New data processing techniques are needed to detect, recognize, and identify targets of interest from sensor returns. Classification algorithms may exploit any type of electromagnetic (and other) target signature, such as radar, infrared, laser, etc. Fusion techniques are of special interest. Key goals are to raise probability of correct identification and to reduce identification time. Techniques that reduce or eliminate the need for a extensive target signature libraries and identify targets irrespective of aspect or orientation should also be considered. Although the techniques must be suited for air-to-air, air-to-surface and/or surface-to-air combat identification applications, they should also be transferable to civil and commercial use.

PHASE I: Phase I activity shall include: 1) developing new data processing techniques, 2) performing analysis on feasibility of new techniques, and 3) limited demonstration of selected techniques to provide proof of feasibility.

PHASE II: Phase II activity shall include: 1) final development of the selected data processing techniques identified in Phase I; 2) prototype demonstration of the data processing algorithm applied to relevant target signatures; and 3) development of a comparative cost/efficiency analysis of the new data processing algorithm against current combat identification capabilities.

PHASE III DUAL USE APPLICATIONS: Resulting technology will be applicable to all DoD components and any commercial industry with detection/identification requirements (e.g., transportation management, law enforcement).

REFERENCES:
1. Proceedings of the 1999 IEEE Aerospace Symposium, Aspen, Colorado (March 1999).
2. Cranos, Roger, "Combat Identification in the Future: Maintaining a Balance," presented at the Society of Photo-Optical Instrumentation Engineers (SPIE) 11th Annual International Symposium on Aerospace/Defense Sensing, Simulation and Controls, 20-25 April 1997.

KEYWORDS: Data Processing Techniques; Detect, Recognize, Identify; Reduce Identification Time; Probability of Correct ID; Combat Identification; Air-to-Air; Air-to-Surface; Surface-to-Air

AF00-251 TITLE: Sensor Systems for Combat Identification

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Intelligence Surveillance and Reconnaissance (ISR) Integration System Program Office (SPO)

OBJECTIVE: Develop and prove new methods of target identification by exploiting target signatures in electromagnetic spectrum.

DESCRIPTION: The need to identify targets has never been greater than it is today. The advent of beyond visual range (BVR) weapons means that visual identification of targets is no longer optimal—more reliable long-range combat identification (CID) information is required to support optimal employment of weapons. Unfortunately, CID technological developments have not historically received the priority necessary to keep pace with developments in many other technology areas. As a result, CID systems currently possess significantly less capability than the weapon systems they support. There are two major technological areas that need to be addressed in attempting to develop robust Combat Identification solutions for the warfighter. They are: (1)

sensor system (hardware) development and techniques to provide target signature (phenomenological) data on air and surface targets at long range/all aspect and (2) data processing techniques (software) to exploit the data and yield a high confidence, unambiguous identification of the target. This SBIR topic addresses the first of these two areas. This SBIR is to develop or modify sensor systems to provide target signature data for the purpose of target identification. The sensors may exploit any type of electromagnetic (and other) target signature, such as radar, infrared, laser, etc. Sensors may be airborne, space, or surface based. Collection techniques should not provide any indication or warning to the target. Application to autonomous platforms is of particular interest. Although the systems must be suited for air-to-air, air-to-surface and/or surface-to-air combat identification applications, they should also be transferable to civil and commercial use.

PHASE I: Phase I activity shall include: 1) developing new sensor concepts for target identification, 2) performing analysis on feasibility of new sensors, and 3) limited demonstration of selected sensors to provide proof of feasibility.

PHASE II: Phase II activity shall include: 1) final development of the selected sensor systems identified in Phase I; 2) demonstration of the sensor system; and 3) development of a comparative cost/efficiency analysis of the new sensor system against current combat identification systems.

PHASE III DUAL USE APPLICATIONS: Resulting technology will be applicable to all DoD components and any commercial industry with detection/identification requirements (e.g., transportation management, law enforcement).

REFERENCES:

1. DTO: Modern Network Command and Control Warfare Technology (WE.23) SE.76

2. Cranos, Roger, "Combat Identification in the Future: Maintaining a Balance," presented at the Society of Photo-Optical Instrumentation Engineers (SPIE) 11th Annual International Symposium on Aerospace/Defense Sensing, Simulation and Controls, 20-25 April 1997.

KEYWORDS: Sensor Systems, Target Identification, Data Collection, Airborne, Space-Based, Air-to-Air, Air-to-Surface, Surface-to-Air, Autonomous Platforms

AF00-252 TITLE: Modern Network Command and Control Warfare (Compass Call Block 40 Improvements)

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Intelligence Surveillance and Reconnaissance (ISR) Integration System Program Office (SPO)

OBJECTIVE: To investigate and develop new concepts and technology in modern network command and control warfare, specifically to detect, deinterleave, and predict the frequency hopping scheme used by non-cooperative communicators in a network for the purpose of conducting electronic warfare.

DESCRIPTION: This concept investigates, simulates, analyzes, develops, and tests software and hardware enhancements to target command and control, frequency hopping networks. The use of frequency hopping offers anti-jam (AJ), low-probability-of-intercept (LPI), and protection from Anti-Radiation Missiles and it is well known that such systems will proliferate. These networks employ sophisticated digital techniques that provide multiplexing and multiple access that offer many advantages for the modern warfighter. Future fast frequency hopping techniques will possibly preclude the use of current follow jamming techniques. It will be necessary to develop new and effective techniques to detect, deinterleave, and identify in real time.

PHASE I: Investigate the feasibility of developing advanced recognition and countermeasure techniques for targeting adversarial frequency hopping radio networks. Investigate how operational and tactical requirements can be satisfied by recently developed algorithms and project performance capabilities based on realizable, state-of-the-art technology.

PHASE II: Develop a prototype system and demonstrate software and hardware enhancement for providing non-lethal means of disrupting enemy frequency hopping command and control networks.

PHASE III DUAL USE APPLICATIONS: The resulting technology will have direct application to civilian law enforcement and drug interdiction where the use of frequency hopping, tactical, radio are proliferating. Also, the algorithms will have potential application in commercial radio system that employ frequency agility and require fast acquisition schemes.

REFERENCES: DTO: Modern Network Command and Control Warfare Technology (WE.23) SE.76

KEYWORDS: Frequency Hopping + Spread Spectrum + Electronic Warfare; Denying and Disrupting Enemy Command and Control; Target Command & Control Systems; Software/Hardware Enhancement for Frequency Hopping

AF00-253 TITLE: Modulators for Analog RF Distribution

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop modulators to meet the performance goals for RF analog distribution.

DESCRIPTION: Photonically implemented (fiber optic) RF analog distribution links exhibit many desirable characteristics, such as small size and weight, low loss, and low electromagnetic interference. The external modulator is a key component in the RF link. Improved modulator performance characteristics over currently available modulators are needed to meet the requirements for Air Force applications. In particular, a reduction in the half wave voltage (or equivalent modulation voltage) is needed. This SBIR seeks the development of wide bandwidth (0.002 to >20 GHz) modulators with half-wave voltage less than 1 Volt, operating in the 1.3 to 1.55 micron wavelength range. Other important factors which should be addressed, include optical power throughput and losses, dynamic range, size, and cost. Integrability with electronics is a desirable feature.

PHASE I: Develop a proposed concept, including experimental results, which demonstrates the viability and feasibility to meet the above requirements.

PHASE II: Fabricate and demonstrate external modulators which meet the above requirements, and commercialize the product.

PHASE III DUAL USE APPLICATIONS: The potential for dual use commercialization is excellent. Although RF distribution links and commercial fiber optic communications are similar technologies, the performance requirements for military systems are much greater than for commercial applications. Modulators meeting the Air Force's requirements, will easily exceed the commercial requirements, and would most likely drive new commercial applications.

REFERENCES:

1. High-Frequency Photonics by TRW Space & Defence Sector Space and Electronics Group, D.T. Nichols and J.D. O'Keefe, Report 98056117
2. Compact Optica Payloads by Hughes Space and Communications Company, D.A. Rockwell and R.J. Francis, Report 98151927
3. RF/Optical Modulator Integration by Tracor Inc. Tracor Aerospace Electronic Systems, J.T. Gallo and A.N. Feineman, Report 98203905

KEYWORDS: Fiber optic link, Microwave, Modulator, Wideband, Analog distribution

AF00-255 TITLE: Laser Navigation Aid

TECHNOLOGY AREAS: Air Platform, Sensors/Electronics/Battlespace

OBJECTIVE: Develop a rugged, eyesafe, rangefinder system to accurately locate aircraft runways for landing.

DESCRIPTION: A compact, low-cost laser transmitter-receiver system is needed for acquisition and ranging of runway locations and altitudes for aircraft landings at unfamiliar or radio-silent locations. The laser source must be totally eyesafe yet be capable of measuring ranges to < 1 m accuracy and distances greater than 5 km. Passive marking of the runway endpoints for enhanced signal return to the rangefinder system is allowed. Typical laser sources operating in this regime are large and complex Nd lasers frequency converted to 1.5 microns. Research and development are desired, which can demonstrate an innovative way of achieving the required rangefinding with a low-cost, highly-robust, compact, airworthy system. A cost goal of less than $15,000/unit for greater than 100 units is desired.

PHASE I: Demonstrate the feasibility of an innovative technique, concept, or device, which would lead to major improvements in cost and size compared to currently available airborne rangefinding systems.

PHASE II: Demonstrate a complete device suitable for flight testing which incorporates the innovation demonstrated in Phase I. Device performance will be tested under a full suite of environmental extremes including lifetime, failure modes, vibration and temperature changes.

PHASE III DUAL USE APPLICATIONS: The contractor will develop a packaged rangefinding system based on lessons learned in Phase II. Follow-on contracts to build electro-optic brassboard systems for specific military applications may be possible. The technology developed to make an eyesafe rangefinder system will also be of interest for some commercial applications. An inexpensive rangefinder system would provide added safety for small aircraft using primitive runways. Once a source becomes available, additional new applications are likely to appear.

REFERENCES:
1. Conference on Lasers and Electro-Optics, 1998 Technical Digest Series, Volume 6 (Optical Society of America, Washington DC).
2. Advanced Solid State Lasers, 1999 Technical Digest, (Optical Society of America, Washington DC).
3. Kamerman, Gary W., ed. Laser radar technology and applications. Bellingham, WA : Society of Photo-Optical Instrumentation Engineers, v2748, 1996. 394p.

KEYWORDS: Laser Radar, Altimeter, Compact, Rangefinder, Navigation, Eyesafe, Low Cost

AF00-256 TITLE: Low Cost Electro-Optical Reconnaissance Sensor System

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop and demonstrate sensor techniques and/or hardware capable of significantly reducing the cost of airborne reconnaissance sensors for high altitude, long range E-O imaging.

DESCRIPTION: Airborne reconnaissance sensors for electro-optical (E-O) imaging, particularly those developed for high altitude aircraft, have historically been high cost, low rate production systems designed to achieve exceptional performance in terms of sensitivity, spatial resolution, and area coverage. With the recent and continuing emergence of lower cost Unmanned Aerial Vehicles (UAVs), however, The Air Force needs to develop more affordable EO sensor systems in possibly greater numbers without excessively diminishing the performance capabilities. The objective of this project is to develop and demonstrate sensor techniques and/or hardware capable of significantly reducing the cost of airborne reconnaissance sensors for high altitude, long range E-O imaging. Proposed concepts should focus on using manufacturing techniques grown from commercial digital still camera processes and/or employing real-time on-board digital processing techniques to relax cost-driving sensor requirements.

PHASE I: Develop a thorough approach for employing the proposed techniques and/or hardware in current or planned E-O reconnaissance sensor systems. In addition the contractor shall make supported predictions of the expected cost savings and the impact on the critical sensor performance parameters.

PHASE II: Develop and demonstrate a prototype sensor system employing the proposed techniques and/or hardware. The prototype demonstration should directly support the critical performance parameters and cost savings predicted in Phase One, and mitigate technical risks associated with future insertion into an airborne reconnaissance system. If feasible, Phase Two could include an airborne prototype demonstration to address airworthiness issues.

PHASE III DUAL USE APPLICATIONS: A low cost E-O reconnaissance sensor would greatly expand the potential applications of high performance reconnaissance systems. Potential commercial applications include airborne remote sensing for geological, land use monitoring, agricultural, and mineral exploration purposes.

REFERENCES: Proceedings of the 1999 IEEE Aerospace Symposium, Aspen, Colorado (March 1999).

KEYWORDS: Airborne reconnaissance, Passive imaging, Electro-optic

AF00-257 TITLE: Global Reference Information Management

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: Develop multiple platform reference system simulation tools for space-based data collection and imaging sensors.

DESCRIPTION: Future military operational concepts emphasize the exploitation and fusion of multi-platform information to support effective reconnaissance and combat operations. Exploitation of space-based resources, in conjunction with theater-wide assets, will enable military leaders to dominate the theater of operations by providing global communications, precision navigation, accurate meteorological data, early warning of missile launches, and signals and imagery intelligence support. However, to exploit the full potential of space-based systems, many technical issues must be resolved. Of particular interest and technical challenge are issues related to the processing and sharing of imagery generated from space and the process of geo-locating objects of interest within those images. This geo-location process requires ultra-precise reference information of the imaging platform. Reference systems information includes position, velocity, attitude, and time, as well as the associated coordinate transformations. Recent Air Force Research Laboratory efforts have been oriented toward the paradigm of multiple aircraft within a theater of operations and have generated simulation software to assess the impact of reference systems errors on the fusion of multi-platform data and imagery, focusing on techniques for selecting the most appropriate coordinate frame/datum for each stage of the fusion process, techniques for maintaining precision and numerical stability during data transformations, and techniques for accurately assessing uncertainty and exploiting it as part of the measurement and sensor management processes. This effort will extend the multi-platform work to include radar imaging from space as an additional off-board data source. The focus of this effort will be on determining reference systems requirements to support space based radar including 1) space-based Synthetic Aperture Radar (SAR), 2) space-based interferometric SAR (IFSAR), and 3) Bistatic SAR (space transmit and air vehicle receive).

PHASE I: Develop software modules to simulate SAR, IFSAR, and Bistatic data collection from space and all pertinent reference information associated with those images. This will be accomplished by utilizing orbital mechanics and models for space based SAR and interferometric SAR for both aircraft and space-based sensors. The preferred approach is to develop Matlab modules that add a space-to-ground geo-location and targeting capability to the Air Force owned TRIMSIM (Theater-wide Reference Information Management Simulation Tool). Acceptable alternatives would be a stand alone simulation capability or modules compatible with another reference system/ targeting simulation tool. This will provide a basis for (a) determining the translation and rotation errors present in satellite-based images as a function of reference system errors for image registration, (b) providing pointing and targeting error for satellite-based SAR targeting for fusion with aircraft-based targeting, and (c) providing stereo SAR and interferometric SAR space to ground surface mapping errors. The simulation capability will be demonstrated using existing images from the Air Force Dynamic Database program or other suitable alternatives.

PHASE II: Use the software tool developed under Phase I to identify and test reference system technologies required for precisely registering remotely sensed data with data from onboard sources and/or other off-board sources. Investigate and define candidate space-based SAR imaging capabilities for target location based on IFSAR, stereo SAR, and Bistatic SAR. Key to these capabilities is accurate reference information to enable the generation of precision terrain elevation data and subsequent precise target location and mutual coherence between Bistatic platforms. One or more system level simulations will be used to determine expected pointing accuracies for actual digital elevation data, which will be compared to ground "truth" and to the pointing accuracies determined by the system level simulations. System level simulation will also be used to investigate spacecraft/spacecraft and spacecraft/aircraft Bistatic performance.

PHASE III DUAL USE APPLICATIONS: Dual use applications include environmental and geophysical monitoring, which would require precise registration of imagery or digital terrain data from varied sources, such as onboard resources, other airborne platforms, space-based assets, and fixed ground sites.

REFERENCES:
1. Berning S., Howe P., Jenkins,T. "Theater-wide Reference Information Management," Proceedings of The National Aerospace and Electronics Conference (NAECON) 1996.
2. Chao, A., Beck, G., Berning, S., "Precise Reference Image Calibration and Alignment," Proceedings of the Institute of Navigation (ION) Annual Meeting, June 1999.

KEYWORDS: Space-Based Synthetic Aperture Radar, Reference Information, Digital Terrain Data, Space-Based Bistatic SAR, Integrated Navigation, SAR Image Registration, Interferometric SAR, SAR Image Geolocation, Multi-platform

AF00-258 TITLE: Hybrid Multi-Function FLIR/MWIR Ladar

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop advanced, multifunction FLIR/ladar techniques and components for long-range, Air/Space non-cooperative identification, ranging, and tracking.

DESCRIPTION: With the advent of multi-national conflicts involving a variety of friends, foes, and non-combatants, long range detection, non-cooperative identification (NCID), and targeting of both air and ground targets has become an extremely important aspect of battle management. In addition, cramped airframe space and diminished budgets continue to push technologies towards multi-function systems. This effort would investigate technologies needed to support a truly multi-function system consisting of a FLIR merged with an MWIR ladar system. The heart of the research would be a hybrid FLIR/Ladar focal plane. The entire focal plane would support FLIR operations; however, the center segment of the focal plane would possess additional performance characteristics necessary to support ladar functions, which may include but are not limited to active 1-D, 2-D, and 3-D imaging, vibration detection and imaging, precision range and velocity. The characteristics of the high performance sector of the array would be tailored to the requirements of the functions included in the design and may include but is not limited to, high spectral/temporal bandwidth, onboard pixel digitization & readouts, and temporal gating. Approaches to provide both active and passive multi-spectral capabilities may also be addressed with particular emphasis on target ID, missile warning and NBC detection and characterization. The technology would provide an optimal mix of passive and active technologies with the potential for enhanced performance in a wide variety of circumstances.

PHASE I: Design and assess system architectures and critical component technologies for airborne applications with secondary consideration for long-term space applications. Perform tradeoff analysis to maximize functional envelope, identify required observables, and define top level focal plane and component/system specifications. Critical issues associated with the technique including focal plane designs, feasibility demonstrations of key technologies, and atmospheric propagation from both air and space based platforms will be investigated.

PHASE II: Fabricate, demonstrate, and quantitatively evaluate a Multi-function FLIR/Ladar for long range, detection characterization, and ID of air, ground, and distributed targets. Critical issues associated with the system would be addressed and fabrication approaches would be demonstrated.

PHASE III DUAL USE APPLICATIONS: A multi-function FLIR/Ladar would greatly increase the potential applications of laser radar systems. Potential commercial applications include surveying, time-of-flight imaging for medical diagnostics, ocean research, and space object imaging applications. Imaging in factories for process control, imaging for nondestructive testing, and imaging for surveillance and security are also examples, where this technology can be applied.

REFERENCES:

1. G.R. Osche, et al., "Laser Radar Cross-section Estimation from High Resolution Image Data", Applied Optics 31:14, 31 (1992).
2. K. Costello, et al., "Transferred Electron Photocathode with Greater that 20% Quantum Efficiency beyond 1 Micron", SPIE 2250:177, (1995)
3. J.C. Hebden, and K.S. Wong, "Time-resolved Optical tomography", Applied Optics 32:4, (1993)

KEYWORDS: Laser Radar, Laser Vibrometry, Active Imaging, Laser Rangefinder, Passive Imaging, Range Imaging

AF00-259 TITLE: Synthetic Prediction Technologies for Multiple Target Scenario Modeling

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop innovative target data collection techniques and phase history modeling techniques for complex settings.

DESCRIPTION: Target classification and identification are capabilities required by the Air Force to successfully carry out many of its combat missions. However, the variability in target signatures as a function of frequency, aspect angles and sensor operating scenarios makes reliable target identification a most formidable task. The Air Force is actively pursuing synthetic data prediction techniques for targets in complex scene settings to support Automatic Target Recognition (ATR), data fusion development and evaluation, space based targeting technologies, reference system sensitivity analysis and battlefield awareness applications. Advances in target Radar Cross Section (RCS) prediction techniques and Computer Aided Design (CAD) geometry modeling tools are allowing synthetic predictions of tactical targets to be used in ATR development. However, enhancements in target geometry and signature data collection and innovative signature modeling techniques for complex natural settings are required to model complex targeting scenarios. Factors that have to be taken into account include scattering mechanisms, target modeling accuracy, measurement costs, computer simulations, and operating scenarios (moving targets, foliage, camouflage, and terrain-target interactions). To examine these issues, both physical and computer models having increasing levels of complexity in terms of materials and numbers and types of scattering centers can be formed and comparisons made between the actual physical electromagnetic scattering and the results from computer simulations. This topic solicits innovative solutions for one or more of the following items: (1) target geometry and material data collection techniques including ground truthing, (2) target signature and clutter measurement techniques, and (3) signature prediction techniques capable of generating phase history data for targets and/or clutter backgrounds.

In regards to item 1, accurate sampling of the target geometry and detailed construction by a specialized modeler are required to build an accurate CAD geometry model for a complex target body. Existing target geometry and material collection techniques for CAD modeling of complex targets are time intensive. Geometry collection methods that support target model builds for RF, IR, and EO models are needed. Novel techniques that use hand portable equipment to efficiently collect target geometry and material information on tactical targets are also of interest. The development of time efficient point collection methods that accurately sample the target of interest and techniques are required. This method must document point and material property data collected to support rapid CAD builds for tactical targets.

A thorough understanding of ground truthing is required to support algorithm development and evaluation in multi-sensor data collection of multi-target scenarios. Innovative field target ground truthing techniques documenting target type, position, pose, configuration, and articulation for both single target and multi-target scenario data collections are needed to support measurement data analysis. Ground truthing techniques that define the background terrain, measurement range clutter and terrain discretes are also of interest.

In regards to item 2, target signature and clutter measurement techniques are essential in the validation of geometry models. Multi-Sensor validation of CAD geometry models involves the comparison of synthetic signature data predicted from the CAD model to high quality measurement data over aspect angles existing in the measurement data. A measurement system to collect high quality calibrated target signature data over broad aspect coverage in elevation and azimuth in the field must be developed and suitable for CAD model validation efforts. In addition to support validation efforts, innovative clutter measurement techniques are needed to assist in characterizing clutter in natural settings. Special emphasis should be given to the RF system working from VHF to W band; however, innovative systems in the IR/EO 12 microns to broad band visible are also of interest.

In regards to item 3, existing full scene image prediction models are image domain based, thus, sensor specific. New phenomenology modeling techniques that support scene simulation for multiple sensors are needed to predict phase history returns from a complex scene including background terrain, trees, vegetation, and cultural clutter objects. These modeling techniques should allow for the prediction phase history such that radar processing for HRR, SAR and signature exploitation techniques can be applied as a post-processing step. These new modeling techniques should also assist in analysis of space based radar applications.

Target predictions take in account complex levels of materials and scattering mechanisms. Synthesizing wideband electromagnetic scattering from target models having increasing numbers of and types of scattering centers is important in producing coherent signatures. Computer modeling requirements are of interest to reproduce the scattering over the desired frequency ranges for successive targets. Accurate and efficient techniques for RCS prediction are also of interest.

PHASE I: Develop a design or limited proof of concept of one or more of the following: (Item 1) a target geometry and material collection system that supports target model builds; (Item 2) a man portable field measurement system capable of collecting calibrated target signature data, or any system capable of innovative and efficient means of characterizing clutter; (Item 3) a prototype a phase history modeling tool for synthesizing clutter scattering, or techniques for synthesizing wide-band electromagnetic scattering predictions with emphasis on target/background interactions. All synthetic signatures should be validated using measured results where possible. Document these efforts and prepare an outline of a program for Phase II.

PHASE II: Demonstrate via actual measurements or computer simulations one or more of the following: (Item 1) a target geometry and material collection system that supports target model builds: (Item 2) a man portable field measurement system capable of collecting calibrated target signature data, or any system capable of innovative and efficient means of characterizing clutter; (Item 3) a prototype a phase history modeling tool for synthesizing clutter scattering, or techniques for synthesizing wide-band electromagnetic scattering predictions with emphasis on target/background interactions. All synthetic signatures should be validated using measured results where possible. Document these efforts and prepare an outline of a program for Phase III. Pay particular attention to documentation on potential for commercialization.

PHASE III DUAL USE APPLICATIONS: The commercial potential is excellent. The development and/or enhancements of synthetic prediction techniques for targets in complex scene settings is expected to be useful in forecasting large area site modeling for cellular communication network design. Also the technology resulting from this effort is expected to be useful for developing more reliable collision-avoidance radars in commercial vehicles, industrial inspection, and manufacturing automation.

REFERENCES:
1. Bhalla, R. , H. Ling, J. Moore, D. J. Andersh, S. W. Lee, and J. Hughes, "3D Scattering Center Representation of Complex Targets Using the Shooting and Bouncing Ray Technique: A Review," IEEE Antennas and Propagation Magazine, Vol. 40, No. 5, October 1998, pp. 30 – 39.
2. Sullivan, D., D. Andersh, T. Courtney, N. Buesing, and P. Jones, "Development of SAR Scene Modeling Tools for ATR Performance Evaluation," Proc. SPIE, Vol. 3721, Algorithms for Synthetic Aperture Radar Imagery VI, April, 1999.
3. T. D. Ross, J. Mossing, "The MSTAR Evaluation Methodology" Proc. SPIE, Vol. 3721, Algorithms for Synthetic Aperture Radar Imagery VI, April 1999.
4. De Carolis, G., F. Mattia, G. Pasquariello, F. Posa and P. Smacchia, "X-Band SAR and Scatterometer Data Inversion based on Geometrical Optics Model and Kalman Filter Approach," Journal of Electromagnetic Waves and Applications, Vol 8., No. 8, 1994, pp. 1017-1039.

KEYWORDS: Automatic Target Recognition, Computer Aided Design Geometry Modeling, Dynamic Ground Truthing, Signature Measurements, Data Collection, Scene Modeling

AF00-260 TITLE: ATR/Fusion Virtual Development and Evaluation Testbed

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

OBJECTIVE: Develop a virtual distributed collaborative ATR and Fusion algorithm development and evaluation GUI based simulation environment.

DESCRIPTION: There is a significant and growing number of manned, unmanned, and national intelligence, surveillance, and reconnaissance data collection platforms. With all this vast amount of available data, there is a considerable requirement to develop and transition both ATR and fusion algorithms to the war fighting community to process, identify, and abstract the data to formulate useful information. In order to tackle such a large and difficult problem, ATR and fusion researchers located throughout the country need to collaborate together and leverage existing methodologies and algorithms to avoid duplicating research. In order to facilitate this type of collaboration, modeling and simulation environments must be assembled to design, develop and evaluate ATR and Fusion Algorithms i.e. multi-sensor tracking, ID, registration, and reference exploitation. The key building blocks of this environment would be as follows: 1) web based access to ATR and fusion data through distributed intelligent agents. 2) common algorithm interfaces to allow for re-use and sharing of algorithms. 3) hierarchical GUI based system to allow for easy algorithm cataloging and web based dynamic execution. 4) single algorithm or module code level collaboration among distributed researches. 5) provide deterministic simulation behavior. 6) ability to mix real time and non real-time algorithms. 7) algorithm and code level configuration management capability. 8) light weight modular components that are based on commercial standards such as CORBA, JAVA, DCOM, OpenGL, etc., and DOD standards such as the High Level Architecture 9) ability to function on Heterogeneous computer systems will the ability to incorporate other types of computing systems such as High Performance Computers (HPC) or embedded computer systems. 10) provides ability to operate with web based security and firewalls to allow protected sites to work together. 11) provides scripting capabilities for multiple unattended test runs for easily algorithm evaluation or metric based comparisons, and 12) produces modules which comply to DOD's High Level Architecture.

PHASE I: Design a virtual ATR/ fusion algorithm development and evaluation testbed incorporating the key characteristics described above. Identify potential Government off the Self (GOTS), Commercial off the Self (COTS) or other components that would be necessary to develop the Virtual Testbed. Identify any additional key characteristics that would be necessary or beneficial to the development of the Virtual Testbed. Develop a prototype-distributed testbed, which implements a few of the key characteristics described above and demonstrates the feasibility of developing the whole system along with a transition path to HLA compatibility.

PHASE II: Develop and implement an HLA compliant distributed collaborative Virtual Testbed. The contractor shall demonstrate the salient features of the distributed system on a least two different systems located at least 10 miles apart from each other.

PHASE III DUAL USE APPLICATIONS: Dual use applications of this technology would include distributed modeling and simulation, collaborative code development, and distributed component level configuration management across multiple development sites.

REFERENCES:
1. Chuck Hlavaty, Ed Waltz "Integration Standards and Performance Metrics for Next Generation Avionics Fusion Architectures," Proc. IRIS National Sensor & Data Fusion Symposium, 1997.
2. T. D. Ross, J. Mossing, "The MSTAR Evaluation Methodology," Proc. SPIE, Vol. 3721, Algorithms for Synthetic Aperture Radar Imagery VI, April 1999.

KEYWORDS: Automatic Target Recognition, Sensor Data Fusion Modeling and Simulation, Distributed Computing, Collaborative Engineering, Client Serve

AF00-261 TITLE: Integrated Aperture for Passive and Active Electro-Optical Systems

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop architectures and components for optical apertures that integrate passive electro-optical (EO) search sensors with active EO systems. The active EO systems can include infrared countermeasure systems and targeting sensors (both coherent and direct detection sensing).

DESCRIPTION: Many future EO systems will consist of a combination of a passive infrared system, which provides some form of wide area search and detection, coupled with an active (laser) system, such as an infrared countermeasure system or a targeting system. To minimize the impact on the host platform, it is desirable for both systems to use the same optical aperture for interface to the external environment. Such a common aperture will have a number of requirements beyond the apertures currently used. These requirements include broad spectral band coverage (minimum 1 – 5 micrometers, possibly 1 – 12 micrometers), wavefront quality suitable for coherent laser radar operation, ability to tolerate large peak powers, and some form of agile steering capability. In addition, some form of device that will enable the passive and active systems to share the same aperture will be required. Because of the advantages of steering both the passive field of view and the laser beam at the output aperture,* methods that will integrate large angle steering into compact, low cost optical apertures are solicited.

PHASE I: Definition of aperture requirements, concept design, concept analysis, and proof-of-concept experiments.

PHASE II: Design, fabrication, and testing of integrated passive/active optical aperture with large angle beam steering. Aperture can be of a few centimeters in size.

PHASE III DUAL USE APPLICATIONS: Development of optical aperture suitable for operation with significant laser fluences and suitable for integration on tactical aircraft. Many sensing systems, including those for medical imaging, can benefit from the integration of passive and active systems. The techniques developed under this effort for integration, as well as for beam steering, will benefit such systems.

REFERENCES:

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2. E. A. Watson, et al., "Application of dynamic gratings to broad spectral band beam steering," in Laser Beam Propagation and Control, Proc. SPIE Vol. 2120, 178-185 (1994).
3. P. F. McManamon, et al., "Optical Phased Array Technology," Proc. IEEE 84(2), 268-298 (1996).

KEYWORDS: Common Aperture, Laser Radar, Infrared Imaging, Beam Steering, Beam Shaping, Achromatic, Compact

AF00-262 TITLE: Registration of Images for Polarimetric Dual-Band FOPEN Radar

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop a automatic image registration algorithm for VHF and UHF radar target detection applications.

DESCRIPTION: The Government is developing a "foliage penetrating" (FOPEN) synthetic aperture radar (SAR) that serves the broad objectives of military counter camouflage, concealment, and deception (CC&D) programs. In order to meet the required specifications for the detection of concealed targets, a dual band design that operates at both UHF and VHF will be implemented. The VHF portion of the radar will provide greater target detection capabilities due to the lower levels of attenuation from the foliage whereas the higher resolution UHF portion of the radar will provide better target/clutter discrimination capabilities.

PHASE I: Analyze algorithm approaches to correlate dual band radar images. These algorithms should take into account aspect-independent features, and other image alignment issues.

PHASE II: Involves the development and testing of algorithms for FOPEN VHF/UHF images. Issues such as the robustness of possible registration features with regard to UHF polarizations should be investigated and addressed.

PHASE III DUAL USE APPLICATIONS: Emergency search and rescue missions that rely on the detection of man-made objects that are embedded in forested regions. Remote sensing applications such as environmental pollution tracking in forested areas.

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2. J. Ripoll, A. Madrazo, and M. Nieto-Vesperinas, "Scattering of Electromagnetic Waves from a Body Over a Random Rough Surface, "Optics Communications, vol. 142, no. 4-6, p 173-8, Oct. 1997.
3. Zheng, Qinfen and Rama Chellappa, "A Computational Vision Approach to Image Registration", IEEE Transactions on Image Processing, Vol. 2, No. 3, July 1993, pp. 311-326.

KEYWORDS: Synthetic Aperture Radar, Foliage Penetration, Image Registration, Target Detection, Polarimetric Radar, VHF/UHF Radar

AF00-263 TITLE: Real-Time High Fidelity Dense RF Environment Simulation Technology

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

OBJECTIVE: To advance the state-of-the-art in real-time high fidelity/dense RF environment simulation.

DESCRIPTION: Evolving 21st Century operational concepts utilize onboard/offboard sensors to significantly enhance situation awareness and response strategy in dense threat environments. Advanced sensors and information processing is a key critical technology base for these concepts. This technology base is even more critical for the protection of space assets. The development and evolution of this technology base through open air/space range research and evaluation is expensive with limited productivity. This limited productivity is due to the lack of good experiment control that is a problem inherent with open air/space range evaluations. In addition, open air/space ranges cannot generate the dense RF environments that would be experienced in actual combat situations. The current RF environment generation technology performance and its associated costs limit the fidelity of the generated combat scenario where the RF waveform/pulse density accuracy must be traded-off with the number of simultaneously active emitters in a dense threat environment. This limitation must be overcome if the DoD High Level Architecture (HLA) concepts/requirements being sponsored by the Defense Modeling and Simulation Office are to become a reality in the defense community. This limitation is even more critical with sensors used for space asset protection because they must operate in a larger environment of RF emitters. The primary focus of this research is to define/evolve affordable real-time high fidelity/dense RF environment generation technology that will enable the defense community to minimize the need for open air/space range evaluation where the advanced sensor/information processing capabilities are evolved and matured in the laboratory through hardware-in-the-loop simulation. This new RF environment generation technology will enable the battlefield to be brought to the laboratory where the advanced sensor/information processing capabilities can be subjected to multiple realistic combat situations making it possible to identify/resolve technical issues before ever flying/fielding the capability. This initiative will provide key simulation technology to evolve/apply electronic warfare concepts/capabilities for the protection of space assets. This simulation technology will make it possible to significantly reduce the time, risk and cost associated with transitioning advanced sensor/information processing capabilities. This research addresses the incorporation of HLA standards per the DMSO M&S Master Plan.

PHASE I: The Phase I effort will identify affordable innovative real-time high fidelity/dense RF environment generation technologies that utilize HLA architecture concepts where demonstrations are linked via HLA standards, a collaborative enterprise technology concept in the Defense Technology Area Plan. The key objective of this research is to minimize the need for open air/space range research/evaluation and enable the development/evolution of advanced sensor/information processing technologies in the laboratory. The Phase I research will identify the critical RF generation technology challenges and define the Phase II approach for developing/demonstrating in the Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL), the critical real-time technology required for real-time high fidelity/dense RF environment generation. Phase I risk reduction experiments will be conducted to demonstrate the feasibility of the proposed Phase II approach.

PHASE II: The Phase II effort will implement and demonstrate the critical real-time high fidelity/dense RF environment generation technology in the Sensors Directorate Integrated Demonstrations and Applications Laboratory (IDAL) through linked simulation via the HLA standards per the DMSO M&S Master Plan.

PHASE III DUAL USE APPLICATIONS: Real-time high fidelity/dense RF environment generation technology is a dual-use technology that has extensive commercial applications for markets such as the telecommunications industry. This RF generation technology can be utilized to develop telecommunications equipment and processes that enable cheaper/more flexible service. This technology can also be utilized to develop and evaluate new multiplexing communications concepts that enable more simultaneous users of the service. This technology will reduce development costs and accelerate product movement to the market place through laboratory rapid prototyping in a RF development environment that realistically represents real-world effects. The real-time high fidelity/dense RF environment generation technology can be implemented in government laboratories and test ranges for the development and evaluation of advanced sensors.

REFERENCES: Edward Eberl, "Changing Requirements for EW Threat Simulation," 22 Oct 98 AD A355202

KEYWORDS: RF Simulator, Threat Environment, Simulation, Situational Awareness, High Level Architecture, Electronic Warfare

AF00-265 TITLE: <u>Distributed Control Evaluation System for Multi-Platform Applications</u>

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

OBJECTIVE: Develop a methodology and test bed for systematic evaluation of distributed sensor control techniques in a multi-platform multi-sensor environment to measure performance, limitations and progress in the state of the art.

DESCRIPTION: Current and future military operational concepts emphasize cooperative multi-platform operations based on shared information from distributed sensor and database resources. Before the concepts for sharing such resources are operationally feasible, many fundamental technical issues must be resolved with respect to evaluation of sensor utilization, data communication, data processing, and command and control strategies. Of particular interest here is the ability to evaluate control of sensors located on multiple cooperating platforms to best achieve global or group objectives. For example, electronically scanned radars on different aircraft might be directed toward different high-priority targets to yield the best total view, based on relative locations and velocities, detection ranges, visibility or pointing constraints, communication bandwidth, available sensor modes, and other factors. Sensor modes, such as Synthetic Aperture Radar and High Range Resolution, may be mutually exclusive. For robustness and reliability, the participating platforms should be able to operate as autonomously as possible, while contributing effectively to the group's mission objectives. In the past 10 years, significant progress has been made in developing new methods for distributed optimal estimation, and methods for evaluation of these techniques are evolving. However, distributed control strategies and methods for their evaluation are often ad hoc, heuristic, or developed on a case by case basis. This often makes meaningful comparison of these strategies problematic. Hence, a general-purpose evaluation methodology and test bed are required. Developing such a capability is especially challenging because there are few working examples of such strategies from which generalizations can be inferred.

PHASE I: Examine recent distributed control methods and identify a generalized set of characteristic features. Develop distributed control metrics suitable for use in multi-platform multi-sensor operations. Demonstrate feasibility by implementing prototype software and evaluating a small number of control strategies and baseline scenarios. The Government will help to identify and provide descriptions, analytical models, and software that can be used in implementing simulations. Expect to use sensor models and associated parameters of a generic nature for exercising algorithms and testing ideas. Define how methods can be readily adapted to testing of new candidate control strategies or problem spaces. Identify limitations of methods and suggest means to circumvent these.

PHASE II: Develop a control strategy evaluation toolkit based on methods and metrics developed in Phase I. The toolkit will consist of software that as a minimum allows the user to readily define scenarios, insert control strategies for evaluation, and measure and assess the appropriate performance metrics. The simulated mission environment will include realistic multi-aircraft operations, target/threat scenarios (envision both air-to-air and air-to-ground), and varied sensor and environment models.

PHASE III DUAL USE APPLICATIONS: Evaluation of distributed control strategies in manufacturing operations where physically distributed monitoring sensors and multistage production processes must be controlled. The FAA can potentially use the distributed control method to enhance aircraft collision avoidance systems. Intelligent vehicle control systems can also potentially use a good distributed control method. Other potential applications include robotic systems with distributed sensors and controllers, and large space structures with distributed sensors and controllers.

REFERENCES: Borman,V.; Pack, J. "Effectiveness Measurements for the Distributed Data Fusion Problem", Jun 94, Report Number: NCCOSC/RDT/E-TR-1648, ADA 283084

KEYWORDS: Distributed Control, Simulation, Sensors, Evaluation

AF00-266 TITLE: Space Based Sensors

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: Develop large lightweight deployable antenna aperture concepts for Space Based Radar applications.

DESCRIPTION: Very large aperture antennas for future space based radar applications will require highly calibrated multi-beam functionality, and for some applications also be able to operate at multiple frequencies with minimum prime power consumption. Possible candidate architectures could include extremely large fully populated phased arrays, constrained feed arrays, and space fed lens arrays. Integrated antenna apertures and innovative beamforming concepts that allow the deployment of multiple subarrays by smaller, less expensive launch vehicles may play a pivotal role in reaching the desired sensor performance requiring less aggregate weight and power. Lightweight, deployable, and mass producible antenna systems concepts are required that will ultimately succeed in achieving reduced life-cycle costs for spaced based radar surveillance. Concepts developed under this SBIR have the potential to greatly enhance and encourage a quickly growing multi-faceted market.

PHASE I: 1) Perform antenna system coverage analyses and trade-offs, concerning one or more concepts. 2) Develop preliminary antenna concept system performance simulation to evaluate beam coverage and illumination efficiency functions. 3) Document results and detail a plan for prototype development/demonstration/simulation in Phase II.

PHASE II: 1) Produce a comprehensive antenna concept system performance simulation to validate plausible antenna system architectures. 2) Identify key sub-system antenna performance requirements. 3) In conjunction with AFRL Sensor personnel select crucial antenna sub-system demonstration hardware and produce a working prototype.

PHASE III DUAL USE APPLICATIONS: Improved space based antenna system performance clearly will save costs for both military and civilian satellite systems. For military radar satellite systems, large saving in the life cycle cost for surveillance radar is expected. Civilian systems, especially the new low orbit system with multiple beam earth coverage, will benefit by the lower cost of mass producible antenna subsystems.

REFERENCES: Proceedings of the Antenna Application Symposium, September 1997, 1998 Electromagnetics Laboratory University of Illinois Urbana-Champaign.

KEYWORDS: Lightweight Antennas, Space Based Radar, Multi-Beam Antennas, Multi-Frequency Arrays, Digital Beamforming Arrays, Space Fed Arrays

AF00-268 TITLE: Affordable Bonded Textile Reinforced Composite Double-Lap Clevis Joints

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop bonded textile reinforced composite clevis joint concepts for improved structural integrity and producibility.

DESCRIPTION: The Air Force has a goal to reduce the cost, yet improve the performance of air vehicle structures. Unitized composite structures with low part and low cost assembly approaches are key to achieving this goal. This topic seeks to develop innovative bonded joints design concepts for high performance unitized composite structures. Bonding is critical for low cost assembly. The design and manufacturing benefits of assembling large numbers of bonded parts allow a low cost alternative to the expense associated with tooling for unitized cocured structure. Historically, the costs to maintain part tolerance on a large unitized structure that is built with complex tooling have been a significant challenge that has inhibited the implementation of composites. Bonded joints will allow the designer to assemble parts that are, in general, flat or slightly curved to allow for low cost fabrication with improved tolerance control. The clevis joint offers a way to react pull-off loads while placing the adhesive in double lap shear as opposed to peel, which is the strongest loading mode for adhesives. This program shall specifically focus on the design aspects of the bonded composite clevis joints reinforced with woven textile fiber preforms. The development shall emphasize concepts to allow for bondline thickness control in the lap joint, stiffness tailoring for improved load distribution and elimination of stress risers, fail-safety using 3D technologies, and definition of guidelines for design of clevis joint structures.

PHASE I: Develop a textile preform reinforced bonded joint design concept, fabricate joint elements, and test to quantify improved joint producibility, static strength, and durability. Design features to be considered include concepts to control bondline thickness, and approaches to improve ultimate load capability and durability, such as hybridized fiber architectures and metallic inserts using low temperature and low pressure cure resins such as electron beam curable materials.

PHASE II: Refine the concept developed in Phase I and apply it to a representative portion of aircraft structure. The refinement of the design will be directed towards understanding the correlation of effects between skin stiffness and joint architecture. Demonstration will be conducted to characterize the producibility, performance and cost of the concept through fabrication and static and durability test of a large scale component. This Phase will provide an evaluation of the concept for weight and assembly cost payoff potential.

PHASE III DUAL USE APPLICATIONS: This technology will find numerous applications in commercial transportation systems where cost and weight are always critical for commercial viability. Applications of this joint concept in the frames and bodies of fuel efficient cars, buses, trucks, and trains will improve structural efficiency, integrity and safety. This joint concept can also be scaled to meet the increasing demand for application of composites in infrastructure, such as highway and pedestrian bridges and other support structures.

REFERENCES:
Robust Composite Sandwich Structures, AIAA 98-1873, Patrick Sheahen and Larry Bersuch, Lockheed Martin Tactical Aircraft Systems, Fort Worth TX, Tom Holcombe and Bill Baron, Wright Laboratory, Dayton OH, 39th AIAA Structures, Structural Dynamics, and Materials Conference, Long Beach CA, 20-23 April 1998.

KEYWORDS: Structure, Composite, Bonding, Assembly, Textile, Adhesive

AF00-269 TITLE: Repair of Ceramic Matrix Composite Structures

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate an economical and reliable repair technique for ceramic matrix composite hot structures.

DESCRIPTION: Ceramic matrix composites (CMCs) are increasingly being considered for a variety of exhaust impinged aircraft structures and engine components. Compared to existing materials used for these applications, CMCs offer potential improvements in durability and maintainability, as well as higher temperature capability and reduced weight. Demonstration of reparability is desired before they can be used in fielded systems. Preliminary development of repair techniques has been accomplished [1-4], however, repair optimization, demonstration of repair durability, and other issues remain to be addressed. Some of these components may be layered or cored structures and contain arrays of cooling holes; this further complicates repair. Repair development efforts proposed here need to dovetail into existing technology demonstrations, such as the AFRL/VA Structurally Integrated Thermal Energy Management (SITE-M) program [4], in order to ensure that they are being accomplished on a realistic component geometry and have a demonstration outlet.

PHASE I: Review the prior and current work on CMC repair and identify a suitable component demonstration path. Select the approaches that are most applicable to the CMC of interest. Fabricate, damage, repair, and mechanically test CMC coupons. Assess the test results and identify repair processes, material improvements, and risk issues associated with repair of the relevant component (e.g., fatigue resistance of repair, repair of damage near an attachment, cost/ease/flexibility of repair technique, etc.). Define support and support related impacts associated with each repair procedure.

PHASE II: Fabricate, damage, repair, and test CMC sub-elements to optimize the repair approach. This iterative task should include specialized testing and repair of damage to various component areas, as needed to address the risk issues identified in Phase I. Damage and repair a representative CMC component to be tested in the previously identified rig or engine test. Thoroughly document the repair procedure. Summarize the test, analyze the results, and identify remaining issues, including supportability and maintainability related issues.

PHASE III DUAL USE APPLICATIONS: CMCs are being developed for a variety of commercial applications, many of which are large components (e.g., heat exchangers, radiant burners, etc.). Repair of damaged or failed regions of these components is expected to be highly desirable from an economic standpoint, and will facilitate their commercial application. Similarly, the repair approaches (e.g., bonding a patch in place) are expected to be applicable to joining of CMCs to themselves. This ability is expected to present additional commercial applications.

KEYWORDS: Repair, Ceramic Matrix Composites (CMC), Hot Structures, Testing, Process Development

AF00-270 TITLE: Design for Limited Life Airframes

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop Design Technology and Acceptance Procedures for Airframes having short (100-1000 hour) usage life.

DESCRIPTION: It is proposed that future air vehicles, especially unmanned air vehicles, will be manufactured in limited quantities and stored in a near ready to fly condition until use. Regular training will not be conducted using these air vehicles. Therefore, the requirements for structural integrity can be expected to be significantly different than those currently in place. This is expected to provide the opportunity to reduce airframe weight through the elimination of the structural material required to meet current durability and damage tolerance requirements. Additionally, shorter lived airframes designed to lower durability and damage tolerance requirements may provide the opportunity to exploit materials, design concepts, and manufacturing processes not currently considered acceptable for aircraft structural use. Although a limited number of vehicles are expected to be manufactured for storage, use for a sustained period of time may require surge manufacturing to maintain inventory, so it is essential that rapid and low cost manufacturing processes be integral to the vehicle design. The Air Force Research Laboratory is seeking innovative design concepts for future air vehicles, using advanced, emerging, or current material systems and advanced, emerging or current manufacturing processes that will reduce the manufactured cost and structural weight of future air vehicles.

PHASE I: A notional vehicle and mission will be identified and the design concepts appropriate to achieving such a vehicle will be demonstrated on a subcomponent or component basis. These components will be selected in such a manner as to develop reasonable confidence in the cost and weight reduction potential. They will also address technical challenges associated with the details of the design methodology and manufacturing processes used. Appropriate failure and durability criteria to assure meeting mission requirements will be proposed, and examined for feasibility through test and/or analysis.

PHASE II: The suitability of the proposed criteria for actual air vehicle structure will be demonstrated through the fabrication and test, according to a proposed plan, of a more complex aircraft structure representative of a critical area of the unmanned vehicle identified in Phase I. This is a demonstration test, and need not be conducted to the standards of a certification effort.

PHASE III DUAL USE APPLICATIONS: The low cost rapid manufacturing technology will be further developed and transitioned. Potential users could include, but not be limited to, the aerospace industry for temporary repair or modification of airframes. General aviation may also benefit from this technology in instances where vehicle use life is shorter or the requirements less stringent.

KEYWORDS: Design Concepts/Criteria, Unmanned Air Vehicles, Reduced Life Cycle Cost, Low Cost Manufacturing, Structural Reliability/Integrity, Advanced Composites

AF00-271 TITLE: Development of Advanced Structural Life Analysis/Enhancement Methodology

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop or refine methodologies to assess and mitigate the effects of aircraft damage.

DESCRIPTION: There is a focus on reducing fixed-wing vehicle operations and support (O&S) cost. A portion of these costs are expected and associated with typical post-procurement life cycle costs for usage below the aircraft's service life goal. Scheduled inspections are an example of this type of cost. O&S costs also increase as these aircraft approach their structural fatigue service life goal and the incidence of cracking increases. Costs related to time-dependent damage, such as general corrosion and environmentally assisted cracking, are also found at greater frequencies. Additionally, O&S costs are incurred as unexpected damage states are found on aircraft, either due to changes in usage or the inaccuracy inherent in structural analysis used to predict structural damage onset, damage progression or failure. O&S costs associated with the various forms of damage can be reduced. One potential way of reducing costs is through the use of more accurate and/or complete analysis methods. Another way to reduce costs is through the application life enhancement methods such as cold-working, riveted, or bonded repair. The relief of parasitic residual stresses, such as those developed through fabrication and assembly, may also reduce the incidence of damage onset. Unconventional design, fabrication and assembly methods may also result in O&S cost savings. For example, unitized structure may offer cost savings during manufacture and fabrication, and it should also result in reduced cracking. However, the cost of repair or other form of damage mitigation, during operations and support, may offset those savings. Analysis methods, to determine the impact of the environment on unitized structure, need to be developed, refined and verified.

PHASE I: Develop structural analysis tools and/or damage mitigation technology for fielded and future aircraft structure.

PHASE II: The structural analysis tools and damage mitigation technology, developed in Phase I, will be refined and/or enhanced and then validated by testing.

PHASE III DUAL USE APPLICATIONS: Many problems plaguing military aircraft are evident in the commercial fleet as well. Close coordination between the USAF and FAA in the area of aging aircraft research has yielded, and will continue to yield, products of mutual benefit. The analysis tool, entitled "Repair Assessment Procedure and Integrated Design (RAPID)," is an example of such a product.

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2. Harris, C. E., "FAA/NASA International Symposium on Advanced Structural Integrity Methods for Airframe Durability and Damage Tolerance," N95-14453, Symposium held in Hampton, VA 4-6 May 1994. Available from www.Amazon.com.
3. Grandt, A. F., "Materials Degradation and Fatigue in Aerospace Structures," AD-A329 663, August 1997.

KEYWORDS: Structural Analysis, Structural Integrity, Repair Design, Structural Life, Enhancement, Advanced Design, Widespread Fatigue Damage, Aircraft Corrosion, Stress Corrosion Cracking

AF00-272 TITLE: Verification and Validation of Integrated and Adaptive Control Systems

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop the theory and processes for the affordable analysis, testing, and verification of adaptive and intelligent control systems performing safety critical tasks.

DESCRIPTION: By their nature, flight and safety critical control systems require extensive certification testing and analysis prior to fielded application. The process involves validating system requirements, verifying performance needs, and demonstrating safe operation for all conceivable fault modes. Historically, reliability for flight critical systems has been achieved through (1) redundant, channelized hardware configurations with cross channel voting, (2) segregated critical functions (i.e. "firewalls"), (3) deterministic software carefully analyzed against timing and performance predictions, (4) test, and (5) more test. Such efforts to assure dependable operation have led applications (such as digital flight control systems) to be relatively expensive and long-lead-time items. However, trends in industry and military applications are leading to more complex and integrated systems, using advances in control theory, and processing capability to implement them. Research and development for the military has also demonstrated the utility of diagnostic capabilities and reconfigurable control. As such, systems now can have the ability to self-diagnose failures and adapt to compensate for them. Such technologies also give the systems the ability to optimize performance against a wide range of unpredictable and changing conditions. All of these advancements are critically important in the application area of Uninhabited Air Vehicles (UAV's). In many cases, these vehicles are smaller and lighter than manned aircraft, and must cost much less for comparable applications. Also, in the absence of an on-board pilot/controller, the UAV must have the on-board capabilities to identify and react to changes in flight characteristics, damage, or failure. The UAV's will also need to be somewhat autonomous in operation, and be adaptable in their reaction to flight conditions and mission changes. As such, it is projected that future combat UAV's will require extensive and complex on-board software systems, hosted on compact and affordable processing configurations such as envisioned for Vehicle Management Systems architectures being developed within the Air Platforms DTAP. To ensure reliability of the UAV system, revolutionary techniques will need to be developed to adequately analyze and ver4i these critical on-board systems. Fundamentally, these techniques must be robust enough to handle adaptive (up to intelligent and on-line learning) systems, yet be as cost effective as current capabilities. Simply put, current software analysis and test techniques are inadequate to handle these emerging adaptive systems with nondeterministic behavior. Innovative solutions for the validation and verification of adaptive/intelligent software systems are therefore desired.

PHASE I: Evaluate limitations of current analysis and test techniques as applied to emerging adaptive/nondeterministic functionality. Establish "Design for Analysis/Test" technique that enables the evaluation/verification of performance without conventional exhaustive/ comprehensive test. Define analysis tools as required. Project design cycle time as compared to current techniques.

PHASE II: Establish and apply three diverse test cases of adaptive systems functionality. Develop conceptual tools as required. Apply techniques to demonstrate ability to verify bounded systems performance.

PHASE III DUAL USE APPLICATIONS: The market for affordable analysis and verification of adaptive/intelligent safety critical systems encompasses a multitude of military and commercial applications. In addition to aircraft, spacecraft could benefit due to the reduced cost and development time required for mission design and certification. Spin-off applications would involve certification of any real-time safety critical systems, such as "free flight" air traffic control, nuclear power plant control, life critical medical systems, and hazardous material handling equipment.

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2. De Feo, P. -1 Mann D,; Methodology Development for Verification and Validation of Flight Critical Systems Software-, Technical Report WL-TR-90-3066; OCT 90.

3. Hitt, E.; Webb, J.; Lulcus, C., Bridgman, M.; Eldredge, D.; Handbook-Volume 1, Validation of Digital Systems in Avionics and Flight Control Applications; DOT/FAA/CT-82/115; Jun 8-Jul 82.

KEYWORDS: Verification and Validation, Flight Critical System, Safety Critical System, System Integration, Integrated Control, Adaptive Control, Intelligent Systems, Autonomous Systems, Software Development, Software Analysis, Determinism

AF00-273 TITLE: Plasma Flow Control Technology

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Develop technology to modify aerospace vehicle flowfields using plasmadynamics.

DESCRIPTION: Sustained hypersonic flight offers potential revolutionary improvements in warfighting and space launch. Limiting factors in vehicle performance include aerodynamic heating, pressure and viscous drag, and maneuverability. Recent research indicates that flowfields may be modified by the creation and manipulation of plasmas near the vehicle. Plasma flow control presents novel challenges in the creation of large volumes of plasma in high-speed flowing gas, computation and measurement of weakly ionized magneto-gasdynamic flows, integration of control schemes for realistic vehicles, and other areas. Innovative solutions to these problems are required in order to bring plasma flow control to full technological maturity.

PHASE I: Define the proposed concept and develop relationships (theoretical or empirical) between the input and desired output. Define tests and computations to demonstrate the feasibility of the concept. Present concepts for integration and maintainability.

PHASE II: Demonstrate the concept in bench-scale laboratory tests. Analyze the costs and benefits of the technique as applied to an aerospace vehicle in flight or ground test in a production-scale facility.

PHASE III DUAL USE APPLICATIONS: Flow control and measurement concepts developed under Phases I and II may potentially be applied to civilian space launch and high speed air vehicles. Plasma flow control hardware and diagnostics are likely to have civilian application in high temperature environments such as furnaces, engines, materials processing, and manufacturing.

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2. Bityurin, V. A., Zeigarnik, V. A., and Kuranov, A. L., "On a Perspective of MHD Technology in Aerospace Applications," AIAA paper 96-2355, 27th AIAA Plasmadynamics and Lasers Conference, June 1996.

KEYWORDS: Magnetogasdynamics, Plasmadynamics, Fluid Dynamics, Plasma, Aerodynamics, Magnetohydrodynamics

AF00-274 TITLE: Simulation Techniques to Coordinate Large Numbers of Air Vehicles

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Aeronautical Systems Center - Engineering

OBJECTIVE: Develop an advanced simulation environment that will support command, control, and optimization of large numbers of air vehicles working together in a force structure.

DESCRIPTION: The Air Force is seeking innovative or creative approaches to optimize the effectiveness of large force structures through the use of modeling and simulation tools or simulation subsystems. The Simulation Based Research and Development technology sought should be applicable to evaluate interactions of large numbers of entities such as found in coordinated force structures. These tools should enable Air Force researchers to conduct technology tradeoff studies to determine the best compromise between force effectiveness, size, and control technique. They should be capable of evaluating mission effectiveness, and demonstrating an end-state capability for large numbers of offensive weapons such as Uninhabited Air Vehicles (UAV). Force structures including "swarms" of smaller UAVs are of particular interest. Real time, full-mission simulation tools are needed to permit the Air Force to determine the most effective way to control large numbers of small offensive and surveillance entities. The proposing company is encouraged to offer innovative approaches to provide simulation techniques supporting large numbers of air vehicles Some potential areas of research include: a) novel concepts to simulate command and control systems for large numbers of air vehicles, b) force structure tactics development using simulation, c) pilot and/or controller evaluation tools, d) force effectiveness via real-time simulation, e) rapid prototyping tool for research, f) novel simulator system technology to improve cues presented to pilots and operators, and g) application of virtual reality technologies to improve coordinated force research.

PHASE I: Define the proposed approach, investigate alternatives, and predict performance of the proposed design.

PHASE II: Conduct the research, and demonstrate the approach, or high risk portions of the approach. The design, including results of any performance tests, shall be documented in a final report.

PHASE III DUAL USE APPLICATIONS: Simulation tools resulting from this SBIR will have diverse application to both commercial and military applications. For example, a tool that supports control optimization of large numbers of entities can be used for air or ground traffic control applications, optimization of biological agents and system-of-systems.

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KEYWORDS: Uninhabited Air Vehicle (UAV), Air Superiority, Control System, Simulation, Air Vehicle, Real-time, Rapid Prototyping, Networking

AF00-275 TITLE: Flow Control for Vehicle Propulsion/Weapons Integration

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Remove operability limitations of weapon systems through the application of active flow control.

DESCRIPTION: The proposed use of active flow control for altering local aerodynamic phenomena has been flourishing with the recent development of small devices to enable such control. These include, but are not limited to, Micro Electromechanical Systems (MEMS) devices, steady or pulsating jets, and virtual jets. These typically small, low power devices, show promise for localized control of shear layers, state of turbulence, and unwanted secondary flows. They also have potential for providing an apparent aerodynamic surface that can be tailored to different operating conditions (virtual shaping). The purpose of this topic is to apply these devices to problematic issues associated with advanced air vehicles and the integration of their propulsion systems and weapons systems. Specific examples include boundary layer separation control, virtual inlet shaping for optimal pressure recovery across a broad Mach range, secondary flow control of compact inlet ducts for elimination of turbine engine distortion, virtual nozzle shaping for area control and thrust vectoring without large mechanical flaps/devices, nozzle jet mixing for reduction of plume temperature and exhaust noise, control of the damaging acoustic environment of weapons bays, and enhancement of store separation characteristics within weapons bays. The applications range from subsonic transports to transonic/supersonic combat vehicles. A key consideration will be that the developed technology is consistent with or enables low observable characteristics of the air vehicle. Areas of interest include: integration of existing devices into air vehicle systems, new actuator designs with expanded frequency, amplitude, or inherent flexibility characteristics, development of rapid flow control design methods allowing designers to utilize the technologies in tradeoff studies, development of control systems (neural net or conventional) for optimization of the device performance, experimental validation of a potential device, or numerical simulation of the device to enhance understanding of the relevant flow physics.

PHASE I: Experimental demonstration of active control device, simulation of single isolated device flow control characteristics, simulation of a flow control strategy, simulation determining optimal sensor/actuator locations.

PHASE II: Demonstration of active device under simulated flight conditions, simulation of bank of devices, implementation of breadboard mockup of control system with sensors/actuators, simulation showing impact of installed devices on mission performance.

PHASE III DUAL USE APPLICATIONS: High-payoff military applications include flow distortion control in low-signature compact inlets for UCAV (unmanned combat air vehicles), separation and acoustic control for integrating Small Smart Weapons onto UCAV, and low-cost, low weight fluidic (vs mechanical) thrust vectoring. Virtually, every commercial market which deals with some aspect of flow control stands to benefit from this technology. High efficiency commercial aircraft, quiet aircraft, more efficient aircraft engines, electronics cooling, enhanced turbine cooling, enhanced fans, compressors, quiet car interiors, are just some of the more obvious examples of the potential commercial applications. The competitive posture of the United States with respect to designing, manufacturing, and selling highly energy-efficient devices is greatly enhanced by this technology. Increased emphasis in the commercial market on quiet products (planes, dishwashers, automobile cabins, hairdryers) , and on higher density electronics (more heat generated in a smaller package) means that active control of aerothermal and aeroacoustic environments will play a major role in new product development.

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KEYWORDS: Flow Control, MEMS – Micro Electromechanical Systems, Weapons Bay, Inlet, Nozzle, Wing Performance Enhancement

AF00-276 TITLE: Network Centric Distributed Vehicle Management Systems

TECHNOLOGY AREAS: Air Platform, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Aeronautical Systems Center - Engineering

OBJECTIVE: To extend Vehicle Management System (VMS) paradigms to develop a safe, multi-ship coordinated control network.

DESCRIPTION: Vehicle Management Systems (VMS) projected for unmanned air vehicles integrate the critical control functions (flight control, engine/propulsion control, thermal management, landing gear, etc) needed to operate safely. Included are elements of sensing (air data, pilot inputs, inertial data, etc), data communications (data links and busses), processing (data conversion, computers), and effecting (control surfaces, thrust vectoring, etc). In projected unmanned vehicle applications, the role of VMS will expand to encompass further responsibilities. One area of importance will be the safety critical management of multiple unmanned vehicles operating in close proximity. In future battlefield scenarios, unmanned tactical aircraft will be working in close coordination as a force multiplier. The combination of the close proximity, precision operation and machine-controlled lethal capacity will foment new requirements for mission/flight safety. To increase the probability of mission success and decrease the probability of fatal mishap, extensive safety checking will be required rapidly and continually.

Recent technology advances have created the means to process large amounts of data in computing systems. For the Network Centric VMS designer, the challenge is to determine data transfer solutions to effectively process the required data among multiple unmanned vehicles for safe, coordinated operations. In normal computer-based VMS architectures, the redundant data bus provides the means to transfer flight critical data between the on-board computation sites. In the multi-aircraft control application, the VMS data bus must extend outside the individual aircraft to encompass and network the rest of the mission unit. This extension across free space will complicate and hinder the overall operation of the network. Most of the free space data communication mechanisms lack the required deterministic, low latency performance required for flight critical networked systems. Environmental factors, both within and outside each aircraft, shall also affect the network performance. To accomplish the project goal, the performance of the free space communication must be made compatible with that of the data bus. As always, volume, weight, and cost will be design constraints, so the implementation of the network must be concise and it must be seamless to minimize latency.

In short, solutions are sought to enable the efficient, deterministic, and safe management/processing of data to be used in network centric control of multiple unmanned aircraft.

PHASE I: Conduct preliminary design trades and analysis of network centric VMS architectures. Techniques for fault tolerant multiprocessor architectures will be extended to develop a physically distributed, multi-vehicle network with capability. Tasks encompass Network Concept Definition, Requirements/Risk Definition, and Technology Trades.

PHASE II: Develop and demonstrate selected architecture. Provide measurement of flight critical performance. Tasks encompass System Simulation/analysis and Key Component Technology Demonstration(s).

PHASE III DUAL USE APPLICATIONS: Network Centric VMS techniques can be applied to a wide range of distributed safety critical applications including nuclear power plant management and "open skies" air traffic control.

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KEYWORDS: Network Centric, Adaptive Control, Safety Critical, Control Architectures, Distributed Networks, Fault Tolerant

AF00-277 TITLE: Simulation Based R&D for Space Vehicle Concepts

TECHNOLOGY AREAS: Air Platform, Information Systems, Space Platforms

OBJECTIVE: Develop an innovative simulation tool to evaluate space vehicle concepts.

DESCRIPTION: The Air Force is seeking innovative simulation tools to support research and development of advanced space concepts in a high fidelity virtual environment. Competing concepts for space vehicle systems and subsystems need to be efficiently evaluated to support optimization of vehicle performance. For example, there is a need to optimize space vehicle design concepts to reduce vehicle weight and drag, increase payload, reduce fuel consumption, reduce cost and turn-around time, etc., while simultaneously supporting Air Force operational requirements. A rapid prototyping evaluation tool is needed to be able to quantify and predict the performance of proposed space vehicle system prior to investing in system development. The tool must predict space vehicle performance interaction with a detailed atmospheric and environmental model. There is also a need to be able to predict or interact with simulated ground based control stations, and air/space communications. Innovative simulation tools which support space vehicle concept investigations including energy management, actuation technology, propulsion, launch/landing systems, and/or vehicle structures are sought.

PHASE I: Define the proposed approach, investigate alternatives, and predict performance of the proposed design.

PHASE II: Conduct the research, and demonstrate the approach, or high risk portions of the approach. The design, including results of any performance tests, shall be documented in a final report.

PHASE III DUAL USE APPLICATIONS: Simulation tools resulting from this SBIR will have direct application to commercial space ventures, such as the X-33/Venture Star, or could be modified to support development of a variety of commercial products. For example, a tool that supports space vehicle energy optimization could be directly applied to commercial satellite launch operations. Space based research tools supporting rapid prototyping could be modified to support commercial development of aircraft or control systems and reduce time-to-market. Space vehicle drag reduction simulation tools could be easily adapted to reduce drag for commercial products such as trucks, racing vehicles, or commercial aircraft. By changing the environmental model, the tool could even be used to optimize performance of ships or submarines.

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KEYWORDS: Space Vehicle, Space Superiority, Modeling, Simulation, Space Operations Vehicles (SOV), Pathfinder

AF00-278 TITLE: Evaluation of Vehicle Wiring Systems

TECHNOLOGY AREAS: Air Platform, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: F-15 Systems Program Office

OBJECTIVE: This topic seeks to conceive and develop sensors and systems to manage the health and status of complex aircraft wiring systems. The method or technology must itself be low cost, passive (does no harm), convenient, easy to use, and comprehensive in its ability to detect, isolate, and perform prognostics on wiring problems that occur during use and maintenance. Most important is the ability to accurately estimate the residual life of the wiring system (or subsystem) being monitored or tested. Prognosis and risk assessment is essential as a means to prevent catastrophic loss of life, as well as loss of aircraft systems. The resulting capability will enable real-time determination of wiring system integrity and provide a means to manage the health of the wiring system like that of Line Replaceable Units (LRUs) as a cost effective means to operate air, space and naval vehicles.

DESCRIPTION: Finding wiring faults is a maintainer's worst nightmare. A number of vehicle performance and maintenance problems can be attributed to poor wiring quality due to aging, or damage. As an example, a recent incident involving the space shuttle Columbia's wiring system ended up delaying a launch for Endeavour three weeks and causing numerous man-hours to inspect dozens of miles of wiring for potential short circuits. The short circuit occurred five seconds after the shuttle Columbia's July 23, 1999 launch because a raised metal portion on a stripped screw had abraded insulation on several wires. Launch vibrations caused intermittent shorting to ground and knocking out power to two of the three engines. Back-up systems took over functions averting a shutdown of the engine system. Wiring damage can be due to maintenance, abrasion, crimping, disconnect cycles, corrosion, vibration, as well as battle damage. These maintenance problems impact safety, life cycle cost, and system operational readiness. Aging effects on the wiring can except the same failures but will take longer to appear and many may start as intermittent type problems.

Generally, wiring is tested only on installation, at major depot overhauls, or inspected when some vehicles are diagnosed with wiring related problems. Trouble shooting wiring problems is a time consuming procedure of studying schematics, testing, using tools such as a Digital Storage Oscilloscopes (DSOs), Digital Volt Ohm Meters (DVOMs), and inspection of wiring and interfaces to perform end to end tests. The time to troubleshoot is often spent just trying to get to wire harnesses and components. Often years of training and experience are required to be proficient in isolating wiring problems.

Deficiencies are usually hard to quantify and some faults are only evident during system operations. This creates an additional burden on technician's whose primary responsibility is not wiring but systems maintenance.

The USAF is seeking research leading to development of new sensors and systems with the capability of determining with precision wiring health and an accurate estimate of the life remaining. Promising technologies in prognostic capabilities for detecting degradation due to physical anomalies include pattern recognition techniques, time domain and frequency domain reflectometry. The basic concept is to determine wiring quality during pre-flight checks, or on demand from flight crew or flight line technicians. In some instances (e.g. post battle) it may be necessary to perform health and status checks in flight, or on demand of the crew. Additionally, there is a need for the ability to retest and certify wiring repairs and harness replacements after it is installed to avoid expensive rework and potential damage that might been caused by incorrectly assembled wiring. As a concept of operation, this can include assessing the health, status, and remaining life of the components of the wiring system, e.g. wiring insulation integrity, metallic fibers, connectors, shields, fiber optics, signal, and power.

PHASE I: Review the prior and current work on prognostics and health management systems. Identify technologies suitable for demonstration. Fabricate and demonstrate a proof-of-principal prototype incorporating sensors integrated to wiring for fault detection and fault isolation. Define potential prognostic algorithms that can predict the life remaining of the wiring system.

PHASE II: Building on the success of Phase I, the Phase II objective will demonstrate a health management system for use on an operational aircraft system that will detect, isolate, and predict the time to wiring failure. The system will provide the knowledge necessary to give the technician enough time to make a repair prior to failure.

PHASE III DUAL USE APPLICATIONS: Transition the system to into a fleet of aircraft, both military and commercial, as an enhancement to present health management systems. Aircraft certification, vehicle safety and manufacturer liability concerns are major reasons for utilization of this technology. With the continued aging of both commercial and military fleets, wiring problems will continue to grow. The diagnostic tools developed under this SBIR will have widespread use. This technology would be applicable to commercial aircraft, ships, auto industry, manufacturing equipment and any complex electronic/electrical systems subject to environmental effects.

REFERENCES: Proceedings of the SAE Aircraft Safety Conference, April 1999, Paper #61472.

KEYWORDS: Wiring, Prognostics, Diagnostics, Sensors, Reflectometry, Life Remaining

AF00-279 TITLE: Guidance and Control Techniques for Hypersonic Vehicles

TECHNOLOGY AREAS: Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Aeronautical Systems Center - Engineering

OBJECTIVE: Develop innovative methods for integrating adaptive/reconfigurable control systems with autonomous guidance systems for hypersonic vehicles.

DESCRIPTION: Adaptive/reconfigurable control systems have been successfully demonstrated on fighter aircraft under manual control. These systems minimize the effect of control surface failure or damage on the human's ability to control the vehicle by maintaining stability and preserving the nominal response characteristics of the vehicle to the greatest extent possible. The human is burdened with the responsibility of modifying his guidance strategy when faced with off nominal responses resulting from surface damage or failure. Hypersonic aerospace vehicles will depend upon autonomous guidance systems for trajectory generation. Even if the inner loop control system is adaptive/reconfigurable, tracking performance degradation is inevitable. Thus the guidance system should make use of the failure information available from the inner loop and make appropriate modifications to the commanded trajectory. Neighboring optimal control approaches could be used to develop guidance laws that adapt to perturbations in control effectiveness. Guidance systems are sought that employ feedback of perturbations in identified control effectiveness to modify commands to the inner-loop such that the vehicle follows a new "neighboring" optimal trajectory to the desired final state. Algorithms and methods that allow real-time estimation of the attainable set of trajectories are sought to determine whether or not the desired final state can be achieved in the presence of the control-failure or damage. The Air Force is seeking methods for creating integrated adaptive/reconfigurable guidance and control strategies for hypersonic aerospace and reusable launch vehicles.

PHASE I: Develop and demonstrate in a non-real-time simulation a candidate method of synthesizing integrated adaptive/reconfigurable guidance and control strategies.

PHASE II: Develop refined methods and tools that allow for rapid development of integrated adaptive/reconfigurable guidance and control systems for prototype vehicles.

PHASE III DUAL USE APPLICATIONS: The methods and tools developed under this effort will be directly applicable to commercial launch vehicles. The methods could also be used in conjunction with inner-loop adaptive/reconfigurable control systems to provide pilots with estimates of the set of attainable flight paths in the presence of control effector failures or damage. Such a system would reduce pilot workload and maximize the likelihood of a safe flight termination.

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KEYWORDS: Multivariable Control, Adaptive Control, Hypersonic Vehicle Control, Reconfigurable Flight Control, Parameter Identification, Integrated Control

AF00-280 TITLE: Enhanced Boundary Layer Transition Prediction

TECHNOLOGY AREAS: Air Platform, Space Platforms

OBJECTIVE: Develop prediction methods for laminar-to-turbulent boundary layer transition which take into account realistic flow conditions.

DESCRIPTION: Sustained hypersonic flight offers potential revolutionary improvements in warfighting and space launch. Aerodynamic heating is a major factor in the design of hypersonic vehicles of all classes. Because heat transfer to the vehicle increases dramatically when the boundary layer transitions from laminar to turbulent, the prediction of the transition location is fundamental to vehicle design. Transition prediction is difficult because of the sensitivity of boundary layer transition to initial and boundary conditions. Prediction methods in the past have largely relied on data correlations. Recent advances in our knowledge of boundary layer stability and computational methods now make it possible to take complex variations in initial and boundary conditions into account in a rational manner. A need exists to incorporate these advances into a self-contained computer program accessible to designers and researchers.

PHASE I: Define the scope of the effort by identifying what initial and boundary condition specifications will be incorporated into the program. Determine how the user will specify initial and boundary conditions in practical use, and how these will be used in transition prediction.

PHASE II: Develop prototype software for transition prediction. Demonstrate the method by computing transition locations for several cases with varying initial and boundary conditions and comparing them to experiment.

PHASE III DUAL USE APPLICATIONS: Software developed under Phase II would be used in the design of advanced vehicles for transport and space launch both in the military and civilian sectors. Weight savings arising from improved transition prediction would lead to increased payload and cost savings. Modeling of initial conditions would allow reliable extrapolation of ground test results to flight.

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KEYWORDS: Boundary Layer, Hypersonic, Laminar, Turbulent, Transition, Prediction

AF00-281 TITLE: Innovative Structural Concept Modeling for Affordable Vehicles

TECHNOLOGY AREAS: Air Platform, Information Systems, Materials/Processes

OBJECTIVE: Develop structural design concepts data for affordable Space Operations Vehicles (SOV) and Uninhabited Air Vehicles (UAV) design processes.

DESCRIPTION: The process of designing an air vehicle can be significantly improved in the early stages. Currently, technologies and costs are intuitively locked-in during the concept design process without the appropriate analysis resulting in failed objectives and unexpected costs. The R&D performed in this topic develops and automates key features of an innovative systems engineering procedure which rapidly reduces this costly gap between intuition and information in the process of synthesizing complex air vehicle system designs. Proposers are encouraged to emphasize process innovation.

Current design processes do not adequately support design or technology innovation or risk reduction. The current process becomes intractable where tomorrow's emerging technologies are required to realize today's design plans. This is the situation the USAF faces today in the identification of critical technologies which facilitate the air platforms for tomorrow's missions. The R&D performed in this topic will identify a set of technologies and concepts which will be folded into an innovative system engineering process. The R&D will identify design process features which lead the designer to select innovative technologies and procedures which rapidly reduce risk. Fixed wing vehicle concepts of immediate interest include any high speed vehicle (TAV (Trans-Atmospheric Vehicles), SOV) or any uninhabited air vehicle (UAV). The design process can expand to include any vehicle concept.

A large number of recent R&D advancements in mathematics and computer science will facilitate the design process. For instance, confidence intervals and fuzzy numbers convey a measure of uncertainty. Object oriented programming can be used to decompose, recompose and prioritize the data and processes. Automated dependency-tracking facilitates the modeling and redesign of highly integrated systems. Data mining may be used to efficiently search out missing pieces of data. These advancements and many others may be considered to create a conceptual design process which leads to the development of tomorrow's flight vehicles.

A successful design concept arises from a team which includes key technology developers. Part of the design process involves the development of relevant data which is important to the vehicle designer. Aircraft structures is unquestionably a key ingredient in a vehicle design has a major influence on the affordability of the concept. New structural concepts are emerging as new materials and process technologies are developed. The concept designer requires relevant data which includes mechanical properties, manufacturing, cost etc. Therefore, the design process is improved if design data is rapidly transferred between the laboratory and the designer.

Examples of new structural concepts include: z-pinning, structural pre-forms, truss core laminates and carbon-carbon structures. A knowledge-based design model will require the data associated with these concepts to be encapsulated in a unified object-oriented format, which will address all aspects of design including (but not limited to) geometry, mechanical properties, process times and material cost. To determine accurate costs for designs with new technologies, the designer needs to synthesize a more accurate activity-based cost (ABC) model. The difficulty with synthesizing ABC models is that the amount of data needed is large, time-consuming to generate, and not available for new technology until late in the design process. The failure, stiffness, and thermal mechanics of emerging structural concepts (e.g., sandwich structures, woven structures, hot structures, etc.) are not well understood. Efforts have focused on developing statistical models and on micro-mechanical models. Regardless, today's designer requires high fidelity design data before proposing expensive engineering developments. The performing company has flexibility in selecting mathematical and software innovations which address these design process challenges. Innovative and creative approaches are encouraged are encouraged.

PHASE I: Identify vehicle component based on a TAV or UAV concept and a suite of structural concepts. Identify requirements for a design environment to develop a unified design object for each structural concept. There will be an emphasis on geometry, loads, mechanical properties (weight, thermal, stress, stiffness), process modeling, and cost. Demonstrated modeling process with one structural concept.

PHASE II: Expand process to include a number of structural concepts. Design a new integrated component with some combination of structural concepts. Examples may be low cost processes for expendable UAV wing carry-through structure or integrated structural concepts for actively cooled thermal structures. Incorporate probabilistic metrics where cost or failure uncertainty is a factor.

PHASE III DUAL USE APPLICATIONS: The proposed aerospace design product transitions to any transportation system such as the automotive or shipbuilding industry.

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KEYWORDS: Design Modeling, Structural Analysis, Knowledge-Based, Cost Modeling, Probabilistics, Process Modeling

AF00-282 TITLE: Aeronautical Sciences and Flight Control Technology for Military Aerospace Vehicles

TECHNOLOGY AREAS: Air Platform, Space Platforms

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: C-130 Aeronautical Systems Center

OBJECTIVE: Develop innovative configuration concepts, integrated design methodologies, and aerodynamic and control technologies for future USAF air and space forces.

DESCRIPTION: The United States Air Force has a vital interest in developing manned and unmanned air and space vehicles that are markedly superior to today's aircraft in the areas of affordability, reliability and mission capability. Affordable access to space requires the development of vehicles that are capable of routine, aircraft-like operations to and from space. Technologies are sought that allow safe operations, enable rapid turnaround, and provide the aerodynamic and control performance levels needed to efficiently operate in and out of contemporary military air fields. Increased affordability in the development, acquisition, and operation of aerospace vehicles requires the creation of new, highly automated design methods and tools. These tools must provide designers with the ability to rapidly synthesize and analyze new vehicle concepts. Multidisciplinary design methods are sought that insure synergistic blends of aerodynamic, thermodynamic, structural, and control system properties are obtained through optimal integration. Improvements in mission capability requires innovative aerodynamic and flight control technologies that enable new levels of speed, reliability, maneuverability, range and payloads to be attained. Advanced configuration concepts and technologies that provide increased system effectiveness (e.g. reduced drag, increased payload, lower weight, etc.) are sought. Adaptive/reconfigurable flight control technologies have been demonstrated that improve the reliability of conventional fighter type aircraft. This technology must be transitioned to unmanned aerospace vehicles that rely on autonomous guidance systems for trajectory control. Integrated adaptive/reconfigurable guidance and control methods are needed that will improve fault tolerance of aerospace vehicles to control effector failures. The methods and tools developed must be applicable to a wide range of aerospace vehicles that will conduct operations in the subsonic, hypersonic and orbital flight regimes. These vehicles will allow the Air Force to realize current objectives in the areas of sustainment, global presence, flexible response, and force projection.

PHASE I: Define the proposed concept, outline the basic principles, and establish the method of solution. Present an example of the advanced performance that will result from the technology. Determine the risk and extent of improvement over existing methods.

PHASE II: Build a prototype application of the equipment or software. Demonstrate the advanced technology under actual engineering conditions.

PHASE III DUAL USE APPLICATIONS: Improved performance and safety of commercial and private aircraft will be realized with the application of this technology. New areas of commercial growth will result from aircraft design tools that allow fast and accurate development of air vehicles to respond to aircraft needs around the world. Examples are devices that allow aircraft to operate from remote fields, carry large payloads at low cost, and are economical to produce and operate. New integrated adaptive/reconfigurable guidance and control methods will substantially enhance safety of flight for the global commercial air fleet. New aerodynamic and flight control design and analysis tools will improve education methods and allow industry to produce with lower initial investment.

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19(6): page 1270-1277.

KEYWORDS: Aerodynamics, Aerothermodynamics, Computational Fluid Dynamics, Hypersonic Configurations, Multivariable Control, Adaptive Control

AF00-283 TITLE: Innovative Weight Efficient Combined Structure/TPS Concepts

TECHNOLOGY AREAS: Air Platform, Materials/Processes

OBJECTIVE: Explore feasibility and establish the weight benefits of structural load-carrying thermal protection system (TPS) concepts.

DESCRIPTION: Traditional TPS approaches are largely parasitic in nature, in that a separate TPS transmits the local aerodynamic loads to an underlying, highly efficient, primary structure. Hot structure requires no separate TPS, in that the structure itself sustains the thermal loading. This approach, however, suffers from having to use generally less structurally efficient, high temperature materials to sustain the thermal environment. The approach proposed by this topic is to investigate more unitized designs in which a highly efficient structure can be given an integral, load sharing, heat resistant, outer surface. An example might be to employ integral weaving to achieve a unitized fibrous preform in which a ceramic matrix material is employed for the outer surface and a more structurally efficient intermediate temperature matrix material is employed for the inner layer. To form a basis for evaluation, a representative vehicle component will be selected upon which to base design development. Candidate approaches will be conceptualized and subjected to thermal structural analyses to assess weight and thermal compatibility. For those approaches deemed feasible, coupon and small panel specimens will be designed, fabricated, and tested in Phase I to assess feasibility. Phase II will involve the scale-up, design, fabrication and testing of larger size components typical of the vehicle's outer moldline structure.

PHASE I: Develop analytical methodologies and concepts

PHASE II: Methodologies and concepts developed in Phase I will be validated by experimentation.

PHASE III DUAL USE APPLICATIONS: The development of structures using advanced materials can be transferred into the commercial market in both the aircraft and automotive industries. The development of these new structures will result in stronger, lighter more efficient commercial aircraft and automobiles.

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KEYWORDS: Hypervelocity Vehicles, Military Space Plane, Space Operations Vehicle, Integrated Thermal Protection Systems, Hot Structures, Cryogenic Tanks, Ceramic Matrix Composites

AF00-284 TITLE: Multifunctional Structures

TECHNOLOGY AREAS: Air Platform

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: C-130 Aeronautical Systems Center

OBJECTIVE: Develop structural concepts that provide subsystem functionality.

DESCRIPTION: Future war fighting forces, such as the Expeditionary Air Force, need small, agile, lightweight, and affordable systems. A revolutionary level of vehicle integration will be required. The airframe and its subsystems functions must be unitized to minimize volume and weight while maintaining affordability. The current approach of airframe and subsystem integration is parasitic secondary attachment of equipment and devices. The goal of this effort is to develop and demonstrated highly innovative multifunctional structures that enable the airframe to concurrently react flight loads and perform thermo-mechanical and/or electro-optical functions in a single component. The distinction between structure and subsystems will be eliminated. The airframe structure will contain the subsystem functionality. Candidate subsystem functions include but are not limited to, thermal management, transmission of onboard electrical and hydraulic power, emission and reception of radio frequency signals, and flight control actuation. The major technical challenge for this effort is the application and processing of multifunction materials and the application of analytical tools to predict functional performance under flight loads. Typical structural material requirements are usually incompatible with electrical and thermal requirements. Materials and concepts that exhibit desired properties for subsystem functionality such as, electrical conductivity or insulation, thermal conductivity or insulation, electromagnetic permittivity, fluid resistance, etc., typically do not possess optimum structural properties, such as modulus, strength, toughness, and fatigue life. Advanced modeling and simulation capabilities must be applied to model intra-dependencies between subsystems functions and structural integrity. Highly innovative solutions are required. For example, conductive fibers may be embedded in molded or laminated composite structures to provide power transmission eliminating cabling and its attendant attachments. Proposed concepts must be highly efficient.

PHASE I: Develop a design concept and materials processing approach for a multifunction structural application. Demonstrate feasibility of the concept through analysis or experiment.

PHASE II: Demonstrate scale up of the multifunctional, structural concept developed in Phase I. Fabricate a critical element of the concept representing the significant structural and subsystem functionality features. Conduct combined structural and functionality testing, and correlate with analytical test data. Emphasis should be placed on durability of the design concept. Potential repair concepts shall also be developed. Quantify weight, volume and affordability payoffs.

PHASE III DUAL USE APPLICATIONS: This technology will find numerous applications in commercial air vehicles and space vehicles where cost and weight are critical for economic viability. A wide variety of applications are also envisioned, for ground transportation vehicles (cars, buses, trucks, and trains) where cost and weight savings are also extremely critical for commercial viability. In addition, increase application of microprocessor technology in "smart" commodity products will also benefit from this technology by allowing embedment of the electronic chips, wiring, power, and other devices. Products such as household appliances, tools, and sporting goods will have embedded electronic function and actuation systems.

REFERENCES: "Ultralightweight Structures," D. M. Kane and J. A. Hangen, WL-TR-3034, Wright Laboratory, Air Force Material Command, Wright-Patterson AFB OH, Sep 1988 to Feb 1991.

KEYWORDS: Structures, Composites, Subsystems, Embedment

AF00-285 TITLE: Low Speed Test Techniques for Powered Lift Configurations

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Demonstrate low speed test techniques for powered lift configurations without Reynolds number sensitivity.

DESCRIPTION: Current approaches for measuring the low speed static and dynamic characteristics of powered lift configurations in a wind tunnel typically provide poor results for high aspect ratio wings with rounded leading edges. This is due to the inability to properly match Reynolds number. A wide variety of new vehicles, such as dual-mode air vehicles (rescue, targeting, and damage assessment), and the advanced theater transport, will use powered lift systems and operate at low speeds. Several low speed wind tunnel facilities exist that provide the ability to gather extremely large amounts of static and dynamic data at very low cost. These facilities have not been used for high aspect ratio powered lift configurations, due to the Reynolds number problem. It is possible that recent advances in flow control devices, and the understanding of separated flows, now allow a simple, reliable means to obtain quality static and dynamic test data at low speeds using small modifications to a configuration. New configurations could be studied in a much more efficient manner, if this capability was available. This would reduce flight control system development cost.

PHASE I: Expectations for this phase would be a computational assessment or limited wind tunnel test to investigate the feasibility of small configuration modifications which provide adequate results in the absence of Reynolds number matching.

PHASE II: Expectations for this phase would be a validated computational tool or test technique, which provides adequate results for a wide variety of configurations.

PHASE III DUAL USE APPLICATIONS: The analysis tool could be used for dual-mode vehicles designed for law enforcement, gas-petroleum-utility checks, and medical rescue.

REFERENCES: "V/STOL Wind Tunnel Testing," D.G. Koenig, AGARD R-710, April 1984.

KEYWORDS: Dual-Mode Air Vehicles, Advanced Theater Transport, Low Speed Aerodynamics, Flow Control

AF00-292 TITLE: Jet Engine Test Cell Air Pollution Control

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop new technologies to reduce and control by 50% air pollution emissions associated with jet engine test cell operations.

DESCRIPTION: The testing of off-aircraft jet engines at fixed stands is part of the normal aircraft flight test and maintenance operations at Edwards AFB. Jet engines are tested to assess flight characteristics, results of engine modifications and success of maintenance work. When tested, the engines are typically run at thrust settings that vary from idle to full military power, and can include use of the afterburner. A jet engine tested off-aircraft at a fixed stand (a test cell), is considered to be a fixed stationary source for air pollution emissions, and typically emits large amounts of nitrogen oxides (NOx), hazardous air pollutants (HAPs) and volatile organic compounds (VOCs).

Because of these emissions, and the fact that Edwards AFB is in a US Environmental Protection Agency (EPA) designated "serious" ozone non-attainment area (where NOx and VOCs emissions are regulated), jet engine test cells at Edwards AFB are regulated by the local air pollution control district and under Title V of the 1990 Clean Air Act Amendments (CAAA). In November 2000, US EPA is required under the CAAA to issue a National Emission Standard for HAP (NESHAP) emissions from jet engine test activities (40 Code of Federal Regulation Part 63). At present, it is not clear how US EPA will regulate jet engine testing under the NESHAP. However, if controls are mandated under the NESHAP, Edwards AFB will be required to either implement controls, or face possible negative mission impacts by limiting jet engine test activities to reduce emissions.

Previous research into developing control technologies for jet engine test cells had demonstrated reductions in NOx and VOC emissions. However, these efforts were based on existing air pollution control technologies, were impractical or too expensive to implement, and imposed too many limitations on the operation of the test cell. The requirement of this project is to develop completely new control technologies that will reduce NOx, HAP and VOC emissions by 50% without imposing any operational restrictions on jet engine test cells.

PHASE I: Research and develop a proposed system design to achieve project goals, including feasibility analysis and cost analysis.

PHASE II: Build a prototype of the proposed system and demonstrate at an Air Force facility that accomplishes off-aircraft jet engine testing.

PHASE III DUAL USE APPLICATIONS: Technologies developed to accomplish this work can be applied to all DoD activities associated with jet engine testing and maintenance, and by commercial industries involved in jet engine manufacturing, testing, maintenance and aircraft construction.

REFERENCES:
1. Nelson, S. G.; Wander, J. D. Control of NOx and Other Pollutants at Jet Engine Test Cells; 89th Annual Meeting; Air & Waste Management Association, Nashville, TN, 3rd Floor, 1996, 1 Gateway Center, Pittsburgh, PA 15222.
2. Durham, M. D.; Haythornthwaite, S. M.; Rug, D.; Wander, J. D. Application of Pulsed Corona Induced Plasma to Jet Engine Test Cells; 90th Annual Meeting; Air & Waste Management Association, Toronto, Ontario, Canada, 1997, 3rd Floor, 1 Gateway Center, Pittsburgh, PA 15222.

KEYWORDS: jet engines, test cells, emission controls, nitrogen oxides, hazardous air pollutants, volatile organic compounds.

AF00-293 TITLE: Embedded Global Positioning System (GPS)/Inertial Navigation System (INS)-Encoded Radar Transponder

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: Using GPS time-space-position information (TSPI) technology, develop a method for improving the performance of a metric tracking radar to obtain constant 15-meter or better positional accuracy at slant ranges from up to 1,000 Km.

DESCRIPTION: This project will perform advanced development directed at satisfying a test & evaluation requirement for safe testing of future manned and unmanned aerospace vehicles. These include endo- and exo-atmospheric aerospace vehicles (X-33, X-34, X-38, and Future X-Vehicles) and surface-to-air missiles for theater missile defense (PAC-3, THAAD, and Navy Lower and Upper Tier). Flight termination decisions are based on TSPI obtained from multiple acquisition systems. The primary TSPI source could be a GPS receiver onboard the vehicle. The GPS receiver data could be transported from the vehicle to the ground stations via telemetry and/or radar transponder links. The GPS receiver data could be imbedded in the telemetry stream, and it could also be modulated onto the radar transponder output signal. The TSPI from the onboard GPS receiver would provide 15-meter or better positional accuracy over the entire flight envelope. This would satisfy the range safety requirement for observing high-quality TSPI from the vehicle in real-time via two independent paths. When tests fail to go according to the plan, the radar approach degrades gracefully. If the GPS receiver drops lock, then the radar can continue to track the vehicle using the transponder return. If the transponder fails to respond then the radar can still skin-track the vehicle. This project will develop the GPS-augmented radar transponder and the associated ground support capabilities. The suggested approach, using a GPS receiver coupled to a radar transponder on board the vehicle under test is not a firm requirement. Careful consideration will be given to other innovative methods of achieving the goal at hand.

PHASE I: Conduct a feasibility analysis and prepare a recommended system design. Submit a final report covering the analysis results and the system design.

PHASE II: Build a proof-of-concept system and demonstrate its operation at the Air Force Flight Test Center (AFFTC), Edwards Air Force Base, CA. Submit a final report on results of the demonstration.

PHASE III DUAL USE APPLICATIONS: Air Traffic Control (ATC), Global Air Traffic Management (GATM). AIR FORCE PROGRAMS SUPPORTED: Manned and unmanned air-vehicle programs (such as F-22, JSF, F-16, F-15, B-1, B-2, X-33, X-34, Global Hawk, and Darkstar). BMDO PROGRAMS SUPPORTED: Theater Missile Defense programs (such as PAC-3, THAAD, and Navy Lower and Upper Tier). NASA/AIR FORCE PROGRAMS SUPPORTED: X-programs (such as X-33, X-34, X-38, and Future X-Vehicle).

KEYWORDS: time-space-position information, radar transponder, global positioning system receiver

AF00-294 TITLE: Directional Airborne Telemetry Antennas

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop affordable, directional airborne telemetry (TM) antennas to functionally replace existing omni-directional antennas on a variety of test vehicles.

DESCRIPTION: Telemetry of data from an air vehicle to ground processing and display facilities is required in many test and training missions. The test and training communities have seen a twenty fold increase in the telemetry data rates over the past 10 years. When this increase in need is coupled with the reduction in available spectrum, caused by the sell-off of government spectrum, the combination creates a major test and training cost and schedule impact to major weapons system programs. Capabilities are needed to increase the efficiency and quality of aeronautical telemetry systems.

Advances in technology may make the application of directional antennas to telemetry practical. Usually these antennas are too large for aircraft installation and difficult to keep pointed to the ground acquisition site. Being able to point the antenna at the receiving site (via positioning cues from the ground and aircraft) will increase the signal to noise ratio (Eb/No) and possibly allow telemetry users to operate on the same frequency, on the same range, with different acquisition antennas. This will allow the ranges to support more missions without additional spectrum.

The development of a directional telemetry antenna may provide a solution to the spectrum encroachment problems. Directional antennas offer the capability to place antenna nulls and lobes to minimize interference and RF coupling. Also a steerable antenna may be configurable in a directional mode to provide point-to-point linkage between the aircraft and the ground. The characteristics of the antenna, driven by position clues from the onboard time/space and position information data and the known location of the acquisition antenna, must be able to steer rapidly enough in a high dynamic maneuvering aircraft. Considering the scope of the unknown involved in this research, the development risk inherent in this project is considered moderate-to-high.

PHASE I: Research emerging technology applicable to directional antennas. Determine the feasibility of developing a directional antenna that meets the size and maneuverability requirements of fighter aircraft. Propose a plan for the development and integration of an airborne directional telemetry antenna for the Phase II effort.

PHASE II: Develop technologies required to support the development of an airborne directional TM antenna. Demonstrate the use of directional antennas for use in the DoD flight test environment.

PHASE III DUAL USE APPLICATIONS: Small, directional antennas could potentially revolutionize the commercial communications industry. Initial commercial applications include commercial airliners, freight companies, and telecommunications companies (proposing the use of UAVs and LEO satellites as data relays).

KEYWORDS: Directional Antennas, Telemetry Antennas, Phased Array Antennas, Steerable Antennas.

AF00-295 TITLE: Low Cost Global Positioning System (GPS)-based Collision Avoidance System

TECHNOLOGY AREAS: Air Platform, Weapons

OBJECTIVE: Develop a low cost GPS-based system that transmits and receives position data through an onboard system.

DESCRIPTION: Air Force Flight Test Center (AFFTC) pilots have routinely identified a midair collision between military aircraft in R2508 as the most likely cause of our next mishap. Currently, collision avoidance is based on "see-and-avoid," SPORT/Joshua traffic advisories, or onboard aircraft sensors. Even using all of these aids to avoid collisions, pilots routinely experience what they perceive as close passes with other military aircraft. Low cost technology is now available which could provide information on other participating aircraft to the aircrew. A low cost GPS system with strap on antenna(s) could be used to determine the participating aircraft's position. As many of the aircraft operating in the R2508 airspace perform close formation and highly dynamic maneuvers, any GPS/antenna implementation should be designed with a high update rate and to preclude the loss of GPS signal lock. Using a modified transponder (possibly Mode S), the aircraft's GPS estimated position could be encoded as is now currently done with altitude (Mode C). Mode S also has the capability to receive encoded data from ground agencies or other aircraft (currently used by traffic alert and collision avoidance system (TCAS)). It should be possible to gather position and altitude data (velocity and heading information is also desired, but is not required) from other participating aircraft and present the information to the pilot on a small, low cost display. The display could also be heading oriented (based on GPS determined ground track) and contain a database which incorporates airspace boundaries, etc.

PHASE I: Development and technical assessment of a low cost prototype system, including at least an end-to-end bench test of all the necessary hardware and software components for at least a ten airplane scenario.

PHASE II: In-flight evaluation of the system in the R2508 complex. This phase would be accomplished in cooperation with the USAF Test Pilot School and would utilize two to three aircraft provided by the school.

PHASE III DUAL USE APPLICATIONS: General aviation collision avoidance, high dynamic vehicle ground collision avoidance.

REFERENCES: A.W. Warren, R.W. Schwa, T.J. Gels and Ark Saharan,
Conflict Probe Concepts Analysis in Support of Free Flight, NASA CR-201623, January 1997, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

KEYWORDS: global positioning system, collision avoidance

AF00-297 TITLE: Motion Enabling Device for Virtual Flight Test Application

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop and demonstrate a fully functional motion enabling-device capable of mounting VFT test hardware in transonic wind tunnels.

DESCRIPTION: Recent efforts at the AEDC have focused on the development and demonstration of a new wind-tunnel test capability called Virtual Flight Testing (VFT). The new capability will provide aircraft and missile designers with a mechanism to evaluate and validate autopilot and flight-vehicle control systems design in a wind-tunnel environment.

Since the wind-tunnel model translational motion must be restrained, a digital reconstruction of the translational motion will be simulated using wind-tunnel measured forces and moments. A critical need for the VFT concept is a motion-enabling device that interfaces directly with the VFT test hardware (i.e., scaled models of aircraft and missiles) in a wind tunnel and measures model forces and moments in a fast-response environment. Listed below are the criteria necessary to successfully incorporate a motion-enabling device into the VFT concept. The motion-enabling device must:

1. Allow for 3-degrees of freedom rotational motion, while restraining any translational motion. The motion-enabling device must provide 360 degrees of rotational motion in both the roll and pitch axes, while allowing for a limited range of angles about the yaw axis. The maximum/minimum yaw angles required are ± 45 degrees.
2. Allow for near friction-free rotational motion.

3. Be able to measure restraining forces due to aerodynamic loads on the model. The motion-enabling device should be designed to support maximum restraining forces of 15,000 lbf. in the pitch and yaw planes and 2000 lbf. in the axial plane. The measuring device must be able to resolve the forces within an accuracy of ± 0.5 % of the full scale value in a fast response environment. It is desired that the measuring device be able to acquire data at a rate of 20,000 samples per second.

4. Be able to generate a retarding force that will damp out any divergent conditions experienced during testing. The requirement to damp out divergent conditions should they exist is a necessary safety feature that would allow for system protection in the event of autopilot failure or a divergent condition being reached.

5. Be designed such that aerodynamic interference affects between the device and test hardware are minimized. The test articles could range in size from 10%-scale models of aircraft to full-scale models of missiles. Test conditions will range from Mach numbers 0.2 to 1.6.

PHASE I: Demonstrate on a limited scale the ability to digitally reconstruct the translational motion of a model in a wind tunnel using measured forces and moments.

PHASE II: Develop, demonstrate, and deliver to the Air Force a full-scale motion-enabling device that meets the requirements listed above.

PHASE III DUAL USE APPLICATIONS: The proposed motion-enabling device will have commercial applications in the development of prosthetic devices that include bio-feedback sensing to induce or assist in movement.

REFERENCES:
1. E. Marquart, C. Ratliff , "An Assessment of a Potential Test Technique: Virtual Flight Testing (VFT)," AIAA Paper 95-3415.
2. American Institute of Aeronautics and Astronautics, Suite 500, 1801 Alexander Bell Drive, Reston, VA 20191-4344.

KEYWORDS: Virtual Flight Testing, translational motion, wind tunnel, motion-enabling device, Mach number, missile .

AF00-298 TITLE: Turbine Engine Augmentor Rumble and Screech Indicator

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: Design and develop a fully functional high-speed turbine engine augmentor combustion monitoring system.

DESCRIPTION: Augmentor (afterburner) operation is often associated with combustion instability that can be potentially detrimental to the turbine engine if the resonant amplitude levels are excessive. During testing of an engine, known to have poor augmentor combustion characteristics, obscuration of the visible augmentor-camera images was noted. The source of the obscuration is believed to be unburned-fuel spray or smoke. The correlation of obscured image and combustion instability could provide the basis for a combustion instability indicator.

Augmentor rumble is generally associated with longitudinal combustion instabilities with acoustics frequencies between 50 -100 Hz. The acoustic frequencies of screech are considered to be as high as 600 Hz and are generally associated with circumferential or transverse modes. A current method to control the potentially devastating combustion instabilities, after the instabilities have begun, is to reduce the fuel flow to the augmentor. A simple, rugged, and low cost sensor system that can determine incipient combustion instability and provided feedback for combustion control is desired. Any sensors used would be expected to be located downstream of the augmentor and must endure the harsh engine exhaust environment

PHASE I: Select and evaluate a promising concept. A proof-of-concept demonstration of the key concept is required in this phase.

PHASE II: Design, assemble, test, and deliver to the Air Force a functional rumble-screech sensor system suitable for use in production turbine engines.

PHASE III DUAL USE APPLICATIONS: Commercialization potential lies within the military aircraft industry. Modifications will also allow the device to be used as part of a feedback control device for non-augmented operation in commercial aircraft turbine engines as well as in stationary gas turbines used for power generation.

REFERENCES:
1. "The Aerothermodynamics of Aircraft Gas Turbine Engines," AFAPL TR 78-52, Gordon C. Oates, July 1978, AD A059 784 (DTIC), Defense Technical Information Center, Suite 0944, 8725 John J. Kingman Road Ft. Belvoir VA 22060-6218.
2. "The Aerothermodynamics of Gas Turbine and Rocket Propulsion," AIAA Education Series, AIAA, NY, NY, Gordon C. Oates ,1984. 59 John St., 7th Floor 10038.
3. "Augmentor Stability Management Program, Final Report," AFWAL-TR-82-2001, R. Ernst, February 1982, AD A117 926 (DTIC) National Technical Information Service, 5285 Port Royal Road, Springfield VA 22161.

KEYWORDS: Turbine Engines, Combustion Instability, Augmentor

AF00-299 TITLE: Thin High Z Converter Foils

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop methods of producing thin high Z foils for low cost nuclear weapons effects simulations.

DESCRIPTION: X-ray production efficiency at low voltages (less than 1 MV) is reduced by self-adsorption. Electrons are typically accelerated across a gap into a high Z (atomic number) foil where bremsstrahlung radiation is produced. Most of the radiation produced is adsorbed before it can exit the foil and be used. Techniques for constructing reflex triodes have been proposed where a hollow cathode is placed on either side of a thin anode/converter and electrons passing through from each cathode are reflected by the electric field of the second converter. The electrons then bounce back and forth through the anode losing a small percentage of their energy and generating additional emissions of x-ray with each pass. This process could result in much more radiation output than a standard diode if the high Z material can be made sufficiently thin to reduce self-adsorption. The development of a technique for producing low cost 2- to 6- micrometers thick Au or Ta foils that are 6 to 18 inches in diameter is needed. To be useful, the foils should have a uniform thickness within +/- 20% and be capable of being stretched flat to within +/-0.2. For Phase I, a sample that will be a support ring 30-mil thick with a 6.5-inch inside diameter (free foil diameter) and 7.75-inch OD is needed. The sample is to be the mass equivalent of a 3-micrometer thick gold foil. The foils must be strong enough to survive careful handling and be mounted in a machine. The cost to fabricate the foils is a critical factor.

PHASE I: An evaluation and demonstration of a proof-of- concept sample foil on the Modified Bremsstrahlung Source (MBS).

PHASE II: Demonstration of layer foils up to 18 inches free diameter on large x-ray simulators. Demonstrate mass producibility and ability to fabricate large very thin diameter foils.

PHASE III DUAL USE APPLICATIONS: The ability to make these foils will allow the rapid generation of high quality transmission electron microscopy (TEM) samples. This will be a milestone in the improvement of metallurgical techniques. Other commercial applications include the general use of thin films and in direct applications for very short pulse x-ray inspection.

REFERENCES:
1. B.V. Weber et al., "Bremsstrahlung X-Ray Source Enhancement Using Reflexing Converters," Journal of Radiation Effects, 12 No 1, 232 (1994).
2. G. Cooperstein et al., "Potential Enhancements of Warm X-Ray Dose from a Reflexing Bremsstrahlung Diode," IEEE Transactions on Nuclear Science, Vol. 42 No 6 (1995). The Institute of Electrical and Electronic Engineers, 445 Hoes Lane, Post Office Box 1331, Piscataway, NJ 08855-1331.

KEYWORDS: X-Rays, Ionizing Radiation, Thin Films, Reflex Diode

AF00-300 TITLE: Miniaturized Robust Multichannel Telemetry System

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop a robust telemetry system that can survive in a hostile temperature and vibration environment while transmitting sensor data from an aerospace ground test article.

DESCRIPTION: Heat flux, pressure, strain gauge, vibration, and temperature data have traditionally relied on extensive wiring or slip-ring schemes to transfer the signal off-board of wind-tunnel models or turbine engines. This leads to long installation and setup times. Aerospace ground-testing customers would like to reduce test costs and cycle times and add more instrumentation by eliminating wires/slip rings. The future telemetry system should fit in a small volume (1/2 inch by 1/2 inch by 1/4 inch) and operate reliably in a 1000°F temperature environment using 100° F cooling water. The system must transmit across a distance of at least 10 feet in a variety of ground test facilities with the potential for significant transmission signal interference. The device must operate with applied G loads in excess of 50 "G's" in a near vacuum and/or operate reliably at temperatures of 350-450°F concurrently with G loads in excess of 50,000 "G's." To be useful, the telemetry system will have to survive in these hostile environments for at least one hour, accept inputs from 50 measurement instruments, and transmit 50 channels of data at rates of at least 500 samples/second per channel. Each channel should have at least 16-bit resolution and must be remotely programmable during a test period without hard wire connections.

PHASE I: Analytically and experimentally investigate the feasibility of developing a telemetry system that can meet the requirements stated in the Description above. A proof-of-concept demonstration is required.

PHASE II: Produce, test, and deliver to the Arnold Engineering and Development Center a working prototype system that meets the requirements stated in the Description above.

PHASE III DUAL USE APPLICATIONS: In addition to companies involved in aerospace ground test facility testing, the technique can be applied to other rotating machinery such as turbine engines. The turbine engine manufacturers are actively searching for a telemetry device of this description. Helicopter rotor track and balance procedures currently utilize mechanical slip rings for data transmission. The telemetry system could be readily adapted for this application providing a more reliable diagnostic method for rotor track and balancing.

REFERENCES:
1. Marquart, E. , Dix, R., and Walker, G., "Kinematic Telemetry in Wind Tunnels," AIAA Paper 95-3984, 1995, American Institute of Aeronautics and Astronautics, Suite 500, 180 Alexander Bell Drive, Reston, VA 20191-4344.
2. Mehregany, M., DeAnna, R.G., and Reshotko, E. "Microelectomechanical Systems for Aerodynamics Applications," AIAA Paper 96-0421, 34th Aerospace Sciences Meeting & Exhibit, Reno, NV, January 1996. American Institute of Aeronautics and Astronautics, Suite 500, 180 Alexander Bell Drive, Reston, VA 20191-4344.
3. Shaver, Joel E., Jones, Gil R., and Walker, Greg P., "Application of Gun-Launched Telemetry at the AEDC Range G Facility," AIAA 96-4508 AIAA 7th International Aerospace Plane and Hypersonic Technologies Conference, Norfolk, VA, November 18-22, 1996. American Institute of Aeronautics and Astronautics, Suite 500, 180 Alexander Bell Drive, Reston, VA 20191-4344.

KEYWORDS: Telemetry, Wind Tunnel Instrumentation. Turbine Engine

AF00-302 TITLE: Intelligent Near Net-shape Manufacturing Cell

TECHNOLOGY AREAS: Materials/Processes

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: C-141 Program Management Directorate

OBJECTIVE: Develop an integrated, near net-shape manufacturing cell to provide improved mission effectiveness and manufacturing supportability.

DESCRIPTION: This topic addresses an intelligent, integrated manufacturing cell that is intended to produce detail machined aircraft structural members directly from digital engineering data through near net-shape metalworking processes as an integrated, intelligent process. This system would employ accepted computer integrated manufacturing (CIM), computer integrated design (CID), finite element modeling (FEM), intelligent processing of materials (IPM) and nonlinear analytical techniques to convert digital engineering data to the appropriate intelligent manufacturing models. The models provide the design for, and allow the manufacture of, metalworking tooling and dies that will be used in the production of the near net-shape high strength aluminum alloy replacement structures. These models are also shared in the detail machining of the near net-shaped products. Furthermore, to improve efficiency and maintain the properties and quality of the original wrought products, the intelligent near net-shape manufacturing cell shall employ additional intelligence by integrating a material or alloy selector as part of the modeler and nonlinear analysis to identify and idealize mechanical properties and to predict and minimize distortion.

PHASE I: The Phase I goals include 1) the evaluation and testing of candidate concepts, 2) an ROI cost assessment, and 3) a feasibility evaluation addressing requirements and capabilities, including capitalization, environmental impact, and facilities and personnel issues. The leading technological concept will be developed to demonstrate proof of concept and to include a conceptual model for evaluation and testing.

PHASE II: After the conceptual model has been tested and refined, a prototype shall be developed and evaluated to demonstrate the intelligent characteristics of the integrated system. The conceptual prototype of the intelligent, integrated system shall include demonstration that the manufactured product complies with the digital data in both the metal-worked and finished machined conditions.

PHASE III DUAL USE APPLICATIONS: The successful application of this technology may revolutionize organic manufacturing capability at this center and result in substantial improvements in weapons system supportability of all the prime weapons systems managed and maintained here. Therefore, this potential also applies to each of the other centers and similar counterparts in other DoD services. But supportability is not just of concern in military applications. The commercial and other civil aviation fleets also require manufacture of structural members in small quantities to support maintenance, repair, and overhaul. In other words, there is a substantial potential for commercialization if this effort is successful.

REFERENCES: Net Shape Technology in Aerospace Structures, ADA176508, NTIS DTIC/STINET; Industrial Technology Modernization Program, ADA208799, National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, DTIC/STINET; Intelligent Processing of Materials, ADA269250, DTIC/STINET; The Role of Manufacturing Workstations in Computer Integrated Manufacturing, ADD802105, IFS (Publications) Ltd., 35-39 High Street, Kempston, Bedford MK 427BT, England.

KEYWORDS: Intelligent Manufacturing, Process Integration, CIM, CID, FEM, IPM

AF00-303 TITLE: Reduction of EMI from Hybrid Electric Drivetrains

TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Research and develop technologies to reduce inherent EMI from high power hybrid electric drivetrains.

DESCRIPTION: Hybrid electric vehicles offer significant military advantages over conventional vehicles, such as reduced fuel consumption, greater torque and a pure electric "stealth" capability with minimal thermal and acoustic signatures. But hybrid power trains inherently produce more electromagnetic interference than conventional drivetrains due to the high power, high speed, switching that takes place for vehicle control. The level of EMI produced in today's hybrid drivetrains is well above limits specified in Mil-Std 461E, and SAE 551, Electromagnetic Interference for vehicles. R&D goal of this topic is to identify causes of EMI in the drivetrain, develop methodologies to minimize EMI and to develop alternative technologies that produce less EMI. Shielding has been found to be a less than cost-effective means of lowering the EMI level for current systems. This research should concentrate on innovative drivetrain design considerations and/or alternative technologies that meet hybrid electric operational parameters. WR-ALC/LEE has deployed three (3) hybrid electric step vans. Electrical schematics detailing available energy will be provided to successful Phase I offeror(s) as GFI. One of the deployed vans will be provided to the offeror for Phase II as GFE to demonstrate the onboard power generation capability.

PHASE I: Identify causes of EMI from existing hybrid electric vehicles. Research, develop and test new technologies to reduce EMI on hybrid electric drivetrains, as described above. Integration with the hybrid drive system must be considered.

PHASE II: Integrate the technologies developed during Phase I into a prototype hybrid drivetrain system. Demonstrate validity of the new technology by testing the drivetrain in an existing Air Force hybrid electric van, bus, and tow tractor. Electromagnetic interference (EMI) as specified in Mil-Std 461, and SAE 551 (latest versions) shall be a prime consideration. Equal in consideration is the overall business case to include reliability, maintainability, environmental impact and commercialization.

PHASE III DUAL USE APPLICATIONS: Hybrid electric drivetrains would have numerous potential commercial applications, including commercial flightline vehicles and support vehicles and support. The cost-effective reduction of EMI from these systems will accelerate the use of hybrid drivetrains in military and commercial applications.

REFERENCES: Statement of Objectives for Hybrid Electric Vehicle, Electric and Hybrid Vehicle Program, DE000189, DTIC/STINET, Electric Vehicle EMI/EMC Test Program, DN816153, DTIC/STINET.

KEYWORDS: Hybrid Electric, electromagnetic interference, hybrid drivetrain.

AF00-305 TITLE: Portable, Field-Functionalized, Multi-component Vapor Detector

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a low-cost, lightweight, easy-to-operate instrument for monitoring hazardous air pollutants.

DESCRIPTION: There are increasingly stringent requirements, including recent aerospace NESHAP standards, to monitor and then control vapor-phase concentrations of organic pollutants in industrial settings. These requirements dictate the use of (1) dedicated analytical instruments for individual or small groups of compounds, (2) use of costly, bulky, and difficult-to-maintain broad-spectrum analytical instruments, or (3) field samples with subsequent, off-line laboratory analyses. All of these approaches are costly, require highly trained personnel, and take significant amounts of time.

This project seeks an innovative multi-component air monitoring system which addresses each of the shortcomings outlined above. Inherent in these goals are concepts which address: (1) Ability to measure low concentrations of multiple organic vapors in the presence of typical ambient water vapor concentrations, (2) the need for detectors which do not require cooling, and (3) the need for a rugged, portable instrument which could be successfully operated by a trained technician.

PHASE I: Design a prototype, field-functionalized OP-FTIR unit with the following target capabilities: (I) A cost of $25K or less, (ii) Simplified operation and output, and (iii) Small, lightweight design. Demonstrate its capabilities by direct comparison with an existing, commercial open-path Fourier transform infrared spectrometer unit.

PHASE II: Develop the prototype design into a commercially viable unit which meets many of the routine air monitoring requirements typically found at industrial sites. The unit must also be developed in such a manner as to ensure data integrity and credibility within the framework of EPA guidance documents and other regulatory requirements (see Refs 1 and 2 as examples for one type of instrument).

PHASE III DUAL USE APPLICATIONS: The proposed field-functionalized OP-FTIR air monitoring system will have numerous benefits to the environmental, military and industrial communities. These include:

- o Users obtain powerful, multicomponent gas analysis at low cost
- o Detection limits are easily improved by coadding additional spectra
- o Rapid temporal scanning of multiple paths is available
- o Path-integrated chemical species concentrations are obtained
- o Samples are not altered by the measurements
- o Inaccessible areas can be monitored

REFERENCES:

1. Russwurm, G. M., METHOD 16 Long-Path Open-Path Fourier Transform Infrared Monitoring of Atmospheric Gases, U.S. Environmental Protection Agency, Cincinnati, OH, EPA/625/R-96/010b, January 1997.
2. Russwurm, G. M. and Childers, J. W., FT-IR Open-Path Monitoring Guidance Document, U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA/600/R-96/040, April 1996. NTIS PB 96170 477, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.
3. Strang, C.R., S.P. Levine, and W.F. Herget. 1989. A Preliminary Evaluation of the Fourier Transform Infrared (FTIR) Spectrometer as a Quantitative Air Monitor for Semiconductor Manufacturing Process Emissions. American Industrial Hygiene Association Journal 50(2):70-77.
4. Levine, S.P., and G.M. Russwurm. 1994. Fourier Transform Infrared Optical Remote Sensing for Monitoring Airborne Gas and Vapor Contaminants in the Field. Trends in Analytical Chemistry 13(7):258=262.
5. Griffiths, P.R., R.J. Berry, and B.K. Hart. 1998. A Low-Resolution Spectrometer for Open-Path Fourier Transform Infrared Spectrometry. Submitted for publication in Field Analytical Chemistry and Technology.
6. Griffiths, P.R., R.J. Berry, and B.K. Hart. 1998. Effects of Resolution, Spectral Window, and Background on Multivariate Calibrations used for Open-Path Fourier Transform Infrared Spectrometry. Submitted for publication in Field Analytical Chemistry and Technology.

KEYWORDS: Open-Path Air Monitor, Environmental Site Monitoring, Industrial Hygiene Monitoring, Real Time Pollutant Monitoring, Air Pollution Monitoring Instruments.

AF00-306 TITLE: Conversion of Static Models and Stimulus Files to Digital Test Interface Format (DTIF)

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop software to automatically convert static models and static stimulus files to the DTIF IEEE standard format for LASAR.

DESCRIPTION: Digital circuits are tested on Automatic Test Equipment using a LASAR generated software routine. Many of these routines use LASAR 5 static models and stimulus patterns. The new version of LASAR uses a different file format for models and stimulus patterns. Static files are plagued with supportability problems and need to be upgraded to match the DTIF standard or the latest version of LASAR. To do this, engineers are required to manually convert the files. This is very time consuming, diverse, and requires constant judgement making. Thus, when making complex digital circuit conversions, mistakes are inevitable.

The LASAR files are in an ASCII format. The data in the files varies widely and there are several variations that require interpretation. Many factors become critical and when the engineer is dealing with thousands of different signal variations and possibilities, mistakes can be made and problems can be compounded.

Conduct research to determine if static LASAR 5 files can be automatically converted into LASAR DTIF files on a personal computer platform. The dynamic software package is needed to augment the engineer's skill and accomplish the proper conversion to LASAR DTIF standard files.

PHASE I: Research will focus on a software approach that will demonstrate the conversion of static LASAR 5 files to LASAR DTIF format files.

PHASE II: Develop a software prototype of the approach(es) defined during Phase I.

PHASE III DUAL USE APPLICATIONS: Will aid in the resolution of major problems like retest-OK (RTOK), and could-not duplicate (CND) in aircraft equipment repair. Significantly improves LASAR test software development time. Significant commercial markets exist for this technology in industrial process control and medical process applications.

REFERENCES:
1. B.V. Weber et al., "Bremsstrahlung X-Ray Source Enhancement Using Reflexing Converters," Journal of Radiation Effects, 12 No 1, 232 (1994).
2. G. Cooperstein et al., "Potential Enhancements of Warm X-Ray Dose from a Reflexing Bremsstrahlung Diode," IEEE Transactions on Nuclear Science, Vol. 42 No 6 (1995). The Institute of Electrical and Electronic Engineers, 445 Hoes Lane, Post Office Box 1331, Piscataway, NJ 08855-1331.

KEYWORDS: X-Rays, Ionizing Radiation, Thin Films, Reflex Diode

AF00-308 TITLE: Model Characterizing Electromagnetic Pulse Response from Continuous Wave Electromagnetic Data

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Provide methods and tools to estimate aircraft survivability/vulnerability to threat level electromagnetic pulse from low amplitude continuous wave data

DESCRIPTION: Directed Energy (DE) weapons are on the drawing boards of both allies and potential adversaries. Electromagnetic pulse generation is anticipated to be the mode of operation of the DE weaponry. USAF systems are currently tested using continuous wave electromagnetic energy. It would be cost effective to develop an analysis methodology/model that could convert system response to continuous wave bombardment to system response to pulse bombardment.

The process shall utilize continuous wave data from the Portable Hardness Surveillance Test System (PHSTS) and other available data as appropriate. The model will extrapolate continuous wave data to enable characterization of system response to high amplitude short duration radiated pulse energy. Testing shall verify model performance. The modeling effort should first extrapolate continuous wave data to estimate system response for relatively low amplitude short duration radiated pulse energy, verify with test, then extend the extrapolation in steps to high amplitude short duration pulse energies specified for a threat level environment for strategic aircraft.

PHASE I: Develop theoretical basis for model, develop preliminary model parameters and algorithms, and devise strategies for test and verification. Deliver documentation describing theory of operation, model parameters and algorithms, and verification test plan.

PHASE II: Finalize model parameters, translate algorithms to program code, and complete test and verification of model. Deliver process documentation, program codes, and final reports of successful verification test. Process must be reliable and maintainable with repeatable results.

PHASE III DUAL USE APPLICATIONS: This inference model would allow extrapolation of relatively low cost and low energy test methods to higher energy broad band interference sources. Potential commercial utilization of this process includes test and verification of commercial aircraft for susceptibility to EMI/EMC from proliferating consumer electronics, proliferating commercial and private RF sources, or EMP from development and terrorist deployment of transportable and inexpensive directed energy weapons.

REFERENCES: EMP Interaction: Principles, Techniques and Reference Data (AD Number A100508), Portable Hardness Surveillance Test System (AD Number ADB143895), Hardness Maintenance/Hardness Surveillance (HM/HS) Baseline Data Report (AD Number ADB162318)

KEYWORDS: survivability, nuclear hardness, hardness maintenance/hardness surveillance (HM/HS), Electromagnetic pulse (EMP), electromagnetic interference/electromagnetic compatibility (EMI/EMC)

AF00-309 TITLE: Virtual Office Application for Next Generation Internet (NGI)

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Take Virtual Office or Concurrent Engineering Applications to more advanced level with NGI utilization.

DESCRIPTION: The Next Generation Internet is planned to be 100 to 1000 times faster than today's Internet. The objective of "Virtual Office Application for NGI" is to research and develop a more advanced Virtual Office Application that can take advantage of the higher level Internet. Limitations of the current Internet, such as speed and security, have affected how virtual offices are being designed and used. For example, speed limitations have affected how real-time concurrent engineering or conferencing is done, have limited the ability to easily access and use large volumes of information, and have limited the degree of real-time activity. In today's Integrated Data Environments, the requirements exist, for example, to easily assemble a group of technical experts that are geographically dispersed, to view a system malfunction immediately, then proceed in real time to collect the information needed to resolve the problem, conduct the analysis, reach consensus, and initiate the logistic activities required to support the results. The NGI provides the technology that can greatly reduce the cycle time of many, if not most, acquisition activities. To take advantage of this technology, we need to redesign and research how to utilize NGI for virtual office applications. The specific functions that will be examined include the following:

1) Planning and Management Capabilities: Explore how NGI can be used to improve how virtual offices are being used to develop and manage strategic plans and program plans. Also explore how issues can be better tracked, managed, and resolved.

2) Data Collection and Management: Explore how NGI can be used to quickly access information that exists in different media and prepare the information to be used quickly. Also explore how this information can be quickly accessed and used, and maintained in a distributed Product Data Management (PDM) system.

3) Communication: Explore concepts for creating virtual offices where the participants, regardless of their location, can interact with one another as though they were physically in the same office performing such activities as Concurrent Engineering and Desktop Video Teleconferencing.

The probability of success is very high based on commitment that the Federal Government has made to developing NGI and the demonstrated success already being experienced using virtual offices. The opportunity is to take the technology and the benefits to another level.

PHASE I: Research the Virtual Office concept that is currently being used within DoD and explore and demonstrate how this concept can be improved using the NGI. An introduction to this capability can be found at the web site www.inforumsolutions.com.

PHASE II: The expectation during Phase II is to expand the demonstration into all functions described above into a production capability such as the Integrated Data Environment for Major End Items, IDE(M), or any Acquisition/Logistics Process.

PHASE III DUAL USE APPLICATIONS: Within all of DoD as well as communication to DoD Industry manufacturers and technical partners, collaboration can make high utilization of this product when developed.

REFERENCES: Information on the Next Generation Internet (NGI) may be found at web site
http://www.news.com/News/Item/0,4,10750,00.html.

KEYWORDS: Next Generation Internet, Virtual Office, Desktop Video Teleconferencing, Integrated Data Environment.

AF00-310 TITLE: Micro-Miniature, Wireless, Telemetry Sensors

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms, Weapons

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Air Force SEEK EAGLE Office

OBJECTIVE: Develop micro-miniature, wireless, telemetry sensors for use in weapons and aircraft testing.

DESCRIPTION: Testing today's ultra-modern military aircraft and weapon systems requires extensive and expensive modification to fleet aircraft and weapon stores to install sensing and transmitting equipment. Once the aircraft is modified it becomes the "test aircraft" and all testing must be scheduled around the "test aircraft's" availability. Not only is this expensive, it is inefficient. A more efficient solution would require development of micro-miniature, wireless, telemetry sensors for measuring the parameters of interest (i.e., pressure, strain, acoustics, temperature, shock, etc.). These sensors could be installed on any available aircraft or weapon, using an epoxy type adhesive, and then transmit the measured parameter to a local (within 50 meters) relay station, the relay station would transmit the data to the ground. The sensors that are developed need to be small and not interfere with the aircraft and weapon airflow and withstand the rigorous flight environments associated with aircraft internal and external carriage. The sensors need to be self-powered, inexpensive (some would be destroyed along with the weapon) and reusable/rechargeable.

PHASE I: Develop a conceptual design, using currently available technologies, for a low profile, streamlined, sensing and telemetry capability for each parameter to be measured. The end product should be a detailed report stating the feasibility of accurately measuring and transmitting the desired parameters using subscale, micro-miniature sensors. Estimated sensor costs should be included.

PHASE II: Finalize the design, develop and test prototypes for a number of different sensors in an aircraft environment. The end product would be low cost, robust, sensors that can be produced in larger quantities.

PHASE III DUAL USE APPLICATIONS: There are numerous applications for wireless sensors in the commercial market. Potential areas are: wind-tunnel use, nuclear power plant monitoring, automotive industry, remote oil field monitoring, and medical monitoring.

REFERENCES: DTIC accession number: ADA310032 "Mobile and Wireless Communications;" ADP010211 "A Distributed, Wireless MEMS Technology for Condition Based Maintenance," National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

KEYWORDS: telemetry, sensors, wireless, miniature, spread spectrum, radio communications, mems technology.

AF00-311 TITLE: Advanced Global Positioning System Hybrid Simulator

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: 746TS Navigation Test and Evaluation Laboratory

OBJECTIVE: Produce a Global Positioning System simulator incorporating new signals and controlled reception pattern antenna simulation.

DESCRIPTION: Due to the vulnerability of Global Positioning System (GPS) receivers to jamming, many technologies are being developed to make receivers more robust in a jamming environment. These technologies include a new military signal structure announced in July 1999. They also include developments such as controlled reception pattern antennas which prevent jamming signals from entering the GPS receiver. Additionally, due to recent presidential directives, the current civilian GPS signal will soon be augmented by two new civilian GPS signals. These changes to the GPS will make current GPS simulators obsolete. Therefore, this SBIR project will develop a new GPS simulator to support testing of new GPS technologies and signals. This simulator will replace current simulators when they become obsolete. The Advanced GPS Hybrid Simulator (AGHS) must be flexible enough to incorporate current GPS signals, near term future GPS signals, and GPS signals that are currently unforeseen. Additionally, the AGHS must support testing of controlled reception pattern antenna (CRPA) systems.

PHASE I: The Phase I SBIR effort will produce a system design for the Advanced GPS Hybrid Simulator. This design will incorporate capability to test new GPS technologies, including but not limited to; the new civilian and military signal structures, the Wide Area Augmentation System (WAAS), the Local Area Augmentation System (LAAS), and the Joint Precision Approach Landing System (JPALS). The AGHS design will also include capability to test Navigation Warfare technologies including receivers incorporating controlled reception pattern antennas (CRPA). The Advanced GPS Hybrid Simulator (AGHS) must be a hybrid digital and radio frequency (RF) GPS simulator. The AGHS must be based on reprogrammable signal generators to allow easy upgrading to support changes in GPS signals. Digital reprogrammability will make the AGHS flexible enough to allow easy upgrading to support changes in GPS signals. This effort will culminate in a system engineering design report detailing how the AGHS will be built, what technologies it will incorporate, what capabilities it will have, and how it will ensure potential for future upgrades.

PHASE II: The Phase II SBIR effort will use the design from Phase I to produce an Advanced GPS Hybrid Simulator. This phase will produce an AGHS prototype and will culminate in its demonstration.

PHASE III DUAL USE APPLICATIONS: If successful, the AGHS will be produced, tested, and integrated into the Navigation Test and Evaluation Laboratory (NavTEL), at the 746th Test Squadron, 46th Test Group, Holloman AFB, NM. Additional potential customers for this product include GPS receiver manufactures such as Rockwell Collins, Trimble, Novatel, and Ashtech. Furthermore, tri-service military research and test agencies such as the Air Force Research Labs, SPAWAR Systems Center, and the Electronic Proving Grounds are likely customers for this technology. Finally, academic institutions involved in GPS research are also likely customers for this technology.

REFERENCES:

1. Parkinson, B., Darrah, J., Remondi, B., Spilker, J.J., Van Dierendonck, A.J., Panel Discussion: GNSS for the 21st Century, Increasing Worldwide Capability and Robustness, Proceedings of the ION GPS-98, Nashville, TN, September 15-18, 1998.

2. Leva, J. L., Pacheco, P., GPS C/A-Code Interference Tests with Proposed Lm Waveforms, Proceedings of the ION GPS-98, Nashville, TN, September 15-18, 1998.

3. Architecture and Requirements Definition Test and Evaluation Master Plan (TEMP) for Joint Precision Approach and Landing System (JPALS) ACAT ID (Potential), Version 3.0, 30 October 1998.

4. Anderson, J., Lucia, D., GPS Modernization Advanced Signal Development Waveform Development Plan, Revision 0, http://www.laafb.af.mil/SMC/CZ/homepage/lm/downld.htm, 20 March 1998.

KEYWORDS: Global Positioning System, GPS, Navigation Warfare, NAVWAR, Controlled Reception Pattern Antenna, CRPA, Wide Area Augmentation System, WAAS, Local Area Augmentation System, LAAS, Joint Precision Approach Landing System, JPAL

AF00-312 TITLE: Directed Energy Weapons (DEW) Vulnerability and Lethality Analysis

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Air Armament Center Test and Evaluation Mission Support

OBJECTIVE: Develop analytic methodologies and processes for estimating DEW effectiveness and target vulnerability to DEW.

DESCRIPTION: High-power radio frequency (HPRF) DE systems are characterized by high frequency bandwidth or power level. Narrowband systems are commonly referred to as High Power Microwave (HPM) while wideband systems are commonly referred to as Ultra Wide Band (UWB). AS DEWs, these RF systems are designed to defeat, destroy or degrade electronic equipment. Their effects can range from temporary lapses in performance to permanent circuit degradation to burnout or destruction. As weapons and weapon systems become more complex, they are increasingly dependent upon sophisticated electronics. This dependency on sophisticated electronics brings with it an increased vulnerability to DE RF radiation, either intentional or via "electronic fratricide." Compact, high-efficiency lasers are critical for Electro-optical (EO) countermeasures (CM), Infrared CM (IRCM) and DEW applications. Diode-pumped lasers, non-linear frequency conversion and laser designs have matured to a point where it has become feasible to incorporate these devices into tactical vehicles and aircraft for self-protection and missile defense. Current methods and models used for estimating weapons effectiveness and target vulnerability were designed to solve problems associated with conventional munitions. Using state-of-the-art, object-oriented languages (like C++) and cutting edge graphical user interface design techniques, the process and procedures for accurately predicting DEW effectiveness and target damage assessment can be enhanced dramatically. This upgraded capability allows for direct linkage to the model-test-model methodology that is critical to today's streamlined, acquisition process. Current damage assessment predictions, using expected value outcomes, do not lend themselves easily to this practice. Innovative concepts are required to increase the utility of model based damage predictions. Finally, this new process should run on both PC based Windows or UNIX operating systems.

PHASE I: Research current technologies and M&S models, determine and document current deficiencies, develop innovative concepts and establish measures of merit for selecting the best value concept. Research feasibility of the selected concept. Define hardware and software requirements.

PHASE II: Design, develop and implement the vulnerability assessment model concept selected in Phase I. Verify and validate the system performance through realistic testing and demonstration.

PHASE III DUAL USE APPLICATIONS: In addition to providing strong M&S support to DoD DEW weapons development and blue system susceptibility testing and analysis, this development will have broad use within the US commercial community. Weapons developers will have an accurate and accepted program for demonstrating the effectiveness and survivability of their products. DEW effectiveness, vulnerability, and lethality (WEVL) forecasting capabilities are of interest to all industries that develop information technology. There have been for example, documented cases of use of lasers to blind military pilots and severely degrade aircraft visual aids (night vision goggles) and flight critical instrumentation/sensors. In addition, modern commercial aircraft rely heavily on computers for autopilots, flight controls, and automated landing systems. These aircraft are particularly vulnerable to terrorist attack using commercially available low-power laser systems and easily developed pulsed or CW RF generators during take-off and landing. In addition, any heavy users (commercial or DoD) of communications and computer systems, e.g. command and control centers, electrical switching stations, computer centers, the internet, etc. may be similarly vulnerable to this kind of attack. In addition, the phenomenology associated with HPRF systems is virtually the same as that seen associated with lightning strikes, exposure to high power radars or any other unintended power surge. The ability to predict, with a credible model, the effects of any type of induced or direct power surge to electronics will be of great interest to any industry that relies on uninterrupted communications or electronic monitoring capability.

REFERENCES: Army Science and Technology Master Plan 10(d,e).

KEYWORDS: Vulnerability, Assessment, Model, Prediction, Probability of Kill, Target Geometry Model, Directed Energy Weapon, Stochastic

AF00-314 TITLE: Electro-Optical Scene Simulation Projector (EOSSP)

TECHNOLOGY AREAS: Information Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS PROGRAM: Air Force Guided Weapons Evaluation Facility

OBJECTIVE: Develop a visible spectrum scene projector mountable on a flight motion simulator that is high resolution, flickerless, and highly uniform.

DESCRIPTION: Current generation weapon systems and upgrades to older weapons that operate in the visible spectrum ("TV-guided") are adopting high resolution charged coupled devices (CCDs) as the detector of choice and are using complex image processing algorithms. The technology to generate the required complex scenes has evolved with the weapon systems but the ability to project the complex scenes to the guidance unit has lagged behind. Current projectors support low-resolution image projection for older vidicon tube technology and low-resolution CCDs. These projectors do not provide the resolution, light intensity, spectrum, image uniformity, and "flickerless" operation required by the newer imaging systems. A new capability must be developed to match image projection capability to the sensors being tested in order to provide realistic hardware-in-the-loop test capability for these systems. Anticipated requirements are:

a. Pixel resolution two times greater than supported CCD imagers (currently 640 x 480 pixels). The display should have a minimum pixel count of 1280 x 1024;

b. Flickerless projection with no synchronization from the CCD imager (no adverse scan related artifacts);

c. Highly uniform image;

d. High contrast ratio (~100 to 1 or better);

e. Minimum of 256 shades of grey;

f. Realistic light intensity levels as compared to measured targets and backgrounds;

g. Realistic spectrum as compared to sunlight;

h. High frame rate operation (30 to 120 frames per second);

i. Variable projected field-of-view from 2 to 20 degrees (zoom or interchangeable optics);

j. Large collimated beam (4 to 12 inch diameter);

k. Multiple video input standards (RS-170, RGB, SVGA/XGA/SXGA, and Onyx Digital Interface required);

l. Weight, form factor, and durability to allow mounting and operation on a flight motion simulator.

PHASE I: Develop the specifications for the EOSSP. Evaluate current technology that may be used to build the projector. Perform requirements, design, and cost trade-off analyses, and define all hardware requirements needed to build the EOSSP. Identify the requirements that cannot be met by current technology and may require further research and development. Using one or more of the most promising display/projection technologies, perform experimental proof-of-principle demonstrations for key requirements to give confidence for the success of a Phase II program. Document the results and prepare a validation test plan.

PHASE II: Design, develop, produce, and deliver a prototype EOSSP that meets the system requirements defined in Phase I. Demonstrate and validate the performance of the EOSSP against a typical high-resolution CCD based imager. Document the results, the design, and the method of operation.

PHASE III DUAL USE APPLICATIONS: Numerous dual-use applications exist for improved display and projection capabilities. Current display systems (monitors and liquid crystal devices) suffer from low brightness and contrast levels when used in high ambient light environments (e.g. outdoors). Large-screen projection systems have brightness and image uniformity problems. Military applications include lightweight, rugged, high brightness and high-resolution displays for aircraft, tanks, and other military vehicles as well as improved display and projection systems for training simulators. Potential commercial applications include high-definition television displays; lightweight, energy efficient computer monitors; improved large-screen projectors; and photographic printing. Microdisplays, in the form of liquid crystal on silicon (LCOS) devices and digital micro-mirror devices (DMD), are an emerging technology that has high potential for being the basis of these dual-use applications.

REFERENCES: Smith, J. Lynn, Visible Projector Design, 16 July 1998.

KEYWORDS: Hardware-in-the-loop simulation; Image projection; Scene projection; Visible projector technology

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Submission of Proposals

DARPA's charter is to help maintain U.S. technological superiority over, and to prevent technological surprise by, its potential adversaries. Thus, the DARPA goal is to pursue as many highly imaginative and innovative research ideas and concepts with potential military and dual-use applicability as the budget and other factors will allow.

DARPA has identified technical topics to which small businesses may respond in the first fiscal year (FY) 00 solicitation (00.1). Please note that these topics are UNCLASSIFIED and only UNCLASSIFIED proposals will be entertained. These are the only topics for which proposals will be accepted at this time. A list of the topics currently eligible for proposal submission is included, followed by full topic descriptions. The topics originated from DARPA technical program managers and are directly linked to their core research and development programs.

Please note that **5 copies** of each proposal must be mailed or hand-carried. DARPA will **not** accept proposal submissions by electronic facsimile (fax). A checklist has been prepared to assist small business activities in responding to DARPA topics. Please use this checklist prior to mailing or hand-carrying your proposal(s) to DARPA. Do not include the checklist with your proposal.

- DARPA Phase I awards will be Firm Fixed Price contracts.
- Phase I proposals **shall not exceed $99,000**.
- DARPA Phase II proposals must be invited by the respective Phase I technical monitor (with the exception of Fast Track Phase II proposals – see Section 4.5 of this solicitation). DARPA Phase II proposals must be structured as follows: the first 10-12 months (base effort) should be approximately $375,000; the second 10-12 months of incremental funding should also be approximately $375,000. The entire Phase II effort should generally not exceed $750,000.
- It is expected that a majority of the Phase II contracts will be Cost Plus Fixed Fee.

Prior to receiving a contract award, the small business **MUST** be registered in the Centralized Contractor Registration (CCR) Program. You may obtain registration information by calling 1-800-334-3414 or internet: http://ccr.edi.disa.mil. The small business **MUST** also have a Commercial & Government Entity (CAGE) Code. This code is part of the CCR registration package. For information call 1-888-352-9333 (Press 3) or 1-888-227-2423 or internet: www.ccr.dlsc.dla.mil.

The responsibility for implementing DARPA's SBIR Program rests with the Administration and Small Business Directorate (ASBD). The DARPA SBIR Program Manager is Ms. Connie Jacobs. DARPA invites the small business community to send proposals directly to DARPA at the following address:

DARPA/ASBD/SBIR
Attention: Ms. Connie Jacobs
3701 North Fairfax Drive
Arlington, VA 22203-1714
(703) 526-4170
Home Page http://www.darpa.mil

SBIR proposals will be processed by DARPA ASBD and distributed to the appropriate technical office for evaluation and action.

DARPA selects proposals for funding based on technical merit and the evaluation criteria contained in this solicitation document. DARPA gives evaluation criterion a., "The soundness and technical merit of the proposed approach and its incremental progress toward topic or subtopic solution" (refer to section 4.2 Evaluation Criteria - Phase I), twice the weight of the other two evaluation criteria. As funding is limited, DARPA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and highly relevant to the

DARPA mission. As a result, DARPA may fund more than one proposal in a specific topic area if the technical quality of the proposal(s) is deemed superior, or it may not fund any proposals in a topic area. Each proposal submitted to DARPA must have a topic number and must be responsive to only one topic.

- Cost proposals will be considered to be binding for 180 days from closing date of solicitation.
- For contractual purposes, proposals submitted to DARPA should include a statement of work which does not contain proprietary information.
- Successful offerors will be expected to begin work no later than 28 days after contract award.
- For planning purposes, the contract award process is normally completed within 45 to 60 days from issuance of the selection notification letter to Phase I offerors.

The DOD SBIR Program has implemented a streamlined Fast Track process for SBIR projects that attract matching cash from an outside investor for the Phase II SBIR effort, as well as for the interim effort between Phases I and II. Refer to Section 4.5 for Fast Track instructions. **DARPA encourages Fast Track Applications between the 5th and 6th month of the Phase I effort. Technical dialogues with DARPA Program Managers are encouraged to ensure research continuity during the interim period and Phase II. If a Phase II contract is awarded under the Fast Track program, the amount of the interim funding will be deducted from the Phase II award amount. It is expected that interim funding will not exceed $40,000.**

To encourage the transition of SBIR research into DoD Systems, DARPA has implemented a Phase II Enhancement policy. Under this policy DARPA will provide a phase II company with additional phase II SBIR funding if the company can match the additional SBIR funds with non-SBIR funds from DoD core-mission funds or the private sector; or at the discretion of the DARPA Program Manager. DARPA will generally provide the additional Phase II funds by modifying the Phase II contract.

DARPA 2000 Phase I SBIR

Checklist

1) Proposal Format

a. Cover Sheet (formerly referred to as Appendices A and B) **MUST** be submitted electronically (identify topic number) ______
b. Identification and Significance of Problem or Opportunity ______
c. Phase I Technical Objectives ______
d. Phase I Work Plan ______
e. Related Work ______
f. Relationship with Future Research and/or Development ______
g. Commercialization Strategy ______
h. Key Personnel, Resumes ______
i. Facilities/Equipment ______
j. Consultants ______
k. Prior, Current, or Pending Support ______
l. Cost Proposal (see Reference A of this Solicitation) ______
m. Company Commercialization Report (formerly referred to as Appendix E) **MUST** be registered electronically (register at http://www.dodsbir.net/submission; include signed hard copy along with proposal) ______

2) Bindings

a. Staple proposals in upper left-hand corner. ______
b. **Do not** use a cover. ______
c. **Do not** use special bindings. ______

3) Page Limitation

a. Total for each proposal is 25 pages inclusive of cost proposal and resumes. ______
b. Beyond the 25 page limit do not send appendices, attachments and/or additional references. ______
c. Company Commercialization Report (formerly referred to as Appendix E) is not included in the page count. ______

4) Submission Requirement for Each Proposal

a. Original proposal, including signed Cover Sheet (formerly referred to as Appendix A) ______
b. Four photocopies of original proposal, including signed Cover Sheet and Company Commercialization Report (formerly referred to as Appendices A, B and E) ______

INDEX OF DARPA FY00.1 TOPICS

DARPA SB001-027	Automatic Terrain Characterization and Feature Identification in FOPEN SAR Imagery
DARPA SB001-028	Acousto-Optic Spectra-Polarimetric Imaging
DARPA SB001-029	High Power Fiber Lasers
DARPA SB001-030	Advanced Gating Techniques for Planar, High power Non-Linear, Semiconductors in Advanced Mobile Power Conditioning Applications
DARPA SB001-031	SiC Inverter
DARPA SB001-032	Group Target Tracking
DARPA SB001-033	Component Technologies for Closed-Loop Adaptive Flow Control

SUBJECT/WORD INDEX TO THE DARPA FY00.1 TOPICS

Subject/Keyword — Topic Number

DARPA 00.1 TOPIC DESCRIPTIONS

SB001-001 TITLE: Conductive Coating with Mid-Infrared Transparency

KEY TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

OBJECTIVE: The objective of this task is to develop a low sheet resistance coating with transparency in the mid-infrared spectral region.

DESCRIPTION: Transparent, conductive coatings are used in numerous optical systems for ElectroMagnetic Interference/Radio-Frequency Interference (EMI/RFI) shielding, static elimination, electrodes on flat panel displays, and light emitting polymer devices. They are also used in applications where fine metal grids would impair optical performance, such as antennas embedded in windshields. The most widely used transparent, conductive coating is indium tin oxide (ITO). ITO is a large band gap semiconductor, which has good transparency in the visible region and near-infrared, along with modest sheet resistivities of ~5 ohms/square. However, the transmittance of ITO and related compounds degrades to unacceptable levels for wavelengths longer than 1.3 microns. Low sheet resistance, transparent conductors are needed for optical systems operating in the wavelength range of 3 to 5 microns. In addition to the standard applications of transparent, conductive coatings for EMI/RFI shielding, etc., mid-infrared coatings are needed in displays for the testing of missile seekers and in active camouflage devices. The goal of this project is to develop conductive films with sheet resistivities of ~1 ohm/square and having a transparency band in the mid-infrared spectral region. Low sheet resistivities of 1 ohm/sq are required for effective shielding and allow for the fabrication of large area displays. The transmittance of the coating should be >70% over a wavelength band of >100 nm. The center wavelength of the transmission window shall be adjustable over the range of 3 to 5 microns by modification of the growth or processing parameters. The film growth should not require excessive substrate temperatures and fabrication procedures should be compatible with standard, thin film processing techniques. The fabrication costs of the coatings should be comparable to ITO coatings.

PHASE I: Demonstrate the fundamental technologies required to produce coatings having low sheet resistivities and high transparency in the mid-infrared.

PHASE II: Demonstrate compatibility with processes and materials used in mid-infrared optical systems. Perform reliability and lifetime measurements on the conductive coatings.

PHASE III DUAL USE APPLICATIONS: EMI/RFI shielding and static elimination in remote sensing systems, air pollution instrumentation, gas analyzers, and mid-infrared astronomy.

KEYWORDS: Transparent Conductors, Thin films, Optical Coatings.

REFERENCES: H.L. Hartnagel, A.L. Dawar, A.K. Jain, and C. Jagadish, "Semiconducting, Transparent, Thin Films," Institute of Physics Publishing, Bristol, U.K., 1995.

SB001-002 TITLE: MEMS-Based Switches for RF Missile Seeker Applications

KEY TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Reduce insertion loss in the on state and increase isolation in the off state switches for RF missile seekers using MEMS technology while maintaining power handling capability of current solid state switches.

DESCRIPTION: Micro electromechanical system (MEMS) technology is rapidly providing solutions to a variety of commercial and military applications in terms of size, performance, and cost. RF MEMS technology has been funded to develop digital receiver and transmitter technology. However, these efforts have focused on communication frequency bands significantly less than that used for RF missile seeker applications. Development of RF MEMS technology of interest to RF missile seekers has been limited. Several key Army missile systems have been identified as potential insertion opportunities for RF MEMS. These systems and their associated frequency bands are: LONGBOW (Ka – 26-40 GHz), BAT P3I (W – 94.5 GHz), and THAAD or PAC-3 missiles (X – 8-12 GHz). The basic missile radar system consists of an exciter to generate a stable waveform to produce a local oscillator signal, a transmitter to amplify or frequency tune the signal to be transmitted, a duplexer that switches the antenna and resulting radar system between transmit and receive modes, an RF receiver to receive the radar return signal and down convert to the first intermediate frequency (IF), an IF receiver to down convert the radar return to baseband before sending the information or video signal for processing. Each of these components contains some form of RF switches. Therefore, the basic building block to prove viability of MEMS technology for RF missile seeker frequencies is switches.

PHASE I: Design and demonstrate proof of principle of a MEMS-based RF switch (single pole, single throw) at X, Ka, or W band. If only one band is selected for demonstration, a path or plan of development for switches at the other bands should also be provided. The RF switch should have a switching speed of 20 ns rise time (10 to 90%) and 150 ns fall time (90 to 10%). The maximum power handling capability of the switch should be 0.5 Watts continuous wave (CW) and 10 Watts peak. The switch(es) shall be capable of operating between temperatures from -55C to 150C. The switch at X-band should have a bandwidth of 8 to 12 GHz, a max insertion loss of 1.3 dB, and minimum isolation of 36 dB. The switch at Ka should have a bandwidth of 26.5 to 40 GHz, a max insertion loss of 1.5 dB, and minimum isolation of 30 dB. The switch at W-band should have a bandwidth of 90 to 100 GHz, a max insertion loss of 2.0 dB, and minimum isolation of 20 dB. Specifications not directly outlined should be commensurate with current technology. Table 1 outlines the electrical specifications. Any available prototype(s) should be delivered to the Government for further testing at the end of Phase I.

Bandwidth, GHz	8 – 12	26.5 – 40	90 – 100
Insertion Loss, dB(max)	1.3	1.5	2.0
Isolation, dB (min)	36	30	20
Switching Speed, ns			
Rise Time, 10 to 90%	20	20	20
Fall Time, 90 to 10%	150	150	150
Power Handling, CW/peak, W(max)	0.5/10	0.5/10	0.5/10

Table 1. Electrical Specifications

PHASE II: Validate design by fabricating fully-packaged prototype(s) of MEMS-based RF switches suitable for RF missile seeker applications, and with performance specifications at or exceeding those named above – teaming with government, industry, or academia foundries as necessary. Physical dimensions should not exceed 0.75 x 0.75 mm. Confirm performance through laboratory testing with interested government users for technology insertion.

PHASE III DUAL USE APPLICATIONS: Switches of the suggested type would have wide applications in both military systems (dual band seeker technology) and civilian products (satellites, antennas, communication systems).

KEYWORDS: MicroElectroMechanical Systems, MEMS, Radar, RF Switch, Missile Guidance.

REFERENCES:

1. Digital Receiver Technology Program, DARPA MTO, Program Manager: Dr. James Murphy, http://www.darpa.mil/ETO/ADC/index.html.
2. Raytheon Systems, UltraComm Program, DARPA ATO, Program Manager: Mr Richard Ridgley.
3. Elliot R. Brown, "RF MEMS Switches for Reconfigurable Integrated Circuits," IEEE Trans. Microwave Theory and Techniques 46 (11), 1868-1880 (1998).
4. Clark T.-C. Nguyen, et al., "Micromachined Devices for Wireless Communications," Proceedings of the IEEE 86 (8), 1756-1768 (1998).
5. Y. C. Lee, et al., "RF MEMS Device, Packaging, and System," http://www.Colorado.EDU/engineering/MEMS/ppt/rf.review

SB001-003 TITLE: Mortar or Rifle Launched, Low Cost, Miniature Ballistic and Glided Flight Surveillance Sensor Systems

KEY TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop and demonstrate low cost, miniature, surveillance sensor systems that are ground deployed from either a mortar launcher or a rifle and are retrievable.

DESCRIPTION: Small, highly mobile, dispersed forces need an organic capability to deploy and retrieve over-the-horizon capable (greater than 30 kilometers) miniature sensor systems to provide near real-time threat and terrain related information. Specifically, research and development leading to the design and demonstration of novel, advanced, rifle and mortar launched and retrievable surveillance sensor systems for the over-the-horizon detection, localization, and classification of ground, and shallow water time critical targets are required. Efforts may address individual miniature system components, such as advanced propulsion systems or sensor systems, as payloads for these ballistic and glided flight vehicles, however concepts for complete mortar and rifle launched systems, are preferable. The use of conformal and deployable wings and control surfaces is required to insure compact stowability and ballistic tube launching of these sensor systems. Parameters of interest that will be utilized to evaluate proposed concepts are projected cost, size, weight, flight duration, maximum altitude, effective trajectory path length from launch to return for recovery, stowage capability, reconfigurability through modular design, power consumption, covert operations, and sensor performance. Aggregate metrics, such as dollars per kilometer squared surveillance coverage, will be utilized to compare proposed concepts.

PHASE I: Concept description and initial design of the miniature, integrated sensor and vehicle system, with an imaging subsystem payload configuration, with clear description and quantification of key predicted performance parameters. A sensitivity analysis that indicates the predicted performance of alternate proposed system configurations, including identification of highest risk aspects of the proposed design, is also required. Risk mitigation demonstrations and/or simulations of key high-risk aspects of the proposed design, to demonstrate proof of concept, is also required.

PHASE II: Final design and demonstration of the proposed miniature, integrated sensor and vehicle system, with post-demonstration analysis sufficient to demonstrate key performance elements for the proposed system. Complete design and demonstration documentation must be delivered.

PHASE III DUAL USE APPLICATIONS: The development of low cost, high performance, modular, miniature surveillance sensor systems will expand the commercial markets for industrial and area security systems, agriculture, forestry, and industrial process monitoring systems and disaster and environmental monitoring systems. Increased performance, component modularity for optimum domain specific tailoring of sensor and surveillance vehicle configurations and the dramatic reduction in size, weight and cost of these sensor systems will increase the range of potential applications for these products. This system could be used for military war fighting applications, overseas peacekeeping operations or enhancing security of the US industrial infrastructure.

KEYWORDS: Projectiles, Sensor Systems, Air Vehicles, Environmental Sensors, Chemical Sensors, Imaging Sensors, Ballistic and Controlled Flight Air Delivery Systems, Low Power Electronics.

SB001-004 TITLE: Computationally Efficient Change Detection and Classification Algorithms for Imaging Systems Using Real-Time Target, Terrain and Urban Feature Data

KEY TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

OBJECTIVE: Development of innovative, computationally efficient feature recognition and change detection algorithms for imaging systems capable of generating, in real-time, 2D and 3D models of terrain, urban, and target features.

DESCRIPTION: The requirement for sophisticated and comprehensive battlefield terrain, urban, and target feature information will continue to increase as combat operations requiring rapid force projection, high mobility of small dispersed units, and precision strike utilizing indirect fire assets, place a growing emphasis on unattended or minimally attended sensor systems. The effective use and control of terrain, urban, and target features are critical to detect, classify, and prosecute targets in land combat scenarios. A requirement exists for software, that transforms sensed 2D imagery of terrain, urban, and target features into scalable 3D model representations, in real-time, and then applies innovative, computationally efficient change detection algorithms to detect and classify targets of interest. An imaging based system, with dynamic terrain, urban, and target feature models and real-time change detection algorithms, will provide a significant force-multiplier affecting mission planning, systems performance, and overall unit effectiveness. Four different types of terrain, urban, and target feature information are required: (1) topography, (2) natural features and man-made structural objects in urban environments, (3) stationary and moving personnel and vehicles and (4) short-term battlefield surface conditions and dynamics. Dynamic 3-D terrain, 3-D feature models and efficient change detection algorithms are the enabling technologies for intelligent, imagery based sensor systems for use with arrayed, unattended ground sensors and autonomous mobile weapon systems. These technologies will also contribute to a significantly improved training capability by enabling realistic simulations of planned and already executed tactical operations.

PHASE I: Concept description, including the identification of key underlying technology and scientific issues, and an initial design of the software with clear description of algorithms, models, approach to parallelism, and limits of scalability. Quantification of key predicted performance parameters and a sensitivity analysis that indicates the predicted performance of alternate proposed software configurations, including identification of highest risk aspects of the proposed design, are also required. Risk mitigation demonstrations and/or simulations of key high-risk aspects of the proposed design, to demonstrate proof of concept, is also required.

PHASE II: Final design and demonstration of the proposed software with analysis sufficient to demonstrate proof of performance. Complete design and demonstration documentation must be delivered. Early emphasis during this phase will be on the generation of research and development tools for the processing, analysis, modeling, visualization, and simulation of detailed terrain, urban, and target feature information.

PHASE III DUAL USE APPLICATIONS: The development of these technologies will expand the commercial markets for intelligent sensor systems. These systems, with an ability to acquire, analyze, portray, and utilize superior terrain and urban feature information during the planning, preparation, and execution of complex and life threatening operations, will significantly improve the probability of operational success at minimum human and material cost. The improved capability to manipulate and evaluate information about terrain and features will facilitate enhanced planning and tactical decision making for applications related to global change and environmental studies. These technologies will also facilitate the development of new and improved techniques and software tools for virtual prototyping which will improve a system developer's ability to rigorously appraise functional designs thereby providing a significant cost saving in whatever application this technology is applied. The overall commercial impact of this intelligent sensor-related research effort will be significant. This system could be used for military war fighting applications, overseas peacekeeping operations or enhancing security of the US industrial infrastructure.

KEYWORDS: Sensors, Imaging Sensors, Terrain and Feature Modeling, Change Detection Algorithms, High Performance Computing, Computer Aided Design, Electronic System Design, Parallel Algorithms.

SB001-005 TITLE: Low Cost, Miniature RF MASINT Unattended Sensor Systems

KEY TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop and demonstrate novel concepts for detecting, localizing and classifying targets with arrays of low cost, miniature, internetted Radio Frequency Measurement and Signature Intelligence (RF MASINT) unattended ground and littoral sensor systems. Innovative solutions are sought for the short range, real time RF MASINT sensing problem using miniature local assets (vice theater or national assets) for the gathering of signal features from RF emitting sources, including vehicles, ballistic munitions, and surface and underground facilities.

DESCRIPTION: Research and development leading to the design and demonstration of novel, advanced RF MASINT unattended sensor systems for the detection, localization, and classification of air, ground, and waterborne time critical RF emitting targets are required. Efforts may address individual miniature RF MASINT sensor systems, however multi-sensor systems, with local signal processing, data fusion and an internetted communications capability are of primary interest. Low power, autonomous wake-up and commanded wake-up capabilities for these unattended systems are required. Efforts of interest also include low power, extended life, high resolution sensors, efficient real-time feature based classifiers, and environmental models for real-time transformation of sparse sensed data to predictions of area weather and propagation related parameters. Also of interest are decision aids to enable optimum configuration and processing of data from RF sensor arrays, and technologies to precision air deliver individual and arrays of unattended sensor systems from either tactical aircraft, unmanned air vehicles, mortars, and artillery shells, including packaging of these sensor systems in submunition sized configurations compatible with area denial missile systems such as the Multiple-Launch Rocket System (MLRS) and Army Tactical Missile System (ATACMS). Parameters of interest that will be utilized to evaluate proposed RF MASINT sensor concepts are projected cost, size, weight, reconfigurability through modular design, power consumption, covert operations, and detection, localization and classification performance. Aggregate metrics, such as dollars per kilometer squared detection coverage-hours of life without battery change, will be utilized to compare proposed concepts. Parameters of interest that will be utilized to evaluate proposed aircraft and unmanned air vehicle delivery system concepts are projected cost, size, weight, stowage capability, altitude and delivery range capability, precision of delivery circular error probable (CEP), and for earth penetrating concepts, the capability to penetrate in varying soil conditions while still maintaining communications and in-situ RF MASINT sensing capability after delivery.

PHASE I: Concept description and initial design of RF MASINT sensor related system with clear description and quantification of key predicted performance parameters. A sensitivity analysis that indicates the predicted performance of alternate proposed system configurations, including identification of highest risk aspects of the proposed design, is also required. Risk mitigation demonstrations and/or simulations of key high-risk aspects of the proposed design, to demonstrate proof of concept, is also required.

PHASE II: Final design and demonstration of the proposed sensor related system, with post-demonstration analysis sufficient to demonstrate proof of performance for the proposed system. Complete design and demonstration documentation must be delivered.

PHASE III DUAL USE APPLICATIONS: The development of low cost, high performance, modular, miniature RF MASINT sensor and related sensor delivery systems will expand the commercial markets for home and industrial security systems, industrial process monitoring systems and environmental monitoring systems. Increased performance, component modularity for optimum domain specific tailoring of sensor configurations and the dramatic reduction in size, weight and cost of these sensor systems will increase the range of potential applications for these products. This system could be used for military war fighting applications, overseas peacekeeping operations or enhancing security of the US industrial infrastructure.

KEYWORDS: Radio Frequency, Antennas, MASINT, Earth Penetration Systems, Terabrakes, Ballistic and Controlled Flight Air Delivery Systems, Real-Time Signal Processing Algorithms, Feature Based Classifiers, Data Fusion Algorithms, Low Power Electronics, Wireless Communications, Low Probability of Detection and Intercept Communications.

SB001-006 TITLE: Distributed Sensor Location Algorithms

KEY TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Design and test algorithms to localize distributed air or underwater sensors that are used to detect, track and localize acoustic targets. The method of target or field interrogation can be either active or passive.

DESCRIPTION: Many distributed surveillance or warning systems "drop" individual sensors which have to be localized precisely later to perform spatially coherent or incoherent operations. Examples are air acoustic sensors for Counter Sniper Operations, Antisubmarine Warfare (ASW) applications, etc. To attach a Global Positioning System (GPS) to each sensor is an expensive solution. By super-triangulation using intentional or naturally occurring transmissions one can obtain localization information "through the system," without mode changes. For example, it is possible to localize K sensors with N or more shots as long as $N > 3K/(K-4)$. End-to-end algorithms are sought and a quantitative discussion of sensitivities to near-singular geometries.

PHASE I: Define the systems for which the algorithm would be applicable and show the expected performance by computer simulation. Develop a systems design and indicate what technical issues to expect, such as multipath effects, shockwave versus muzzleblast, singular geometries, etc.

PHASE II: Develop a simplified or modify an existing government-furnished equipment (GFE) system and conduct testing in a realistic environment. Quantify the measured performance.

PHASE III DUAL USE APPLICATIONS: Military use applications are, in air, sniper or artillery detection and localization; underwater, submarine or torpedo detection and localization with non-fixed sensors. A commercial application of the method of localizing distributed sensors is for Systems for Urban Gunshot Detection and localization, as deployed by the police in some cities.

KEYWORDS: Counter-Sniper, Distributed Sensors, Random Array, Dynamic Localization.

SB001-007 TITLE: Autonomous Clandestine Precise Deployment of Communications/Sensor Packages

KEY TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Sensors/Electronics/Battlespace

OBJECTIVE: Develop innovative technology for the delivery of small packages into hostile territory. The packages, with 1 kg to 10 kg mass, must be placed on high ground such as on treetops and building tops and this must be done without being detected by the enemy. The technology desired is a vehicle with an integrated vision system and flight management system that will maneuver to the most advantageous position given the constraints of the vehicle's maneuverability and power source.

DESCRIPTION: Future military concepts employ unattended sensors and communications devices that are employed in the enemy's area of operation. The emplacement of such devices is very challenging due to many factors. First they must be placed to provide maximum line of sight or viewing conditions. Because the details of terrain and forestation may not be known, the deployment system must have the ability to autonomously search and find the best position for placement such as on the tallest tree or building. The other major factor is that the deployment process must be clandestine. DARPA envisions that the delivery system will be in the form of an air vehicle but land and sea vehicles may be utilized as well. The enabling technology is believed to consist of a stealthy vehicle and a tightly coupled flight management capability and automatic scene understanding system to drive the vehicle to the best high spot. If an air vehicle is used, because of atmospheric variations (winds and thermals) and flight control boundaries, the air vehicle must continuously search for the best remaining high spots (i.e., the options are reduced with time in flight). During flight or movement, multiple imaging sensor viewpoints are needed to develop/refine the understanding of the scene. That is, multiple viewpoints may need to be registered against the scene to create synthetic stereo image pairs to get a three dimensional model. Any imaging sensor maneuvers made to acquire different image viewpoints will limit the future spots that can be reached because of factors such as power supply use, loss of altitude and so forth. Consequently, scene understanding accuracy (e.g., height estimates) is a tradeoff against the gain in reaching a better landing spot. The design options that should be considered include:

- Powered/un-powered vehicles
- Controls: aero surfaces, jets, parafoil, tracks multiple legs, ...
- Sensor: ladar, visible band EO synthetic stereo, combinations, ...
- De-acceleration/transition: sticky webs, breaking jets, ...
- Algorithms: flight management, imagery object recognition, scene understanding, ...

PHASE I: The first phase should identify alternative solutions and conduct enough analysis to recommend one or more options for further investigation.

PHASE II: In the second phase, prototypes for one or several concepts will be constructed and demonstrated. DARPA will provide test payloads and a test range to conduct flight tests and demonstrations.

PHASE III DUAL USE APPLICATIONS: The ability to precisely deploy sensor and communications packages in hostile areas has direct application to police and civil actions, counter-terrorists actions, forest fire containment, and natural and unnatural disaster response. The clandestine mode is of utility to police and federal law enforcement authorities.

KEYWORDS: Autonomous Air Vehicles, Sensor Deployment

SB001-008 TITLE: Miniature Cryoelectronic Receivers

KEY TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop a miniature cryogenic receiver "front-end" for sub-scale ultra-sensitive receivers, operating as battlefield sensors.

DESCRIPTION It is well-known that receivers, even those operating within a limited bandwidth, should not be designed with a front-end filter, since that usually is the principal contributor to an unacceptable system noise figure. The exception to this rule is a high-temperature superconducting (HTS) filter; its combination of low insertion loss and sharp "skirts" provides an exceptionally low system noise floor and suppresses interference significantly. It is of great interest to reduce the size and power requirements (principally due to cryocooler operation) of present front-end preselector cryogenic modules, which consist of HTS filters and low-noise amplifiers (LNA) held at 80K temperature. This reduction can be achieved by addressing the principal issues of thermal isolation and small cryocooler development. The following goals are given: 0.25 Watt cooling lift at 80K for the cryocooler, and overall cryo-module weight of 2 pounds (each a factor of 10 below present standards). The attainment of such a small, cold front-end, when mated to digitization and processing chips, will make possible a new class of miniature portable receivers with unsurpassed sensitivity and interference rejection.

PHASE I: Design a miniature cryogenic "front-end" for a specific receiver function, containing an HTS filter and LNA combination, specifying the means of achieving thermal isolation while maintaining input/output leads for RF signals and power. At this stage, available cryocoolers may be indicated for use, but a prescription given for future changes.

PHASE II: Fabricate and demonstrate the performance of the miniature cryogenic receiver front-end.

PHASE III DUAL USE APPLICATIONS: The availability of such miniature ultra-sensitive receivers, which perform a kind of spectral excision, will apply to a broad range of military systems and commercial markets. Applications such as COMINT, SIGINT, SAR, …., are currently being investigated; commercially, these sensors will be important immediately in cellular communication and SATCOM.

KEYWORDS: Cryogenics, Cryoelectronics, Receivers, Superconductors.

REFERENCES: Patten, F. W., DARPA Program in Cryoelectronics, 1999 International Workshop on Superconductivity, Kauai, HI, USA.

SB001-009 TITLE: Self-Decontaminating Materials

KEY TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop safe, efficient and cost effective self-decontaminating materials for neutralizing chemical and biological threat agents from personnel, electronic equipment, exterior and interior spaces of aircraft, ships, land vehicles, and buildings.

DESCRIPTION: Current chemical and biological (CB) decontamination procedures tend to be agent specific, corrosive, damaging to sensitive electronics, and usually require subsequent clean up. They create a logistics burden and do little to improve operational readiness after a CB attack. Innovative approaches are needed for the development of materials, which are self-decontaminating with respect to chemical agents, toxins, spores, bacteria, and viruses. Materials or coatings that emulate processes for neutralization of CB agents (i.e.: enzyme solutions/foams, metal and/or oxide catalysts, emulsions, or oxidative chemistries) may be explored. Example approaches include materials that can entrap and internally neutralize the agent or that become catalytically active in response to contact with an agent. A detailed understanding of CB agent chemistry (biochemistry) should be utilized to develop material compositions and microstructures suitable for neutralization of harmful agents. Greater interest will be shown to those approaches, which have the potential for the broadest range of utility.

PHASE I: Demonstration of conceptual feasibility for a self-decontaminating material/coating.

PHASE II: Rigorous analysis and laboratory demonstration of surface self-decontamination using suitable surrogates.

PHASE III DUAL USE APPLICATIONS: Development of self-decontaminating materials for CB countermeasures will have commercial applications in the food processing industry and in hospitals.

KEYWORDS: Chemical and Biological Agents, CB, Catalysts, Antimicrobial, Germicidal.

SB001-010 TITLE: Printed Optics

KEY TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop the machine capability to fabricate gradient index of refraction lenses via direct deposition with positional control of composition.

DESCRIPTION: Gradient Index of Refraction lenses (GRIN) are commonly fabricated by chemical diffusion into cylinders (radial GRIN), or plates (axial GRIN) as a means of developing a specific refractive index profile. The limitation of this process is a restriction to compositions with a fast diffusing specie, and to small size scale lenses since diffusion times scale with the square of the diffusion distance. An added disadvantage of diffusion processing is the composition dependency of diffusion constants, which distorts the desired composition profile. All of the limitations of the current manufacturing process for GRIN lenses may be addressed if composition profiles are printed using the three dimensional equivalent of a color printer. The printing of mosaic lenses becomes straightforward. Axial and radial composition profiles can be printed in the same lenses for achromatic lenses. Lenses with non-uniform magnification (fish eye) can be printed. And compositions with high transmission in the infrared, but without sufficient transport coefficients to be fabricated by diffusion processing would be possible with printed optics. Printed optics also has the potential to be manufactured at much lower cost than geometric lenses since no lens specific tooling is required and all optical surfaces are polished flat. Success in this project will depend on the integration of machine design and control for three dimensional deposition of composition; optical expertise in the design of GRIN lenses; and, materials expertise to produce optically transparent materials with virtually no porosity and smooth composition profiles at size scales small relative to the wavelengths of interest.

PHASE I: Design a machine capable of manufacturing Printed Optic lenses greater than five inches in diameter directly from CAD (computer aided design) files without lens specific tooling. Develop the materials processing technology to produce optical quality lens materials, which are compatible with the designed machine.

PHASE II: Build the machine designed in Phase I. Demonstrate the fabrication of five-inch diameter gradient index of refraction lenses. Characterize the optical quality of the lens.

PHASE III DUAL USE APPLICATIONS: Because of its simplicity and low cost potential, printed optics has the potential to replace geometric optics. Just-in-time manufacturing will replace assembly of catalogue optical elements. Applications include missile seekers and proximity detection systems for munitions, photographic lenses, binoculars, telescopes, and night vision systems.

KEYWORDS: Gradient Index of Refraction Optics, Solid Freeform Manufacturing, Rapid Prototyping, Tool-Less Manufacturing.

REFERENCES:

1. D. T. Moore, "Gradient-index optics: a review", Applied Optics, vol.19, no. 7, 1 April 1980, 1035-1038.
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SB001-011 TITLE: Comparative Gene Sequence/Expression Analysis of Pathogenic and Non-Pathogenic Micro-Organisms

KEY TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Identify gene sequence "targets" that permit development of sensitive and specific (low false alarm) rapid-detection assays to distinguish biological warfare (BW) threat pathogens from ubiquitous, non-pathogenic, near-neighbors, surrogates, and obscurants in complex and unpredictable environments. Development of such suitable genetic markers and associated high throughput genomic technologies may also contribute to the development of approaches for the treatment of unconventional pathogens.

DESCRIPTION: This solicitation seeks to exploit high throughput (production) sequencing/gene expression technologies to: 1) distinguish between BW agents and their phylogenetic non-pathogenic nearest neighbors and 2) develop innovative technologies/methodologies for sequence annotation that improve our understanding of pathogenesis. The candidate pathogens are to be selected exclusively from among the relatively short list of bacteria, viruses and rickettsia identified in reference 2. Multiple awards are anticipated, with each individual award focusing on a narrow range of pathogens. To avoid unnecessary duplication of efforts, each offering team is asked to identify 4-5 pathogens of potential interest (and their corresponding non-pathogenic nearest neighbors) from which the sponsor can then down-select prior to the Phase 1 award.

PHASE I: Establish genomic libraries for target BW pathogen(s) and appropriate nearest neighbor(s); initiate sequence analysis.

PHASE II: Complete sequence analysis and annotation of BW pathogen(s); demonstrate methodology for distinguishing between target pathogen(s) and nearest neighbor(s).

PHASE III DUAL USE APPLICATIONS: Enhanced capability for diagnosis and treatment of broad range of infectious diseases.

KEYWORDS: Pathogens, Gene Sequencing, Annotation

REFERENCES:
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SB001-012 TITLE: Improving Recall for Automatic Extraction Systems

KEY TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective is to improve the recall (percentage of relevant domain facts extracted) of domain independent natural language text extraction systems.

DESCRIPTION: Domain-independent information extraction systems are information extraction systems that perform shallow, broad extraction. The major advantage of these systems is that no customization is required to apply them to a new domain. These systems have been developed and used for automatically populating knowledge bases. While these systems are very accurate (i.e. their precision is very high), they do not have comparable coverage (i.e. their recall is not as high). This SBIR is looking for proposals to develop the next generation of domain-independent information extraction systems. These systems should be capable of performing shallow, broad extraction with both high precision and high recall.

PHASE I: Recall enhancing algorithms defined and implemented; recall and precision performance validated experimentally.

PHASE II: Embed the recall-improving algorithms in a domain independent text extraction system. Test the system on a large corpus of free text documents to update a large knowledge base. Provide complete documentation of test results.

PHASE III DUAL USE APPLICATIONS: Many military, law enforcement and commercial knowledge bases and data bases are manually maintained because of insufficient recall performance. Timelines and workloads will be greatly reduced through automatic extraction that is both high precision and high recall. Improved extraction performance will greatly extend the market for domain independent extraction systems in support of link analysis, event recognition and question answering.

KEYWORDS: Text Extraction, Natural Language Processing, Automatic Data Base Update, Question Answering.

SB001-013 TITLE: Intelligent Adaptive Software Construction

KEY TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Experimentally develop and test a revolutionary approach to using Artificial Intelligence for software development and adaptation..

DESCRIPTION: This Program will experimentally develop and test a revolutionary approach to software development and adaptation. The approach, which combines analogic reasoning capabilities with planning technology, can provide a new approach to system synthesis and analysis. While the Program is defined in terms of software design and evolution, the same approach should hold for hardware (or combined hardware/software) systems, engagement planning (where the components are actions that may be taken to accomplish an objective under stated constraints), production planning, etc. Software development/evolution (which is a design, rather than production, activity) may be conducted by recognizing units at various levels of granularity (cliches, patterns, modules, packages, statements, expressions,...) that need to be connected together to perform the desired function. To go from Point A (e.g., radar signal received) to Point B (e.g., radar track displayed), a designer may "connect the dots" of cliches at the next lower level (e.g., radar signal transformed to x,y,z coordinates; point matched with existing tracks; tracks in current window displayed,...). This can be viewed as a route planning problem (with the added complications that dots are described in varying dimensionality, some dots may be missing -- requiring that components at the next lower level be connected to form the dot;....). The recognition of which components (dots) play which role(s) is a matter of identifying which cliches are appropriate at a given point and recognizing how lower level components are aggregated to form higher level components. The situation is the same, in reverse, for understanding existing systems/software -- instantiations of components represent higher level abstractions. Based on the above, we need to look at approaches to design that are based on reasoning by analogy (e.g., Case Based Reasoning) with an overlay of rule/production-based logic to guide the criteria for judging similarity (which will vary with context). Projects might demonstrate technology to:

- Define schema/frames for representing software components.
- Demonstrate component (cliche) recognition in existing code.
- Demonstrate ability to identify needed sub-components (e.g., to provide required function)
- Specify consensus schema/frames for representing software components at various levels of granularity (e.g., subsystem, package/module, statement, expression) and refinement (e.g., architecture, design, code)
- Demonstrate ability to identify needed sub-components, determine appropriate ordering, and identify missing components.
- Conduct initial demonstrations and plan large-scale demonstrations, if justified.

PHASE I: Prototype demonstration and design.
PHASE II: Demonstration of 2 orders of magnitude reduction in cost to modify system.

PHASE III DUAL USE APPLICATIONS: This is a revolutionary approach to the design and adaptation of most systems and software. Its application of planning and Case Based Reasoning will automate the production of all software. Indeed, the earliest applications could well be in business areas where the "business rules" to be implemented are well understood.

KEYWORDS: Adaptive Software, System Synthesis, Engagement Planning, Production Planning.

SB001-014 TITLE: <u>Visualization of Information in Support of Asymmetric Operations</u>

KEY TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Military planners use detailed maps of terrain, combined with relevant information derived from a variety of sources to understand potential actions/counter actions that are available to both himself and his opponent. This approach has worked well for hundreds of years since most military operations occurred in physical space. However, part of the shifting in military warfare present today is from action in 3D space, to asymmetrical threats that require dealing with the gathering, interpretation and use of information as a military weapon. Military planners today have sophisticated tools available to visualize 3D space, such as paper or electronic representations of terrain, but they do not have an equivalent for visualizing the "information space". This effort is designed to focus on this limitation by providing military commanders with ways of displaying what information someone knows, how he knows it, how good it is and how what someone knows (or does not know) can be used to manipulate the outcome of a military engagement (or to prevent such an engagement). Develop techniques that allow military planners to determine what military information, relevant to their tactical situation, is available to an adversary, and present the data in such a way that a military planner can use the data for course of action development.

DESCRIPTION: Military planners rely on information derived from a wide range of sources as the basis of their decision making process. This information represents the collective understanding of the current situation of friendly, enemy and neutral components. It also represents the best understanding of what information an opposing force may have as well about his current situation. To obtain the goals set forth for a particular operation, planners must be able to quickly integrate relevant data and develop an understanding of both current and future situations, so as to rapidly take advantage of opportunities as they present themselves. Information Operations is a term broadly used to describe the emerging area of military operations related to understanding information flow on a battlefield and how it effects military outcome. By being able to better understand how this process occurs, military commanders are better able to understand and manipulate a situation to either take advantage of a lack of situational awareness by an opposing commander, or by doing things that add to his confusion of the situation. However, in order to do this, methods of displaying the "information terrain map" must be developed.

PHASE I: Identify advanced concepts/algorithms which will offer potential improvement in the ability of military commanders to understand what information is available and how it can impact his planning and execution process. In particular, visualization techniques should be used that allow a commander to rapidly understand the "information terrain" as well as provide techniques to analyze potential actions that could be taken based on this information. Low to medium technical risk and high potential for successful development will be included in the technical merit selection criteria. Identify experimentation techniques and metrics that would be used in a Phase II effort to validate.

PHASE II: Develop and test one or more techniques/algorithms selected in Phase I by integration within a command and control planning structure as proposed in Phase I. Execute experiments to validate the concepts/algorithms developed against the metrics identified in Phase I.

PHASE III DUAL USE APPLICATIONS: The basis of any planning systems, whether it's used within a military context or for corporate strategic planning, is information. The art to planning is understanding who knows what and what advantage can be gained by understanding an opponents lack of situational awareness. The opponent could be another military commander, but could also be a corporate competitor. Although the information critical to planners within a military or corporate environment will be different, the underlying technologies necessary for visualization of the information "terrain" are similar.

KEYWORDS: Visualization, Information Operations, Information Space.

SB001-015 TITLE: Adversarial Reasoning

KEY TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop and demonstrate a technique for assessing the risk posed by enemy actions that can be applied during interactive specification of a course of action (plan).

DESCRIPTION: Command and control systems incorporate a variety of tools to assist command staff in interactive specification of a course of action. The process is still time consuming, and often results in plans that are infeasible, either because they are physically impossible, logically inconsistent, or vulnerable to obvious enemy counteractions. In today's environment of asymmetrical threats, the range of factors that must be considered by planners has increased. Ideas for testing the physical and logical feasibility of individual planned actions during plan specification have been demonstrated. These ideas portend significant reductions in plan development time by assisting planners in avoiding infeasible actions. Implementation of tools that perform these tests will not assess the risk of plan failure due to potential counteractions of the enemy. Techniques are needed that incrementally assess planned actions against enemy counteractions and alert planners when significant risks are uncovered. Incremental testing during plan specification is necessary because planning a single course of action may take hours, and immediate feedback will allow planners to augment or discard risky plans. The value of this assessment increases with the number of factors that must be considered by planners. As additional factors must be considered, the expertise to evaluate the enemies response must be provided by humans or through automated decision support. Adversarial reasoning permits these additional factors to be considered without increasing the number of humans necessary to support the planning process. Applying constraint reasoning and rule-based critique, the primary techniques developed for feasibility testing, are not sufficient for adversarial reasoning. Of course a decision aid should not bother with counter-plans that are physically infeasible. What is necessary is a method for evaluating planned actions against hypothetical counteractions that are both physically possible and consistent with the assumed capability and intent of the enemy force.

PHASE I: Develop a concept of operations for an adversarial reasoning component to an interactive planning aid. Describe how evaluation would proceed, including how it would relate to physical feasibility testing, specification of possible enemy intent, and other significant factors. The concept of operations for this aid must include the ability to include traditional combat factors as well as asymmetrical factors. Describe the theoretical basis for the process, contrasting or comparing it to adversarial reasoning approaches in the literature, including Game theory, legal reasoning, and argument theory. Develop a plan for implementing and testing a demonstration prototype in Phase II.

PHASE II: Develop a proof-of-principal prototype based on the concept developed in Phase I. Develop and conduct experiments to test the effectiveness and usefulness of the approach. Document the research and experiments.

PHASE III DUAL USE APPLICATIONS: The development of adversarial reasoning algorithms and technologies will have a very strong commercial potential, to include a wide range of business planning and commercial gaming applications.

KEYWORDS: Adversarial Reasoning, Asymmetrical Threats, Planning, Risk Assessment.

SB001-016 TITLE: Real-Time Service Provisioning Over Unreliable Networks

KEY TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Creation of scalable technologies that enable real-time provisioning of reliable and secure end-to-end network services with pre-defined quality-of-service over unreliable, heterogeneous networks.

DESCRIPTION: Research and development leading to tools that enable real-time provisioning of scalable end-to-end secure and reliable services with quality of service, over unreliable, heterogeneous networks. Efforts must clearly define quality of service, to be studied and implemented, through quantifiable measures such as bandwidth guarantees, delay, jitter etc.; and reliability, through measures characterizing service interruption times incurred by path protection algorithms that provision alternate service paths in the event of failures. Efforts may be restricted to, Internet protocol (IP) and/or asynchronous transfer mode (ATM) networks, and to wired or wireless networks or a combination of them, but must address end-to-end provisioning leveraging any local mechanisms already defined in the networks. Efforts of interest include provisioning of virtual IP paths that are compatible with, and leverage, emerging backbone technologies such as multi-protocol label switching and differentiated services. Algorithms research areas of relevance include: algorithms for classifying packets, for efficient provisioning of virtual paths and network resources to packet classes, and for path protection. Mechanisms for security may use Internet protocol security (IPSec) definitions or others with similar capability. Efforts may build on existing algorithms, or create new ones, but in all cases the proposals must clearly identify the protection speed, scope of quality of service to be implemented, type of networks for which the tool is applicable, and limitations of the approach.

PHASE I: In detail, define the network environment. Define and evaluate algorithms for packet classification, for optimal provisioning of paths and network resources to packet classes, and for path protection. Identify candidates for implementation.

PHASE II: Implementation of the algorithms, from Phase I, in efficient software/hardware combination. Integration of these components into existing networks. Demonstrate system that can provably achieve 100-300 msec provisioning/protection times in a nationwide network; and greater than 95% delivery of implemented quality of service.

PHASE III DUAL USE APPLICATIONS: The ability to provision secure and reliable services over IP networks is an important extension of the capabilities of these networks. Enterprises and organizations that require mission-critical applications and real-time service integration will benefit from this technology.

KEYWORDS: Network Service Provisioning, Reliable and Secure Networks, Quality-of-Service, High-Speed Networks, Wireless Networks, Multi-Service Networks.

SB001-017 TITLE: Applications for Multi-Terabit Networking

KEY TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Exploit the new high-speed networking technology capable of supporting tens and hundreds trillion bits (Terabit) of information per second to enhance or revolutionize today's real-time network based applications and operations. Demonstrate networked applications that run over such multi-terabit networks and individually sink and source information streams that are three to four orders of magnitude greater in speed or capacity than are currently available over data networks. Specifically, prototype and conduct experiments with end-to-end applications that require sustained or burst rates of 100 Megabits per second to several Gigabits per second unlike today's limited applications that at best can handle up to few Megabits per second.

DESCRIPTION: Network centric operations is a concept that has great support in both industry and DOD. There are a plethora of opportunities to employ this model in several operating environments and to develop requisite personnel training programs needed to support the operation of the network in Government and private sector applications. However, a clear and compelling examples of the network centric behavior is not readily forthcoming especially for those enabled by Multi-Terabit networks that can offer applications end to end bandwidths of greater than 100 Megabits per seconds. An overall architecture that supports new business models and operational paradigms in a high-speed network environment needs to be investigated. The business processes developed to exploit the capabilities offered by the network architecture must be adaptable to new business methods that focus on increasing operating efficiencies. Moreover, new applications and uses for this new network environment must be well defined, and criteria for quantifying operating efficiencies must be established. The integration of business processes that support the seamless use of data and information from distributed repositories is one example of an area that should be explored in this work. Another example is the real-time streaming of high-resolution video and audio streams to users, or sensor output.

PHASE I: Develop an information architecture that incorporates a high-speed national network, create methods for protecting data and information, and develop business processing models. Conduct analysis to predict the affordability and improved performance that will be gained in using the integrated system. There must be a plan for experiments to determine effectiveness of the implemented architecture.

PHASE II: Build and implement a prototype high-speed networked application that demonstrates the ability to manage and protect information. Experiments must be conducted on wide-area networking test bed involving multiple users at distributed locations. Evaluate the affordability from an infrastructure cost perspective, and measure the business process improvements realized through the implementation.

PHASE III DUAL USE APPLICATIONS: Demonstrate the technology operating on the high-speed network and clearly show the cost savings and effectiveness of the approach for both a key commercial area and a critical military application.

KEYWORDS: High Speed Networking, Gigabit, Sec Applications, Embedded Processors

REFERENCES: http://www.darpa.mil/ito/research/ngi/index.html

SB001-018 TITLE: Alternative High-Bandwidth Communications Technologies

KEY TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Creation of alternative, secure, high-bandwidth communications methods for distributed computing, making innovative use of commercial off the shelf technology.

DESCRIPTION: Research and development leading to the innovative use of COTS systems and technologies that will allow geographically distributed individuals to communicate and collaborate security. Current technologies allow fixed network users to participate in local intra-organizational private networks. Also, remote users are allowed to connect to these same networks, although communications are not secured. Research efforts should address the application of current fixed private network technologies to the organizational remote user, who needs secure access while remotely connected. Research must consider higher bandwidth capabilities available from commercial interests. Additionally, capabilities for incorporating wireless users must be demonstrated.

PHASE I: Develop a small operational prototype that provides virtual private network capabilities to remote users over high-bandwidth connections, providing distributed computing functionality for the "road warrior".

PHASE II: Expand the prototype to include wireless users. Document the scalability of the application, showing how it could be applied to additional operational models and larger communities, such as the military.

PHASE III DUAL USE APPLICATIONS: Develop a small operational prototype of the secure remote user and secure wireless capability for 20 distributed users and place the prototype into operation within a cross-organizational environment. The development of innovative distributed computing methodologies will be immediately valuable to the DoD, addressing current inter-organizational communication difficulties. Additionally, the private sector is rapidly becoming aware of the dangers of unprotected communications on the Internet. Innovative solutions that reduce the risk of Internet use will be highly valuable.

KEYWORDS: Distributed Computing, Virtual Private Network

SB001-019 TITLE: Software Applications for Asynchronous Collaboration

KEY TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this effort is to design and develop applications that go beyond the current e-mail and shared files in supporting asynchronous collaboration in working groups. These applications should support group and situation awareness while reducing the overhead involved in explicit collaborations.

DESCRIPTION: Recent efforts in collaboration software have focused on synchronous collaboration (e.g. desktop video conferencing, application sharing). While these tools are useful in spanning distances, our problem is often on spanning time – hence asynchronous collaboration tools are needed. The traditional asynchronous tools of e-mail and shared files have not changed significantly since they were first introduced. We are seeking software technologies to support individual awareness of group work, including individually customizable organization of group communications; intelligent and adaptable information filtering and dissemination techniques; technologies and visualizations for structural differencing; and applications and visualizations for managing common information spaces. We seek technologies to support group communications, work flow, work products, and their integration. Applications must operate on heterogeneous platforms and scale to support hundreds of users. Efforts can include workflow types of applications, applications to support messaging within the context of work and structuring of messages in the context of that work, applications to collect, organize, and distribute organizational memory, as well as tools to allow collaborators to customize asynchronous applications to their particular domain. Novel applications are encouraged. Applications must have good user interfaces including visualizations where applicable.

PHASE I: In detail, define the application and create a prototype. Document one or more scenarios in which the application should produce significant benefits for a working group.

PHASE II: Fully implement the application using user centered design methodology. Conduct experiments using one of the scenarios from Phase 1 and document measurable benefits.

PHASE III DUAL USE APPLICATIONS: The applications will be tested within a military exercise or in a commercial scenario. These applications will impact tasks requiring the integration of information from distributed working groups. Typical domains include military planning activities, aircraft operations, medical diagnosis, disaster relief, manufacturing, and education.

KEYWORDS: Asynchronous Collaboration, Awareness, Group Ware.

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SB001-020 TITLE: Representations and Protocols for Universal Access to the World-Wide Web

KEY TECHNOLOGY AREAS: Information Systems, Human Systems

OBJECTIVE: Creation of extensible markup language (XML) versions and accompanying protocols for serving diverse hand-held devices with content and modality of information from World Wide Web servers that is matched to their capability.

DESCRIPTION: XML and accompanying representational standards have created the capability for "writing once and publishing everywhere." XML enables this by tagging content to describe its meaning, independent of the display medium. "Stylesheets" reformat the work automatically for various devices. This is a call for proposals to push the development of XML-based representations and stylesheet translators that further enable the development of a wide variety of different portable, wireless devices. Some devices may be voice-only, others combinations of voice, text and image. The intent is to create widely-accepted representations and processes to further enable the diversity of such devices by ensuring their seamless interoperation with the majority of the content of the World Wide Web.

PHASE I: In detail, define the approach to representation and translation tools that maximize efficiency with respect to diverse services, to be supplied to a wide range of devices. The deliverable will be a test-bed server that works with a sample of cutting-edge devices.

PHASE II: Create a stylesheet translator that enables dialogic interaction with content-full web sites such that effective telephonic interaction with the content can be obtained automatically. The style sheet will be evaluated by subjects "browsing" the web site by using only a telephone and spoken dialogue.

PHASE III DUAL USE APPLICATIONS: Militarily relevant devices for a variety of different contexts will be proposed and tested against the capabilities of universal access across the spectrum of military needs. In addition, the needs of the physically and cognitively disabled citizens will be addressed in terms of providing equal access to the contents of the World Wide Web.

KEYWORDS: World Wide Web, XML, Stylesheet, Extensible Stylesheet Language, Voice-Enabled Browsing, Multimodal Dialogue Systems, Internet Protocols and Standards.

SB001-021 TITLE: Read-Out Technology for Uncooled Thermal Imaging Arrays

KEY TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Development of new concepts for reading and addressing multi-element thermal imaging arrays with a low noise detector interface that introduces minimum detector signal loss.

DESCRIPTION: Substantial progress has been made in thermal imaging arrays that operate without the burden of cryogenic cooling. Arrays with thermal sensitivity of approximately one hundred milli-degress Kelvin are routinely produced, and research devices have achieved substantially greater thermal sensitivity. Enhanced performance has led to new applications in both commercial and military systems. This flood of new applications has also stimulated interest in higher performance for specialized applications and to improve yield margin to further reduce cost. Investigations of array performance indicate that the detector read-out mechanism remains a barrier, but that substantial improvements are possible with new concepts and novel approaches. Fundamentally, the read-out must address each detector in the array, determine the thermal signal at the detector and convert the information to an electrical signal. Conventional techniques employ an electrical read-out, similar to commercial visible imaging arrays. This read-out makes contact to the detector, resulting in some loss of thermal signal. Ideally, new concepts in detector array read-out technology are desired to eliminate or drastically reduce the signal loss at the detector, and provide for a detector that performs at or near the theoretical limit. Characteristics of the new approaches include electronic circuits for ultra-low noise, especially one-over-f noise; methods to reduce thermal loss at the detector; technology to integrate the detector with the read-out; and signal processing to compensate for non-uniformity in the array. These characteristics must be integrated into an array capable of being produced with high pixel density, and of course, at low cost.

PHASE I: The design and model for the thermal detector read-out circuit will be developed. This will include the optical, electrical, and if appropriate, mechanical properties necessary to determine the performance of the device. The model will be used to analyze noise mechanisms and the potential for operation at the thermal performance limit.

PHASE II: Devices will be designed and fabricated to demonstrate the read-out concept, and measurements made to compare to theoretical predictions. Prototype arrays will demonstrate the viability of meeting thermal imaging performance metrics. The arrays should demonstrate thermal sensitivity in a laboratory environment, and show the initial feasibility of large high-density image sensors.

PHASE III DUAL USE APPLICATIONS: Multiple applications exist for the thermal imaging cameras in both military and commercial sectors. Improvements in thermal sensitivity and simplification of array read-out technology will reduce camera cost and enhance performance, further expanding the applications base. Examples of applications for the low cost thermal imaging include: rifle sights, night driving, surveillance, police and firefighter applications, and industrial process control.

KEYWORDS: Thermal Detectors, Read-Out Technology, Uncooled Infrared, Imaging Technology.

SB001-022 TITLE: Integrated Microfluidic Technologies for Molecular Level Manipulation of Biological Fluids

KEY TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To develop microfluidic technologies that enable the chip-scale integration of processes to interface, sample, manipulate, detect body fluids (blood, interstitial fluids, saliva, perspiration, etc.) at the molecular level.

DESCRIPTION: Research and development of innovative solutions towards the complete integration of microfluidic components, fabrication processes, and biological/chemical assays on chip-scale microsystems. These efforts take current microfluidic technologies, many which are developed in the current Microfluidic Molecular Systems (MicroFlumes) Program, and develop chip-scale devices specific for interfacing to body fluids for continuous monitoring of physiological responses. The detection of proteins through "cellular-level gene expressions" and nanotechnology for molecular level probing are highly encouraged. On the other side of the spectrum, micromachining technologies for heterogeneous integration of microfluidic components with different materials are sought. Additional efforts encouraged include device technology that interface with living creatures for drawing/injecting body fluids, novel separation/mixing techniques, single processes combining detection and sample preparation, on-chip reconstitution, on-chip fluidic manifolds to interface with biochip arrays, pumping/valving devices and schemes for multiplexing arrays of valves and pumps.

PHASE I: Theoretical/computational proof-of-concept and comparison with existing state-of-the-art technologies. Design of prototype devices and plans to micromachine devices.

PHASE II: Development of prototype micromachined device. Testing to compare with Phase I predictions will be required.

PHASE III DUAL USE APPLICATIONS: Microfluidics technologies developed under this topic will be the basis for embedded chips on soldiers to monitor physiological signatures for early detection of bio-warfare agent exposure, triage of bio events, and vital signs monitoring. An example for a commercial application is the continuous monitoring of high-risk, post-operation patients for the first sign of sepsis, infection, or pressure drop.

KEYWORDS: Microfluidics, Nanotechnology, Molecular Recognition, Integrated Chips, Continuous Monitoring.

SB001-023 TITLE: Lasers for Optoelectronic Enhancement of Analog to Digital (A/D) Converter Performance

KEY TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Promote the development of laser modules that take advantage of emerging high repetition rate mode locked laser technologies to enhance the performance of high speed (high sampling rate) A/D converters.

DESCRIPTION: Progress toward advancing the technology for very-high-resolution, high-sampling-rate A/D modules in the range from 1 to 10 Giga-samples-per-second has been extremely slow, due in large part to difficulties in design and fabrication of electronic circuits capable of meeting the required performance. In particular, the generation and distribution of precise timing (clock) signals for these applications could be greatly enhanced through the use of mode-locked laser sources with low (on the order of 10 femtoseconds) pulse-to-pulse timing jitter and low amplitude fluctuations. Innovative approaches are sought for achieving compact modules for generation of very sample mode-locked laser sources using fiber optic and integrated optical components. Candidate technologies include compact, high optical Q resonators based on low-loss fiber ring resonators (Sigma Fiber Laser designs) laser designs and compact, high Q optical resonators based on micro-cavities.

PHASE I: Develop proof of concept design, either through fabrication of prototype modules or by detailed modeling of designs based on demonstrated performance of existing components.

PHASE II: Develop and demonstrate a fully functional prototype capable of demonstrating critical functionality, providing design documentation for a full-scale implementation.

PHASE III DUAL USE APPLICATIONS: The development of efficient, compact, very stable and portable mode-locked laser sources could find application in commercial and military optical communication systems and in a broad range of other systems applications where timing synchronization over extended distances is important.

KEYWORDS: Optoelectronics, Lasers, Mode-Locked Lasers, Low Jitter Timing Laser Sources.

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SB001-024 TITLE: Terahertz Device Technology

KEY TECHNOLOGY AREAS: Sensors/Electronics/Battlespace, Space Platforms

OBJECTIVE: Development of solid state terahertz devices for operation in the range between 0.3 THz to 10 THz suitable for coherent sources and detectors for use in space-based and short range terrestrial communications, atmospheric sensing, near object analysis, and chemical and biological detection.

DESCRIPTION: The electromagnetic spectrum from 0.3 THz to 10 THz is scientifically rich but relatively technologically poor. The region represents a gap separating electronics, oriented towards transport, from photonics, oriented toward quantum transistors. Devices that mix quantum and transport physics will fill this void. The region offers the potential for a number of applications including space-based and short-range terrestrial or near earth communications, atmospheric sensing, collision avoidance for aircraft and ground vehicles, and near object observation and spectroscopy. To realize this potential the appropriate sources, detectors, and systems need to be developed. Innovative approaches are needed leading to the development, fabrication, and operation of coherent solid state terahertz sources. Efforts may include electrically excited devices as well as those driven by solid state optical lasers. Three terminal devices, and classical approaches, such as Gunn diode oscillators may be considered as long as proper power and efficiency advances are addressed. Highly desired are approaches in quantum wells and tunneling devices, as well as other novel quantum structure approaches. Desired are devices and device concepts that will deliver coherent radiation at potentially milliwatt power level, ultimately coupled efficiently in THz circuits, guided wave structures and antennas. Work is needed in detectors to greatly improve the sensitivity, speed, and bandwidth. Specifically desired are efforts in semiconductor-based quantum well structures and the subsequent development of a useable detector that is narrow band, widely tunable, and yet highly sensitive. Other solid-state approaches may be considered. Approaches toward compact system modules addressing both generation and detection are also of interest.

PHASE I: Clearly demonstrate the feasibility of the proposed approach. Define a device that will deliver up to milliwatts of coherent radiation at specified frequencies in the THz regime. And/or define the detector or detector structure detailing optimal geometry, bandwidth limitations, tunability, and current-carrying capacity. The definition of the device/system-module needs to include principal of operation, material, processing, associated circuit or guided wave structure, and regime of operation.

PHASE II: Build upon Phase 1 work and demonstration of system components and implementation of a prototype. Perform appropriate analysis and modeling, grow the material or structure, fabricate the device and test its performance.

PHASE III DUAL USE APPLICATIONS: Terahertz electronics and photonics have many potential commercial and military applications. Covert communication on the battlefield or in space, chemical agent detection, atmospheric environment sensing, near object detection, material imaging will benefit from new technology in this part of the electromagnetic spectrum. New terahertz electronics will also make possible ultra high speed signal processing.

KEYWORDS: Microelectronics, Photonics, Terahertz, Terahertz Electronics, Communications, Sensing, Heterojunctions, Quantum Wells, Semiconductors, Solid State, Sources, Detectors, Chemical Sensors, Bio-Detection.

SB001-025 TITLE: High Power Semiconductor Devices

KEY TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Create technologies for efficient design and fabrication of high power switching electronic devices and circuits, based on silicon-carbide (SiC).

DESCRIPTION: Devices fabricated in high power handling silicon-carbide (SiC) semiconductor material system are emerging. The difficulties in designing and processing SiC devices must be overcome to allow the technology to realize its potential. Results on SiC indicate that devices may handle high voltages and currents, but may also have very high power dissipation density (on order of 1E3 W/sq. cm). Innovative technologies are needed for design, fabrication, and integration of new classes of SiC high-power solid-state electronic components, such as diodes and switches, with conventional sensors and microelectronic control. These new devices and circuits are needed to meet the widespread military and commercial needs for switching devices and integrated circuits that can satisfy the very high-current and high-voltage requirements of power transmission and distribution systems, hybrid- and all-electric vehicles, more-electric aircraft, and other types of electrical equipment and machinery. Forward currents are expected in the 100-1000A range and reverse voltages in the 1000-10000V range. New design and analysis tools that efficiently couple electronic, electromagnetic, and thermal phenomena together may be useful to fully realize the potential of SiC technology. In addition, SiC is a difficult material to process, and innovations in process technology that allow higher yield or advanced device performance may be important. As appropriate, offerors should provide an analysis of current technologies and clearly describe the projected benefits of the proposed approach.

PHASE I: Perform fundamental experiments and computer simulations that confirm feasibility of the technology for application to high power devices.

PHASE II: Develop cost-effective processes or design tools for high power devices. As appropriate, demonstrate critical aspects of developed technology for scaled or intended applications. For design tools, verify accuracy and efficiency of approach.

PHASE III DUAL USE APPLICATIONS: While not yet a mature overall technology, SiC materials and devices have inherent advantages for handling high powers. Commercial and military applications for SiC high power devices and circuits include, uncooled switching devices and integrated circuits for electrical power transmission and distribution systems, hybrid- and all-electric vehicles, more-electric aircraft, and other types of electrical equipment and machinery.

KEYWORDS: High Power Electronics, Design, Fabrication, Silicon.

SB001-026 TITLE: Materials and Tools for Heterogeneously Integrated Microelectronics

KEY TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Develop new silicon-compatible microelectronic materials, and design and fabrication tools to enable the efficient implementation of advanced monolithic electronic systems, based on very short channel transistors, and other devices, and their integration in large numbers, focusing on application-specific and signal processing circuits.

DESCRIPTION: The minimum lithographically defined feature size of a silicon field-effect transistor will decrease from the present 180 nanometers (nm) to 25 nm during the next decade. At the 25 nm scale, it will be possible to monolithically fabricate as many as 1E12 transistors, perhaps in more than one layer of active devices. The availability of this large number of devices may allow tremendous flexibility and function in circuit architectures. In addition, it may be possible to heterogeneously integrate alloys such as SiGe selectively, enabling high performance devices. A new class of design and fabrication tools will be required to enable and exploit these capabilities. New cost-effective fabrication tools that enable production of devices on multiple layers or selective formation of silicon alloy devices may be needed. Complexities are also expected in designing and verifying efficient, high performance circuits with such large levels of integration and new design/analysis technologies are needed to solve these problems. Advanced physics-based tools and models are required to better understand the operation and sensitivities of these very short channel devices. It is anticipated that the coupling of design and fabrication will need to be very tight for the terascale integrated circuit. Integrated physical and statistical technology design/analysis tools have proven to be highly effective in devolving the coupling between design and process for the 0.5 and 0.25 micron technology generations. Development and extensions of new technology coupled modeling tools for the 25 nm scale device may be critical to yield circuits at high integration levels.

PHASE I: Determine the necessary features, specifications, and requirements of design and fabrication tools. Develop strategies to develop, integrate, and verify point tools in advance of availability of fully scaled 25 nanometer circuits. As relevant, perform critical lab experiments to verify technological basis of fabrication tool.

PHASE II: Execute the technical approach developed in Phase I. Complete implementation of theories, numerical or analytic solvers, integration of models and code modules, and demonstrate capabilities of prototype design/analysis tools.

Develop plans to support continuous upgrades to tools beyond Phase II. As relevant, develop experimental hardware that conclusively demonstrates fabrication technology and establishes transition path.

PHASE III DUAL USE APPLICATIONS: Semiconductor technologies such as design and fabrication tools have both military and commercial utility. These tools could be used to design, analyze, verify, and ultimately fabricate any type of circuit. Semiconductor technology is being driven by commercial products with high product volumes. The military needs complex, high performance components at low product volumes. The design tools under development in this topic will impact the development of both commercial high volume parts and military high performance parts.

KEYWORDS: Semiconductors, Silicon, Terascale Integration, Computer Aided Design.

SB001-027 TITLE: Automatic Terrain Characterization and Feature Identification in FOPEN SAR Imagery

KEY TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: The objective of this program is to extract topographic, terrain cover and cultural feature information from single and multiple pass FOPEN SAR imagery.

DESCRIPTION: DARPA is currently developing a Foliage Penetration (FOPEN) syn-thetic aperture radar (SAR) system [1] to detect concealed targets. The dual-band sys-tem, operating simultaneously at both VHF and UHF, will begin to collect data in FY00. The VHF radar, which is horizontally polarized, operates from 25 to 88 MHz, while the UHF radar, which is fully polarimetric, operates from 150 to 575 MHz. The radars are mutually coherent. A significant challenge in FOPEN SAR operation is to achieve a high probability of target detection while minimizing the number of false alarms due to forest clutter. Automatic Detection and Cueing (ATD/C) algorithms are being developed for this purpose. It has been observed that the best-performing features for ATD/C process-ing can vary with the characteristics of the foliage (e.g. tree height and density), the slope and roughness of the terrain, the season of the year and other environmental characteris-tics. This effort will develop tools to automatically characterize the local environment so that the optimal set of features can be used in the ATD/C processing. In addition, DARPA plans to investigate FOPEN Ground Moving Target Indication (GMTI) radar. The target tracking performance of such a radar could be significantly enhanced if con-textual background information were available. Information such as road locations and areas in which moving targets cannot operate could be extracted from a FOPEN SAR map or from multiple-pass Interferometric SAR imagery, and provided to the target tracker.

PHASE I: Investigate techniques and develop algorithms that accurately characterize the topography, determine the foliage characteristics and identify cultural features in FOPEN SAR imagery. FOPEN imagery will be made available by the Government to support this effort.

PHASE II: Develop software tools and demonstrate the capability to provide accurate characterizations of the area imaged by the FOPEN radar. The software tools will operate under the Khoros environment used for FOPEN SAR ATD/C processing. The software tools will be provided to the Government with SBIR restricted rights at the conclusion of the Phase 2 effort.

PHASE III DUAL USE APPLICATIONS: The techniques that are developed will be applicable to potential future commercial uses of FOPEN SAR such as developing Land Use and Land Cover map products, monitoring forest resources and performing search and rescue missions. The techniques will also be useful for planning military operations by providing accurate and up-to-date terrain assessments.

KEYWORDS: FOPEN, SAR, Interferometric SAR, Terrain Feature Extraction.

REFERENCES: Davis, M. E. et al, "Technical Challenges In Ultra-Wideband Radar Development for Target Detection and Terrain Mapping", Proceedings of the IEEE International Radar Conference, 1999.

SB001-028 TITLE: Acousto-Optic Spectra-Polarimetric Imaging

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Design and develop acousto-optic spectra-polarimetric imaging system to include acousto-optic crystals and polarimetric imaging spectrometers for application in the visible-near infrared, short wave infrared, and long wave infrared, for the purposes of military target detection.

DESCRIPTION: Advances in imaging spectrometers and acousto – optic materials are making possible the combination of multi/hyperspectral and polarimetric imaging for the purposes of military target detection in cluttered environments. Specifically the combination of these technologies in a compact system would provide significant value to the military. Current concepts indicate specific shortfalls in the following three areas: (1) robust-detailed compact system designs (2) combined multi/hyperspectral – polarimetric target detection algorithms and, (3) long wave infrared/polarimetric acousto – optic materials development.

PHASE I: Develop robust spectra-polarimetric acousto-optic imaging system design. Develop long wave infrared/polarimetric acousto-optic material. Develop combined spectra-polarimetric target detection algorithms.

PHASE II: Develop/build and test prototype spectra-polarimetric acousto-optic imaging system. Fabricate/demonstrate long wave infrared/polarimetric acousto-optic material. Demonstrate/verify performance of combined spectra-polarimetric target detection algorithms against real or simulated data.

PHASE III DUAL USE APPLICATIONS: This system or advances developed could be used in a broad range of military and civilian applications to include security and law enforcement, adverse weather aviation landing systems, medical diagnostics, and search and rescue operations.

KEYWORDS: Sensors, Multi/Hyperspectral, Polarimetry, Optical System, Acousto-Optics.

SB001-029 TITLE: <u>High Power Fiber Lasers</u>

KEY TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: The goals of the program are to develop innovative approaches to scale up the output power of fiber lasers to 1 kW from a single aperture.

DESCRIPTION: Fiber lasers with double clad structure are a new generation of diode pumped solid state lasers that are efficient (~ 25 %), have single mode output and can be implemented with air cooling alone. Tens of watts of output power from fiber lasers have been demonstrated. The cavity and pumping scheme are built into a waveguide structure. The guided nature of the fiber laser is self-aligning; therefore the cavity is extremely robust against alignment disruption. The fiber lasers can be mass-produced at low cost. High power fiber lasers have numerous defense applications such as cw lidar sources, pump source for frequency converters for infrared countermeasures and isotope separation. In addition, high power fiber lasers may be coherently combined to provide a potential multi-kilowatt laser sources for tactical battlefield applications.

PHASE I: Define, analyze innovative design concepts for double clad fiber laser architecture for single mode output power of 1 kW from a single fiber. Demonstrate perform fabrication and fiber drawing for the selected designs.

PHASE II: Demonstrate 1 kW single mode output power from a fiber laser.

PHASE III DUAL USE APPLICATIONS: The high power fiber lasers have many commercial applications in graphic arts industry, industrial machining and medical applications. A successful demonstration of higher output power from a single fiber would provide an opportunity to develop a military systems with components available from commercial-off-the shelf.

KEY WORDS: Fiber Lasers, Laser Diodes, Diode Pumping, Cavity, Single Mode, Double Clad Structures.

REFERENCES:
1. M. Muendale, SPIE 3264-05, 1998.
2. V. Dominic, et. al, CPD11-1, CLEO 1999, Baltimore MD.

SB001-030 TITLE: <u>Advanced Gating Techniques for Planar, High Power Non-Linear, Semiconductors in Advanced Mobile Power Conditioning Applications</u>

KEY TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace

OBJECTIVE: Demonstrate advanced gating technique(s) on planar silicon devices.

DESCRIPTION: Present state-of-the-art gating of planar, high power, non-linear, semiconductor devices such as thyristors, gate turn-off thyristors (GTO's), MOS-controlled thyristors (MCT's) and MOS turn-off thyristors is accomplished through plasma spreading as stimulated by the injection of an electric current through the devices gate structure. The gate structure(s) typically share surface area with the emitter in these planar devices. In order to maximize the performance of these devices for high power applications, the gate structure(s) can consume a large fraction of that surface area, thus complicating and compromising the area/volume available for the conduction of load current and heat. This compromise typically forces the necessary area/volume of active semiconductor to increase rapidly with increasing di/dt, current or charge transfer requirements. In the most severe service, as might be found in the switching of advanced rotating machines and high energy capacitive stores in a burst mode, the area/volume of active semiconductor (and therefore, device count) becomes unmanageable for many future applications. Devices made from wide bandgap semiconductor materials such as silicon carbide have the potential to operate at higher temperatures, higher di/dt's, and higher current densities than the present state-of-the-art devices in silicon. However, the ultimate performance of these devices will also be compromised if alternative gating techniques are not developed. Therefore, the proposed techique(s) should be applicable to devices made from candidate wide bandgap materials as well as silicon.

PHASE I: Demonstrate advanced gating technique(s) on planar silicon devices. Show relevance of the approach for application in wide bandgap devices.

PHASE II: Demonstrate advanced gating technique(s) on wide bandgap devices. Implement the gating technique(s) on silicon or wide bandgap devices of substantial area for direct application in advanced, compact, mobile power conditioning.

PHASE III DUAL USE APPLICATIONS: Applications include load leveling and peak demand management for both military and commercial electric and hybrid electric vehicles.

KEYWORDS: Energy Storage, Semiconductor Materials, High Temperature Electronics, Wide Bandgap Devices, Switching.

SB001-031 TITLE: SiC Inverter

KEY TECHNOLOGY AREAS: Ground/Sea Vehicles

OBJECTIVE: Development of a SiC-based inverter to provide power for the traction motors for an electric or hybrid electric ground vehicle.

DESCRIPTION: Using SiC switches in electric or hybrid electric vehicle traction inverters promises to reduce significantly the size of the propulsion system including the supporting cooling system. Recent advances in SiC devices indicate that SiC power semiconductor switches will soon be available for use in inverters. The unique performance characteristics and cooling requirements of the devices need to be applied to inverter design. The results should be an inverter that can be integrated into an electric or hybrid electric vehicle in less space than current silicon-based power electronics. The design concept should be scaleable across the size range of future hybrid electric military vehicles.

PHASE I: Design and analyze a SiC-based inverter for an electric or hybrid electric ground vehicle. Estimate the effect on performance and design of using the proposed inverter in a hybrid electric military ground vehicle such as a HMMWV, RST-V, or larger combat vehicle.

PHASE II: Build and test the SiC-based inverter. Determine one or more paths to military application and commercialization.

PHASE III DUAL USE APPLICATIONS: Electric and hybrid electric vehicles are being developed for all sizes of vehicles, from motorcycles, to cars and to heavy trucks. Hybrid electric vehicle technology is expected to be used for future ground vehicles for the military.

KEYWORDS: SiC, Inverters, Hybrid Electric Vehicles, Electric Vehicles.

SB001-032 TITLE: Group Target Tracking

KEY TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Development and demonstration of theory, algorithms and software for tracking groups of targets with inter-target motion constraints.

DESCRIPTION: Current Multiple Hypothesis Tracking (MHT) technology provides a rigorous approach to the development of tracking algorithms and software based upon statistical estimation theory. The theory has been widely applied to a variety of sensor systems, including the Discoverer II space-based radar system. A limitation of the current theory is that the targets being tracked are required to move independently of one another. The removal of this limitation would greatly extend the domain of applicability of the MHT technology. A straightforward example is the case of military vehicles moving together as a unit. Exploiting the correlations in the movements of the vehicles in the unit should provide improved tracking performance; e.g., by estimating the behavior of vehicles in the unit that are not detected during a particular sensor revisit using the behavior of the vehicles in the unit that are detected. Alternatively, by tracking the unit as an entity rather than the vehicles in the unit individually, it should be possible to use lower revisit rates and hence less sensor resources. A less obvious example is the case of a military vehicle observed by a high resolution radar. Here it is desired to track the bright points in the radar return to estimate the 6-dimensional motion of the vehicle in order to form a Moving Target Image (MTIM). Assuming that these bright points arise from features on the surface of the vehicle, their motion is related by rigid body constraints.

PHASE I: Develop the necessary theoretical extensions and approximations necessary to achieve a computationally feasible solution. Implement a prototype algorithm to demonstrate the application of the theory.

PHASE II: Develop a software package implementing the algorithms. Demonstrate the software using data from one or more application domains.

PHASE III DUAL USE APPLICATIONS: There is a growing requirement for automatically processing video imagery in the industrial security, transportation, and entertainment industries. The problem of tracking extended objects using features derived from processing individual video frames is identical to the group target tracking problem (where the features correspond to targets). Thus, the software developed should have wide commercial applicability.

KEYWORDS: Target Tracking, Radar, Video.

SB001-033 TITLE: Component Technologies for Closed-Loop Adaptive Flow Control

KEY TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Development of new actuator and actuation system concepts, and/or more powerful, more effective, larger-scale actuators to effect closed-loop active flow control for enhanced air vehicle performance.

DESCRIPTION: An initial round of innovative adaptive flow control actuators and concepts are being evaluated under existing DARPA contracts in the Micro Adaptive Flow Control Program for selected military system applications. These concepts include (but are not limited to) aspiration controls for highly loaded compressor blades, active control of complex downwash flows for tilt-rotor aircraft, active flow control of retreating blade stall for rotorcraft, smart aeroelastic mesoflaps for shock wave/boundary layer control in inlets, and reconfigurable piezoelectric synthetic jet actuators for flight controls. The full potential for adaptive flow control applications, particularly in air platforms, is limited by the available technology for innovative and robust actuators, sensors, and controls. We wish to accelerate development of innovative flow control component technologies that can ultimately be leveraged into large system benefits. Currently the application of adaptive flow control to full systems is limited by actuator output, particularly with respect to actuator bandwidth and energy delivered to the flow. Innovative high-output actuators that implement smart materials, novel energy delivery methods, compliant mechanisms, and high power densities should be considered. Demonstration of the contribution to typical full-scale implementations should also be considered.

PHASE I: Define the new component technologies which will have large benefits when applied to adaptive flow control, demonstrate feasibility of the new technology, and quantify the expected benefits.

PHASE II: Develop a full implementation of a technology that has crucial benefits to adaptive flow control. Demonstrate prototype devices and establish their range of performance.

PHASE III DUAL USE APPLICATIONS: Adaptive flow control technology has a wide range of applicability in the civilian community in situations where viscous effects in flows produce performance degradation. In addition to the applicability of this technology to commercial air transports, adaptive flow control can show system benefits in diverse areas such as ground vehicle drag reduction, ventilation systems, and chemical processing plants.

KEYWORDS: Active Flow Control, Adaptive Flow Control, Flow Actuators, Synthetic Jets, Unsteady Aerodynamics, Viscous Flows

REFERENCES:
1. Smith, B. L. and Glezer, A. "Vectoring and Small-Scale Motions Effected in Free Shear Flows using Synthetic Jet Actuators," AIAA Paper 97-0213.
2. Amitay M., Honohan A., Trautman M. and Glezer A., "Modification of the Aerodynamic Characteristics of Bluff Bodies Using Fluidic Actuators", AIAA Paper 97-2004.
3. A. Seifert, A. Darabi, and I. Wygnanski, Delay of Airfoil Stall by Periodic Excitation, J. of Aircraft, v. 33, pg. 691, 1996.

BALLISTIC MISSILE DEFENSE ORGANIZATION (BMDO)
SMALL BUSINESS INNOVATION RESEARCH PROGRAM
Submitting Proposals - Instructions

Send Phase I proposal packages (the unbound original, to make extra copies, and six bound copies (i.e. stapled), to immediately forward to evaluators, of the full proposal, PLUS one additional copy of the Proposal Cover Sheet (formerly "Appendices A and B") by US mail (or any commercial delivery service). Also, the Company Commercialization Report needs only to be with the unbound original. **DO NOT** attach the Company Commercialization Report to the six bound copies. The mailing address follows and the BMDO SBIR website address is provided.

Ballistic Missile Defense Organization
ATTN: TOR/SBIR (BOND)
1725 Jefferson Davis Highway, Suite 809
Arlington, VA 22202

For Administrative HELP ONLY call: **800-WIN-BMDO**
Internet Access: **www.winbmdo.com**

Proposals delivered by other means will not be accepted. Proposals received after the closing date will not be processed. BMDO will acknowledge receipt of proposals, **IF AND ONLY IF**, the proposal includes a self-addressed stamped envelope and a form that needs no more than a signature by BMDO.

Proposers are required to register on the DoD Electronic Submission Web Site (http://www.dodsbir.net/submission/) and, as instructed on the Web Site, to prepare a BMDO Proposal Cover Sheet and Company Commercialization Report to be included in their proposal.

BMDO is working toward developing and deploying a ballistic missile defense system and providing a technology base that will allow the Department of Defense to protect the warfighters against increasingly sophisticated and lethal missiles around the world. BMDO accomplishes these efforts through three broad mission focus areas: Theater Missile Defense (TMD), National Missile Defense (NMD), and Advanced Technology Developments (ATD).

TMD systems respond to and protect U.S. forces, allies, and other countries from existing and emerging short to medium range threat missiles, including cruise missiles. Six Major Defense Acquisition Programs represent the majority of BMDO investments: PATRIOT Advanced Capability-3 (PAC-3), Navy Area Theater Ballistic Missile Defense (TBMD), Theater High-Altitude Area Defense System (THAAD), Navy Theater Wide, Medium Extended Air Defense System (MEADS), Space Based Laser (SBL). NMD is concerned with the possibility of a limited ballistic missile strike against the United States (all 50 states). The key component systems currently under consideration include: ground-based interceptors; ground-based radars; upgraded early-warning radars; forward-based X-Band radars; battle management, command, control, and communications (BMC3); and advanced sensor technology developments. External elements to NMD include the existing early warning satellite system and its planned follow-on: the Space Based Infrared System (SBIRS) which include both the HIGH and LOW components. Finally, BMDO depends on advanced technology developments, of all aspects, to invigorate its ability to implement both TMD and NMD systems in response to increasingly sophisticated ballistic missile threats, to include cruise missiles. Therefore, the continued availability of such advanced technology developments has become an increasingly vital and critical element of the overall BMDO mission.

The intent of BMDO, first and foremost, is to seek out the most innovative technology that might enable a defense against a missile in flight -- lighter, faster, stronger, more reliable, and less expensive technologies are all of interest. Proposing companies need not know specific details or requirements of possible BMDO systems, research and development goals, or specific technology needs or requirements, but must understand that potential technologies should have application to ballistic missile defense at some level. (A better fire extinguisher, although it may be new and innovative and exhibit a potential commercial market, does not support ballistic missile defense requirements at any level.) All topics seek to solicit Research or Research and Development proposals from the small business community. Furthermore, all selections shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not yet been fully established.

Specifically, **BMDO seeks to invest seed-capital, which supplements private sector co-investment support, in a product with a future market potential (preferably private sector) and a measurable BMDO benefit.** The BMDO SBIR/STTR Program will neither support nor further develop concepts **already mature enough to compete** for private capital or for mainline government research and development funds. BMDO prefers projects that move technology into the private sector market by a market-oriented small company with the best demonstration of volume commercialization with private sector co-investments. Phase I proposals should focus primarily on the innovation of the proposed technology. Proposals should illustrate the concept or feasibility, and the merit of a Phase II for a prototype or at the very least a proof-of-concept. Phase II competition will also be judged intensely on future market possibilities and commercialization potential demonstrated. The demonstration of commercialization potential is best evidenced by Phase II funding commitments, public or private, submitted as part of the Phase II proposal. BMDO evaluates the presence of other indicators of commercialization potential, but only: 1) support-in-kind from private sector sources, and/or 2) a company's self-investment are considered appropriate other indicators by BMDO in assessing the private sector commercial potential of Phase II proposals.

BMDO does not specifically require co-investment in Phase II, and expects to make some Phase II awards in which the co-investment is not a factor in the selection decision each year. However, co-investment is strongly encouraged, and historically, the best companies with the best proposals demonstrate the commercialization potential of their technology by exhibiting private sector co-investment support, at some level, **and/or** the commitment of a government program willing, as part of the Phase II, to co-invest and leverage the SBIR/STTR investment at the time of selection. This co-investment standard is now set by the proposing companies, your competition, by attracting an average of a dollar-for-dollar match (1:1) of private sector co-investment support to the SBIR/STTR funding requested. Those companies, that do not demonstrate the commercial potential of their Phase II technology through a co-investment arrangement and/or other means, do not compete well at BMDO.

Phase II proposals may be submitted anytime, for any amount, in any format after the Effective Date of the Phase I effort. Unique efforts showing time sensitivity or submitted for *FasTrack* will be given due consideration for Phase II start-up funding and Phase I proposals may include a post-Phase I optional tasking that will permit rapid start-up if the Phase II or *FasTrack* application is approved. The latest information on how BMDO implements its *FasTrack* Program may be found at the website address under the *FasTrack* or Frequently Asked Questions (FAQs) sections.

BMDO implements a Phase II Enhancement policy across all SBIR selections by providing some initial funding and then matching private sector co-investments at some ratio and up to some ceiling. BMDO reserves the right to provide less funding than the company initially proposes. To encourage the transition of SBIR technology into DoD acquisition programs, additional government, non-SBIR, funding may be applied to any existing BMDO SBIR Phase II contract with no ceiling, under BMDO's Phase II Enhancement policy. These arrangements, however, must be coordinated through the managing agency implementing the contract. Also, a company that exhibits a unique and compelling rationale may receive additional Phase II SBIR funding to attract a significant level of private-sector funding as co-investment. These Phase II extensions or "add-ons" shall only occur to existing Phase II efforts and are treated on a case by case basis. BMDO, on the average, approves only one Phase II extension per year.

A Principal Investigator at the small business who is tenured faculty is **NOT** considered primarily employed by a small firm if they receive compensation from the university while performing the SBIR or STTR contract; any waiver must be requested explicitly with a justification showing a compelling rational and national need; BMDO expects to grant no such waivers.

BMDO intends for a Phase I to be only an examination of the merit of the concept or technology, that still involves technical risk, with a cost under $65,000. Although proposed cost will not affect selection for negotiation, contracting may be delayed if BMDO reduces the proposed cost. **DO NOT** submit the same proposal, or variations thereof, to more than one BMDO topic area; each idea will be judged once in an open competition among all proposals. Furthermore, BMDO performs numerous cross-reference checks within each solicitation and with other DoD components. It is suggested that you **do not** use the title of the BMDO SBIR Topic as the title of your Phase I proposal.

Because BMDO seeks the best nation-wide experts in innovative technology, proposers may suggest technical government reviewers by enclosing a cover letter with the name, organization, address, phone number, and rationale for each suggestion. BMDO promises only to consider the suggestion and reserves the right to solicit other evaluations.

Implementation of DoD's Fast Track Policy at BMDO

Rationale for BMDO's Implementation Plan

The Defense Department's SBIR program has implemented a Fast Track policy for companies which, during their Phase I efforts, attract outside investors (government or private sector) that will match Phase II SBIR funding, in cash, at the matching rates described in the solicitation. Companies that obtain such outside cash investments and qualify for the SBIR Fast Track receive:

- a significantly higher chance of Phase II award, and
- interim funding between Phase I and Phase II, as well as expedited processing, to ensure no significant funding delays between Phases I and II.

The following summarizes how the DoD Fast Track policy is implemented at BMDO. This Implementation Plan is specifically required since the BMDO SBIR Program has evolved to the level that most companies competing for a Phase II award from BMDO obtain private-sector investment support – not just companies participating in the Fast Track. In fact, the BMDO SBIR Program, in its decision process for Phase II award selections, uses as a primary selection criterion (but not the only criterion) a company's ability to demonstrate commercial potential by attracting private-sector investment support during the performance of the Phase II. The value that BMDO places on this support depends on a number of factors, including the type of investment support (e.g. cash, support-in-kind, or self-investment), amount of the matching support, and timing of the matching support.

Thus, implementation of the DoD Fast Track policy at BMDO needs to occur in such a way that Phase II proposals with the greatest commercial potential, as measured by the amount of private-sector investment support, receive the highest priority for Phase II award.

BMDO's Fast Track Implementation Plan – "*FasTrack*" – has been in effect since the FY96.1 DoD SBIR solicitation and is approved for implementation by the Under Secretary of Defense for Acquisition and Technology (USD(A&T)).
BMDO's *FasTrack*:

- is consistent with the general principles of the DoD Fast Track policy, described above; and
- has demonstrated a track record of success. Specifically, BMDO implemented its *FasTrack* policy during 1996-1999 using the procedures outlined below, with the approval of the USD(A&T). 36 Phase I projects qualified for BMDO *FasTrack* during this time period -- the highest amount per dollar of SBIR funds of any DoD SBIR component. 35 of these projects were selected for Phase II award and also received interim funding between Phase I and Phase II.

The BMDO *FasTrack* Implementation Plan

a. In General. BMDO implements a *FasTrack* SBIR process for companies which, during their Phase I projects, attract one or more private-sector, outside investors that will match Interim SBIR Funding (between Phase I and Phase II) and Phase II SBIR funding, in cash, and at the matching rates described in subsection (c) below. Such companies shall receive (subject to the qualifications described herein):

(1) Interim Funding of $30,000 to $40,000 between Phase I and Phase II;

(2) BMDO's highest priority for Phase II selection and award; and

(3) An expedited Phase II selection decision and an expedited Phase II award.

Questions about the BMDO *FasTrack*, including any of the provisions discussed below, should be directed to the BMDO SBIR/STTR Program Manager, Mr. Jeff Bond, at 703-604-3538 (FAX -3956). The BMDO SBIR Home Page contains a BMDO *FasTrack* Timeline showing the schedule of events for a company participating in BMDO's *FasTrack* program (see http://www.futron.com/bmdo/3FAST/fasttrk.gif).

b. How to Qualify for BMDO *FasTrack*. To qualify for BMDO *FasTrack*, a company that has received a BMDO-sponsored Phase I award must submit the following five items within four (4) months of the effective date of the Phase I award. (Note: The effective date is the date on which the Phase I contract actually takes effect and the company may begin to incur costs under the contract.):

(1) A completed DoD/BMDO *FasTrack* application form (which follows this Plan). A copy of the completed DoD/BMDO *FasTrack* application must also be sent to the DoD SBIR Program Manager at the address listed on the back of the form.

(2) A Commitment Letter from a private sector, outside investor (or investors) – such as another company, a venture capital firm, or an "angel" investor – stating that the investor(s) will match the Interim Funding and the Phase II funding, in cash, at the matching rates listed in subsection (c) below. The investment must qualify as a "Fast Track investment," and the investor as an "outside investor," as defined in Reference F of the SBIR solicitation (i.e. the investor cannot be an affiliate of the SBIR company). Additionally, under BMDO *FasTrack*, federal, state, and foreign governments do not qualify as valid investors.

The Commitment Letter should state that the investor's funds will pay for work that is connected to the specific SBIR project, and should also describe the general nature of that work. The work funded by the investor may be additional research and development on the project or, alternatively, it may be other activity related to the project (e.g., marketing) that is outside the scope of the SBIR contract. The investor may provide its matching funds to the company contingent on the company's being selected for Phase II (procedures for accomplishing this must be discussed with the BMDO SBIR Program Manager, Mr. Jeff Bond, at 703/604-3538).

(3) A concise Statement of Work and Cost Proposal for the Interim Funding effort (typically less than 4 pages in length).

(4) An Executive Summary of the current status of the Phase I effort (typically less than 4 pages in length).

(5) A copy of the first page of the Phase I contract (i.e. the signature page).

Additionally:

(1) The company must submit its Phase II proposal within five (5) months of the effective date of the Phase I award;

(2) The company must submit a Private Sector Investment Certification (PSIC) within seven (7) months of the effective date of the Phase I award, indicating that the investor's matching funds have been transferred to the SBIR company. The PSIC consists of: (a) a letter, signed by the investor and the company, that states the amount of cash that has been transferred; and (b) documentation to substantiate that the transfer of funds has occurred (e.g. a bank statement, wire transfer, or copies of canceled checks).

If not all the investor's funds are transferred to the company by the end of the seventh month, the company will still qualify for the *FasTrack*. However, it will receive a lower preference for Phase II selection than other *FasTrack* participants, as described in subsection (e) below. Additionally, BMDO will match any investor funds transferred to the company after the seventh month at only a $1 to $1 matching rate, rather than at the more favorable matching rates listed in subsection (c) below. Also, BMDO will only provide installments of Phase II funds to the company after corresponding installments of matching funds have been transferred from the investor to the company. (e.g. The company and investor must certify that

$60,000 in matching funds has been transferred to the company before BMDO will release a corresponding $60,000 installment of Phase II SBIR funds.)

A company which fails to meet these conditions in their entirety within the time frames indicated will generally be disqualified from BMDO *FasTrack* consideration. If disqualified, the company shall still be eligible to compete for a "standard" Phase II award through the regular BMDO Phase II procedures with no penalty.

c. Matching Rates. BMDO *FasTrack* matching rates differ slightly from the matching rates under the DoD Fast Track policy. The BMDO rates are as follows:

(1) For SBIR companies that have 10 or fewer employees **and** have never received a Phase II SBIR or STTR award from any federal agency, the investor's Commitment Letter must state that the investor shall provide at least $1 to match every $4 of Interim SBIR Funding and Phase II funding. (e.g. If the company proposes Interim SBIR Funding of $40,000 and Phase II SBIR funding of $600,000, the investor must provide a commitment of matching funds of $10,000 and $150,000 respectively for the two efforts.)

(2) For SBIR companies that have received fewer than five (5) Phase II SBIR/STTR awards from the federal government, and do not fall into category (1) above, the investor's Commitment Letter must state that the investor shall provide at least $1 to match every $2 of Interim SBIR Funding and Phase II funding. (e.g. If the company proposes Interim SBIR Funding of $40,000 and Phase II SBIR funding of $600,000, the investor must provide a commitment of matching funds of $20,000 and $300,000 respectively for the two efforts.)

(3) For SBIR companies that have received five (5) Phase II SBIR/STTR awards or more from the federal government, the investor's Commitment Letter must state that the investor shall provide at least $1 to match every $1 of Interim SBIR Funding and Phase II funding. (e.g. If the company proposes Interim SBIR Funding of $40,000 and Phase II SBIR funding of $600,000, the investor must provide a commitment of matching funds of $40,000 and $600,000 respectively for the two efforts.)

d. Benefits of Qualifying for BMDO *FasTrack*. A company that qualifies for BMDO *FasTrack* will:

(1) Receive Interim Funding of $30,000 to $40,000 between Phase I and Phase II (However, the Interim Funding plus the Phase I award shall not exceed $100,000).

(2) Receive BMDO's highest priority for selection for Phase II award. Specifically, BMDO shall select the company for Phase II award assuming its project meets or exceeds a "technically sufficient" level, as described in Section 4.3 of the current solicitation. As discussed in subsection (e) below, among *FasTrack* companies, those that receive all of their investor matching funds within seven months after the effective start date of Phase I receive higher preference for selection than *FasTrack* companies that receive some or all matching funds after the seventh month.

(3) Receive notification of whether it has been selected for Phase II award within 60 days after the completion of its Phase I project.

(4) If selected, receive its Phase II award within an average of five months after the completion of its Phase I project, to ensure no significant funding delay between Phase I and Phase II. (Note: Although BMDO makes all of its Phase II selection decisions, the Phase II contracts are processed by other DoD organizations, and BMDO therefore does not directly control the timing of the contract awards. However, most BMDO *FasTrack* awards have been made within five months after the completion of the Phase I effort.)

e. BMDO *FasTrack* Preference Levels. As discussed above, companies that qualify for the BMDO *FasTrack* receive BMDO's highest priority for Phase II selection and award. Among *FasTrack* companies, those that receive all of their investor matching funds within seven months after the effective start date of Phase I receive higher preference for selection than *FasTrack* companies that receive some or all matching funds after the seventh month, as follows:

Preference Level 1 applies to *FasTrack* companies that receive **all** of the matching funds for the Interim effort and the Phase II effort within seven months after the effective start date of the Phase I award.

Preference Level 2 applies to *FasTrack* companies that receive all of the matching funds for the Interim effort but only some of the matching funds for the Phase II effort within seven months after the effective start date of the Phase I award.

Preference Level 3 applies to *FasTrack* companies that receive all the matching funds for the Interim effort but none of the matching funds for the Phase II effort within seven months after the effective start date of the Phase I award.

REFERENCE B (BMDO)

U.S. DEPARTMENT OF DEFENSE / Ballistic Missile Defense Organization

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
FASTRACK APPLICATION COVER SHEET

Failure to fill in all appropriate spaces may cause your application to be disqualified

To qualify for the **BMDO** SBIR Fastrack, a company must complete this form and meet the other requirements detailed in the BMDO section of the solicitation (and also on the BMDO SBIR Web Site). Instructions on where to submit this form are on the back.

TOPIC #: ____________ CONTRACT #: ____________________

PHASE I EFFECTIVE START DATE: ____________

SPONSORING DOD COMPONENT: ____________________

PHASE I COMPLETION DATE: ____________

PHASE I TITLE: ____

____

FIRM NAME: ____

MAIL ADDRESS: ____

CITY: ____________________ STATE: ________ ZIP: ____________

TAXPAYER IDENTIFICATION NUMBER: ____________________

NAME OF OUTSIDE INVESTOR: ____

MAIL ADDRESS: ____

CITY: ____________________ STATE: ________ ZIP: ____________

TAXPAYER IDENTIFICATION NUMBER: ____________________

BUSINESS CERTIFICATION:

	YES	NO	MATCHING RATE	
> Do you have 10 or fewer employees and have never received a Phase II SBIR award from the federal government (including DoD)? (if YES, the minimum Investor matching rate is $1 for every $4 in BMDO SBIR funds)	☐	☐	$1 : $4	☐
> Have you received 5 or more Phase II SBIR awards from the federal government (including DoD)? (If YES, the minimum Investor matching rate is $1 for every $1 in BMDO SBIR funds)	☐	☐	$1 : $1	☐
> If you answered NO to both questions, the minimum Investor matching rate is $1 for every $2 in BMDO SBIR funds.			$1 : $2	☐
> Does the outside funding proposed in this application qualify as a "Fastrack investment", and does the investor qualify as an "outside investor", as defined in DoD Fast Track Guidance (Reference F)? If you have any questions about this, call the DoD SBIR Help Desk (800-382-4634). The Help Desk will refer any policy and/or substantive questions to appropriate DoD personnel for an official response.	☐	☐		

Caution: knowingly and willfully making any false, fictitious, or fraudulent statements or representations above may be felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to $10,000, up to five years in prison, or both.

PROPOSED SBIR INTERIM FUNDING: ____________

INVESTOR MATCHING INTERIM FUNDS: ____________

PROPOSED SBIR PHASE II FUNDING: ____________

INVESTOR MATCHING PHASE II FUNDS: ____________

FIRM CORPORATE OFFICIAL

NAME: ____________________

TITLE: ____________________

TELEPHONE: ____________________

INVESTOR CORPORATE OFFICIAL

NAME: ____________________

TITLE: ____________________

TELEPHONE: ____________________

____________________ ________
SIGNATURE OF FIRM CORPORATE OFFICIAL DATE

____________________ ________
SIGNATURE OF INVESTOR CORP. OFFCIAL DATE

Nothing on this page is classified or proprietary information/data

INSTRUCTIONS FOR COMPLETING REFERENCE B (BMDO)

SUBMISSION:

Submit all items to:

Ballistic Missile Defense Organization
ATTN: TOI/SBIR (Bond)
1725 Jefferson Davis Highway
Suite 809
Arlington, VA 22202

IMPORTANT: Please also send a copy of this application form, when completed, to:
DoD SBIR Program Manager
1777 N. Kent Street, Suite 9100
Arlington, VA 22209

For further information on the BMDO SBIR Program, visit the BMDO SBIR Web Site **http://www.futron.com/bmdo/bmdo.htm**

REQUEST FOR COPIES OF THIS FORM:

Additional copies of this form may be downloaded from the DoD SBIR Web Site (http://www.acq.osd.mil/sadbu/sbir/001/bmdo_ft.pdf). They may also be obtained from:

DoD SBIR Support Services
2850 Metro Drive, Suite 600
Minneapolis, MN 55425-1566
(800) 382-4634

Ballistic Missile Defense Organization Topics

BMDO/00-001 Directed Energy Concepts and Components

BMDO/00-002 Kinetic Energy Kill Vehicles and Components

BMDO/00-003 Sensors

BMDO/00-004 Manufacturing Sciences and Technology/Unit Cost Reduction

BMDO/00-005 Non-Nuclear Power Sources and Power Conditioning

BMDO/00-006 Propulsion and Logistics Systems

BMDO/00-007 Thermal Management

BMDO/00-008 Survivability Technology

BMDO/00-009 Lethality and Vulnerability

BMDO/00-010 Computer Architecture, Algorithms, and Models/Simulations

BMDO/00-011 Optical Computing and Optical Signal Processing

BMDO/00-012 Structural Concepts and Components

BMDO/00-013 Structural Materials and Composites

BMDO/00-014 Electronic Materials

BMDO/00-015 Superconductivity Concepts and Materials

BMDO/00-016 Surprises and Opportunities

BMDO FY00 SBIR TOPIC DESCRIPTIONS

BMDO 00-001 DIRECTED ENERGY CONCEPTS AND COMPONENTS

DOD KEY TECHNOLOGY AREA: Air Platforms, Materials/Processes, Sensors, Electronics, and Battlespace Environemnts, Space Platforms, Weapons, Nuclear Technology

INTRODUCTION: As part of BMDO's charter to provide for defense against future missile threats, various programs are created to further validate potential technologies to design, develop, and deploy systems in support of various efforts. These new programs provide future decision-makers an option to greatly enhance the capabilities of future TMD and NMD systems. BMDO investigates numerous directed energy technologies for both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly sophisticated systems which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. All areas of the electromagnetic spectrum provide potential avenues toward finding and disabling a ballistic missile in flight. Furthermore, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Current examples under consideration include the Space Based Laser, Airborne Laser, the ground based radar systems associated with THAAD and Patriot, and any other comparable sub-system, component, or subcomponent that can potentially support next generation developments. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: BMDO seeks new, innovative and applied research toward advanced technology developments in the generation, propagation, and detection of directed energy in all forms. Dual-use systems under consideration include, but are not limited to, solid-state lasers (i.e. diode lasers), chemical lasers, excimer lasers, IR/Vis/UV lasers, x-ray lasers, gamma-ray lasers, free electron lasers, quantum lasers, particle beams, radio-frequency (RF) and millimeter wave (MMW), and other unique hybrid approaches including explosively or electrically driven devices. Included herein are such topics as beam control, target acquisition, tracking and pointing, mirrors, beam propagation and steering, optics, antennas, conversion methods, countermeasures, coatings, and micro-optical-mechanical devices incorporating these aspects. Furthermore, any component or subcomponent that is utilized by any of these systems is of interest. Examples of such component specific technology include traveling wave tube amplifiers, timing circuits, pulse forming networks, stimulators, laser/radar arrays, transmit/receive modules, and amplifiers. Components, sub-components, or piece part specifics may be ground, air, or space based in their final application.

PHASE I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company A, whose advanced x-ray source is being utilized for waste sterilization, was sponsored from this topic. Company B utilized their tunable filters with the citrus industry and for military hyperspectral image applications.

BMDO 00-002 KINETIC ENERGY KILL VEHICLES AND COMPONENTS

DOD KEY TECHNOLOGY AREAS: Air Platforms, Material/Processes, Space Platforms, Weapons

INTRODUCTION: Potential adversaries are expected to improve their ballistic missile systems and develop countermeasures to U.S. ballistic missile defense programs. The future designs of potential threat improvements that BMDO must address can not be determined explicitly. Broad-based kinetic energy interceptor technologies will potentially contribute to more than one program and possibly to more than one defense area. These kinetic energy weapons benefit from innovations offered in 1) discrimination, 2) agility, 3) accuracy, and 4) affordability. BMDO is constantly investigating potential technologies for both TMD and NMD applications. Additionally, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from the commercial industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Kinetic energy (KE) weapons candidates presently include a variety of ground and space based interceptor concepts including their propulsion sub-system components. System elements include ground-based launchers, axial and divert motors/nozzles, smart projectile components, and endo/exoatmospheric guidance and control mechanisms. Technology challenges for KE systems include: finding the booster hardbody within the plume, differentiating the missile warhead from the various other incoming objects within a threat complex, high performance axial and divert propulsion sub-systems (especially very low mass divert systems), miniature inertial navigation units, array image processing, C.G. Control algorithms, fast frame multicolor and ultra-violet seekers, missile autopilots, acquisition and track; target discrimination, seeker operational environments, lethality/miss distance; aero-optical effects, guidance and fuzing accuracy, shroud separation, window thermal-structural integrity, non-nuclear kill warhead performance, target acquisition in a hostile environment, performance and survivability of electronics in a hostile environment; firing rate, projectile guidance and control and projectile launch survivability; and, common among all systems reliability, producibility, safety (non-hazardous operation), maintainability, and low cost/low mass; aeroshell ablation control; electromagnetic launches.

PHASE I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company C advanced the metal armature developments for military railgun efforts. Company D began with a bone implantation technology and international investments that resulted from divert motor rocket nozzles. Company E, with a market cap of $52M+, expanded with technology genesis from this topic to a dynamic frame seeker and chip-stacking developments. Company F, with a market cap of $304M+, supported ballistic missile defense efforts with their enhanced lethality kinetic energy projectile and has subsequently graduated out of the small business status, but continues to support the DoD in R&D efforts.

BMDO 00-003 SENSORS

DOD KEY TECHNOLOGY AREAS: Air Platforms, Sensors, Electronics, and Battlespace Environments, Space Platforms, Human Systems, Weapons

INTRODUCTION: BMDO investigates various sensor technologies for both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly robust and sophisticated sensor systems which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. All areas of the electromagnetic spectrum provide potential avenues toward finding and disabling a ballistic missile in flight. Furthermore, sensor systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Sensors and their associated systems/sub-systems will function as the "eyes and ears" for ballistic missile defense applications, providing early warning of attack, target detection/classification/identification, target tracking, and kill determination. New and innovative approaches to these requirements using unconventional and innovative techniques are encouraged across a broad band of the electromagnetic spectrum, from radar to gamma rays. Passive, active, and interactive techniques for discriminating targets from backgrounds, debris, decoys, chaff, electronic countermeasures, and other penetration aids are specifically sought. Sensor-related device technology is also needed. Examples of some of the technology specific areas are: cryogenic coolers (open and closed systems), cryogenic heat transfer, superconducting focal plane detector arrays (for both the IR and sub-mm spectral regions), next generation InSb focal plane arrays, signal and data processing algorithms (for both conventional focal planes and interferometric imaging systems), low-power optical and sub-mm wave beam steering, range-doppler lidar and radar, passive focal plane imaging (long-wavelength infrared to ultra-violet: novel information processing to maximize resolution while minimizing detector element densities), large format focal plane arrays (cooled and un-cooled), interferometry (both passive and with active illumination), QWIPs, integrated UV/VIS/MIR/IR focal plane arrays, gamma-ray detection, neutron detection, intermediate power frequency agile lasers for diffractive beam steering and remote laser induced emission spectroscopy, lightweight compact efficient fixed frequency radiation sources for space-based ballistic missile defense applications (uv-sub-mm wave), new optics and optical materials. Entirely new and high-risk approaches are also sought. Please indicate the particular identifying letter your specific proposal/technology addresses:

BMDO/00-003**A** - Acoustic and Seismic
BMDO/00-003**B** - Radar and MMW
BMDO/00-003**C** - UV (<0.3 microns)
BMDO/00-003**D** - Visible (0.3 - 0.9 microns)
BMDO/00-003**E** - IR (>0.9 microns)
BMDO/00-003**F** - Gamma/X-Ray
BMDO/00-003**G** - Other

PHASE I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company G, with annual commercial sales of $15M+, is noted for its laser diode pumped q-switched solid state laser products developed under this topic. Company H, with a market cap of $33M+, transferred its microwave based infrared detector and superconducting millimeter wave mixer technologies funded under this topic for a variety of cryogenic systems and products. Company OO's high power laser array transmitters are utilized on the next generation of military and commercial satellites for communications. Company QQ, with a market cap of $2,871M+, received funding from this topic for their target surveillance, pointing, acquisition, and tracking sensors used by both military and civilian customers.

BMDO 00-004 MANUFACTURING SCIENCES AND TECHNOLOGY/UNIT COST REDUCTION

DOD KEY TECHNOLOGY AREAS: Air Platforms, Materials/Processes, Space Platforms, Weapons

INTRODUCTION: BMDO continually investigates various diverse technologies for both TMD and NMD applications. As such, advanced technology demonstrations for affordability and advanced industrial practices to demonstrate the combination of both improved manufacturing process technologies and improved business methods are of interest. BMDO makes significant investments each year in the continued development of increasingly survivable, robust and sophisticated technology based systems. All areas of research, engineering, and manufacturing process technologies provide potential avenues toward finding and disabling a ballistic missile in flight. Furthermore, entire sensor systems, components, sub-components, or piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Proposed efforts funded under this topic may encompass any specific manufacturing process technology at any level resulting in a unit cost reduction. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: BMDO seeks drastically lower unit cost of components through manufacturing revolutions that will lead to high volume production from commercial sales. This will result in an improvement in the affordability of new ballistic missile defense systems and the development of cost effective methods to sustain existing developments while impacting the next generation of acquisition systems. Affordability has become a significant factor in all aspects of the total life-cycle consideration of any military program. Therefore, BMDO will consider proposals that offer such a high unit cost reduction that a heretofore purely anti-missile military technology would become a high volume commercial item. Innovative approaches that will allow BMDO to economically acquire new technologies for the next generation of ballistic missile defense systems and maintain these systems while providing for their upgrades will make total life-cycle costs more affordable. Whereas all other BMDO SBIR topics seek first and foremost a revolution in the military capability of the technology, this topic seeks only a revolution in the reduction of unit cost specifics. BMDO seeks herein only projects that are too risky for ordinary capital investment by the private sector. The proposals must include and will be judged, in part, on an economic analysis of the expected market impact and the viability of the product proposed. Incremental advancements will receive very little consideration. Innovative manufacturing technologies which reduce the cost per unit, repair, or remanufacturing/reengineering of entire sensor systems, components, sub-components, or piece part specifics are under consideration.

PHASE I:Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II:Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company J, with a market cap of $11M+, founded its technology developments under this topic with low-cost radioisotope-powered voltaic cells for military applications and a wide variety of other commercially viable electronic material based applications to include quantum-wire lasers.

BMDO 00-005 NON-NUCLEAR POWER SOURCES AND POWER CONDITIONING

DOD KEY TECHNOLOGY AREAS: Air Platforms, Ground and Sea Vehicles, Space Platforms, Weapons

INTRODUCTION: New and unique non-nuclear power sources and new materials and electronics that provide for the efficient use of power are under consideration by BMDO for both TMD and NMD applications. New technology could conceivably provide support to future systems, which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. All areas of power technology, except nuclear power, provide potential avenues toward finding and disabling a ballistic missile in flight. BMDO SBIR shall not consider any nuclear power source proposal. Furthermore, entire power source systems, components, sub-components, and piece part specifics are constantly under evaluation by the various component TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: New technologies for providing power which provide substantial improvements in lower recurring cost, lower mass, and/or smaller size are sought for all ballistic missile defense applications. New concepts for compact power sources and power conditioning devices for transportable or mobile systems at 200 kW to 1 MW also need to have high efficiency, low signatures, and high reliability. Power generation, power storage, and power conditioning devices that operate at cryogenic temperatures for use in a new concept for all cryogenic systems are sought. Power conditioning devices of interest include, but are not limited to, capacitors, inductors, switches, and transformerless approaches. Space assets' power sources in the 0.5 to 5 kW power range, including solar arrays and their photovoltaic cells, need to tolerate high natural radiation levels. Satellite energy storage systems or novel battery technologies must provide cycle lifetimes of up to 40,000 cycles and may be utilized in low earth orbit sensor satellites, airborne platforms, or ground based assets. Onboard power sources for interceptor missiles need to be periodically testable and have a quick start-up capability. Power conditioning systems and components for space assets should provide very high efficiency.

PHASE I:Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II:Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company K, with a market cap of $7M+, has provided for commercializing its self-restoring fault current limiter after it was incorporated into military efforts. Company MM, with a market cap of $144M+, has developed new solar cells with increased efficiencies that are utilized by both military and civilian interest.

BMDO 00-006 PROPULSION AND LOGISTICS SYSTEMS

DOD KEY TECHNOLOGY AREAS: Air Platforms, Space Platforms, Weapons

INTRODUCTION: BMDO is constantly investigating various propulsion technologies for both TMD and NMD applications. Significant investments are made each year in the continued development of increasingly robust and responsive systems which may eventually find their utilization in a ballistic missile technology program or major defense acquisition programs. All areas of propulsion technology provide potential avenues toward finding and disabling a ballistic missile in flight. Furthermore, entire propulsion systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: In general, missile defense places unprecedented demands on all types of propulsion systems; interceptors, launch to low earth orbit, orbit transfer, orbit maneuvering, and station keeping. Specifically, advancements are needed to achieve major reductions in the costs of placing and maintaining payloads in desired locations. Approaches leading to techniques, methods, processes, and products in support of these propulsion and logistics objectives are sought. Propulsion approaches include liquid, solid, and electric. Advancements are needed in propulsion-related areas, e.g. extending storage time of cryogenic fluids (e.g. H_2 and Xe), reduction of contamination from effluents, and sensors and controls for autonomous operation. Areas of interest include the entire spectrum of space transportation and support: efficient launch systems for small technological payloads as well as full system payloads, assembly, and control systems; expendable and recoverable components; improved structures and materials; and increased propulsion efficiency. In anticipation of solar power demonstration missions incorporating electric thrusters, BMDO seeks high power electric thruster modules (e.g., electrodes, insulators, ignition systems, propellant controls, command and control systems, thermal management systems, and power conditioning units). With the advent of small surveillance satellites, low power (0.5 to 2 kW) electric propulsion is under consideration for station keeping and orbit transfer; for such systems emphasis is being placed on achieving higher power densities for components of the integrated system (thruster, power conditioning unit, fuel control, gimbals, and fuel storage). Low mass or miniature interceptors require advances in divert (small thrusters) propulsion systems (either solid or liquid). High acceleration divert and attitude control systems greater than 10Gs are under consideration.

PHASE I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company L developed a laser radar tracking technology that finds commercial use in laser eye-surgery applications, but was also investigated for tracking ballistic missiles in flight.

BMDO 00-007 THERMAL MANAGEMENT

DOD KEY TECHNOLOGY AREAS: Air Platforms, Ground and Sea Vehicles, Space Platforms, Weapons

INTRODUCTION: BMDO constantly investigates various thermal management and cooling technologies for both TMD and NMD applications. Therefore, a significant investment is made each year in the continued development of increasingly robust and sophisticated heating/cooling system technologies, which may eventually find their utilization in a ballistic missile technology program or major defense acquisition program. Furthermore, thermal management (heating and cooling) systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Higher power levels of various ballistic missile defense assets must dissipate heat at state-of-the-art capabilities for waste thermal energy acquisition, transport, and dissipation to space. Technology advancements are required in thermal management for power generation systems, space platform payloads, heat pump radiators, and all associated electronics. Some space platforms will require years of storage of large amounts of cryogen with minimum cryogenic loss and high cryogen delivery rates under condition of zero-g. Concepts, devices, and advanced technologies for all types of space-based power cycles are sought which can satisfy these projected ground/air/space platform requirements.

PHASE I:Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II:Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Currently addressing electric vehicle technology applications for military and commercial interest, Company M got its initial start, and now with a market cap of $75M+, with active magnetic vibration isolation controls funded under this topic. Company SS developed a radiation hardened accelerometer that is used in the Safe-and-Arm device of the PAC-3 missile and by half of the automotive airbags in the U.S.

BMDO 00-008 SURVIVABILITY TECHNOLOGY

DOD KEY TECHNOLOGY AREAS: Air Platforms, Materials/Processes, Space Platforms, Weapons, Nuclear Technology

INTRODUCTION: Missile defense elements must operate and survive against determined attacks. Threat actions can generate a reasonable set of hostile man-made environments before and during operations. Collateral environments and natural space environments (atomic oxygen, space radiation and micrometeorites/debris) provide additional technical challenges, which also affect civilian assets. Survivability engineering technology and survivability enhancement options are required to achieve a cost-effective, yet integrated solution to a dynamic and diverse set of hostile environments with a focus toward improving aspects of threat sensing, hardening, passive defense, and camouflage, concealment and deception (CCD). Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Sensor technologies enable the defense elements to detect nuclear events, laser and radio frequency weapon attacks, and to respond appropriately. Sensor technologies that can characterize the threat according to direction of attack, and spectral characteristics are currently under consideration. Technologies to enhance passive defense missile systems, ground/air/space assets, and support equipment are needed to operate against the threat support sensors, including radar, passive visible/IR sensors and seekers, and laser radar.

Passive hardening against the nuclear, laser, RF, ballistic and debris environments is specifically needed, in addition to novel radiation hardening technologies and approaches against the natural space environments. Sensor technologies and their associated systems, communications antennas (RF and laser), attitude sensors, solar power, propulsion, structure and thermal control are all directly exposed to nuclear, laser, RF and debris in addition to the natural space environments. Materials and component designs, which are intrinsically hard to these environments, and/or protective devices are needed, specifically with dual-use commercialization applications. A key ballistic missile defense area of consideration is seeker/sensor subsystems, the components of which (baffle materials, mirrors, optics, structures, focal plane arrays, read out electronics, and processing) must survive the laser, nuclear, IR, and natural environments. Nuclear and laser hard concepts, materials, and devices for protection against unknown or agile lasers and rejection of RF energy. Structures and coatings providing appropriate thermal characteristics, stability under mechanical impulses and hardness to laser and RF radiation are needed. Processors, high-power ICs, and other electronic devices capable of operating in unique hostile environments presented by the strategic applications while retaining full functionality are desired. Long term space (commercial and government) applications are direct beneficiaries of these advanced technology developments. Countermeasures and integration of CCD technologies are particular useful to the operational forces and, in general, attempt to incorporate the latest military and commercial technologies to ensure an effective response to any advanced threat. A new class of weapons technologies are evolving incorporating non-lethal methods. These have a broad range of applications as a survivability countermeasure or must themselves be countered to assure full operability. Non-lethal technology efforts in this area have dual-use applications.

PHASE I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company N, with a market cap of $1,165M+, got started with its hardened electronics for military environments and civilian applications. Company O markets holographic products to the commercial market that started with rugate filters for sensor protection of military optics.

BMDO 00-009 LETHALITY AND VULNERABILITY

DOD KEY TECHNOLOGY AREAS: Air Platforms, Space Platforms, Weapons

INTRODUCTION: In implementing its TMD and NMD program activities, BMDO is continuing its developments of such efforts as the PATRIOT Advanced Capability-3 (PAC-3) missile system which has four major systems components: radar, engagement control station, launching station, and interceptors. The Navy Area Wide system will develop a sea-based capability that builds upon the existing AEGIS/Standard Missile air defense system. This system is based on the AEGIS-class cruisers and destroyers, which provide all elements of missile defense and are particularly suited to protecting forces moving inland from the sea. The Theater High-Altitude Area Defense System (THAAD) system will form the largest umbrella of missile protection in a specific theater, arching over all other missile defense systems. THAAD consists of four major systems components: truck-mounted launchers; interceptors; radar system; and battle management, command, control, communications, and intelligence (BMC3I). These increasingly sophisticated systems will provide the opportunity to destroy short and medium range ballistic missiles and other threats in the atmosphere far enough away that falling debris will not endanger friendly forces. The various BMDO technology and acquisition programs, in support of the TMD and NMD missions, are continually evaluating the latest advanced technology developments from industry as potential replacements for the current state-of-the-art sensor systems, components, sub-components, or piece part specifics. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: A major factor in determining the effectiveness of a ballistic missile defense is the lethality of the directed energy and/or kinetic energy devices used against responsively hardened targets, bulk powder, and submunition targets. Battlefield by-products of post-intercept events are currently under consideration. New concepts and technologies that produce a much higher probability of hit-to-kill intercepts are required to support applications. Ground and Point-of-Intercept technologies, instrumentation, concepts, and innovative methodologies are under consideration for cost effective incorporation into BMDO lethality efforts. Additionally, novel concepts and techniques that reduce the vulnerability of ballistic missile defense systems will increase the operational confidence level of dedicated assets. Commercial applications may benefit from the incorporation of the techniques utilized in cost-reduction, measurement and diagnostics, and meteorology instrumentation packages.

PHASE I:Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II:Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company P was started after receiving initial funding under this topic for its solid state optical devices, which are now commercially available products.

BMDO 00-010 COMPUTER ARCHITECTURE, ALGORITHMS, AND MODELS/SIMULATIONS

DOD KEY TECHNOLOGY AREAS: Air Platforms, Information Systems Technology, Space Platforms, Human Systems, Weapons

INTRODUCTION: BMDO investigates various computer technologies in support of both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly robust and sophisticated battle management, command, control, and communications (BMC3I) systems which may eventually find their utilization in, and support of a ballistic missile technology program or major defense acquisition program. All areas of computer software development provide potential avenues toward supporting the ability of future BMDO systems to find and disabling a ballistic missile in flight. Furthermore, complete computer systems, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Missile defense systems for battle management demand order-of-magnitude advances. A system must acquire and track thousands of objects with hundreds of networked sensors and data processors, direct weaponry to intercept targets, and determine the degree of kill. Areas of specific interest include:

- New computer architectures which are robust, compact, and fault-tolerant, but allow for the extremely rapid processing of data. Architectures may be implemented by new designs or innovative applications of existing technologies, such as optical signal processing, systolic arrays, neural networks, etc.
- Very high-level language (VHLL) design for both the development and testing of extremely large software systems.
- Novel numerical algorithms for enhancing the speed of data processing for sensing, discrimination, and systems control. These may be specifically tailored to a particular task (for instance, the execution of a phase retrieval algorithm for interferometric imaging) and may include neural networks.
- Language design to develop code optimized for highly parallel processed architectures.
- Software engineering processes, methods, and environments for next generation revolutionary paradigms. Areas of interest include: architectures; COTS-based development; risk management; sizing and costing estimation; measurement; supportability; quality; development and acquisition processes; and "Best Practices" for design, development, integration, testing, and support of real-time distributed large-scale software systems.
- Software product line technologies, including domain analysis and engineering, software product line acquisition planning, component evaluation and cataloguing, organizational reuse assessments, and software product line risk management.
- Testing techniques that will provide a high level of confidence in the successful operation of concurrent, real-time, distributed large-scale software systems. Examples include sensitivity analysis, data flow testing, mutation testing, static concurrency analysis, and dependency analysis.
- Computer network and communications security. Areas of interest include: intrusion monitoring, detection, and defense; rapid recovery methodologies; "self-healing" systems capable of isolating corrupted nodes, reallocating resources, and reconstituting lost information; R&D for trusted computer systems in accordance with DoD 5200.28.STD, and integration of COMPUSEC with COMSEC (DoD 5200.5).
- Self-adaptive processing, simulations, and unconventional computing approach. Algorithms and architectures for advanced decision-making. Data compression and adaptive bandwidth management techniques.
- Neurocomputing and Man-Machine Interface - rule-based artificial intelligence and neural networks combined for decision making flexibility and system robustness; development of decision trees and information display for highly, automated, short response time, training adaptive high volume scenarios development of autonomous intelligent agents and self-learning decision aids which operate in distributed heterogeneous environments.
- Software architectures for embedded computer networks that especially facilitate incremental system and software integration, hardware and software maintenance, and system evolution, without significant performance degradation.
- Hardware and software self-diagnostic capabilities for monitoring the operational readiness and performance of space and ground systems incorporating embedded computer networks.
- Virtual environments to allow diverse groups to interact in real time and increasingly realistic ways over large distances which may include hostile environments definition and ground effects modeling and simulation efforts.
- Advanced interface effectors, including visualization, multi-sensory, and virtual reality technologies, for total information presentation and improved situational awareness in missile defense application areas.

PHASE I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company Q, with commercial and military sales of its automatic parallelization tool for sequential programs, marketed as *INSURE++* and *CodeWizard for Java*, is in excess of $10M/year.

BMDO 00-011 OPTICAL COMPUTING AND OPTICAL SIGNAL PROCESSING

DOD KEY TECHNOLOGY AREAS: Air Platforms, Information Systems Technology, Materials/Processes, Space Platforms, Weapons

INTRODUCTION: In implementing its TMD and NMD program activities, BMDO is continuing its developments of such efforts as the PATRIOT Advanced Capability-3 (PAC-3) missile system which has four major systems components: radar, engagement control station, launching station, and interceptors. The Navy Area Wide system will develop a sea-based capability that builds upon the existing AEGIS/Standard Missile air defense system. This system is based on the AEGIS-class cruisers and destroyers, which provide all elements of missile defense and are particularly suited to protecting forces moving inland from the sea. The Theater High-Altitude Area Defense System (THAAD) system will form the largest umbrella of missile protection in a specific theater, arching over all other missile defense systems. THAAD consists of four major systems components: truck-mounted launchers; interceptors; radar system; and battle management, command, control, communications, and intelligence (BMC3I). These increasingly sophisticated systems will provide the opportunity to destroy short and medium range ballistic missiles and other threats in the atmosphere far enough away that falling debris will not endanger friendly forces. The various BMDO technology and acquisition programs, in support of the TMD and NMD missions, are continually evaluating the latest advanced technology developments from industry as potential replacements for the current state-of-the-art sensor systems, components, sub-components, or piece part specifics. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Dense computing capability is sought in all architectural variations, from all optic to hybrid computers. Specific examples of areas to be addressed include, but are not limited to, high speed multiplexing, monolithic optoelectronic transmitters, holographic methods, reconfigurable interconnects, optoelectronic circuits, and any other technology contributing to advances in intra-computer communications, optical logic gates, bistable memories, optical transistors, and power limiters. Non-linear optical materials advancements and new bistable optical device configurations.

PHASE I:Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II:Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company R took a unique technology approach in addressing fiber-optic and other optical communications applications to both the military and commercial industry. Company S is providing a low-loss electro-optical switching array, Company T is providing optical bus extenders and fiber-optic modulators, Company U has funded technology which utilized wavelength division multiplexing techniques; all three support the ever growing optical communication industry.

BMDO 00-012 STRUCTURAL CONCEPTS AND COMPONENTS

DOD KEY TECHNOLOGY AREAS: Air Platforms, Materials/Processes, Space Platforms, Weapons

INTRODUCTION: The tremendous explosion in the commercial industry to develop innovative structural components has sustained BMDO investigations into various technologies in support of both TMD and NMD applications. As such, a significant investment is made each year in the continued development of increasingly robust and viable concepts which may produce technologies that eventually find their utilization in, and support of, a ballistic missile technology program or major defense acquisition program. All considered technologies provide potential avenues toward supporting the ability of future BMDO systems to address vibrations and structural integrity more efficiently than current methods will allow. Furthermore, components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Minimum weight structures are needed in ballistic missile defense applications to withstand high-g loading, acoustic and thermal environments of ground based interceptors, and to provide solid bases for space systems pointing and tracking. Such structures will benefit from: (1) innovative vibration control techniques, (2) innovative fabrication approaches to cut structure cost, (3) innovative use of advanced materials and/or design approaches to minimize structure weight, and (4) innovative rapid prototyping techniques. For instance, techniques and experimental verification are needed for active and/or passive methods to measure and control vibrations caused by thermo-mechanical flutter, thruster firing, or structure borne noise caused by on-board mechanisms. "Active" structural elements containing materials and electronics to provide predictable mechanical displacement in response to applied electrical signals are of interest. Maximization of displacement, mechanical strength, and reliability; parameter stability over extended temperature ranges; and minimization of driving voltage, power, and weight of these elements are desired. Producibility improvements for curved actuator elements, flextensional, and other integrated motion amplifiers are of interest. Fabrication approaches that provide minimum weight with reduced assembly, inspection, and scrap rates for conventional, advanced composite, and "active" structures are needed to reduce costs. Of course, novel designs and material usage to reduce structure weight, while maintaining or increasing capability, are always desirable goals.

PHASE I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company V took its ultrasonic motor technology to the commercial industry and that motor can now be found in assorted novelty and gift items. Company W, with a very accurate and precise gimbal for military laser communications, also has sales to the commercial optical communications industry.

BMDO 00-013 STRUCTURAL MATERIALS AND COMPOSITES

DOD KEY TECHNOLOGY AREAS: Air Platforms, Materials/Processes, Space Platforms, Weapons

INTRODUCTION: The commercial industry has made advances in the development of stronger, lighter, and cheaper materials for use in structural applications. BMDO investigates various composites technologies for both TMD and NMD missile applications. Furthermore, a significant investment is made each year in the continued development of increasingly viable technologies which may eventually find their utilization by a ballistic missile technology program or major defense acquisition program. All areas of composites development potentially support BMDO and its next generation of TMD and NMD systems. Furthermore, new structural materials and composites and the associated components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Many of the anticipated structural advances sought will depend on major improvements in materials properties and cost effectiveness. Space structures supporting seekers and antenna must accommodate retargeting maneuvers without detrimental jitter from vibrations and thermo-mechanical flutter. Surface launched interceptors must withstand high-g loads, aerothermal heating, and structural vibration without compromising tracking accuracy. Lightweight materials are very beneficial for both ground and space based systems. Specific goals require advanced techniques and processes that include imparting oxidation resistance and damage tolerance to composites and creating high elastic modulus composites for use over a broad range of temperatures. The following are specifically sought: (1) innovative manufacturing methods for producing high modulus, fiber-reinforced glass, light metal (i.e. aluminum or magnesium), or resin matrix composites; (2) innovative procedures for the production of instrumentation, sensors, and software for on-line process monitoring and evaluation of high modulus, fiber-reinforced composites during fabrication; (3) novel approaches to tailor fiber/matrix interfaces to maximize capability in advanced composites; (4) novel methods to cut fabrication cost of metallic and/or composite spacecraft and interceptor structures; (5) innovative tooling techniques for near-net shape production of advanced composites; (6) novel low-to-no outgassing joining/bonding techniques for advanced composites; (7) innovative surface modifications to promote wear resistance; (8) new methods for integrating instrumentation (e.g., embedded sensors) into advanced composite materials and structures; and (9) novel instrumentation for determination and telemetry of material properties and data from space. Advances are also sought in materials for optical system components, mechanical moving assemblies, and protective coatings.

PHASE I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company X licensed the technology which produced commercial sales in excess of $100M for its solid lubricants for space structures for both military and civilian applications. Company PP performed so well with their technology that a Fortune 500 business completely bought it and the company now operates as an independent division based on its silicon carbide optical surfacing process sponsored under this topic. Company RR developed a product line of beryllium aluminum metal matrix composites that are utilized in the commercial sector and by the PAC-3 missile system.

BMDO 00-014 ELECTRONIC MATERIALS

DOD KEY TECHNOLOGY AREAS: Air Platforms, Materials/Processes, Sensors, Electronics, and Battlespace Environment, Space Platforms, Weapons, Nuclear Technology

INTRODUCTION: In implementing its TMD and NMD program activities, BMDO is continuing its developments of such efforts as the PATRIOT Advanced Capability-3 (PAC-3) missile system which has four major systems components: radar, engagement control station, launching station, and interceptors. The Navy Area Wide system will develop a sea-based capability that builds upon the existing AEGIS/Standard Missile air defense system. This system is based on the AEGIS-class cruisers and destroyers, which provide all elements of missile defense and are particularly suited to protecting forces moving inland from the sea. The Theater High-Altitude Area Defense System (THAAD) system will form the largest umbrella of missile protection in a specific theater, arching over all other missile defense systems. THAAD consists of four major systems components: truck-mounted launchers; interceptors; radar system; and battle management, command, control, communications, and intelligence (BMC3I). These increasingly sophisticated systems will provide the opportunity to destroy short and medium range ballistic missiles and other threats in the atmosphere far enough away that falling debris will not endanger friendly forces. The various BMDO technology and acquisition programs, in support of the TMD and NMD missions, are continually evaluating the latest advanced technology developments from industry as potential replacements for the current state-of-the-art sensor systems, components, sub-components, or piece part specifics. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: The necessary advances in electronics for the many ballistic missile defense applications will require advances in electronics materials. Primary emphasis lies in advancing the capability of integrated circuits, detectors, sensors, large-scale integration, radiation hardness, and all electronic components. Novel quantum-well/superlattice structures that allow the realization of unique elective properties through "band gap engineering" are sought, as are new organic and polymer materials with unique electronic characteristics. In addition, exploitation of the unusual electronic properties of gallium nitride is of considerable interest. Specifically, under high speed switching conditions at >10GHz and/or cryogenic temperatures. Among the many BMDO electronic needs and interest are advances in high frequency transistor structures, solid state lasers, optical detectors, low dielectric constant packaging materials, tailored thermal conductivity, microstructural waveguides, multilayer capacitors, single-electron transistors, metallization methods for repair of conducting paths in polyceramic systems, and sol-gel processing for packaging materials.

PHASE I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company Y, with a market cap of $693M+, commercialized technology that allowed for the delivery of ultra-pure materials to semiconductor thin film reactors and has graduated from small business status. Company Z, with a market cap of $7M+, manufactures radiation detection devices and was funded for avalanche photodiode arrays under this topic. Company AA, with a market cap of $216M+, has a substantial market share of the atomic layer epitaxy growth method of semiconductor compound materials based on their efforts developed under this topic. Company BB, with a market cap of $273M+, which manufactures flat panel display devices, received some initial funding for their silicon-on-insulator films and organometallic chemical vapor deposition technology developments. Company CC, with a market cap of $178M+, commercialized technology based on degradation resistant laser diodes. Company DD, with a market cap of $30M+, is commercializing technology based on its surge suppression devices and marketed as SurgX. Company EE, with a market cap of $1,776M+, had initial funding for its high bandgap compounds and laser diode products to develop a number of commercial and military products, and has graduated from small business status. Company KK established a multilayer coating technology that can be easily transported to any location for application. Company FF developed a magnetoresistive non-volatile random access memory chip, which is also radiation hardened, and is utilized in a number of space applications for the military and commercial sectors. Company LL, with a market cap of $26M+, was started with their first Phase I from this topic and the products are used in electronics, structural ceramics, composites, cosmetics and skin care, and as industrial catalysts. Company NN, with a market cap of $510M+, is leveraging technology developed under this topic for the efficient production of semiconductors from waste recovery during the manufacturing process.

BMDO 00-015 SUPERCONDUCTIVITY CONCEPTS AND MATERIALS

DOD KEY TECHNOLOGY AREAS: Air Platforms, Materials/Processes, Space Platforms, Weapons

INTRODUCTION: New developments in industry support the viability of using superconductivity in novel ways. BMDO investigates various superconducting technologies for both TMD and NMD applications. Furthermore, a significant investment is made each year in the continued development of efforts which may eventually find that their utilization of superconductive technologies support a ballistic missile technology program or major defense acquisition program. All areas of superconductivity research provide potential avenues toward supporting further research with the goal of finding and disabling a ballistic missile in flight. Furthermore, superconductive components, sub-components, and piece part specifics are constantly under evaluation by the various TMD and NMD elements and program offices for replacement by the latest technology developments from industry. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: BMDO is interested in demonstrating both high temperature superconductor (HTS) and low temperature superconductor (LTS) devices to enable or improve strategic defenses. Emphasis in HTS technology focused toward components integrated with state-of-the-art cryoelectronics for communications systems at K- and S-bands and radar systems in the X-band power and inductive energy storage are of specific ballistic missile defense interest. The demonstration of HTS materials toward limited detection of radiation in the optical, IR, MWIR, and LWIR bands as well as for signal processing applications is also of interest. The emphasis in LTS technology is in the development and demonstration of high sensitivity detectors, digital electronics, and memory enabling on-focal plane array signal processing and operating at temperatures greater than 10K. Efforts should address packaging and interface issues and systems integration with cryocoolers and stored cryogens.

PHASE I: Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company GG, with a market cap of \$59M+, fabricates optical components for industrial and military applications finds traceability back to superconducting detectors funded under this topic. Company HH, with a market cap of \$15M+, demonstrated success from its technology based on multi-GHz superconducting shift registers.

BMDO 00-016 SURPRISES AND OPPORTUNITIES

DOD KEY TECHNOLOGY AREAS: Any potential new development may address a DoD Key Technology Area from this topic, provided it supports BMDO mission interest at some level. DoD Key Technology Areas: Air Platforms, Information Systems Technology, Ground and Sea Vehicles, Materials/Processes, Sensors, Electronics, and Battlespace Environment, Space Platforms, Human Systems, Weapons, Nuclear Technology

INTRODUCTION: BMDO increasingly depends on advanced technology developments, of all kinds, to invigorate its ability to find and disable missiles in flight and to defend against an increasingly sophisticated threat, to include cruise missiles. Therefore, the continued availability of emerging technology has become a vital part of the BMDO mission. BMDO has interest and investments in specific technology programs that pursue speculative, high-risk technologies that could spur a revolutionary leap or enhancements in either Theater Missile Defense or National Missile Defense capabilities. Specific goals include, but are not limited to, quickening the pace of technology and innovation developments and decreasing the time required to transform scientific breakthroughs into actual applications. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: Since ballistic missile defense is an exploration at technology's leading edge to begin with, it recognizes that surprises and opportunities may arise from creative and innovative minds in a variety of technology sectors. BMDO will consider proposals in other technologies where they present a completely unique and unusual opportunity for ballistic missile defense applications. The proposing company should take special care to describe the specific technology in complete detail and specify why ballistic missile defense applications would benefit from exploring its unique and novel implications. Proposing companies should make particular note that proposals in this topic will receive preliminary screening at BMDO and that they may be rejected as too far afield without the benefit of a full technical review received by proposals in the topics already listed. It is recommended that the proposing company focuses their submission toward one of the specific outlined topics above unless the technology proposed is truly an unquestionable innovation. This full and open call is for new/novel/innovative/unique advanced technology developments, and not for the recycling of old ideas, incremental advancements, or questionable improvements.

PHASE I:Demonstrate the likelihood that a new and innovative research and development approach can meet any of the broad needs discussed in this topic for future BMDO systems consideration.

PHASE II:Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate a degree of commercial viability.

SUCCESSFUL PHASE 3/DUAL-USE COMMERCIALIZERS (Real-World Examples): Company JJ, with a market cap of $833M+, was funded for technology to further its intelligent client-server software solutions for mission-critical decision applications in real-time military and commercial environments.

DEFENSE THREAT REDUCTION AGENCY

The Defense Threat Reduction Agency (DTRA) is actively involved in meeting current threats to the Nation and working toward reduction of threats of all kinds in the future. This covers a multiplicity of disciplines. As a result, the Agency is seeking small business with a strong research and development capability and experience in weapons effects, phenomenology, operations and counterproliferation. (Please noted, DTRA is not interested in weapon development, design or manufacture.) DTRA invites small businesses to send proposals to the following address

Defense Threat Reduction Agency
ATTN: AM/SBIR
45045 Aviation Drive
Dulles, VA 20166-7517

The proposals will be processed and distributed to the appropriate technical offices for evaluation. Questions concerning the administration of the SBIR program and proposal preparation should be directed to:

Defense Threat Reduction Agency
ATTN: AM/SADBU, Mr. Bill Burks
45045 Aviation Drive
Dulles, VA 20166-7517
Tel.: (703) 326-8674
Fax: (703) 810-4675
E-mail: billy.burks@dtra.mil

Use of e-mail is encouraged for correspondence purposes.

DTRA has identified 18 technical topics numbered DTRA 00-001 through DTRA 00-018. These are the only topics for which proposal will be accepted. The current topics and topic descriptions are included below. The DTRA technical offices which manage the research and development in these areas initiated these topics. Several of the topics are intentionally broad to ensure any innovative idea fitting within DTRA's mission may be submitted. Proposals do not need to cover all aspects of these broad topics. Questions concerning the topics should be submitted to Mr. Burks at the above address or to the Topic Authors identified elsewhere.

Potential offerors must submit proposals in accordance with the DoD Solicitation document. Proposal selection will be limited to those proposals in Phase I which do not exceed $100,000 and six months of performance. For information purposes, Phase II considerations will be limited to proposals of $750,000 and 24 months of performance, or less.

DTRA selects proposals for funding based on the technical merit of the proposal, criticality of the research, and the evaluation criteria contained in this solicitation document. As funding is limited, DTRA reserves the right to select and fund only those proposals considered to be superior in overall technical quality and filling the most critical requirements. As a result, DTRA may fund more than one proposal under a specific topic or it may fund no proposals in a topic area. Proposals which cover more than one DTRA topic must be submitted once, referencing the several areas of applicability.

While funds have not specifically been set aside for bridge funding between Phase I and Phase II successful proposals, the potential offeror is advised to read carefully the conditions set out in this solicitation for FAST TRACK Phase II awards. Gap funding will not be considered for other Phase II awards.

In order to enhance Phase II efforts and to assist in assuring acquisition support from the DTRA SBIR program, the Agency may provide a Phase II Awardee with additional Phase II SBIR funding beyond the initial award sum. The additional funding is conditioned on the company matching the additional SBIR funds with DoD acquisition funds or monies provided from external sources. At the discretion of the DTRA requiring activity, additional dollars may be provided by DTRA activities with heavy interest in the areas of endeavor being pursued by the Phase II award recipient under the SBIR contract applying the same matching arrangement. These conditions will be applicable to awards made pursuant to this DoD solicitation and subsequent solicitations, for a trial period not to exceed three years.

DTRA FY00 TOPIC DESCRIPTIONS

DTRA 00-001 TITLE: Biological and Chemical Agent Neutralization

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Exploitation of the high power electromagnetic beam/RF energy to neutralize chemical and biological agents that may be used in standard warfare or by terrorists. Of interest is the potential for totally destroying the chemical and biological potency. This may be accomplished by breakdown of the agents' molecular (chemical-bond) structures due to resonance interaction with the specific frequencies of the tunable high power, remotely operated EM single or multiple sources; and/or by other chemical or physical means.

DESCRIPTION: Collateral effects which may be created when attacking an enemy chemical or biological facility pose an important problem. The problem is more severe for chemical agents than for biological agents due to the large amounts stored in typical facilities. There are several methods which may prevent collateral casualties from agents released into the atmosphere and agents remaining in the facility. These include irradiation by RF sources and other chemical and physical means.
Using air-dropped munitions and/or irradiation of EM beam power levels, frequency bands of the RF source resonant with those of the chemical/biological molecules' rotational and vibrational energy bands/levels need to be investigated. Critical resonant frequencies and RF power levels that cause the desired effects in typical agents need to be identified and analyzed. Also, controlled experiments to check the results of the analysis shall be proposed.

In addition to or in lieu of irradiation, other chemical or physical means of neutralizing chemical and/or biological agents released into the atmosphere and remaining in the facility are needed.

Proposals using any single method or combination of methods are sought.

PHASE I: Identify chemical/biological agents of interest. Conduct initial studies as to the possible RF frequency bands and in-band energy density required to inactivate or destroy the agents' molecules individually and/or other possible chemical or physical methods to neutralize hazardous agents. Determine critical frequencies, waveshapes, and power levels along with the rep-rates of the EM power source and/or identify other chemical or physical methods to neutralize agents . Demonstrate the effectiveness of the source/method/chemical against selected agents.

PHASE II: Complete develop and demonstrate the methodology identified in phase I in a realistic large-scale environment. Improve the methodology so that more than one type of the targets and agents can be neutralized or destroyed effectively. Also develop methodology for assessing damage in-toto of the typical chemical/biological agents.

PHASE III DUAL USE APPLICATIONS: The methodology developed could be applied in a broad range of military and civilian applications where effective neutralization of chemical or biological agents is needed e.g., medicine and industry.

KEY WORDS: Chemical or biological agents, neutralization, molecular structure, RF source, munitions, containment.

REFERENCES: (U) Agent Defeat Weapon Program Review 98-2 Meeting Minutes, 28-29 October 1998, NWCA-MM-98-5, AF NWCA (CP), Kirtland AFB, NM 87117.

DTRA 00-002 TITLE: Multiple Sensor Characterization of Inaccessible geologic Formations for Hard Target Defeat

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop methods to assess the weapons penetrability of near-surface geologic materials at inaccessible sites by exploiting multiple sensor signatures from visible, infrared, and radar earth remote sensing systems.

DESCRIPTION: The use of earth-penetrating weapons, either conventional or special weapons, is critically dependent on the near surface geological characteristics of target regions. For example, mere division of near-surface materials into soil or rock provides a first order set of information on which to evaluate the penetrability of an area. In addition, mere assessment of soil covered areas as tree covered or clear, provides an additional evaluation of the effectiveness of penetrating weapons. Finally, more refined evaluation of rock penetration can be accomplished with simple assessments of rock unconfined compressive strengths, rock quality, and rock size distributions. Exploitation and fusion of civilian remote sensing systems, such as the LANDSAT series and the Shuttle Imaging Radar/RADARSAT series can estimate such information. As a result of these open collectors, and the advances in data fusion resulting from computer processing advances, Small Businesses should be able to develop advanced multiple sensor data fusion systems that could have critical implications for use of earth-penetrating weapons and, with minor variations, could have extensive civilian applications. This development supports the following Counterproliferation Support and Operations Directorate programs: Hard Target Defeat, Special Ops Forces Support, and CP Analysis and Planning System (CAPS).

PHASE I: Design and demonstrate a prototype overall exploitation system that includes specification of penetrability mapping approach, multiple sensor data requirements, and data fusion techniques. Proposer should include compatibility of exploitation system with the DTRA IMEA-N (Integrated Munitions Effectiveness Assessment – Nuclear) targeting and damage assessment system in the design.

PHASE II: Complete development and demonstrate prototype exploitation system to include prototype penetrability maps on at least three areas of interest. Demonstration will include IMEA-N compatibility and utility.

PHASE III DUAL USE APPLICATIONS: Similar remote sensing data fusion techniques have broad applications in Land-Cover Mapping, engineering applications and mining patterns, agriculture and soils assessment, and urban-industrial patterns assessments.

DTRA 00-003 TITLE: Atmospheric Transport and Dispersion of Nuclear, Chemical, Biological, and/or Radiological Substances in Urban Areas

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop and apply a viable methodology for solving the urban transport problem.

DESCRIPTION: Hazard Prediction and Assessment Capability (HPAC) identifies danger areas caused by release of nuclear, chemical, biological, and/or radiological (NBCR) substances. HPAC provides military and civilian planners and decision makers with projected consequences of possible events. HPAC also provides the war fighter or first responder confronted with a real world event with danger areas from NBCR releases. The HPAC Urban Modeling Program is being designed to meet military urban model requirements for collateral effects applications. The Program is being developed collaboratively with both DOE and UK. The DoD OIPT on M&S is not addressing applicability of models but considering V&V methodology concerns. DOE POC is Dr Page Stoutland, NN-20, and CDR John Wiedner, DP-23. UK POC is Dr Andrew Becket at DERA (Porton-Down). This program is being coordinated with CB defense JMSG business manager (Dr Ron Ferik) to coordinate CB defense and counterproliferation/ collateral effects activities in this area. This program is also being coordinated with Mr Carmen Spencer, Director of CB Defense at DTRA. HPAC supports the following Counterproiferation Support and Operations Directorate (CP) Programs: CP ACTD, CAPS, CATS, Force Protection, and Assessments and Mitigation Technologies. HPAC also supports two CP Enabling Centers: Modeling and Simulation, and Operational Support.

Currently HPAC models non-urban areas very well. However, in urban areas, street canyons, roughness and composition of roads, and varying building heights, shapes, and surface characteristics drastically affect dispersion of NBCR substances. HPAC needs more complex algorithms to accurately model NBCR dispersion and the associated casualties.

PHASE I: Determine how best to attack the urban modeling problem for dispersion. Develop enabling methodologies. Develop an algorithm which provides the 20% solution to the problem. Test and validate the algorithms. Apply HPAC with the algorithms in live, preplanned events, such as the Presidential Inauguration and the Winter Olympics.

PHASE II: Use the methodology developed in Phase I to significantly improve the accuracy of the Phase I algorithm. Desired accuracy in this phase is 70%.

PHASE III DUAL USE APPLICATIONS: This algorithm will provide military planners, operational military forces, and civilian first responders with the capability to accurately assess hazard areas resulting from release of NBCR materials in or near urban areas.

KEYWORDS: Hazard prediction, simulation, modeling, tests, operations, nuclear, chemical, biological, radiological, transport, dispersion, casualties, hazard areas

DTRA 00-004 TITLE: Supporting Weather for Atmospheric Release Modeling

TECHNOLOGY AREAS: Chemical/Biological Defense, Sensors/Electronics/Battlespace

OBJECTIVE: Improve existing and increase new initiatives in modeling, methodologies, and sensors relating to specification, forecasting, communication, and visualization of atmospheric conditions to worldwide application of hazard prediction tools. Scales of interest include altitudes of surface release of materials (0m) to missile intercept of hundreds of kilometers (120km). Additionally, scales span from urban influence to synoptic applications, with recent emphasis increasing for the urban environment.

DESCRIPTION: A growing threat of attack from factions or states involving nuclear, chemical, biological or radiological agents is cause for concern and requires preparation. Meteorology is key to determining the collateral effects of hazardous release. Being able to accurately forecast future or specify current meteorological conditions for a region of interest is crucial in determining the collateral effects of a hazardous release. The continual advance in computing has allowed atmospheric models to be run on today's platforms that are more powerful than supercomputers from only a few years ago. Numerical weather prediction (NWP) model resolution improvements will continue to lead to vast increases in data volume. Being able to communicate large amounts of data to field-deployed units' personal computers (PCs) in austere military conditions is a challenge. Methods of improving the meteorological input to the atmospheric transport model (ATM), without the need to transmit entire volumes of data, must be employed to keep transmission time minimal for immediate hazard prediction calculations. Meteorological sensors and techniques for their employment, such as data analysis or assimilation, that enhance the knowledge of the theater meteorological environment from 0-120km altitudes are sought. These sensors can also include "stand-off" capability for the battlefield environment. Sensors may include ground-, air-, or satellite-based systems, including remotely piloted aircraft equipped with meteorological and other sensors. Continual developments are needed for the lower layer meteorological prediction models but there are a vacuum of meteorological efforts for the region in the troposphere and beyond. Methods and techniques are being sought to improve efficiency of existing NWP, ATM, or other applications in a multiple-processor architecture, whether in a single box or many networked boxes. Another area of concern is characterizing the natural variability of weather and determining the uncertainty of a dispersion calculation given a particular meteorological situation as described by observed or forecast weather. Innovative ideas are sought to aid in estimating the uncertainty of a forecast or analysis, which may be a function of time, surface features, climate, resolution, etc.

PHASE I: Develop or adapt model, application, sensor, or technique and demonstrate operational utility toward hazard prediction modeling.

PHASE II: Develop and demonstrate prototype model, application, sensor or technique in an operational environment; test and evaluate to quantify accuracy, representativeness, and operability.

PHASE III DUAL USE APPLICATIONS: Techniques, models, and methodologies developed under this topic have a wide range of applications for military, civilian, and commercial sectors. New or improved weather-related products can be employed at DOD or national weather centers, university, or countless commercial weather establishments.

KEYWORDS: Meteorology, atmospheric modeling, numerical weather prediction, data assimilation, sensors, multiple-processor, weather, high altitude weather, visualization, hazard prediction, urban modeling

DTRA 00-005 TITLE: Source and Transport Modeling of Biological Agent Slurries

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Develop a viable methodology for modeling the source development and transport of biological agent slurries through the atmosphere.

DESCRIPTION: The proliferation of weapons of mass destruction (WMD) as seen during the Gulf War has created the need for research to quantify collateral effects and to develop a real time collateral effects prediction capability to decrease the possibility of non-combative casualties resulting from attacks on nuclear, biological and chemical facilities or enemy WMD use. The Defense Threat Reduction Agency (DTRA) is developing the capability to predict collateral effects as part of its Collateral Effects (CE) Program . Hazardous agent releases resulting from the use of conventional weapons against chemical or biological weapons production and storage facilities, including the weapons themselves, and enemy or terrorist use of weapons of mass destruction are characterized by physics based modeling tools and comprise the focus of this program.

The tools provide the capability to accurately predict the effects of hazardous material releases into the atmosphere and its impact on civilian and military populations. Such releases may derive from the use of WMD weapons or from conventional weapon strikes against WMD production and storage facilities. Similar effects may result from commercial nuclear, chemical or pharmaceutical accidents or terrorist action.

Existing hazard prediction software can model only dry biological agent releases resulting from weapons of mass destruction and the transport of dry agent particles through the atmosphere. These sources include bacterial spores and viral particles, which have been lyophilized or freeze dried and then milled to a fine powder. However, wet biological agents such as slurries are not currently modeled. A lack of data concerning factors such as droplet evaporation, humidity effects, purity and viability of the liquid agent, particle size and bins, agent degradation or kill, and dissemination efficiency has hindered wet agent modeling. An urgent need exists to develop a methodology to model the source term development and transport of wet biological agents or slurries.

The technical risk is high due to the lack of data on explosively released wet biological materials and their transport through the atmosphere.

PHASE I: Determine the data requirements to model the source term development and transport of wet agents. Develop a test plan to fill data requirements. Conduct testing to obtain data per the test plan.

PHASE II: Use the research in Phase I to develop the physics to model wet biological agents source development and transport.

PHASE III DUAL USE APPLICATIONS: There is potential value to the commercial sector relating to hazardous materials (HAZMAT) incidents or accidents and terrorist action. Data and technologies developed by this effort would be useful to commercial hazard prediction models such as CAMEO and MIDAS-AT as well as other government models.

KEYWORDS: Hazard prediction, simulation, modeling, nuclear, chemical, biological, radiological, transport, dispersion, casualties, hazard areas

DTRA 00-006 TITLE: EM Measurements of Manmade and Natural Geomaterials

TECHNOLOGY AREAS: Chemical/Biological Defense, Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Development of a procedure for electric potential measurements during uniaxial or triaxial laboratory testing of rock and concrete specimens.

DESCRIPTION: Two years ago DTRA/CPTP began making simple electric potential measurements on field tests involving live weapon drops and static detonations in rock. The original objective of these measurements was to provide, from a remote location, detonation time diagnostics to determine weapon performance and status. These measurements have provided good information for this purpose; 1-3 channels of electric potential measurements are now standard on all CPTP field tests; our data set now contains electric records from approximately 25 tests. However, examination of the electric records obtained from both non-detonation events as well as signals produced during the penetration phases of the live weapon drops suggests that electric activity is generated by the penetration/damage process and not the detonation process. A very limited literature search has suggested that electrical emissions, due to microfracturing are observed when rocks are stressed in the laboratory which could be extended to field experience. Determination of electrical properties and electric potential or other EM type measurements of natural or man-made rocks during the standard stress-strain tests in the lab should aid in establishing a tie between damage processes and the observed electrical activity in the field testing.

PHASE I: Development of a methodology and procedure for measurement of electric potential during laboratory rock and concrete uniaxial and triaxial loading tests.

PHASE II: Tests of important rock types that correspond to penetration and high explosive loadings.

PHASE III DUAL USE APPLICATIONS: Extension to oil and mining production companies. The goal of this effort is development of a technique for correlation of observed electrical activity with degree of material damage.

KEYWORDS: Rock Fracture, Piezoeletric Effects, Electric Potential, Rock Properties.

DTRA 00-007 TITLE: Arms Control Activity Remote Monitoring

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace

KEY TECHNOLOGY AREAS: Information Systems Technology, Sensor Software Technology

OBJECTIVE: Enhance capabilities to remotely monitor arms control treaty compliance-related activities at specific locations without disclosing sensitive or classified information and/or distinguish between allowed and disallowed activities. The goal is an algorithm and system design that would perform data fusion from a variety of sensor types installed at a facility and apply a set of behavior rules to monitor a security area without disclosing sensitive or classified information.

DESCRIPTION: Technology able to support the verification of future arms control treaties is needed to allow treaty inspectors to monitor the transportation, dismantlement, and storage of treaty limited items. Many Object and Pattern Recognition (OPR) systems based on video surveillance input have been demonstrated. Some arms control applications may prohibit the use of video images due to sensitive or classified objects and/or activities in the field of view. The security issue may be resolved by replacing or complementing video cameras with other sensor technologies such as IR or radiation detectors.
A remote OPR system is advantageous because it provides a less intrusive alternative to full time inspector presence in sensitive areas. Monitoring must have minimal impact on normal operations while protecting against illicit activities such as diversion or theft.

Current algorithms based on optical images are able to identify treaty limited objects and monitor security protocols such as a two-man rule. The developed algorithm should be able recognize items of interest and have behavioral rules defined so that prohibited actions can be recognized and trigger alarm conditions. Some of the limitations of an optical-based OPR system such as shadowing and obscuration can be overcome by combining sensor technologies. Radiation detectors would be applicable for a strategic treaty verification tool. Flexibility of application and circumstance is important. Ideally, the operator/inspector will never see visual images.

The developed algorithm should use an innovative approach to combine the capabilities of multiple (performer selected) COTS sensor technologies to enhance object and pattern recognition for the remote monitoring of special nuclear material at a fixed storage location. A preference will be given to self-correcting or learning algorithms over hard-wired decision tree algorithms. The algorithm should be capable of evaluating data at a rate of at least 30 times per second.

PHASE I: Develop software algorithm and system design based on input of multiple COTS sensors of at least two different sensor technologies. The design should include data acquisition and sensor specifications in order to remotely monitor 20-gallon sized containers of nuclear material.

PHASE II: Develop and demonstrate a prototype system in a realistic nuclear storage environment. Conduct testing to prove feasibility over extended operating conditions.

PHASE III DUAL USE APPLICATIONS: a remote OPR monitoring system has a wide variety of military and commercial applications for surveillance and security. Examples are the remote monitoring of nuclear components and reducing manpower requirements to secure industrial facilities.

KEYWORD LIST: arms control verification, arms control compliance, pattern recognition, sensor fusion, remote monitoring

DTRA 00-008 TITLE: Alternative Technologies for Nuclear Weapon Treaty Verification

TECHNOLOGY AREAS: Chemical/Biological Defense, Information Systems, Sensors/Electronics/Battlespace, Weapons, Nuclear Technology

OBJECTIVE: Define and develop non-nuclear radiation based "alternate technologies" for use in verifying the presence or absence of nuclear weapons, nuclear weapon components, and high explosives (HE) components from nuclear weapons located in containers. The goal is inexpensive, man portable, non-nuclear radiation based sensors capable of verifying future potential strategic treaties without revealing classified nuclear weapon design information, that can be operated by non-technical inspector personnel.

DESCRIPTION: Technology able to support the verification of a future potential START III treaty is needed to allow treaty inspectors to verify the presence or absence of nuclear weapons, nuclear weapon components, and high explosives (HE) components from nuclear weapons located in containers prior to warhead dismantlement. An additional requirement is the absolute need to protect critical nuclear weapon design information during and after verification measurements.

Numerous nuclear radiation detection based verification systems have been designed, developed, tested and produced. An inherent problem with these systems is they provide too much information, therefore revealing critical nuclear warhead design information during verification measurements. As an alternative, DTRA is in the early stages of determining alternate technologies based on all other non-nuclear radiation based physical principles and signatures of nuclear weapons for making verification measurements while protecting critical nuclear weapon design information.

The performer has significant flexibility, since any non nuclear radiation detection technology and a wide range of verification approaches should be considered. Examples of technologies requiring development to establish technical feasibility include 1) chemical microsensors and accurate yet portable gas chromatographs tailored to sample and analyze a nuclear weapon container atmosphere and 2) a mass properties sensor tailored to analyze induced acoustic vibrations from the contents of a nuclear weapon container through the container wall and related air-gaps.

Research is needed to define and then develop potential verification systems based on alternate technologies. Additionally, simple simulators should be developed that simulate, to the extent possible in a commercial unclassified environment, the makeup of the nuclear weapon environment. Finally, initial testing should be done with the developed system against those simulators, in preparation for final tests against classified Department of Energy simulators or real warheads and components.

PHASE III DUAL USE APPLICATIONS: Counter-proliferation & non-proliferation – for example, monitoring of nuclear materials associated with civilian nuclear power plants. Law enforcement, customs and border inspections – for example, inspection of sealed containers for weapons/drugs or of atmosphere of truck shipments for nuclear materials. Industrial and laboratory security – Similar to customs application, to detect theft of high value or nuclear items in containers.

KEYWORD LIST: Acoustic, Heat Transfer, Infrared, Chemical Microsensors, Gas Chromatography, Chemical Analysis, Arms Control Verification, Arms Control Compliance, Warhead Monitoring, Nuclear Weapons, High Explosives

DTRA 00-009 TITLE: Innovative Methods of Identifying Nuclear Explosions Versus Chemical Explosions and Natural Events

TECHNOLOGY AREAS: Chemical/Biological Defense, Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Develop innovative sensors whose outputs may be combined with seismic signals to distinguish between nuclear explosions, chemical explosions, or natural events

DESCRIPTION: Global networks of sensors have been, and are being, deployed to monitor for clandestine nuclear tests. One processing center for data from such a network is being developed at the Center for Monitoring Research (CMR) in Arlington VA in support of the Comprehensive Nuclear Test Ban Treaty (CTBT). The sensor data streams at CMR include hydroacoustic, infrasound and radionuclide sensors as well as seismic. These sensors are called out in the CTBT. A potentially powerful means of identifying the type of source of events ("discrimination"), particularly small events, in the seismic stream is to combine the seismic signals with signals from one or more of the other sensor data streams ("data fusion"). Identification of these small events, however, can still be problematic, with difficulties in distinguishing between small nuclear explosions, chemical explosion, and small earthquakes. Therefore, DTRA has a need for the development of sensors other than the ones currently being used (hydroacoustic, infrasound, and radionuclide) to assist in the identification of source type for small events in the seismic data stream. The CTBT does provide for additional types of sensors if these sensors would be useful in better identifying and locating events. Innovative approaches, such as sensors detecting changes in the Earth's gravity field or electromagnetic field, may be of interest. New concepts for identifying radionuclide products (such as tunable laser excitation). Space-based sensors, however, will not be considered. The work should include appropriate algorithms to carry out the identification of source type.

PHASE I: Carry out preliminary design of proof-of-concept tests.

PHASE II: Build prototype/acquire sensor(s), conduct test sufficient to demonstrate proof-of-concept.

PHASE III DUAL USE APPLICATIONS: A successful proof-of-concept test could lead to deployment of a new sensor network to assist in treaty compliance monitoring. Additionally, sensors based on measurements of the earth's gravity field or electromagnetic field could lead to improved scientific monitoring of the earth. These types of sensors, or sensors based on other principles, could be used to detect and monitor natural events (included those potentially hazardous).

REFERENCES: www.pidc.org

KEYWORD LIST: seismic signals, nuclear explosions, chemical explosions, discrimination, fusion, sensors

DTRA 00-010 TITLE: Innovative Infrasound Sensors with High Reduction of Natural Background Noise

TECHNOLOGY AREAS: Sensors/Electronics/Battlespace

OBJECTIVE: Design and prototype innovative sensor for infrasound (low frequency sound) with high signal-to-noise ratio for spatially coherent signals

DESCRIPTION: The opening of the Comprehensive Nuclear Test Ban Treaty (CTBT) for signature has reinvigorated the field of infrasound (low frequency sound) because the CTBT specifies a network of infrasound sensors to monitor compliance with respect to atmospheric nuclear tests. At present, the bandwidth of interest is 0.02-4 Hz. One of the problems in the detection of the infrasonic signals from atmospheric tests is that the technology uses extended sensing systems and arrays that average pressures over meters to kilometers of distance to reduce the effects of local variations and to enhance the effects of propagating pressure fronts. These sensing systems, however, are still sensitive to weather conditions (especially snow) and greater signal to noise performance is needed. New, innovative techniqueswith infrasound sensors are sought that can reduce the effects of local pressure variations and increase the resolution of infrasonic signals from atmospheric explosions. Issues are improved signal to noise performance in the frequency band, improved durability in remote deployments and environmental extremes, ability to operate in all-weather conditions, and cost.

PHASE I: Demonstrate concept by a benchtop model or other means.

PHASE II: Build prototype and conduct field tests to demonstrate superiority over current sensor.

PHASE III DUAL USE APPLICATIONS: Environmental monitoring.

REFERENCES: www.pidc.org

KEYWORDS: Infrasound, CTBT, Comprehensive Nuclear Test Ban Treaty, Sensors, Acoustic, Spatial Filtering.

DTRA 00-011 TITLE: Low Power, Room Temperature Systems for the Detection and Identification of Radionuclides from Atmospheric Nuclear Tests

TECHNOLOGY AREAS: Chemical/Biological Defense, Sensors/Electronics/Battlespace, Weapons, Nuclear Technology

OBJECTIVE: Innovative approach to the detection of airborne radionuclides with room temperature sensors.

DESCRIPTION: Detecting clandestine nuclear tests requires monitoring the environment to detect anomalous events. Two sensors in the Comprehensive Nuclear Test Ban Treaty (CTBT) monitoring system are systems designed to detect radioactive particulates and Xenon isotopes respectively from atmospheric nuclear tests. At present, these systems require mechanical cooling in order to achieve the necessary sensitivity and resolution of the germanium gamma-radiation sensor. This need to cool the detector results in high power consumption as well increasing the size and bulk of the detector and associated equipment. Another way of cooling the detectors is to use liquid nitrogen, as is often done in laboratories. However, these detectors will be placed in locations where liquid nitrogen is not readily available. DTRA therefore seeks an alternative approach, one that would eliminate the cooling requirement, for use in the remote and environmentally hostile locations associated with projected CTBT monitoring requirements. This new approach would have the detector performing at normal room temperatures. Alternative approaches would likely involve new materials since all current technology germanium detectors require cooling. The proposed approach should reduce the amount of power required by the sensor system, have good signal to noise ratios, still be of reasonably small size, with sensitivity and resolution on the order of current germanium detectors.

PHASE I: Demonstrate concept via breadboard model or other means

PHASE II: Build prototype and conduct tests sufficient to demonstrate proof-of-concept

PHASE III DUAL USE APPLICATIONS: Unattended radiation monitoring capability for industrial and medical facility monitoring.

REFERENCES: www.pidc.org

KEYWORD LIST: gamma detectors, gamma radiation, nuclear test, radionuclide, xenon

DTRA 00-012 TITLE: Tracking Atmospheric Plumes Based on Stand-Off Sensor Data

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop an approach to identifying and locating the source of nuclear events that generate atmospheric plumes by backtracking their atmospheric plumes.

DESCRIPTION: At present, a worldwide network of 80 radionuclide monitoring stations is being set up under the Comprehensive Nuclear Test Ban Treaty (CTBT) to monitor radioactive fall-out from atmospheric nuclear tests. These stations sample the air for radioactive particulates and radioactive Xenon on a daily basis. To interpret the results, a means of estimating where any suspicious radionuclides might have originated is needed. However, no automated process exists that will allow determination of possible sources of any detected radionuclides, nor is it clear what approach would work. Software exists that will track a plume forward in time from its origin, but no comparable software exists for tracking a plume backward in time. The ability to rapidly and automatically track a plume backward in time would greatly enhance the value of the radionuclide detectors. DTRA therefore seeks a software system that will track a plume backward in time, thereby allowing a projection of the potential origin of air parcels sampled by a monitoring station. Ideally, an accuracy of 1,000 sq. km. would be desirable. The system should take account of the properties of the radionuclides involved (e.g., settling, washout by rain, chemical reactions) as well as weather patterns. Appropriate historical data to test the system should be identified, and such a test should be part of the proposed work. The system is being considered for the Prototype International Data Center (PIDC) presently being developed for the CTBT, and should be able to use the type of data being produced at the PIDC. Off-line analysis is envisaged. Either an automated or interactive system, or a combination of both, will be considered.

PHASE I: Develop overall software system design and demonstrate proof-of -concept

PHASE II: Produce prototype software modules and conduct tests showing validity of approach.

PHASE III DUAL USE APPLICATIONS: Atmospheric monitoring of pollutants from fixed sources, such as power plants (nuclear and non-nuclear)

REFERENCES: www.pidc.org

KEYWORD LIST: radionuclide, atmospheric plumes, backtracking, atmospheric nuclear tests, fall-out, weather, meteorology, pollutants.

DTRA 00-013 TITLE: Improved Seismic Event Location Estimates

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Innovative Techniques for Developing Improved Hypocenter Location Estimates to Reduce the Area of Potential Search for Suspicious Events under the Comprehensive Nuclear Test Ban Treaty (CTBT).

DESCRIPTION: Under the CTBT, all nuclear testing by the signatory states is illegal. To enforce this ban, an international monitoring system is being developed to detect clandestine tests. It will consist of seismic, hydroacoustic, infrasonic, and radionuclide sensors. If an anomaly is detected with any of these sensors, member states have the right to demand an On-Site Inspection to obtain direct evidence of a treaty violation. The area to be inspected will probably be defined by the uncertainty ellipse obtained from seismic arrival data. The maximum allowable search area under the treaty is 1,000 km2. Because this is a relatively large area, and because exhaustive searches of such regions can be difficult and expensive, there is a need to develop new, innovative techniques for obtaining improved hypocenter estimates. These new techniques should both increase confidence in the coordinates obtained for the event and reduce the parameter uncertainty estimates to a minimum. Potential modes of accomplishing this improvement include, but are not limited to, the use of data from seismic stations that are not part of the CTBT International Monitoring Station (IMS) system, the use of data from non-seismic systems, and the development of new analytical approaches (such as Artificial Intelligence). For data from non-IMS sources, data quality control is an issue of interest and innovative techniques will be needed to rapidly determine the usability and degree of confidence to be placed in these data. Any proposed approach must involve operations that can be accomplished within a relatively short time frame (a few days) and that will yield results with a high degree of confidence, both scientifically and politically.

PHASE I: Develop overall system design and demonstrate proof-of -concept

PHASE II: Produce prototype software modules and conduct tests showing validity of approach.

PHASE III DUAL USE APPLICATIONS: Better and more rapid location of earthquakes, thereby allowing rapid determination of future seismic hazards.

REFERENCES: www.pidc.org

KEYWORD LIST: Seismic, hydroacoustic, infrasonic, nuclear test, location, hypocenter, artificial intelligence, data analysis

DTRA 00-014 TITLE: Innovative Wide-Area Detection and Mapping Technologies to Locate Minefields Containing Antipersonnel Landmines

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop innovative technical capabilities to detect and map APL minefields for use in verification and monitoring regimes of potential APL agreement/ban treaties such as the Convention on Conventional Weapons (CCW) Modified Protocol II, the Ottawa Convention on APL Ban, the Conference on Disarmament (CD) Process for APL Ban and others as appropriate.

DESCRIPTION: The US government has a long-range goal of banning the indiscriminate use, export, stockpiling and production of APL to mitigate or eliminate post-conflict civilian casualties. The Defense Threat Reduction Agency (DTRA) is responsible for providing RDT&E support for all arms control treaties including the proposed ban on APL. To verify and monitor APL ban provisions and to provide requisite technical assistance in conducting APL mapping and demining operations, DTRA is seeking innovative and statistically meaningful technical capabilities for WAD that have the potential to minimize risk to inspection/remediation personnel. DTRAs limited review of other WAD technology R&D efforts sponsored by other US Government (USG) offices and Separate Operating Agencies (for example, see references) determined that technical efforts have concentrated on detecting and clearing individual mines rather than on WAD and mapping of APL minefields. DTRA seeks innovative "out of the box" WAD R&D technology developments that will allow safe and rapid delineation of boundaries of areas containing mines. Proposed technologies and systems may include model and algorithm development to accomplish minefield detection and location display as well as full-scale prototype hardware and software developments associated with fieldable prototype demonstration systems.

The potential needs of DoD and DTRA germane to an agreement banning APLs are focused on developing multiple innovative WAD technologies and proof-of-concept prototype systems for worldwide APL detection, verification, and mapping use. Multiple R&D technology developmental efforts may be funded. The following are desired constraints on the proposed innovative WAD and mapping technologies/systems:

- High probability of detection of minefields containing metallic and non-metallic APL
- Real-time display or processing of data not required
- Large area coverage
- Detection operations conducted under non-hostile conditions

PHASE I: Demonstrate feasibility of the proposed innovative WAD and mapping technologies (or suite of technologies), models, algorithms. Provide logical approach and develop overall conceptual design of applicable WAD and mapping system that confirms the presence or absence of APLs.

PHASE II: Develop proof-of-concept prototype device/system that demonstrates the viability of the proposed innovative technologies, etc., to detect and map APL minefields. Submit final prototype design of the proposed WAD and mapping system.

PHASE III DUAL USE APPLICATIONS: Detection of unexploded ordnance (UXO) as part of military base clean-up operations in the US as well as arms control treaty/agreement applications.

REFERENCES:

1. GAO Report on UXO, Report No. 95-197, 20 SEP 1995.

2. Review & Identification of DOE Laboratory Technologies for Countermine/Unexploded Ordnance Detection, Cyrus Smith, Oak Ridge National Laboratory, 2 DEC 1996 (Reissued 2 DEC 1997).

DTRA 00-015 TITLE: CW Field Analysis Using Novel Sample Preparation Methods

TECHNOLOGY AREAS: Chemical/Biological Defense, Sensors/Electronics/Battlespace

OBJECTIVE: Explore innovative technologies and methods to increase the speed and accuracy of Chemical Warfare (CW) agent analysis by Gas Chromatography/Mass Spectrometry (GS/MS) in field environments in order to improve inspector safety and US capability to demonstrate its compliance with and verify/monitor compliance of other states parties with existing and future arms control treaties and agreements including the Chemical Weapons Convention (CWC) and a Bilateral Destruction Agreement (BDA).

Gas Chromatography/Mass Spectrometry (GC/MS) is a mainstay of chemical agent analysis for compound detection and identification. Next generation mass spectrometers are being developed for Chem-Bio Defense and include Time-of-Flight (mini-TOF), Matrix-Assisted Laser Desorption/Ionization (MALDI), and a threshold photoionization quadrupole ion trap/time-of-flight mass spectrometer for rapid analysis of chemical agents, biological agents, and explosives. Introducing samples such as water, soils, or wipe matrices into the mass analyzer requires a series of preparation procedures conducted prior to the determinative analysis. To date, sample preparation technology has not kept pace with instrument developments.

There is a requirement to identify and develop innovative technologies and methods to increase the speed and minimize the logistics for conducting sample analysis for chemical warfare (CW) agents by GC/MS. GC/MS has been accepted as the preferred method for determinative analysis for CW by the Organization for the Prohibition of Chemical Weapons (OPCW). Samples are collected and analyzed for the presence of CW agents, degradation compounds, and/or precursor chemicals (Schedules 1, 2, & 3) as specified in the "Annex on Chemical Contents, Section B" of the Convention on the Prohibition of the Development, Production, Stockpiling, and Use of Chemical Weapons and on Their Destruction. Schedule 1 compounds include the threat agents typically monitored in a battlefield environment. In addition to the collection of ambient air samples, the capability to collect more complex matrices is necessary to ensure a safe battlefield environment. Samples also may be collected and analyzed in order to satisfy implementation requirements under the CWC and in support of a future Bilateral Destruction Agreement (BDA).

Direct sample introduction of most environmental matrices (water, soil/solids, wipes/swipes) into mass spectrometer instrumentation is not feasible. A series of procedures must be employed to extract the compounds of interest (e.g., target analytes) into an organic solvent media more appropriate for conducting determinative analysis by GC/MS. Sample preparation protocols are the same when confirming the safety of a battlefield environment or verifying compliance with the CWC Development of automated sample preparation techniques is desired to permit continuous analysis. Sample preparation and subsequent instrument analysis will be performed in field laboratory environments.

DESCRIPTION: Preparing environmental samples prior to GC/MS analysis remains a "weak-link" in the sampling and analysis process. The preparation of samples for GC/MS analysis currently includes liquid/liquid or liquid/solid extractions, and subsequent derivitization reactions. These procedures are time-consuming and can be complex, use specialized equipment, and the protocols have specific reaction times conducted at recommended temperatures. Currently, as few as five samples can be prepared for analysis during an eight hour time period using existing analytical procedures. This throughput is unacceptable during a time-oriented mission such as the 84-hour on-site limit specified under the CWC during the conduct of a challenge inspection. Furthermore, the analytical procedures involve significant sample handling that may adversely affect sample extraction efficiency. The rigorous protocols increase the exposure risk of laboratory personnel to contaminants that may be present in the sample matrix including chemical agents. Extensive sample handling also leads to the potential of inadvertent sample contamination/ cross-contamination, casting doubts on the authenticity of the analytical data.

The current extraction procedures are complex, requiring specialized operator expertise and training. Also, the existing procedures require the use of potentially hazardous reagents (e.g., flammable solvents), adding to the complexity in deploying a transportable laboratory. To date, the techniques have been unable to extract critical compounds from specific environmental matrices and have not been able to result in reproducible analytical determinations. It is critical that the analytical procedures be conducted to ensure that resulting GC/MS analysis data are reproducible at detection limits that meet treaty requirements, generally in the 10-ppm range.

Devices, materials, and procedures will be developed to significantly improve sample preparation in the GC/MS analytical process. All devices and materials must specifically target extraction of CW agents, precursors and degradation products. The procedures must successfully perform in the presence of significant environmental interferents or contaminants (e.g., hydrocarbon backgrounds). Performance will be characterized by sample throughput, ease of conducting the procedures, success in extraction of key analytes, resultant reproducibility of GC/MS detection data, and toxicity of extraction materials used (if applicable). Extraction throughput goal will be to prepare no fewer than 16 individual samples (comprised of various matrices) during an eight hour time period.

PHASE I: Demonstrate the feasibility/proof-of-concept of alternative extraction equipment, materials, and procedures for use in the preparation of environmental samples to include water, soil/solids, wipes/swipes for GC/MS analysis of compounds related to chemical arms control treaties and agreements (CW agents, precursors, and degradation compounds).

PHASE II: Develop proof-of-concept and reduce to practice; demonstrate the proposed technology; prototype methodology/standard operating procedures; conduct field trials.

PHASE III DUAL USE APPLICATIONS: Investigate use for Counter-Terrorism/ Domestic Preparedness; environmental on-site analysis for remediation/hazardous waste assessment/clean-up (e.g., DoD installations)

DTRA 00-016 TITLE: New Innovative Technologies for the Development and Demonstration of Radiation Hardened Microelectronics and Photonics

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace, Nuclear Technology

OBJECTIVE: Develop and demonstrate innovative concepts, methods and technologies for the radiation hardening and radiation effects characterization of semiconductor microelectronics and photonics devices, circuits and materials.

DESCRIPTION: Radiation effects from either nuclear weapons or the natural space environment can degrade or destroy semiconductor microelectronic and photonic devices, circuits or materials. Moreover, as microelectronics and photonics technologies continue to evolve their susceptibility to radiation effects increases in many cases. In addition the problems associated with the characterization of radiation effects in these advanced technologies also are becoming more difficult. Thus, future methods to radiation harden microelectronics and photonics and to characterize their radiation response will require the development and demonstration of new cost-effective and minimally invasive concepts, methods and technology.

Very deep submicron microelectronics has been shown to be extremely susceptible to radiation effects. These devices use small feature size and many new types of materials to achieve high performance to the detriment of radiation robustness. Thus, minimally invasive concepts, methods and technology to increase radiation hardness without loss of electrical performance or significant increase in cost are required. Moreover, methods to characterize the radiation response of the new materials and devices are required.

Very high-speed microelectronics and photonic devices and materials have been developed to facilitate the rapid transfer of data. However, these devices and the subsystems fabricated using this advanced technology have been shown to be very susceptible to radiation effects. Here again, minimally invasive an cost-effective concepts, methods and technology are required to reduce the susceptibility of these technologies to radiation effects and allow them to be used in DoD missile and space systems. In addition new methods to characterize the radiation response of these technologies are required.

Very significant investments have been made by commercial semiconductor manufactures and system designers to develop extremely high performance circuits such as microprocessors, digital signal processors, microcontrollers, etc. However, for the DoD to take advantage of these developments these devices must be redesigned such that they can be fabricated using radiation hardened processes and design rules. One method to accomplish this redesign is through the use of Electronic Design Automation (EDA). Thus, cost-effective EDA concepts, methods and technology are required to support such an approach.

Traditionally the radiation response of microelectronic and photonic devices and circuits have been obtained through testing. However, such an approach is both costly and time consuming. A more cost-effective and accurate approach would entail the modeling and simulation of the basic response of a device or circuit starting with the initial fabrication parameters, e.g. material, temperature, time, etc. Thus, the development and demonstration of concepts, methods and technologies to simulate and model the radiation response of complex microelectronics and photonic devices are required to reduce our reliance on expensive and inaccurate radiation testing.

Presently used methods to ascertain the radiation hardness of a semiconductor device or circuit require destructive testing using a suitable radiation source. A more cost- effective approach would be to identify and correlate the electrical response of certain key device performance parameters to the radiation response. This would allow for the non-destructive characterization of device radiation performance and significantly reduce the need for expensive and time consuming radiation testing. Thus, the development and validation of concepts, methods and technology to demonstrate such an approach is required.

PHASE I: demonstrate the feasibility of the concept, method or technology.

PHASE II: develop, test and evaluate the concept, method or technology.

PHASE III DUAL USE APPLICATIONS: In addition to supporting DoD space and missile system applications the above-described thrusts will also serve to support commercial communications and scientific space system applications. This support will be of significant value to Dod due to significant use of commercial space systems assets for DoD applications, e.g. Iridium,etc.

REFERENCES:
(1) Messenger and Ash, "The Effects of Radiation on Electronic Systems", Van Norstrand Reinhold Company, 1986
(2) Dressendorfor & Ma,"Ionizing Radiation Effects in MOS Devices & Circuits".John Wiley & Sons,1989
(3) Glassstone and Dolan, The Effects of Nuclear Weapons, 1977
(4) Transient Radiation Effects in Electronics Handbook,DNA-H-95-61

DTRA 00-017 TITLE: New, Innovative Technologies for EMP/HPM Hardening of Military and Commercial Systems and Equipment

TECHNOLOGY AREAS: Materials/Processes, Sensors/Electronics/Battlespace, Nuclear Technology

OBJECTIVE: Develop and demonstrate innovative concepts, methods and technologies for hardening military and commercial-off-the-shelf (COTS) equipment, systems, and networks against the effects of nuclear Electromagnetic Pulse (EMP) and High Power Microwaves (HPM).

DESCRIPTION: Electromagnetic (EM) environments generated by nuclear and RF (radio frequency) weapons can degrade or destroy sensitive electronic and electrical devices. With improvements in integrated circuit technology, e.g., higher clock speeds, lower logic levels/gate thresholds, and smaller size, there is a trend towards greater susceptibility. This is exacerbated by component and equipment manufacturer's usage of non-conductive material (e.g., composites, plastics) to house the electronics. Thus, there is a need for innovative, cost-effective hardening technologies and methods for design, analysis, testing, maintenance and surveillance.

Integrated hardening and testing devices and techniques that address EMP, HPM, and other natural and man-made EM environments are desirable.

The military has mandated use of COTS (electronics) equipment to the maximum extent possible. A significant challenge is to ensure that COTS is survivable when integrated into military systems that must operate in and through EMP, HPM and other stressing EM environments found in the battlespace of the future. Methods, devices, and materials for characterizing and expediently/cost effectively hardening COTS are required.

The military is highly reliant on the commercial infrastructure for effectively accomplishing many of its missions. Innovative concepts and technologies for protecting critical elements of the U.S. infrastructure and tools/methodologies for use in assessing potential vulnerabilities are needed.

PHASE I: demonstrate the feasibility of the concept, method, or technology.

PHASE II: develop, test, and evaluate the concept, method, or technology.

PHASE III DUAL USE APPLICATIONS: In addition to supporting DoD equipment, systems, and networks hardening applications, the above thrusts will also serve to support commercial electronics equipment protection applications. This support may be leveraged by DoD since a) OSD has mandated the use of COTS equipment, materials, and commercial standards to maximum extent possible and b) the military is highly reliant to the use of the U.S. commercial infrastructure for the completion of many o f its critical missions.

REFERENCES:
(1) Glasstone and Dolan, The Effects of Nuclear Weapons, 1977
(2) MIL-HDBK-423, High-Altitude electromagnetic Pulse (HEMP) Protection for fixed and Transportable Ground-Based C4I Facilities, Volume I Fixed facilities

DTRA 00-018 TITLE: New, Innovative Technologies for X-Ray Simulators and Other Pulsed Power Applications

TECHNOLOGY AREAS: Chemical/Biological Defense, Weapons, Nuclear Technology

OBJECTIVE: Develop innovative technologies for the efficient production of x-rays for nuclear weapons effects testing and for the application of compact pulsed power to military and civilian systems.

DESCRIPTION: X-ray nuclear weapon effects testing uses radiation sources that generate primarily cold x-rays (1-15 keV), warm x-rays (5-60 keV), or hot x-rays (&#61502:30 keV). Soft x-rays are used for optical and optical coatings effects testing; warm x-rays are used for thermomechanical and thermostructural response testing; and hot x-rays are used for electronics effects testing. Future requirements for x-ray nuclear weapon effects testing will require improvements in existing radiation source capability, to increase yield and power, improve spectral fidelity, and increase predictability and experimental control. These improvements may require new concepts in source design, experimental and measurement techniques, data analysis and modeling, and methods to reduce facility system and operation costs. The proposer should be familiar with the present capability to produce x-rays for nuclear effects testing.

Plasma Radiation Source (PRS) devices are typically gas puffs or wire arrays that are imploded by conduction of large currents to generate soft x-rays. Present PRS designs for high-power DTRA simulators are limited by Rayleigh-Taylor and MHD instability growth, and active research is investigating innovative load designs. Greater understanding is needed of factors influencing instability growth. Such factors include geometry, coupling to the generator, plasma properties, ionization dynamics and radiation transport. Innovative load designs might also include novel methods for increasing radiation yield and spectral fidelity in a high-power, optically thick medium, as has been done by using mixtures. An important contribution could come from physics-based modeling of this complex system, particularly with the high-performance parallel computers now available.

PRS devices generate copious amounts of extraneous debris (material, atomic charged particles, sub-keV photons), from which test objects must be shielded. Better techniques and diagnostics are needed to characterize the debris impacting a test object. Debris shields must minimize particle flux and maximize exposure area without significantly reducing x-ray fluence. New methods, or a combination of methods, may be needed to stop, mitigate, and/or delay debris generated for radiation simulators.

Plasma opening switches (POS) are important for obtaining maximum performance from x-ray sources, particularly with the next generation of DTRA high-power generators. Interest is focused primarily on using POSs for pulse sharpening in order to drive high fidelity bremsstrahlung diodes. POS performance appears to be affected by plasma composition, plasma flow symmetry, current diffusion during conduction, and power losses, and innovative diagnostics are needed to quantify these factors. Better computer modeling is needed, especially to understand the opening process and its relationship to conduction dynamics.

Bremsstrahlung Radiation Source (BRS) devices generate hot x-rays by impinging an electron beam onto a target converter. Improved BRS converter and/or beam transport designs are needed to meet future test requirements, by increasing x-ray production (dose), better tailoring pulse width (increased dose rate), and improving spectral fidelity. These improvements could be effected by innovative new BRS designs, or by better understanding and refinement of existing BRS designs. Comprehensive computer modeling (e.g., PIC codes) of cathode formation and electron emission, beam transport, and/or converter physics, could provide an important contribution.

Future requirements for systems employing pulsed power will necessitate improvements in efficiency, energy density, reliability, repeatability and overall performance over the existing state of the art. Innovative approaches for component or subsystems development are sought to meet future demands for radiation simulators and other pulsed power applications. Examples include more energy efficient pulse forming technologies, high energy density capacitors, more efficient insulators, improved and more reliable switching technologies, and improved power flow electrical circuit models. Pulsed power technologies include those that operate at kilovolts to megavolts and kiloamperes to megamperes, support repetition rates from single pulse to 10 kilohertz, and provide individual pulse risetimes in the nanosecond to millisecond range.

Current DoD pulsed power applications includes x-ray simulators, armor/anti-armor; electromagnetic/electrothermal guns; mine-countermine; electrical vehicle stoppers, and directed energy weapons; etc. Development of new and innovative applications requiring advanced pulsed power technology is also desired, especially applications that may expand a primarily DoD driven requirements base into the commercial sector and reduce component and system costs.

PHASE I: demonstrate the feasibility of the proposed concept.

PHASE II: develop, test and evaluate proof-of-principle hardware. In some cases this will be required to be demonstrated in its working environment on a radiation simulator that will involve coordination with DTRA to schedule testing in an above ground test simulator.

PHASE III DUAL USE APPLICATIONS: In addition to the applications cited for developing the environments for simulating the effects of nuclear weapons, the technologies could be useful with the commercial operations of advanced computer modeling of plasmas, nuclear instrumentation, very fast closing valves, material surface treatments, environmental clean-up and high brightness x-ray sources. In addition to the DoD applications cited, these pulse power component technologies will be useful in cleaning up smokestack effluents, general environmental pollution control, metal cutting, and electric vehicles.

REFERENCES:

(1) Inductive Energy Technology for Pulsed Intense X-Ray Sources, K. D. Ware, P. G. Filios, R. L. Gullickson, J. E. Rowley. R. F. Schneider, W. J. Summa, I. M. Vitkovitsky, IEEE Transactions on Plasma Science, Vol. 25, No. 2, April 1997.

(2) Glasstone and Dolan, The Effects of Nuclear Weapons, 1977

(3) DNA EM-1, Capabilities of Nuclear Weapons

(4) Radiation Test Facilities and Capabilities, 1997, DASIAC, 2560 Huntington Ave., Alexandria, VA 22303 (also on web site: http://www.dswa.mil/dswainfo/es/hp.htm)

(5) J. C. Martin on Pulsed Power, Edited by T. H. Martin, A. H. Guenther, and M. Kristiansen, Plenum Press, New York and London, 1996, ISBN 0-306-45302-9.

UNITED STATES SPECIAL OPERATIONS COMMAND

Proposal Submission

The United States Operations Command's (USSOCOM) mission includes developing and acquiring unique special operations forces (SOF) equipment, material, supplies and services. Desired SOF operational characteristics for systems, equipment and supplies include: lightweight and micro-sized; reduced signature/low observable; built-in survivability; modular, rugged, reliable, maintainable and simplistic; operable in extreme temperature environments; water depth and atmosphere pressure proof; transportable by aircraft, ship and submarine, and deployable by airdrop; LLPI/LPD jam resistant C3I, electronic warfare capable of disruption and deception; near real-time surveillance, intelligence and mission planning; highly lethal and destructive; low energy/power requirements; and compatible with conventional force systems.

USSOCOM is seeking small businesses with a strong research and development capability and an understanding of the SOF operational characteristics. The topics represent a portion of the problems encountered by SOF in fulfilling its mission.

Inquires of a general nature or questions concerning the administration of the SBIR program should be addressed to:

United States Special Operations Command
Attn: SOAL-KS/Ms. Karen L. Pera
7701 Tampa Point Blvd.
MacDill Air Force Base, Florida 33621-5316
Tel: (813) 828-7549
Fax: (813) 828-5481
Email: perak@socom.mil

USSOCOM has identified 4 technical topics for the FY '00.1 solicitation. Proposals will only be accepted for these 4 topics. The USSOCOM technical offices responsible for the research and development in these specific areas initiated topics. The same office is responsible for the technical evaluation of the proposals. Proposal evaluation factors are listed below. Each proposal must address each factor in order to be considered for an award. Scientific and technical information assistance may be requested by using the DTIC SBIR Interactive Technical Information System (SITIS).

Firms may submit a proposal with an optional task, which would be performed during the period between Phase I-completion and Phase II contract award. The optional task provides the opportunity to reduce the gap between Phase I and II funding. The maximum amount of SBIR funding used for an USSOCOM Phase I award, with Option, is $100,000. Options must be submitted with the basic Phase I proposal and will be included in the basic Phase I proposal 25-page limitation. The basic Phase I proposal shall be evaluated exclusive of the option tasks and must be proposed and priced separately. The option portion of the proposal will be evaluated using the same evaluation criteria as Phase I proposals. The transition option work shall be included as an option in the Phase I contract and evaluated for USSOCOM unilateral exercise at any time after Phase I award through the conclusion of the basic Phase I contract. The maximum time frame for a Phase I with or without option is 6 months. Exercise of any option shall be at the sole discretion of USSOCOM and shall not obligate USSOCOM to make a Phase II award.

Evaluation Criteria – Phase I & II

1) The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

2) The qualifications of the proposed principal/key investigators supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

3) The potential for commercial (Government of private sector) application and the benefits expected to accrue from this commercialization.

Selection of proposals for funding is based upon technical merit and the evaluation criteria included in the solicitation. As funding is limited, USSOCOM will select and fund only those proposals considered to be superior in overall technical quality and most critical. USSOCOM may fund more than one proposal in a specific topic area if the technical quality of the proposals are deemed superior, or it may fund no proposals in a topic area. Fast Track Phase II proposals will be evaluated under the Fast Track standard discussed in Section 4.3 of this solicitation.

USSOCOM also encourages contractors to participate in the SBIR Fast Track program as described in the DOD 00.1 Solicitation. Proposing Options in the Initial proposal will not prevent a contractor from participating in the Fast Track Program, however, the total USSOCOM funds for a Phase I, Options, and the Fast Track funding will not exceed $140,000. It is anticipated the vast majority of Fast Track proposals will receive interim funding between Phases I and II, and that the percentage of Phase I Fast Track projects that are selected for Phase II awards should be significantly higher that the overall percentage of Phase I projects that are selected for Phase II.

The Phase II enhancement plan for the Special Operation Command is intended to encourage the acquisition programs to leverage the technology being developed under the SBIR program. The SBIR program will provide a one to four match of SBIR dollars to non-SBIR program dollars (from acquisition programs, the private sector, etc.) for Phase II work, not to exceed $100,000 in additional SBIR funding. The additional SBIR dollars will only be available for testing and/or further development that will result in a prototype as a deliverable. Offerors are strongly encouraged to develop a Phase II proposal that will include a tangible product to be used for marketing purposes.

Electronic Submission Instructions

DoD and USSOCOM have implemented an electronic proposal submission process. The Proposal Cover Sheet (formerly, "Appendix A and B") and the Company Commercialization Report Data will be submitted electronically at WWW.DODSBIR.NET/SUBMISSION. The help desk for this site is SBIRHELP@teltech.com or 1-800-328-4634. For assistance with technical proposal uploads, phone 727-549-7030 or duffj@ctc.com. The Cost Proposal is to be submitted using the format shown in Reference A of the DOD SBIR Solicitation. The Cost Proposal will be submitted as part of the technical proposal and is included in the 25 page technical proposal maximum. One paper copy of the Proposal Cover Sheet, Company Commercialization Report, cost proposal, and technical proposal is required with an original signature and will be submitted to the address shown below by 3:00PM EST on January 12, 2000:

United States Special Operations Command
Attn: SOAL-KB/SBIR Program, Topic 00-00_
7701 Tampa Point Blvd.
MacDill Air Force Base, Florida 33621-5316
(Phone number for express packages is 813-828-6512)

USSOCOM requires all Phase I monthly reports to be submitted via e-mail. Offerors must understand e-mail is the communication medium of choice for the SBIR program. Should an offeror be awarded a Phase I, the offeror will be expected to be able to communicate reports via e-mail.

Electronic Technical Proposal Submission

The term "Technical Proposal" refers to the part of the submission as described in Section 3 of the Solicitation. WordPerfect, Text, MS Word and MS Works are the preferred formats for submission of proposals for all systems. Please use standard fonts in order to prevent conversion difficulties. The offeror is encouraged, but not required, to embed graphics within the work processed document. Separate files may be submitted as Bitmap (.bmp), Graphics Interchange Format(.gif), JPEG (.jpg), PC Paintbrush (.pcx), WordPerfect Graphic (.wpg) and Tagged Image Format (.tif). The various files comprising the electronic version are required to reflect the paper version and will not exceed the page limitation. The offeror is responsible for performing a virus check on each proposal submitted via the internet address. The detection of a virus on any submitted electronic technical proposal may be cause for the rejection of the proposal. Offerors will receive an electronic confirmation receipt of the proposal. The proposal will not be opened prior to the closing date and time. Withdrawal of proposals must include the topic number and the title of the proposal and may only be made by an officer of the company and must be made electronically. We strongly suggest that the files be Zipped. Previous experience has shown some internet service providers (ISPs) are limited as to the size of the files they can transmit or they may take too long to transmit and will "time-out". Recommend you contact your ISP provider several weeks prior to submission of the proposal to determine if they will be able to transmit the expected size file. USSOCOM will not accept e-mail submissions. The web sites stated above **MUST** be used for the submittal process.

USSOCOM offers information on the Internet about its SBIR program at http://www.socom.mil and http://www.acq.osd.mil/sadbu/sbir.

USSOCOM
FY '00.1 SBIR TOPIC INDEX

USSOCOM
FY '00.1 SBIR TOPIC DESCRIPTION

SOCOM 00-001 TITLE: Extreme Environment Hand-Wear system

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Design a multi-purpose hand protection system that: protects from extreme environmental conditions, including wind, rain, temperatures down to -40F, while providing the wearer comfort and sufficient dexterity to perform mission essential tasks such as rappelling, fast-roping, operating a weapon.

DESCRIPTION: Special Operations Forces (SOF) use a variety of protective hand-wear but no single system offers the operator sufficient protection from the elements while providing for the dexterity and durability to perform all mission essential tasks. Of primary interest are novel and innovative solutions, e.g., new and novel applications of available or emerging materials in innovative designs/configurations, as there is nothing in the commercial or military market, or under development that will provide the desired capability.

PHASE I: Survey and obtain or develop candidate hand-wear materials, designs, configurations, and systems for evaluation. Determine, by calculation, sample testing or simulation, the value of conceptual system(s) in the context of SOF operating environments and mission essential tasks. Prototype most promising candidates and conduct laboratory testing to establish environmental and ergonomic performance, and conduct a qualitative assessment of compatibility with SOF mission essential tasks. This will lead to a recommendation for Phase II design(s).

PHASE II: Develop applicable and feasible prototype demonstrations and/or proof-of-concept devices for the approach described, and demonstrate the degree of commercial viability.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian applications where extreme environment hand protection with maximum dexterity/durability is necessary - for example, helicopter door gunners, pipeline operators, snow mobilers and ice boaters.

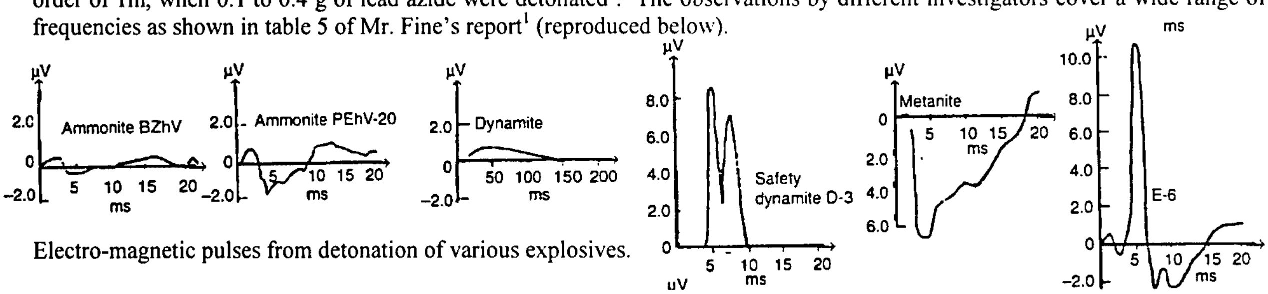
SOCOM 00-002 TITLE: RF Detector/Emitter

TECHNOLOGY AREAS:Chemical/BiologicalDefense, Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: To investigate explosives that emit a discrete radio frequency (RF) signal when activated. Specifically, we will search for a small explosive, which can be added to blocks of C4. When the C4 is activated, the additive will ignite and a discrete RF signal will be emitted. This RF signal will then be detected by receivers in subsequent detonating charges. Once this signal is received, the charges will be detonated. These charges also contain the additive that will emit an RF signal to other follow up explosive charges. It is clear that with the use of this additive, one can activate several in-line explosive charges by sympathetic detonation (i.e. without the use of cables connecting the linear array of charges).

DESCRIPTION: It is a known fact that during an explosion an electrical pulse is generated. The pulse characteristics are not only dependent on the type of explosive, but also on its size, shape and containment. Much literature exists on the RF radiation from explosions. Mr. Fine and Mr. Vinci[1] conducted an extensive literature search of emitted frequencies from various explosives.

During their literature search, Mr. Fine and Mr. Vinci came across explosives that emit distinctive pulse shapes. Figure 3 on page 9 of their report[1] (reproduced below) shows six distinctively shaped pulses in the amplitude range of 0.5 to 10 microvolts from the six different explosives. These pulses were reported by Stuart[2]. Anderson and Long[3] found that the electromagnetic pulse shape and amplitude from detonation of tetryl or Composition B were affected by encasing the charges in 0.5 inch thick plaster of paris, or be seeding the uncased explosive with 15 percent by weight of sodium bicarbonate powder[4]. Takakura[5] reported E-fields on the order of 400 microvolts/meter in the frequency band from 6 to 90 MHz at distances on the order of 1m, when 0.1 to 0.4 g of lead azide were detonated[6]. The observations by different investigators cover a wide range of frequencies as shown in table 5 of Mr. Fine's report[1] (reproduced below).



Electro-magnetic pulses from detonation of various explosives.

Table 5. Frequency bands observed by investigators reviewed.

Investigator	Type of explosive used	Amount of explosive used	Delay/ duration of observed signals	Frequency range	Possible cause suggested by authors
			Experimental values of frequency ranges		
Trinks	Tube-launched artillery projectiles	None given	—	1–100 kHz 2 MHz–1 GHz 10 MHz–2 GHz	Muzzle flash, ionization of gases near muzzle. Pulses upon impact at target. Radiation at detonation from "microsparks" caused by charge equalization at detonation.
Takakura	Lead azide	0.1–0.4 g	80–100 μs delay	6–90 MHz	Acceleration of electrons ejected by ionization and dipole formation at shock front.
Stuart	Large caliber guns		—	250 MHz–1 GHz	None given, experimental results only.
Curtis	RDX	10 g	2 s delay/19 s duration	0.5–350 Hz	None given, experimental results only.
Gorshunov et al	50/50 trinitrotolul hexogen	1000–5000 g	—	30 Hz–20 MHz	Electrical charges generated asymmetrically from scattered electrified detonation products.
Cook	Composition B	70–1100 g	—	Below 10 kHz	Gaseous detonation products form a plasma at surface of gas cloud from ionization by passing through earth's electric field. Gas cloud discharges on contact with ground.
Wouters	None given	1,300 g 500 ton (= 4.5 × 10⁸ g)	None explicitly given 8 ms duration (1.3 kg) 32 ms duration (500 ton)	—	Blast temperature ionizes detonation products and ambient air and produces a plasma.
van Lint	Bare spheres to metal-cased bombs	10–345,000 g (bare spheres to metal-encased bombs)	100–200 μs delay	50 MHz–1 GHz	Separation of charge at interface of explosion products and air to form a vertical dipole moment, with asymmetry induced by reflection of shock wave from ground. Electric sparks from explosion products interacting with casing fragments.
Andersen and Long	Bare, plaster-encased, and seeded explosives Tetryl, Composition B	20–1,087 g	300–600 μs delay	Less than 600 kHz	Detonation ionizes detonation products, which transfer charge by friction to inert casing particles and fragments.

Investigator	Type of explosive used	Amount of explosive used	Delay/ duration of observed signals	Frequency range	Possible cause suggested by authors
			Theoretical estimations of frequency ranges		
Fine and Vinci	Theoretical calculations on model of bare generic explosive with 25-MJ yield	Approximate size of 60-mm mortar	—	0–2 THz 0–3 MHz 3 MHz	Electrons accelerating across shock wave. Electrons accelerating across plasma shell. Electrons accelerating in earth's ambient magnetic field.

Our aim is to select a seeding agent, which when enclosed and activated by the main charge, will produce a discrete RF signal that can be detected and used to activate subsequent explosive charges. Another variation is to seed a small portion of the main charge and encapsulate it. The encapsulated charge is activated first, so it emits the RF signal prior to detonation of the main charge.

The employment of this product with explosive charges will eliminate the need for connecting cables. Thus, lessening the weight the operator must carry, as well as the complexity and time expended to set up multiple charges.

PHASE I: Investigate this phenomenon and determine "coded" RF signals that can be generated. For this study, various antennas, explosive shapes and sizes, containment materials and additives will be investigated.

PHASE II: Based on the results of Phase I, pellets will be constructed, which when added to a main charge will produce the expected RF signal and sympathetic triggering of subsequent charges. Testing should show that these pellets, when added to a small portion of the main charge, are activated prior to detonating the main charge and emit the expected RF signal. Testing should also show that receivers in subsequent charges will detect the RF signal and can initiate detonation of its pellet and explosive charge.

PHASE III DUAL APPLICATIONS: The technologies developed under this program will produce additives, which when combined with a main charge are used to activate other explosives without physically connecting them. These systems will be very effective in mining operations, avalanche control and demolition operations where precise control and activation of consecutive charges is required.

REFERENCES:

[1] Jonathan E. Fine and Stephen J. Vinci , "Causes of Electromagnetic Radiation from Detonation of Conventional Explosives: A Literature Survey," Army Research Laboratory Report No. ARL-TR-1690, DTIC Reference: ADA359740, December 1998, Adelphi, MD 20783-1197.

[2] William D. Stuart, "Data Interpretation for Hostile Weapons Location Program, Vol IV: Electromagnetic Emissions from weapons and Explosions," Advanced Research Projects Agency (now DARPA), ESD-TR-75-221, June 1975, p.22.

[3] W.H. Andersen and C.L. Long, "Electromagnetic Radiation from Detonating Solid Explosives," J. Appl. Phys., Vol. 36, No. 4, April 1965, pp 1494-1495.

[4] Fine and Vinci, Op. Cit. Pp 16-18.

[5] Tatuo Takakura, "Rad Noise Radiated on the Detonation of Explosive," Publications of the Astronomical Society of Japan, Vol.7, No. 4, 1955, pp 210-220.

[6] Fine and Vinci, Op. Cit., pp 25-26.

SOCOM 00-003 TITLE: High Performance Assault Zone Marking System

TECHNOLOGY AREAS: Air Platform, Sensors/Electronics/Battlespace, Weapons

OBJECTIVE: Provide an assault zone marking system that can guide aircraft doing instrument approaches in adverse weather (200' ceiling/.5 mile visibility).

DESCRIPTION: Assault zone marking systems facilitate instrument approaches of fixed and rotary wing aircraft. Special Operations Forces operating in extremely low ceiling/visibility (LC/V) conditions and with minimal administrative and logistics support. Present assault zone lighting systems do not always provide sufficient illumination for effective operations in these situations. At the same time, the solution set is somewhat limited because SOF must utilize self-contained, man-portable, and rapidly deployable systems. New technologies are available, across the electromagnetic spectrum, that can be used synergistically with existing aircraft sensors to solve this problem. For example, high intensity/efficiency lamps and lasers can greatly increase the visibility of current assault zone lighting systems without increasing operational signature or power requirements.

PHASE I: Analyze the operational deficiency and constraints, and propose alternative solutions. Demonstrate performance improvements over current assault zone lighting systems or completely new solutions to this problem, by laboratory-level demonstration, simulation, or calculation. Propose operational configuration and concept of the most promising alternatives.

PHASE II: Design, build, test, and report on the optimal design resulting from Phase I, and fabricate flying test-bed brass-board prototypes.

PHASE III DUAL USE APPLICATIONS: Boating, automotive, and aircraft industries would utilize high performance/efficiency situational awareness systems for operating in poor visibility conditions. For example, if the optimal solution was a high performance landing zone lighting system it would have applications for other government agencies (e.g. forest service to assist in marking locations during forest fire operations), and economical marking of temporary or small commercial landing strips.

SOCOM 00-004 TITLE: SOF Ground Route Planner

TECHNOLOGY AREAS: Information Systems, Sensors/Electronics/Battlespace, Human Systems

DOD ACQUISITION PROGRAM SUPPORTING THIS TOPIC: Mission Planning and Rehearsal (MPARE)

OBJECTIVE: Design and build an interactive software application which uses all levels of Digital Terrain Elevation Data (DTED), Digital Feature Analysis Data (DFAS), and Interim Terrain Data (ITD)/Terrain Analysis Data Base (TADB) to allow an operator to compare an estimated level of work associated with one potential route to another.

DESCRIPTION: SOF personnel routinely have to carry loads in excess of 100 pounds when they conduct cross country ground movements. Accordingly, the level of effort required to move across terrain often is a major planning factor. Currently, no known tool tailored to the needs of these individuals exists. The route they select is based on a variety of factors, ranging from a gross estimation of the difficulty of the terrain, safety, likelihood of detection from ground and air based observers, to the potential presence of hostile elements. Often the chosen route is a compromise of several mission-related factors, and is selected in a time constrained environment. The lack of planning time often results in a less than optimum selection. Providing a tool to calculate a "work factor" for each route, or one that will generate a number of optimum routes, with associated time-lines, will greatly assist planners.

Given the work required on a nominal route--a flat straight line--as a reference factor, the software should be able to use standard digital terrain information to calculate the work associated with traversing a particular route. Work calculations should be based on two primary factors: change in elevation and obstacle transit. Other factors, such as weather and urban terrain, will also apply. Changes in elevation along a route have a major impact on the effort required to use it. Climbing (positive elevation changes) requires the user to expend major energy reserves. Descending (negative elevation changes) also requires the user to expend much more energy than he would on a level route. Traditional work calculations will factor the potential energy gained in climbing as a savings for a descent. This is not true for this situation, where descending is added work, and often almost as hard as climbing. Also, transiting obstacles usually directly adds to work. Traversing a mangrove swamp, for example, is a slow and work intensive process. In the rare instances where an obstacle has negligible impact on work, time is often the most affected factor.

Both input and output formats and processes must be user friendly and intuitive. User programmable variables must make sense to an average user. Pop-up help cues should be built-in. Output should be immediately recognizable to the user. The route walk-through visualization should be as realistic as feasible—given funding constraints. Should vertical overhead imagery be available, the software should have a mechanism to import it and warp it to DTED derived contours, or at least the ability to be upgraded to perform this function with minimal effort.

Inherent in this requirement is researching "industry standard" work factors related to the task. Where needed work factors do not exist, experiments should be conducted to develop them.

The software should be compatible with a Windows NT environment on a high-end personal computer (PC). The software should be able to work in both a network environment and on a stand-alone PC.

PHASE I: Demonstrate the likelihood that a new and innovative development approach can meet the broad objectives described above, and demonstrate user interfaces.

PHASE II: Demonstrate applicable and feasible prototype demonstrators and/or proof-of-concept systems for the described requirement, and demonstrate a degree of commercial viability.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR has additional commercial applications. These additional applications include:

Military:

- Ground sensor emplacement planning tool.
- Determine likely enemy axis of approach.
- Convoy route planning.
- Conventional force ground tactical movement planning tool.
- Mission rehearsal support.
- Terrain following or nap of the earth low-level aviation mission preparation visualization tool.

Civilian:

- Planning tool to support recreational activities.
- Planning tool to assist in Search and Rescue planning.
- Planning tool to assist in fighting forest fires.
- Planning tool to select optimal ground routes for new roads, railway systems, pipelines, aqueducts, and recreational trails.

NATIONAL IMAGERY AND MAPPING AGENCY

SUBMISSION OF PROPOSALS

The mission of the National Imagery and Mapping Agency (NIMA) is to provide timely, relevant, and accurate imagery, imagery intelligence, and geospatial information in support of national security objectives. Therefore, NIMA pursues research which will help it guarantee the information edge over its potential adversaries. Potential proposers unfamiliar with NIMA can find more information about it on NIMA's home page at http://www.nima.mil.

NIMA has developed three topics to which small businesses may respond in the fiscal year 2000 SBIR Phase I iteration. These three topics are described on the following pages. NIMA will accept only unclassified proposals on its topics.

Proposers shall mail or hand-carry three copies of each proposal to the NIMA SBIR Contracting Officer (CO), Mr. Quan Tran. His mailing address is as follows:

NIMA
4600 Sangamore Rd.
Bethesda, MD 20816-5003

Mail Stop D-88
Attn: Mr. Quan Tran

To hand-carry the documents, proposers shall contact the CO to arrange a pick-up time. In addition to the address above, the CO may be contacted as follows:

Telephone: (301) 227-7822
Fax: (301) 227-2306
E-Mail: tranq@nima.mil

Proposers are encouraged, but not required, to also submit their proposal on a Zip disk in HTML 3.2 format with the root file called "index.htm". All other proposal files, if any, on the disk must be accessible through hyperlinks from the "index.htm" file.

Proposal submission questions shall be addressed to the CO, Mr. Quan Tran. All other questions shall be directed to the NIMA SBIR Program Manager, Dr. Kathleen Morrish. She may be reached as follows:

NIMA
12310 Sunrise Valley Dr.
Reston, VA 20191-3449

Mail Stop P53
Attn: Dr. Kathleen Morrish

Telephone: (703) 262-4557
Fax: (703) 262-4588
E-Mail: morrishk@nima.mil

Each NIMA Phase I contract will have a base period of performance of six months, with an option of an additional three months. The price of each proposal shall not exceed a total of $100,000, with $70,000 allotted to the base proposal and $30,000 to the option. The option shall be included with the base proposal at the time of submission. The base proposal plus option shall be prepared single spaced in 12 point Times New Roman font, with at least a one inch margin on top, bottom, and sides, on 8 ½" by 11" paper. The pages shall be numbered. The base proposal plus option shall not exceed 25 pages. Exercise of the option will be at the sole discretion of NIMA.

NATIONAL IMAGERY AND MAPPING AGENCY
SBIR 00.1 TOPIC DESCRIPTIONS

NIMA 00-001 TOPIC: Evaluating the Ability of Commercial Sensors to Satisfy Tactical Level, Geospatial Data Requirements in the Littoral Zone

KEY TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environments; Information Systems

OBJECTIVE: Determine the extent to which tactical level geospatial data from emerging commercial remote sensing systems can improve the recognition, interpretation, and data quality of features and attributes in the littoral zone that are critical to U.S. Navy and Marine Corps amphibious assault plans and operations.

DESCRIPTION: The Navy and Marine Corps require remotely sensed, mission-specific, geospatial data in support of their Littoral Warfare program. Emerging sensor technologies appear to have the potential to deliver this data. NIMA seeks an empirical assessment of the ability of selected commercial sensors and image processing procedures to identify and characterize required mission-specific features and attributes. It is expected that data from multiple sources will be needed to satisfy the off-shore and on-shore collection and data quality requirements of this program. In order to evaluate the adequacy of this data, a testbed representing ground truth should be established using sensors and procedures of known fidelity. These would include side-scan sonar, echosounding, seabed metric videography, topography, topographic laser ranging, multispectral and hyperspectral optical sensing - actual or simulated - and advanced software to classify, fuse, and deliver preprocessed geospatial data to an off-the-shelf Geographic Information System (GIS). It is recognized that the choice of sensors for testbed construction ("reference data set") will not be identical to those selected for comparative evaluation ("experimental data set").

PHASE I: Conduct an interpretative examination of the state-of-the-art in hydrographic and topographic remote sensing and data fusion in the littoral zone. Develop an operational concept including a comprehensive design and methodology to demonstrate and evaluate the prospective value of commercial sensors in support of the Littoral Warfare Data (LWD) program.

PHASE II: Develop, in a naturally diverse coastal study area, a testbed representing ground truth ("reference data set"), and an "experimental data base" from a minimum required set of commercial sensors. Support the methods to be used to compare the data quality of the "experimental" with that of the "reference" database. Demonstrate a prototype system using Navy and Marine Corps mission-specific specifications as the standard.

PHASE III DUAL USE APPLICATIONS: In addition to the military application discussed above, there is a large and expanding demand in state and federal regulatory agencies, and in industry, for improved techniques of multi-source data collection in the coastal zone. This is true, for example, of NOAA's responsibility to upgrade and maintain U.S. nautical charts; the Bureau of Commercial Fisheries' requirement to conduct intensive fish habitat monitoring in littoral waters; and the Corps of Engineers' need to maintain detailed data bases, on and off shore, in support of environmental impact studies for pipeline routes, dredging operations, and the like.

NIMA 00-002 TOPIC: Intelligent Software Agents in Distributed Information Environments

KEY TECHNOLOGY AREAS: Information Systems

OBJECTIVE: Develop intelligent software agents tailored for imagery and geospatial analysis.

DESCRIPTION: The Intelligence Community is an information-rich domain with a growing number of tools available to help imagery and geospatial analysts extract information for the policy makers, the decision makers, and the commanders in the field. Information today is growing in volume, is more complex and varied than in the past, comes in multimedia formats, and is distributed. Tools that exist today to assist in the analysis of this data tend to be time-consuming and cumbersome to use. NIMA would like to apply intelligent agent technology to address this problem. Intelligent software agents must "understand" the intelligence problems the analyst is addressing, what information can/should be brought to bear on the problems, locate and process information on behalf of the analyst, and provide insight and recommendations to the analyst.

PHASE I: Investigate intelligent software agent technologies. Identify existing technologies and propose new technologies that show the most promise for use by imagery and geospatial analysts.

PHASE II: Develop and demonstrate prototype tools that implement the technologies identified in Phase I. Assess their usefulness.

PHASE III DUAL USE APPLICATIONS: In addition to military applications, the technologies described above can be used for civilian mapping, charting, and geodesy functions. They also pertain to medical applications, such as medical diagnosis from large amounts of multimedia data.

NIMA 00-003 TOPIC: Innovative Database Design and Methodology for Reasoing about Imagery, Geospatial Information, and Related Information

KEY TECHNOLOGY AREAS: Information Systems; Human Systems

OBJECTIVE: Develop a database design that efficiently handles geolocation in time and all three spatial dimensions, and also naturally represents objects and their properties and relationships on, above, and below the earth's surface. Develop methodologies for reasoning about the information in this database in conjunction with other sources of data (e.g., imagery, text information, and metadata, in separate files or other databases).

DESCRIPTION: Databases used today for geophysical data storage are adapted to function well with static, two-dimensional positional data. It is necessary to resort to methods such as tables to represent the vertical dimension and the non-geopositional aspects of objects located on, above, or below the earth's surface, and time is not usually considered. Further, methodologies to reason about the data in these databases are limited in their ability to consider diverse sources of data.

NIMA seeks an innovative database design that recognizes the earth's surface as a truly three-dimensional object which may intersect a normal to the geoid at multiple locations, due to natural structures such as cliff overhangs. In addition, the database should handle in an efficient manner the objects which exist on, above, and below the earth's surface. These objects may be very stable overall, like rock strata. They may be relatively stable, like buildings. They may be semi-stable, like trees, or periodic, like snow or crops. And they may be transitory, like a train on a track. Further, the objects may be associated with complex data, such as information on the type of crop in a field: its need for rainfall, susceptibility to insect infestation, etc. The data may be in any computer-storable form: text, tables, raster and vector imagery, etc. The location and properties of objects and points on, above, and below the earth's surface may be associated with measures of error. The objects may have elaborate internal structures that need to be represented in the database, like the inside of an important building. And the objects may interrelate. In addition, the objects and the earth itself can change with time, on time scales that are very short (destruction of a building by a bomb) or very long (decay of a mountain due to erosion).

The database must be associated with a front end that allows the user to input, update, maintain, and use the information in a natural fashion in near real time. It should be constructed so that it has no inherent, non-physical limitations in terms of the number of associations between its data elements. It should also have no inherent, non-physical limitations on the number of links to other sources of data that support it. And it needs to incorporate capabilities for verification and validation of data content and relationships in the context of its own data.

Finally, NIMA seeks innovative ways to identify, locate, access, filter, fuse, reason about, and present information derived from the data in this database and other linked data sources in response to users' queries. The database should be designed to facilitate automated reasoning. The user should have the ability to request a trace of from where the information came for each successful query. The information presented as a result of the query should include an error analysis about the result. For instance, if a street address is desired, the methodology could return one or more addresses and an estimated probability that the addresses are correct. If a geographic location is needed, the methodology could return coordinates in an appropriate coordinate space and the error associated with the coordinates. In both cases, images of the locations or other pertinent information could also be presented. If significant inconsistencies appear in the data, the methodology should flag them so the user has a chance to resolve them. And the database should have a natural, user-friendly human-computer interface that makes it easy both to present queries and to receive and use the results of queries. A virtual reality type of interface is envisioned.

PHASE I: Investigate database designs and human-machine interface designs to efficiently handle geolocation in time and all three spatial dimensions, efficiently handle related non-geospatial data, and also naturally represent objects on, above, and below the earth's surface and their properties and relationships. Identify those database designs and human-machine interface designs which show the most promise in terms of system performance, ease of population, ease of change, ease of maintenance, and ease of use. Also, investigate methodologies to identify, locate, access, filter, fuse, reason about, and present information in response to queries on the data in this database and other data sources. Identify those methodologies which show the most promise in terms of accuracy, efficiency, and utility.

PHASE II: Develop and demonstrate a prototype database and human-machine interface that implements the best designs identified in Phase I. Assess its usefulness in terms of system performance, ease of population, ease of change, ease of maintenance, and ease of use. Also, develop and demonstrate a prototype reasoning capability that implements the methodologies identified in Phase I. Assess its usefulness in terms of accuracy, efficiency, and utility.

PHASE III DUAL USE APPLICATIONS: In addition to military applications, the techniques described above are necessary to revolutionize civilian imaging, mapping, charting, and geodesy functions. They will move them from today's static, separate, two-dimensional forms to an intelligent, fused, virtual reality system that provides the user with whatever information is desired about a place or object. There is also medical application, where image data (e.g., X-ray, MRI), textual medical history data, and even information about where a person lives can be combined to identify and describe normal and abnormal structures imaged in a patient for pretreatment investigation, post-treatment comparison, and storage in medical records.

9.0 SUBMISSION FORMS AND CERTIFICATIONS

Section 9.0 contains:

Reference A: **Cost Proposal Outline**
A cost proposal following the format in Reference A must be included with each proposal submitted.

Reference B: **Fast Track Application Form**
A DoD pilot program under which projects that attract outside investors receive interim funding and selection for Phase II award provided they are "technically sufficient" and have substantially met Phase I goals.

Reference C: **Proposal Receipt Notification Form**

Reference D: **Directory of Small Business Specialists**

Reference E: **SF 298 Report Documentation Page**

Reference F: **DoD Fast Track Guidance**

Reference G: **DoD's Critical Technologies**

Reference H: **DoD SBIR/STTR Mailing List Form**

U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM COST PROPOSAL

Background:

Offerors should indicate the following terms, as appropriate, in their proposal, following the instructions in Section 3.4(m) of this solicitation.

Cost Breakdown Items (in this order, as appropriate):

1. Name of offeror
2. Home office address
3. Location where work will be performed
4. Title of proposed effort
5. Company's taxpayer identification number and CAGE code. *(Note: Offerors that do not yet have these items -- e.g., because the company does not yet exist at the time of proposal submission -- should so indicate in the cost proposal. Such offerors, if selected for award, should talk with their DoD contracting officer about obtaining these items, both of which are required before a contract can be awarded.)*
6. Topic number and topic title from DoD Solicitation Brochure
7. Total dollar amount of the proposal
8. Direct material costs
   a. Purchased parts (dollars)
   b. Subcontracted items (dollars)
   c. Other
      (1) Raw material (dollars)
      (2) Your standard commercial items (dollars)
      (3) Interdivisional transfers (at other than cost dollars)
   d. Total direct material (dollars)
9. Material overhead (rate_____%) x total direct material = dollars
10. Direct labor (specify)
    a. Type of labor, estimated hours, rate per hour and dollar cost for each type (e.g., "computer programmer, 40 hours, $26 per hour, $1040 cost") Include the name as well as hours, etc. of all key personnel.
    b. Total estimated direct labor (dollars)
11. Labor overhead
    a. Identify overhead rate, the hour base and dollar cost
    b. Total estimated labor overhead (dollars)
12. Special testing (include field work at government installations)
    a. Provide dollar cost for each item of special testing
    b. Estimated total special testing (dollars)
13. Special equipment
    a. If direct charge, specify each item and cost of each
    b. Estimated total special equipment (dollars)
14. Travel (if direct charge)
    a. Transportation (detailed breakdown and dollars)
    b. Per diem or subsistence (details and dollars)
    c. Estimated total travel (dollars)
15. Subcontracts (e.g., consultants)
    a. Identify each, with purpose, and dollar rates
    b. Total estimated subcontracts costs (dollars)
16. Other direct costs (specify)
    a. Total estimated direct cost and overhead (dollars)
17. General and administrative expense
    a. Percentage rate applied
    b. Total estimated cost of G&A expense (dollars)
18. Royalties (specify)
    a. Estimated cost (dollars)
19. Fee or profit (dollars)
20. Total estimate cost and fee or profit (dollars)
21. The cost breakdown portion of a proposal must be signed by a responsible official, and the person signing must have typed name and title and date of signature must be indicated.
22. On the following items offeror must provide a yes or no answer to each question.
    a. Has any executive agency of the United States Government performed any review of your accounts or records in connection with any other government prime contract or subcontract within the past twelve months? If yes, provide the name and address of the reviewing office, name of the individual and telephone extension.
    b. Will you require the use of any government property in the performance of this proposal? If yes, identify.
    c. Do you require government contract financing to perform this proposed contract? If yes, then specify type as advanced payments or progress payments.
23. Type of contract proposed, either cost-plus-fixed-fee or firm-fixed price.

U.S. DEPARTMENT OF DEFENSE

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
FAST TRACK APPLICATION COVER SHEET

Failure to fill in all appropriate spaces may cause your application to be disqualified

To qualify for the SBIR Fast Track, a company must submit a Fast Track application and meet the other requirements detailed in Section 4.5 of the solicitation. This form, when completed and signed by both the company and its investor, should be included as the cover sheet of the Fast Track application. Instructions on where to submit the application are on the back of this form.

TOPIC #: ______________ CONTRACT #: ________________________ PHASE I EFFECTIVE START DATE: ______________

SPONSORING DOD COMPONENT: ________________________ PHASE I COMPLETION DATE: ______________

PHASE I TITLE: ____

____

FIRM NAME: ____

MAIL ADDRESS: ____

CITY: ________________________ STATE: __________ ZIP: ______________

TAXPAYER IDENTIFICATION NUMBER: ________________________

NAME OF OUTSIDE INVESTOR: ____

MAIL ADDRESS: ____

CITY: ________________________ STATE: __________ ZIP: ______________

TAXPAYER IDENTIFICATION NUMBER: ________________________

BUSINESS CERTIFICATION:

	YES	NO
> Has your company ever received a Phase II SBIR or STTR award from the federal government (including DoD)? If yes, the minimum matching rate is \$1 for every SBIR dollar. If no, the minimum matching rate is 25 cents for every SBIR dollar. (Matching rates differ slightly for BMDO applicants – see the BMDO section of this solicitation)	☐	☐
> Does the outside funding proposed in this application qualify as a "Fast Track investment", and does the investor qualify as an "outside investor", as defined in DoD Fast Track Guidance (Reference D)? If you have any questions about this, call the DoD SBIR Help Desk (800-382-4634). The Help Desk will refer any policy and/or substantive questions to appropriate DoD personnel for an official response.	☐	☐

Caution: knowingly and willfully making any false, fictitious, or fraudulent statements or representations above may be felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to \$10,000, up to five years in prison, or both.

PROPOSED SBIR AND MATCHING FUNDS:

> Proposed DoD SBIR funds for the interim effort: \$______________

> Proposed DoD SBIR funds for Phase II: \$______________

> Total proposed DoD SBIR funds (interim + Phase II): \$______________

> Amount of matching funds (cash) the investor will provide: \$______________

By signing below, the parties are stating that the outside investor will provide matching funds, in the amount listed above, contingent on the company's selection for Phase II SBIR award. If the matching funds are not transferred from the investor to the company within 45 days after DoD has notified the company that it has been selected for Phase II award, the company will be ineligible to compete for a Phase II award not only under the Fast track but also under the regular Phase II competition, unless a specific written exception is granted by the Component SBIR program manager.

COMPANY OFFICIAL	OUTSIDE INVESTOR OFFICIAL
NAME: ______________	NAME: ______________
TITLE: ______________	TITLE: ______________
TELEPHONE: ______________	TELEPHONE: ______________
______________ SIGNATURE ______ DATE	______________ SIGNATURE ______ DATE

Nothing on this page is classified or proprietary information/data

INSTRUCTIONS FOR COMPLETING FAST TRACK COVER SHEET

SUBMISSION:

Submit the Fast Track application, including the three items discussed in Section 4.5(b), to the technical monitor for your Phase I project. In addition, submit a copy of the entire application to the Program Manager of the DoD Component funding the SBIR project (addresses below). Finally, send a copy of this application cover sheet, when completed, to the DoD SBIR Program Manager, OSD/SADBU, 1777 N. Kent Street, Suite 9100, Arlington, VA 22209. Do not submit other items in the Fast Track application to the DoD SBIR Program Manager.

Department of the Army
Dr. Kenneth A. Bannister
Army SBIR Program Manager
Army Research Office - Washington
5001 Eisenhower Avenue, Room 8N23
Alexandria, VA 22333-0001

Department of the Navy
ONR 362 SBIR
ATTN: Vincent Schaper
800 N. Quincy Street
Arlington, VA 22217-5660

Department of the Air Force
AFPL/XPTT, Steve Guilfoos
1864 4th Street, Suite 1, Bldg.15
Wright Patterson AFB, OH 45433-7131

Defense Advanced Research Projects Agency
ATTN: SBIR Program Manager Ms. C. Jacobs
3701 N. Fairfax Drive
Arlington, VA 22203-1714

Chemical and Biological Defense Program
Dr. Kenneth A. Bannister
Army Research Office - Washington
5001 Eisenhower Avenue, Room 8N23
Alexandria, VA 22333-0001

Ballistic Missile Defense Organization
ATTN: TOI/SBIR (Jeff Bond)
1725 Jefferson Davis Highway
Suite 809
Arlington, VA 22202

Office of the Director, Defense Research and Engineering
Lab Management & Tech Transition
ATTN: SBIR Program Manager
3040 Defense Pentagon
Washington, DC 20301-3040

Defense Threat Reduction Agency
ATTN: AM/SADBU, Mr. Bill Burks
45045 Aviation Drive
Dulles, VA 20166-7517

US Special Operations Command
ATTN: SOSB/Ms Karen L. Pera
7701 Tampa Point Blvd.
MacDill AFB, FL 33621-5323

National Imagery and Mapping Agency
Kathleen Morrish
Mail-Stop: P-53
12310 Sunrise Valley Drive
Reston, VA 20191-3449

REQUEST FOR COPIES OF THIS FORM:

Additional forms may be downloaded from our Home Page (http://www.acq.osd.mil/sadbu/sbir). They may also be obtained from your State SBIR Organization (Reference D) or:

DoD SBIR Support Services
2850 Metro Drive, Suite 600
Minneapolis, MN 55425-1566
(800) 382-4634

Reference C
DoD SBIR Solicitation 00.1

Proposer: If you wish to be notified that your proposal has been received, please submit this form with a stamped, self-addressed envelope.

Remember to Stamp Your Self-Addressed Envelope!

TO: ____

____

____
Fill in firm's name and mailing address

SUBJECT: SBIR Solicitation No. 00.1

Topic No. ______________
Fill in Topic No.

Proposal Title ____
Fill in the Title of Your Proposal

This is to notify you that your proposal in response to the subject solicitation and topic number has been received by

____
Fill in name of organization to which you will send your proposal.

____ ______________
Signature by receiving organization Date

Associate Directors of Small Business assigned at Defense Contract Management Districts (DCMD):
(DCMD EAST -- http://www.dcmde.dla.mil; DCMD WEST -- http://www.dcmdw.dla.mil)

DCMD EAST (DCMDE-DU)
ATTN: Steven T. Shea
495 Summer Street, 8th Floor
Boston, MA 02210-2184
(617) 753-4318
(617) 7533174 (FAX)
bdu1150@dcmde.dla.mil

DCMC Atlanta (DCMDE-GADU)
ATTN: Jim Masone
805 Walker Street, Suite 1
Marietta, GA 30060-2789
(770) 590-6197
(770) 590-6551 (FAX)
jmasone@dcmde.dla.mil

DCMC Lockheed Martin Marietta (DCMDE-RHD)
ATTN: Erma A. Peacock
86 South Cobb Drive, Building B-2
Marietta, GA 30063-0260
(770) 494-2016
(770) 494-7883 (FAX)
epeacock@dcmde.dla.mil

DCMC Baltimore (DCMDE-GTDU)
ATTN: Gregory W. Prouty
217 East Redwood St.
Baltimore, MD 21202
(410) 962-9735
(410) 962-3349 (FAX)
gprouty@demde.dla.mil

DCMC Birmingham (DCMDE-GLDU
ATTN: Jim W. Brown
Burger Phillips Center
1910 3rd Avenue, N., Suite 201
Birmingham, AL 35203-3514
(205) 716-7403
(205) 716-7875 (FAX)
jibrown@dcmde.dla.mil

DCMC Boston (DCMDE-GFDU)
ATTN: Philip R. Varney
495 Summer Street
Boston, MA 02210-2138
(617) 753-3467/4110
(617) 753-4005 (FAX)
pvarney@dcmde.dla.mil

DCMC Indianapolis (DCMDE-GIDU)
ATTN: D. Middleton
8899 E 56th Street
Indianapolis, IN 46249-5701
(317) 510-2015
(317) 510-2348 (FAX)
dmiddleton@dcmde.dla.mil

DCMC Clearwater (DCMDE-GCDU)
ATTN: Sandra Scanlan
Gadsen Building
9549 Koger Blvd., Suite 200
St. Petersburg, FL 33702-2455
(727) 579-3093
(727) 579-3106 (FAX)
sscanlan@dcmde.dla.mil

DCMC Cleveland (DCMDE-GZDU)
ATTN: Catharine H. Szlembarski
555 E 88th Street
Bratenah, OH 44108-1068
(216) 681-1571
(216) 681-1719 (FAX)
cszlembarski@dcmde.dla.mil

DCMC Dayton (DCMDE-GYDU)
ATTN: Thomas E. Watkins
1725 Van Patton Drive, Building 30, Area C
Wright-Patterson AFB, OH 45433-5302
(937) 656-3104
(937) 656-3228 (FAX)
twatkins@dcmde.dla.mil

DCMC Detroit (DCMDE-GJDU)
ATTN: David C. Boyd
Building 231
Warren, MI 48397-5000
(810) 574-4474
(810) 574-6078 (FAX)
dboyd@dcmde.dla.mil

DCMC Hartford (DCMDE-GUDU)
ATTN: Carl Cromer
130 Darlin Street
East Hartford, CT 06108
(860) 291-7705
(860) 291-7779 (FAX)
ccromer@dcmde.dla.mil

DCMC Long Island (DCMDE-GGDU)
ATTN: Eileen Kelly
605 Stewart Ave
Garden City
Long Island, NY 11530-4761
(516) 228-5722
(516) 228-5938 (FAX)
bvc2251@dcrb.dla.mil

DCMC Syracuse (DCMDE-GSDU)
ATTN: Ralph Vinciguerra
615 Erie Blvd. West
Syracuse, NY 13204
(315) 448-7897
(315) 448-7914 (FAX)
bsu6449@dcmde.dla.mil

DCMC New York (DCMC-GNDU)
ATTN: John Castellane
Ft. Wadswoth
207 New York Avenue
Staten Island, NY 10305-5013
(718) 390-1016
(718) 390-1020 (FAX)
bvn3724@dcmde.dla.mil

DCMC Orlando (DCMDE-GODU)
ATTN: Barbara Gaines
3555 Maguire Blvd
Orlando, FL 32803-3726
(407) 228-5149
(407) 228-5221 (FAX)
bgaines@dcmde.dla.mil

DCMC Pittsburgh (DCMDE-GPDU)
ATTN: David Chapman
1612 Federal Building
1000 Liberty Avenue
Pittsburgh, PA 15222-4190
(412) 395-5977
(412) 395-5907 (FAX)
dchapman@dcmde.dla.mil

DCMC Springfield (DCMDE-GXDU)
ATTN: Otis Boggs
Building 1, ARDEC
Picatinny, NJ 07806-5000
(973) 724-8204
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Standard Form 298 (Rev. 2-89)

DoD Fast Track Guidance

This paper contains DoD's official guidance on what types of relationships between a small company and outside investors in the company qualify as an investment under the SBIR and STTR Fast Track ("Fast Track investment"). It includes specific examples of company-investor relationships that we have been asked about and our official responses on whether these relationships qualify as a Fast Track investment. If you have questions about whether a particular company-investor relationship qualifies, please contact the DoD SBIR/STTR Help Desk (tel. 800/382-4634, fax 800/462-4128, e-mail SBIRHELP@us.teltech.com). The Help Desk will refer any policy or substantive questions to appropriate DoD personnel for an official response.

I. General Guidance on What Qualifies As A "Fast Track Investment"

- The investor must be an "outside investor," which may include such entities as another company, a venture capital firm, an individual "angel" investor, a non-SBIR/non-STTR government program, or any combination of the above. It does not include the owners of the small business, their family members, and/or "affiliates" of the small business, as defined in Title 13 of the Code of Federal Regulations (C.F.R.), Section 121.103. As discussed in that Section:

  - Concerns are affiliates of each other when one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.
  - [We] consider factors such as ownership, management, previous relationships with or ties to another concern, and contractual relationships, in determining whether affiliation exists.
  - Individuals or firms that have identical or substantially identical business or economic interests, such as family members, persons with common investments, or firms that are economically dependent through contractual or other relationships, may be treated as one party with such interests aggregated.

  Although DoD is guided by this definition of affiliation in the Code of Federal Regulations, we also exercise our own discretion in determining whether a particular entity qualifies as an "outside investor."

- The <u>investment</u> must be an arrangement in which the outside party provides cash to the small company in return for such items as: equity; a share of royalties; rights in the technology; a percentage of profit; an advance purchase order for products resulting from the technology; or any combination of the above. The investor's funds must pay for activities that further the development and/or commercialization of the company's SBIR technology (e.g., further R&D, manufacturing, marketing, etc.).

II. Specific examples of What Does and Does Not Qualify As a "Fast Track Investment"

<u>A. Examples of What Qualifies as an "Outside Investor"</u>

(1) Can a small company contribute its own internal funds to qualify for the Fast Track?

No. DoD is seeking outside validation of the commercial potential of the company's technology, and therefore requires that the funds come from an outside investor. Also, cash from an outside investor shows up plainly on the company's books and therefore can be more readily verified than a company's own matching contribution.

(2) Company A spins off company B, which wins a phase I SBIR award. Company A then wants to contribute matching funds to qualify company B for the Fast Track. Can A be considered an outside investor for purposes of the Fast Track?

In making our determination of whether company A is an outside investor, we would be guided by the definition of "affiliates" in 13 C.F.R. Sec. 121.103, discussed above. Our presumption is that in this example A and B would be considered "affiliates," and that A would therefore not be an outside investor for purposes of the Fast Track. However, that presumption could be rebutted by showing, for example, that the spin-off occurred several years ago and that A and B do not exercise control over one another, do not have common ownership or management, have different business interests, etc.

(3) Small company S wins a phase I SBIR award. The president of S is a major shareholder in another company Y, which wants to contribute matching funds to qualify S for the Fast Track. Can Y be considered an outside investor?

Our presumption is that Y would not be considered an outside investor. Our determination would be guided by whether the president's stake in Y is large enough that S and Y would be considered "affiliates" under 13 C.F.R. Sec.121.103. Subsection (c.) of Section 121.103 specifically discusses affiliation based on stock ownership:

c. Affiliation based on stock ownership.
   1. A person is an affiliate of a concern if the person owns or controls, or has the power to control 50 percent or more of its voting stock, or a block of stock which affords control because it is large compared to other outstanding blocks of stock.
   2. If two or more persons each owns, controls or has the power to control less than 50 percent of the voting stock of a concern, with minority holdings that are equal or approximately equal in size, but the aggregate of these minority holdings is large as compared with any other stock holding, each such person is presumed to be an affiliate of the concern. If S and Y are found to be affiliates, we would determine that Y is not an outside investor.

(4) Does the outside investor have to be a single entity (e.g., a single venture capital firm) or can it be more than the entity (e.g., two angel investors and a venture capital firm)?

It can be more than one entity.

(5) Small company A contributes matching funds to small company B in order to qualify B for the Fast Track, and, at the same time, B contributes matching funds to A in order to qualify A for the Fast Track. Do A and B qualify as outside investors under the Fast Track?

No. A and B's relationship is such that their investment in each other would not provide outside validation of the commercial potential of their respective SBIR projects. We would therefore not consider them to be outside investors for purposes of the Fast Track.

(6) Can the brother of an employee of small company S contribute funds to qualify S for the Fast Track?

Probably not. Again, we would be guided by the definition of "affiliates" in 13 C.F.R. Sec. 121.103. The brother presumptively would be an affiliate of company S and not an outside investor.

(7) Venture capital firm V currently is a 22 percent shareholder in small company S. Can V invest additional funds in S to qualify S for the Fast Track?

Our presumption is yes. In making our determination, we would be guided by whether V and S are "affiliates," as defined in 13 C.F.R. Sec. 121.103. Section 121.103 provides (in subsection (b)(5)) that a venture capital firm is not affiliated with a company if the venture capital firm does not control the company -- e.g., by owning more than 50 percent of the stock of a small company (prior to its investment under the Fast Track), as described in 13 C.F.R. 107.865.

(8) Large company L makes a cash investment in small company S, and then serves as a subcontractor to S on an SBIR project. Can L's investment in S count as a matching contribution for purposes of the Fast Track?

Only L's cash investment net of its subcontracting effort can count as matching funds for purposes of the Fast Track. For example, if L invests $750,000 in S and subcontracts with S for $250,000, only L's net contribution ($500,000) can count as matching funds for purposes of the Fast Track.

(9) Company Y makes a cash investment in small company S for purposes of the Fast Track, and also enters into a separate contract with S under which Y provides certain goods/services to S in return for $500,000. Can Y's cash investment in S count as a matching contribution for purposes of the Fast Track?

As in the previous example, only Y's cash investment net of the $500,000 it receives from S can count as matching funds for purposes of the Fast Track. However, if the separate contract between Y and S pre-dates S's submission of its phase I SBIR proposal, Y's entire cash investment can count as matching funds for purposes of the Fast Track.

(10) A group of investors wishes to invest funds in small company S to qualify S for the Fast Track. One of the investors is the mother of S's president, who wants to contribute $50,000 toward the effort. Can the group's investment in S count as a matching contribution to qualify S for the Fast Track?

The mother's investment of $50,000 does not count, because she is not an outside investor (see item (6) above). Contributions of the other investors can count provided that they meet the other conditions for the Fast Track (e.g., each must be an outside investor).

B. Examples of What Qualifies as an "Investment"

(1) Can a loan from an outside party qualify as an "investment" for purposes of the Fast Track?

No. The rationale behind the Fast Track is that an outside party is betting on the company's success in bringing the technology to market -- not just its ability to repay a loan.

(2) How about a loan that is convertible to equity?

A loan that is convertible to equity at the company's discretion would count as an investment under the following circumstances: (1) the loan is provided by a public entity (e.g., a state agency), or (2) the loan is provided by a private entity, and the SBIR company actually converts the loan to equity before the end of phase I.

(3) Can in-kind contributions from an outside investor count as matching funds under the Fast Track?

No. The matching contribution must be in cash. A cash contribution is a stronger signal of the outside investor's interest in the technology, and can be readily verified.

(4) Can a purchase order from an outside investor count as a matching contribution under the Fast Track?

An advance purchase order for new products resulting from the SBIR project can count as a matching contribution under the Fast Track. The purchase order must be for one or more products directly resulting from the SBIR project (including, for example, a duplicate of the prototype that will be delivered to DoD at the end of phase II). The investor must provide its cash payment to the small business during phase II, within the time frame set out in the solicitation (section 4.5). To ensure that the investor's funds are "at risk," the payment cannot be refundable to the investor if the product is not delivered or does not work.

(5) Can the funds raised from an initial public offering (IPO) count as matching funds for purposes of the Fast Track?

Yes, as long as the offering memo indicates that a portion of the funds from the IPO will pay for work (e.g., R&D, marketing, etc.) that is related to the SBIR project.

(6) If large company L pays small company S for work related to S's SBIR project and expects a deliverable (goods or services) from S in return, would that qualify as an "investment"?

With the exception of an advance purchase order (discussed in (4) above), this arrangement would not qualify as an investment, for the same reason a loan does not qualify. Specifically, in this situation the large company is not betting on the small company's success in bringing the technology to market, but merely on its ability to provide the deliverable.

C. Examples Re: Timing/Logistics of the Fast Track Investment

(1) Can entity E's investment in small company S during the first month of S's phase I SBIR project count as a matching contribution to qualify S for the Fast Track?

Yes, provided that E is an outside and that the other Fast Track conditions are met. The investment can occur any time after the start of the phase I project.

(2) Small company A, which has won a phase I award, spins off small company B to commercialize the SBIR technology. A then convinces angel investor I to invest funds in B. Can I's investment in B count as a matching contribution to qualify A for the Fast Track?

For I's investment in B to qualify A for the Fast Track, DoD must determine that A and B are substantially the same entity, as evidenced, for example, by their meeting the definition of "affiliates" in 13 C.F.R. Sec.121.103.
If DoD determines that A and B are substantially the same entity, I's investment in B could qualify A for the Fast Track. Of course, the parties must also meet the other conditions for the Fast Track (e.g., I must be an outside investor).

(3) Small company S is collaborating with a university on an STTR project. Investor I wishes to provide funds to the university in order to qualify S for the STTR Fast Track. Can I's investment in the university count as a matching contribution to qualify S for the Fast Track?

In order to qualify S for the STTR Fast Track, I's investment of funds must be in small company S, not in the university. S can then subcontract some of the funds to the university. The rationale is that a cash investment in the small company is a very strong indication of commercial potential, whereas an investment in the university is less so.

(4) Must the activities funded by the investor be included in the statement of work for the small company's phase II contract?

No. The investor's funds must pay for activities that further the development and/or commercialization of the company's SBIR technology (e.g., further R&D, manufacturing, marketing, etc.), but these activities need not be included in the phase II contract's statement of work. In practice, funds from private sector Fast Track investors generally are not included in the phase II contract's statement of work, whereas funds from government Fast Track investors (such as DoD acquisition programs) sometimes are.

DoD's Key Technology Areas
(from the Defense Technology Area Plan)

The following is an outline of the Defense Technology Area Plan.

1.	**Air Platforms** -- Fixed-Wing Vehicles; Rotary-Wing Vehicles; Integrated High Performance Turbine Engine Technology (IHPTET); Aircraft Power; High-Speed Propulsion and Fuels.
2.	**Chemical / Biological Defense** -- CB Detection; CB Protection; CB Decontamination; CB Modeling and Simulation; Medical Chemical Defense; Medical Biological Defense.
3.	**Information Systems Technology** – Decisionmaking; Modeling & Simulation Technology; Information Management Assurance & Distribution; Seamless Communication; Computing and Software Technology.
4.	**Ground and Sea Vehicles** -- Ground Vehicles; Surface Ship Combatants; Submarines.
5.	**Materials / Processes** -- Materials and Processes for Survivability, Life Extension, and Affordability; Manufacturing Technology; Civil Engineering; Environmental Quality.
6.	**Biomedical** -- Infectious Diseases of Military Importance; Combat Casualty Care; Military Operational Medicine; Medical Radiological Defense.
7.	**Sensors, Electronics and Battlespace Environment** -- Radar Sensors; Electro-Optical Sensors; Acoustic Sensors; Automatic Target Recognition; Integrated Platform Electronics; Radio-Frequency Components; Electro-Optical Technology; Microelectronics; Electronic Materials; Electronics Integration Technology; Terrestrial Environments; Ocean Battlespace Environments; Lower Atmosphere Environments; Space/Upper Atmosphere Environments.
8.	**Space Platforms** -- Launch Vehicles; Space Vehicles; Propulsion [Integrated High-Payoff Rocket Propulsion Technology (IHPRPT)].
9.	**Human Systems** - - Information Display and Performance Enhancement; Design Integration and Supportability; Warrior Protection and Sustainment; Personnel Performance and Training.
10.	**Weapons** - - The Weapons area has three broad categories. 1) Conventional Weapons: Countermine/Mines; Guidance and Control; Guns; Missiles; Ordnance; Undersea Weapons; and Weapon Lethality / Vulnerability. 2) Directed-Energy Weapons: Lasers; and High-Power Microwave. 3) Electronic Warfare: Threat Warning; Self-Protection; and Mission Support.
11.	**Nuclear Technology** - - Warfighter Support; Systems Effects and Survivability; Test and Simulation Technology; Scientific and Operational Computing.

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