Naval Postgraduate School
Monterey, California 93943-5138

NPS-09-02-005

SUMMARY OF RESEARCH 2000

Department of Physics

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Chair

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Associate Chair for Research

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Prepared for: Naval Postgraduate School
Monterey, CA 93943-5000

NAVAL POSTGRADUATE SCHOOL
Monterey, California

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Dean of Research

REPORT DOCUMENTATION PAGE

Form approved
OMB No 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 2001	Summary Report, 1 October 1999-30 September 2000

4. TITLE AND SUBTITLE
Summary of Research 2000, Department of Physics

5. FUNDING

6. AUTHOR(S)

Faculty of the Naval Postgraduate School

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Postgraduate School
Monterey, CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

NPS-09-02-005

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey, CA 93943-5000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
The views expressed in this report are those of the authors and do not reflect the official policy or position of the Department of Defense or U.S. Government.

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

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13. ABSTRACT (Maximum 200 words.)

This report contains project summaries of the research projects in the Department of Physics. A list of recent publications is also included, which consists of conference presentations and publications, books, contributions to books, published journal papers, and technical reports. Thesis abstracts of students advised by faculty in the Department are also included.

14. SUBJECT TERMS

15. NUMBER OF PAGES
66

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

NSN 7540-01-280-5800

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std 239-18

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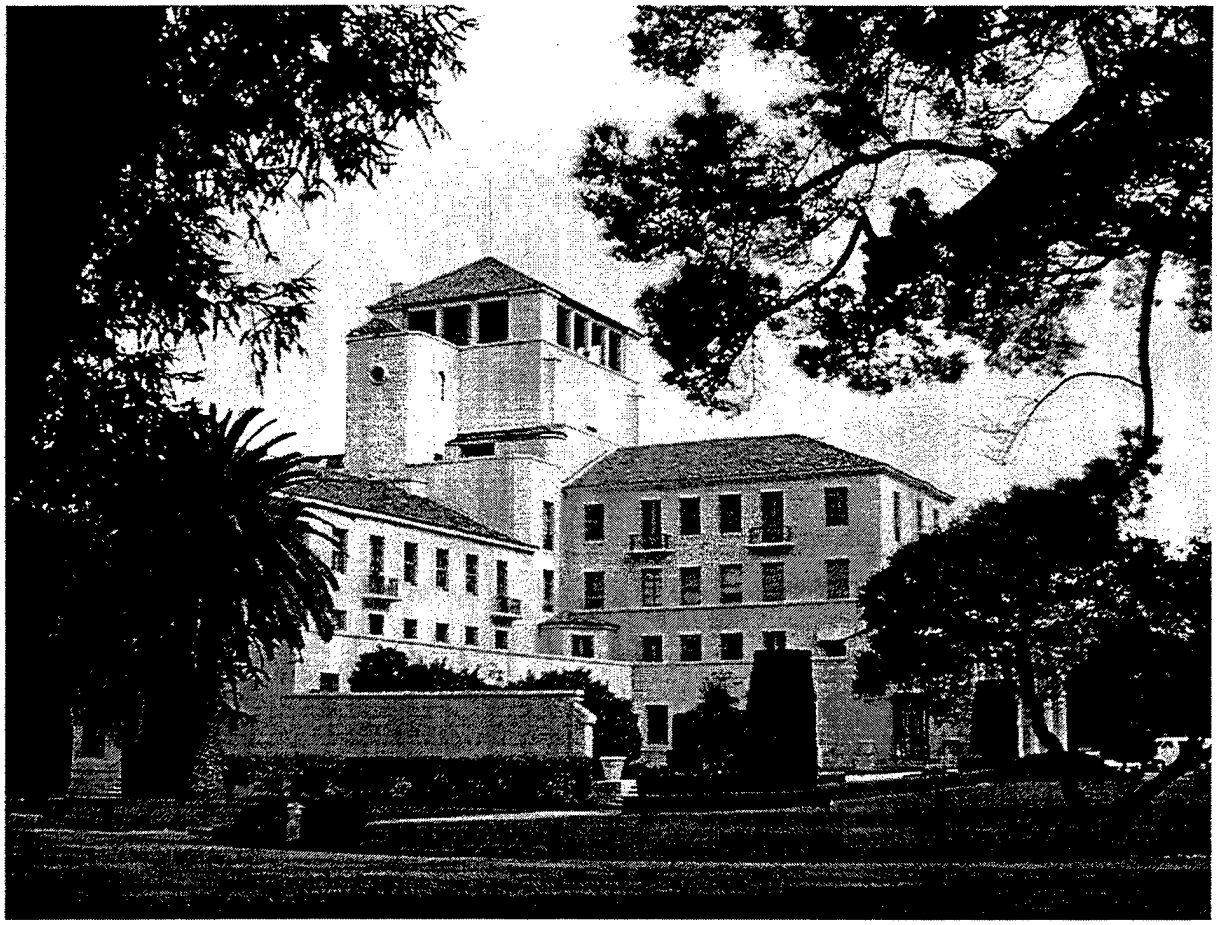

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PREFACE

Research at the Naval Postgraduate School is carried out by faculty in the four graduate schools (School of International Graduate Studies, Graduate School of Operations and Information Sciences, Graduate School of Engineering and Applied Sciences, and Graduate School of Business and Public Policy) and three Research Institutes (The Modeling, Virtual Environments, and Simulation (MOVES) Institute, Institute for Information Superiority and Innovation (I2SI), and Institute for Defense System Engineering and Analysis (IDSEA). This volume contains research summaries for the projects undertaken by faculty in the Department of Physics during 2000. The summary also contains thesis abstracts for those students advised by Physics faculty during 2000.

Questions about particular projects may be directed to the faculty Principal Investigator listed, the Department Chair, or the Department Associate Chair for Research. Questions may also be directed to the Office of the Associate Provost and Dean of Research. General questions about the Naval Postgraduate School Research Program should be directed to the Office of the Associate Provost and Dean of Research at (831) 656-2099 (voice) or research@nps.navy.mil (e-mail). Additional information is also available at the RESEARCH AT NPS website, http://web.nps.navy.mil/~code09/

Additional published information on the Naval Postgraduate School Research Program can be found in:

- *Compilation of Theses Abstracts:* A quarterly publication containing the abstracts of all unclassified theses by Naval Postgraduate School students.
- *Naval Postgraduate School Research*: A tri-annual (February, June, October) newsletter highlighting Naval Postgraduate School faculty and student research.
- *Summary of Research*: An annual publication containing research summaries for projects undertaken by the faculty of the Naval Postgraduate School.

This publication and those mentioned above can be found on-line at:
http://web.nps.navy.mil/~code09/publications.html.

INTRODUCTION

The research program at the Naval Postgraduate School exists to support the graduate education of our students. It does so by providing military relevant thesis topics that address issues from the current needs of the Fleet and Joint Forces to the science and technology that is required to sustain the long-term superiority of the Navy/DoD. It keeps our faculty current on Navy/DoD issues, to maintain the content of the upper division courses at the cutting edge of their disciplines. At the same time, the students and faculty together provide a very unique capability within the DoD for addressing warfighting problems. Our officers must be able to think innovatively and have the knowledge and skills that will let them apply technologies that are being rapidly developed in both the commercial and military sectors. Their unique knowledge of the operational Navy, when combined with a challenging thesis project that requires them to apply their focused graduate education, is one of the most effective methods for both solving Fleet problems and instilling the life-long capability for applying basic principles to the creative solution of complex problems.

The research program at the Naval Postgraduate School consists of both reimbursable (sponsored) and institutionally funded research. The research varies from very fundamental to very applied, from unclassified to all levels of classification.

- Reimbursable (Sponsored) Program: This program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policymakers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. The sponsored program utilizes Cooperative Research and Development Agreements (CRADAs) with private industry, participates in consortia with government laboratories and universities, provides off-campus courses either on-site at the recipient command, by VTC, or web-based, and provides short courses for technology updates.

- Naval Postgraduate School Institutionally Funded Research (NIFR) Program: The institutionally funded research program has several purposes: (1) to provide the initial support required for new faculty to establish a Navy/DoD relevant research area, (2) to provide support for major new initiatives that address near-term Fleet and OPNAV needs, (3) to enhance productive research that is reimbursably sponsored, and (4) to cost-share the support of a strong post-doctoral program.

In 2000, the level of research effort overall at the Naval Postgraduate School was 137 faculty work years and exceeded $43 million. The reimbursable program has grown steadily to provide the faculty and staff support that is required to sustain a strong and viable graduate school in times of reduced budgets. In FY2000, over 93% of the research program was externally supported. A profile of the sponsorship of the Naval Postgraduate School Research Program in FY2000 is provided in Figure 1.

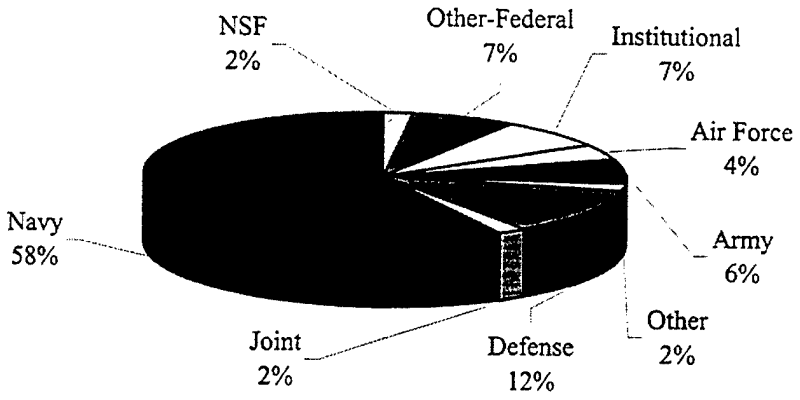


Figure 1. Profile of NPS Research and Sponsored Programs ($43M)

The Office of Naval Research is the largest Navy external sponsor. The Naval Postgraduate School also supports the Systems Commands, Warfare Centers, Navy Labs and other Navy agencies. A profile of external Navy sponsorship for FY2000 is provided in Figure 2.

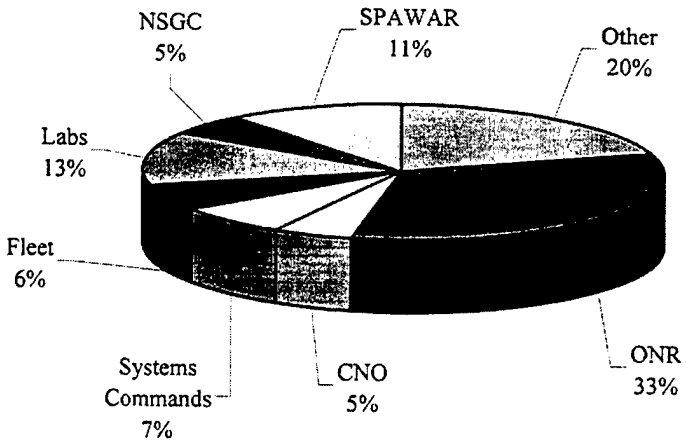


Figure 2. Navy External Sponsors of NPS Research and Sponsored Programs ($25M)

These are both challenging and exciting times at the Naval Postgraduate School and the research program exists to help ensure that we remain unique in our ability to provide education for the warfighter.

DAVID W. NETZER
Associate Provost and Dean of Research

December 2001

DEPARTMENT OF PHYSICS

WILLIAM MAIER
CHAIR

DEPARTMENT SUMMARY

OVERVIEW:

The Department of Physics has unique resources and faculty expertise dedicated to Weapon Systems Technologies.

CURRICULA SERVED:

- Combat Systems Science and Technology
- Applied Physics
- Engineering Acoustics

DEGREES GRANTED:

- Master of Science in Physics
- Master of Science in Applied Physics
- Master of Science in Engineering Acoustics
- Doctor of Philosophy

RESEARCH THRUSTS:

- Optical and Electromagnetic Signal Propagation, Detection and Sensor Systems
- Conventional and Nuclear Weapons and their Effects
- Underwater Acoustics
- Free Electron Laser Physics
- Physical Acoustics
- Solid State Physics

RESEARCH CHAIR:

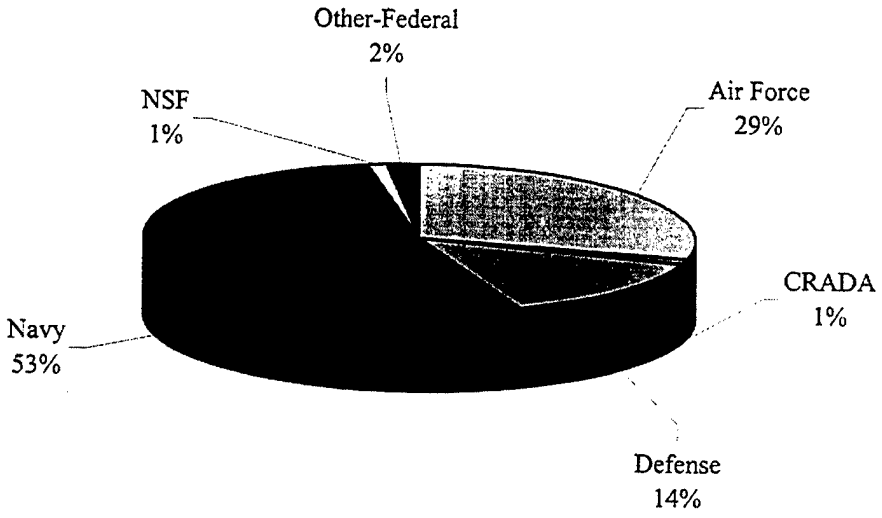
- Lawrence Livermore National Laboratory Chair Professor
- Engineering Acoustics Chair Professor

RESEARCH FACILITIES:

- The Physics Laboratories are equipped to carry on instruction and research work in acoustics, atomic, and molecular physics, electro-optics, spectroscopy, laser physics, computational physics, optical propagation, sensor physics and transient electrical discharges.
- The Optical Physics and Sensors Laboratory uses imaging, spectroscopic and sensing systems from far infrared to ultraviolet wavelengths, including instrumentation for seagoing, airborne and ground-based measurements.
- The Acoustics Laboratory equipment includes a large anechoic chamber, a small reverberation chamber and a multiple-unit acoustics laboratory for student experimentation in acoustics in air. Sonar equipment, test and wave tanks and instrumentation for investigation in underwater sound comprise the Underwater Acoustics Laboratory, a scale-model of a shallow water waveguide for the study of environmentally adaptive sonar and high-speed digital acoustic communication. The Physical Acoustics Laboratories are equipped with a variety of modern data collection and processing equipment.

RESEARCH PROGRAM-FY2000:

The Naval Postgraduate School's research program exceeded $43 million in FY2000. Over 93% of the Naval Postgraduate School Research Program is externally funded. A profile of the external research sponsors for the Department of Physics is provided below along with the size of the FY2000 externally funded program.



Size of Program: $1928K

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FREE ELECTRON LASER DAMAGE FOR SHIP DEFENSE

W. B. Colson, Distinguished Professor
Department of Physics
Sponsor: Thomas Jefferson National Accelerator Facility and Naval Postgraduate School

OBJECTIVE: Research the laser damage from a free electron laser with short picosecond pulses.

SUMMARY: The power density required for defense against sea-skimming missiles is 10 kW per square centimeter. The free electron laser at Thomas Jefferson National Accelerator Facility was used at the required power density to observe and measure the damage to several types of materials. The damage rates were analyzed with the goal of determining whether the unique short pulse format of the free electron lasers would damage materials more efficiently than the more typical cw laser.

PUBLICATIONS:

Colson, W.B., "Short-Wavelength Free Electron Lasers in 2000," *Nuclear Instruments and Methods in Physics Research,* (to be published in 2001.)

Thomson, R.W., Jr., Short, L.R., McGinnis, R.D., Colson, W.B., Shinn, M.D., Gubeli, J.F., Jordan, K.C., Hill, R.A., Biallas, G.H., Walker, R.L., Neil, G.R., Benson, S.V., and Yunn, B.C., "TJNAF Free Electron Laser Damage Studies," *Nuclear Instruments and Methods in Physics Research,* (to be published in 2001.)

McGinnis, R.D., Thomson, R.W., Jr., Short, L.R., Herbert, P.A., Lampiris, D., Christodoulou, A., Colson, W.B., Shinn, M.D., Neil, G.R., Benson, S.V., Gubeli, J. F., Evans, R., and Jordan, K.C., "Free Electron Laser Material Damage Studies," Naval Postgraduate School Technical Report, NPS-PH-01-001, 2000.

PRESENTATION:

Colson, W.B., "Short-Wavelength Free Electron Lasers in 2000," poster paper at the Twenty Second International Free Electron Laser Conference, Duke University, Durham, NC, August 2000.

THESIS DIRECTED:

McGinnis, R.D., "Free Electron Laser Development for Directed Energy," Ph.D. Dissertation, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Directed Energy Weapons

KEYWORDS: Free Electron Laser, Industrial Laser Processing

HIGH POWER FREE ELECTRON LASER FOR SHIP DEFENSE

W. B. Colson, Professor
Department of Physics
Sponsor: Naval Sea Systems Command

OBJECTIVE: In order to develop the technology for using free electron lasers to defend ships against sea-skimming missiles, the high average power infrared wavelength free electron laser at the Thomas Jefferson National Accelerator Facility, Newport News, VA is studied.

SUMMARY: The Jefferson National Accelerator Facility has developed superconducting accelerator to power a free electron laser with infrared wavelengths. We studied design modifications that would increase the laser power from 1,700 Watts to 10,000 Watts. NPS research studied the inverse tapered undulator with the goal of taking the free electron laser to higher average power.

PUBLICATIONS:

Colson, W.B. and McGinnis, R.D., "The Free Electron Laser With Inverse Taper," *Nuclear Instruments and Methods in Physics Research,* 49-52, 2000.

McGinnis, R.D., Blau, J., Colson, W.B., Massey, D., Crooker, P.P., Christodoulou, A., and Lampiris, D., "Simulations of the TJNAF 10kW Free Electron Laser," *Nuclear Instruments and Methods in Physics Research,* (to be published in 2001).

Christodoulou, A., Lampiris, D., Colson, W.B., Crooker, P.P., Blau, J., McGinnis, R.D., Benson, S.V., Gubeli, J.F., Neil, G.R., "Simulations of the TJNAF FEL With Tapered and Inversely Tapered Undulators," *Nuclear Instruments and Methods in Physics Research,* (to be published in 2001).

PRESENTATIONS:

Colson, W.B. and McGinnis, R.D., "The Free Electron Laser With Inverse Taper," poster paper at the Twenty Second International Free Electron Laser Conference, Duke University, Durham, NC, August 2000.

McGinnis, R.D., Blau, J., Colson, W.B., Massey, D., Crooker, P.P., Christodoulou, A., and Lampiris, D., "Simulations of the TJNAF 10kW Free Electron Laser," poster paper at the Twenty-Second International Free Electron Laser Conference, Duke University, Durham, NC, August 2000.

Christodoulou, A., Lampiris, D., Colson, W. B., Crooker, P.P., Blau, J., McGinnis, R.D., Benson, S.V., Gubeli, J.F., and Neil, G.R., "Simulations of the TJNAF FEL With Tapered and Inversely Tapered Undulators," poster paper at the Twenty Second International Free Electron Laser Conference, Duke University, Durham, NC, August 2000.

THESES DIRECTED:

Massey, D.S., "Simulations of Darmstadt Free Electron Laser and a Comparison of High Gain Free Electron Lasers," Masters Thesis, Naval Postgraduate School, September 2000.

Christodoulou, A., "Simulations of the TJNAF Free Electron Laser With Negative Taper and Laser Damage Studies," Masters Thesis, Naval Postgraduate School, September 2000.

Lampiris, D., "Simulations of the TJNAF Free Electron Laser With a Tapered Undulator and Experimental Results of Laser Damage," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Directed Energy Weapons

KEYWORDS: Free Electron Laser, Industrial Laser Processing

INFRA-RED RESEARCH: THERMAL IMAGING MODELS

A.W. Cooper, Professor
Department of Physics
Sponsor: Naval Sea Systems Command

OBJECTIVE: To evaluate the potential of polarization filtering in target discrimination range improvement in FLIR imagery, and to compare available TDA FLIR range prediction models for potential joint service use. This project is continuing.

SUMMARY: NPS polarized measurements showed improved IR target/background contrast for ship targets. Previous TDA models to demonstrate improvement in target detection or identification ranges have been inconsistent in the treatment of target and sea radiances, and results have been inconclusive.

During this year modeling was improved with the addition of the MUSES (MUltiService Electro-optic Signature) ship signature model and an operational polarized MRTD function for the sensor. The polarized version of the SEARAD code was used for sea and atmospheric extinction and path radiance. A Mid Latitude Summer at sea weather file predicted 33.5% increase in detection range. +2% and +8% degree of polarization (i.e. plane of polarization vertical) on the target increased this to 35.6% and 39.8% respectively. This model should now be applied for other targets and climatic conditions. The U.S. Army ACQUIRE Tactical Decision Aid FLIR field performance code was compared to the Navy/Air Force WinEOTDA code for Joint Service operations in littoral waters, using a naval target and a weather data set from the Gulf of Oman. Differences in the inputs, algorithms, and predictions of the codes were analyzed, using a FLIR92 model output for a generic second-generation sensor in both models. WinEOTDA showed consistently longer detection ranges than ACQUIRE, and were significantly more sensitive to sensor altitude, but less sensitive to target aspect angle.

THESES DIRECTED:

Celalettin, G., "Evaluation of Tactical Decision Aid Programs for Prediction of Field Performance of IR Sensors," Masters Thesis, Naval Postgraduate School, September 2000.

Yildirim, M.Y., "Modeling Second Generation FLIR Sensor Detection, Recognition and Identification Range with Polarization Filtering," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Sensors, Battlespace Environments, Modeling and Simulation

KEYWORDS: Atmospheric Optics, Infrared Sensors, FLIR, TDA

SPECTRAL IMAGERY IN THE NEAR-ULTRAVIOLET

D.S. Davis, Associate Professor
Department of Physics
Sponsor: Defense Intelligence Agency

OBJECTIVE: The objectives of this project were to continue calibrations of the Naval Postgraduate School Ultraviolet Imaging Spectrometer (NUVIS) and to undertake the development of an improved next generation UV imaging spectrometer.

SUMMARY: Most of the project's objectives were met. When we completed the analysis of the sulfur dioxide calibration data recorded by NUVIS, it was realized that substantial gaps remain in the available spectral abundance data set, both in the published literature and our in-house data. Those gaps are in both the extremely low-abundance and middle-high abundance regimes. Therefore, during the spring and summer of CY01 we are going to attempt to fill in those gaps. Development of a next-generation successor instrument, now designated as LINUS (Lineate Imaging Near-ultraviolet Spectrometer) are proceeding well. The optical subsystems of the instrument have been completely designed, and we are awaiting the delivery of some custom-fabricated components from an external supplier. The mechanical and opto-mechanical designs of LINUS are now complete, and about 75% of the hardware has been procured or fabricated in-house. We currently plan "first light" tests in late spring of 2001, with field test to follow by late summer.

THESIS DIRECTED:

Kompatzki, R.C., "Design and Development of the Image Scanner for the Lineate Imaging Near-ultraviolet Spectrometer (LINUS)," Masters Thesis, Naval Postgraduate School, December 2000.

OTHER:

The following project deliverables have been produced, but are considered proprietary to the project: 1) High resolution platinum hollow cathode emission line spectra for UV wavelength calibrations, covering

the entire near-ultraviolet spectral region. The voluminous plots and tabulated data have been generated from the NIST Atomic Data online database. 2) *Mathematica* computer software to generate and to display the platinum data. 3) Extensive optical design studies for LINUS, using *Optica* and *ZEMAX*. A set of opto-mechanical and mechanical design drawings, in *AutoCAD* form, for LINUS

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Sensors, Optics, Ultraviolet, Environmental Monitoring, Remote Sensing

SINKING OF A BODY DUE TO BUBBLES

Bruce Denardo, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School Research Initiation Program

OBJECTIVE: A closed body floats in a fluid when its average density is less than the density of the fluid. If gas bubbles are introduced into a liquid, the average density of the resultant fluid is reduced. If this new density is less than that of the body, then one might think that the body would sink. However, the bubbles also produce upward forces on the body, due to drag produced by the entrained flows in the fluid, and bubbles sticking to the body. It is thus not obvious whether the introduction of the bubbles can cause a floating body to sink, or, if sinking does occur, what the value of the average fluid density is required relative to the density of the body. Further uncertainty exists due to the substantial amount of turbulence that would occur. This possible sinking effect has been suggested as the cause of the demise of some ships: Large deposits of methane gas under the ocean floor could erupt and the resultant bubbles might sink a ship on the surface. Our objective was to measure the average fluid density required to sink a body, and to compare this to the average density of the body for different values of this density. This is necessary if a reliable prediction is to be made regarding the amount of bubbles that a ship can tolerate before sinking. Of future interest is the effect of bubbles on reducing the buoyant force on submerged bodies such as submarines and divers.

SUMMARY: We performed experiments to accurately measure the critical average fluid density of bubbly water required to barely sink a spherical body. The average density of the body was varied from 0.99 to 0.75 the density of water. Bubbles were generated over the entire cross section of the water column, which we refer to as a *closed* environment. A theory was developed to predict the critical average fluid density. The theory assumed a "shadow" region directly above the body where there are no bubbles, and neglected any drag or other possible forces other than static buoyancy. The experimental data are in reasonable agreement with the theory for low airflow rates. At greater airflow rates, the experimental average fluid density is less than the predicted value, which may be due to bubbles entering the shadow region as a result of turbulence. We also investigated bubbles in an *open* environment, which more accurately models the situation in an ocean. In this case, there was expected to be a much greater upward drag force on the body due to circulatory flow. However, our preliminary experiments indicated that this is not true. Further investigations are needed to resolve this.

PUBLICATION:

Denardo, B., PringLe., DeGrace, C., and McGuire, M., "When Do Bubbles Cause a Floating Body to Sink?" to be submitted to *American Journal of Physics*, 2001.

THESES DIRECTED:

DeGrace, C., "Sinking a Body With Bubbles in Closed and Open Environments," Masters Thesis, Naval Postgraduate School, December 2000.

Pringle, L., "Experimental Investigation of Sinking a Buoyant Body in Water with Bubbles," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Other (Bubbly Liquids)

KEYWORDS: Bubbly Liquids, Buoyancy

PARAMETRIC EXCITATION

Bruce Denardo, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School Research Initiation Program

OBJECTIVES: To investigate the feasibility of exciting a sound mode in a gas-filled resonator by parametric excitation (modulating a parameter upon which the resonance frequency depends). For this to occur, the drive amplitude must be greater than a threshold value that is inversely proportional to the quality factor of the mode. When this condition is met in any oscillator, the response amplitude grows exponentially until it is saturated by a nonlinearity of the system. Hence, large response amplitudes may be possible. This research may thus lead to the use of parametric drives in various practical devices such as thermoacoustic refrigerators, acoustic compressors, acoustic pumps, and intense underwater sound sources.

SUMMARY: Parametric excitation was previously attempted for a double Helmholtz resonator (two cavities connected by a neck). The threshold for excitation was not obtained due to the interesting fact that the quality factor of the mode decreased as a result of turbulence generated by the drive. This was the dissertation research of University of Mississippi Ph.D. candidate Wayne Prather (1999), whose work I supervised. An NPS student and I are currently conducting feasibility analyses of parametric excitation in longitudinal and cylindrical resonators that are geometrically modulated. We will also investigate the possibility of pulsing the medium of a resonator with microwaves or a laser.

DoD KEY TECHNOLOGY AREAS: Other (Acoustical Resonators, Nonlinear Oscillations)

KEYWORDS: Parametric Excitation, Parametric Instability, Nonlinear Oscillations

NON-RADIATING WAVE SOURCES

Bruce Denardo, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School Research Initiation Program

OBJECTIVES: A nonradiating wave source is one that generates waves over some region, but where no waves propagate outside the region. The nonradiation is not due to nonuniformity of the medium, but to destructive interference of the waves in the region of the source. Surprisingly, nonradiating sources have been predicted to exist, although none have been observed. Our goal was to construct several types of vibrating wire apparatus and observe nonradiating sources in one dimension. The work is important because it will indicate the extent to which nonradiating sources can occur in actual systems. Another objective was to perform numerical simulations in which the realistic effects of dissipation, nonuniformity, and nonlinearity are included. A possible future objective is to theoretically investigate nonradiating sources in two and three dimensions, and to explore the possibility applying the results to reduce the acoustical and electromagnetic emissions of vehicles such as submarines.

SUMMARY: We constructed an apparatus in which nichrome (resistive) wire is held under tension by a hanging weight, and an oscillatory current is fed through the wire. Part of the wire lies between the pole faces of a magnet, which exerts an oscillating force on the current in the wire. When the frequency of the current corresponds to an integral number of wavelengths over the length of the forcing region, nonradiation is predicted to occur: the wire should oscillate in the driven region, but be motionless outside this region. If the amplitude of the current is sufficiently large, the wire glows uniformly in the motionless region. The wire is cooled in regions where it is in motion, which reduces the glow. We observed the lowest two nonradiating excitation in this way. We also conducted extensive numerical simulations of nonradiating sources on a mass-and-spring lattice. In the ideal case in which dissipation, nonuniformity,

and nonlinearity are not present, our simulations are in essentially exact agreement with the theory. The presence of any of these effects causes radiation to "leak" from the driven region. Adjustments of the drive frequency and amplitude were shown to minimize this radiation.

PRESENTATION:

Denardo, B., "Nonradiating Wave Sources," contributed talk at Joint Meeting of Northern California/Nevada Sections of the American Association of Physics Teachers, Stanford University, Palo Alto, CA, 7-8 April 2000.

THESIS DIRECTED:

Miller, G., "Observations of Quasi-Nonradiating Wave Sources in One Dimension," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Other (Nonradiating Waves)

KEYWORDS: Nonradiating Waves, Noise Cancellation, Inverse Problem

EXECUTION OF TOTAL SHIP SYSTEMS ENGINEERING MEMORANDUM OF AGREEMENT

Robert C. Harney, Senior Lecturer
Department of Physics
Charles N. Calvano, Professor
David W. Byers, Visiting Professor
Department of Mechanical Engineering
Sponsor: Naval Sea Systems Command

OBJECTIVE: Continue the development of the interdisciplinary Total Ship Systems Engineering (TSSE) Program, exploring added opportunities for state-of-the-art education of officer students, increasing connectivity with operational analysis efforts in the Navy, fostering research into total ship systems engineering problems and processes, maintaining continuity and in-depth experience in the faculty, supporting NAVSEA in its efforts to conceive and explore future ship innovations, and working with NAVSEA to make the annual TSSE student capstone design project relevant to Navy needs.

SUMMARY: This is a multi-year activity. In CY2000, the TSSE faculty participated in numerous visits and discussions with NAVSEA and other key individuals involved in the "future Navy" to obtain programmatic guidance and foster relevance. These discussions included individuals at Headquarters NAVSEA, NSWC Carderock and Port Hueneme Divisions, the Naval Warfare Development Command, the Naval Undersea Warfare Center, the CNO Strategic Studies Group, the CNO Executive Panel, Marine Corps Concepts Development Center, and several departments of N8. The final report for the CY99 TSSE capstone design project (a surface warfare test ship) was completed and delivered to its NSWC Port Hueneme customer in January 2000. At the customer invitation, the TSSE faculty participated in a panel discussion on battlefield interoperability at an American Society of Naval Engineers meeting in June 2000. In light of the major efforts to define a Navy after Next, the FY2000 TSSE capstone design project was aligned with the Capabilities of the Navy After Next (CNAN) Study being promoted by the Naval Warfare Development Command. The students designed a combatant (called SEA LANCE) who was capable of laying the Expeditionary Grid (of remote sensors and remote-controlled weapons, which was briefed to a number of groups in December 2000. The final report will be delivered in March 2001. During the conduct of the TSSE project, the students involved other faculty at NPS to a greater degree than previously attempted. NPS' naval architects, electric power, radar cross-section, and naval campaign analysts all contributed substantially to the success of the project. To facilitate faculty development, a round-robin faculty exchange was arranged for September 2000 to August 2001. Professor Calvano went to the Royal College of Military Science at Shrivenham UK to teach systems engineering and understand the UK approach to systems engineering. David Byers was in turn assigned from Carderock to NPS to take over

Calvano's ship design courses. This is the first step in a more formal and lasting relationship between TSSE and NSWC Carderock. The first volume of a four-volume sequence on the science of combat systems was completed in time to be used in the first course of the CY2001 TSSE program sequence. Further improvements to the TSSE laboratory in the way of computing equipment and presentations equipment were also made.

PUBLICATIONS:

Calvano, C., Harney, R., Wickersham, D., Farsaris, I., Malone, P., Ruley, D., York, N., "The Surface Warfare Test Ship," Naval Postgraduate School Technical Report, NPS-ME-00-001, January 2000.

Harney, R., *Combat Systems Vol. 1: Sensor Functional Characteristics*, Naval Postgraduate School, 545 pp., October 2000. Internally published book used in TSSE and SEI courses.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles–Ships and Watercraft

KEYWORDS: Sea Lance, Survivability, Total Ship Systems Engineering, Navy After Next

NAVY AFTER NEXT PLATFORM INVESTIGATION

Robert C. Harney, Senior Lecturer
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Charles N. Calvano, Professor
David W. Byers, Visiting Professor
Department of Mechanical Engineering
Sponsor: Naval Undersea Warfare Center-Newport Division

OBJECTIVE: Assist the Naval Warfare Development Command in its studies of Capabilities for the Navy After Next (CNAN) through direct participation by Total Ship Systems Engineering (TSSE) students and faculty in program activities.

SUMMARY: This is a continuing project. In CY2000, the TSSE program (faculty and students) functioned as a full member of the CNAN program team. The TSSE faculty (and some students) attended meetings and contributed to the platform design and expeditionary grid subteams. The entire TSSE output in the second half of CY2000 was directed at developing a design of a combatant (called SEA LANCE) which is capable of laying the Expeditionary Grid (of remote sensors and remote-controlled weapons. This design consists of a novel combatant-plus-tow architecture. Both combatant and tow employ a novel wave-piercing catamaran design. The tow carries all of the grid elements as defined in the Toolbox developed by the Expeditionary Grid team. Grid elements are deployed by gravity feed out the bottom between the twin hulls. Once grid deployment is complete, the combatant can abandon the empty tow and become a 450-ton, 38-knot missile patrol boat carrying a variety of sensors, four large antiship missiles, and over 50 dual-purpose short-range anti-surface and anti-aircraft missiles. A 10-boat squadron of Sea Lance ships carries more air defense and antiship weaponry than the combined surface combatant ships of a carrier battle group, providing considerable additional capability and flexibility to the battle group commander. The Sea Lance concept has met an extraordinarily favorable reception. The concept has been briefed through the CNAN team, the Naval Warfare Development Command, and all the way to the CNO. Further action is awaiting the delivery of the final report (in March 2001). A *USNI Proceedings* article describing the concept should also be ready for submission in the same time frame.

PUBLICATION:

Calvano, C., Byers, D., Harney, R., Papoulias, F., Ciezki, J., Markle, H., Trevisan, R., Barney, T., Eimers, K., Farman, G., Altekin, A., Kompatzki, R., and Nash, C., "Sea Lance Littoral Warfare Small Combatant System," Naval Postgraduate School Technical Report, NPS-ME-01-001, January 2001.

Harney, R., "The Enemy's Access Denial System: Potential Competitor Exploitation of U. S. Military Vulnerabilities," Naval Postgraduate School Technical Report, NPS-JW-01-014, 413 pp., December 2000.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles–Ships and Watercraft

KEYWORDS: Sea Lance, Expeditionary Grid, Total Ship Systems Engineering, Navy After Next, Combatant

DEVELOPMENT OF HIGH-PRESSURE MINITIATURIZED THERMOACOUSTIC REFRIGERATION PROTOTYPE

Thomas Hofler, Associate Professor
Department of Physics
Sponsor: Rockwell Science Center

OBJECTIVE: The technical objective of this CRADA is the fabrication of a miniaturized TAR device compatible with operation at elevated pressures. To enable this evaluation, NPS will build in accordance with Rockwell Science Center specifications and deliver to RSC a functional miniature TAR prototype capable of operating at elevated pressures. RSC is pursuing separate R&D activities complementary to the proposed work, and the elevated-pressure prototype will be used by RSC for comparison with the results of alternative research and development efforts being pursued by RSC, to provide quantitative technical information on potential future paths for performance enhancement.

SUMMARY: Thermoacoustic Refrigeration represents an attractive phenomenon for thermal management purposes. Due to the absence of purely mechanical components, it has the potential for miniaturization to support chip-level cooling of electronic components. The performance and efficiency of these miniaturized Thermoacoustic Refrigerators (TAR) will depend strongly on a number of different parameters with one important factor being the operating pressure of the working fluid. To permit characterization of the effects of pressure on the performance of miniaturized TAR devices, NPS shall build according to RSC specifications and deliver to RSC a functional miniature TAR prototype capable of operating at elevated pressures. The elevated-pressure prototype will be used by RSC for comparison with the results of alternative research and development efforts being pursued by RSC, to provide quantitative technical information on potential future paths for performance enhancement. The proposed collaboration offers a mechanism for NPS personnel to apply their established expertise in thermoacoustics to this miniaturized applications area.

DoD KEY TECHNOLOGY AREAS: Other (Thermoacoustics)

KEYWORDS: Thermoacoustic Refrigerators (TAR), Miniaturized, High-Pressure

MATCHED FILTER NON-COHERENT COMMUNICATIONS FOR MODEMEX

Thomas Hofler, Associate Professor
Kevin Smith, Associate Professor
Andres Larraza, Associate Professor
Department of Physics
Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: To test matched filter detection methods for underwater acoustic modem applications, in the laboratory, and provide signal information for at-sea testing. Results will be compared to time reversed acoustic methods currently being researched in our laboratory.

DoD KEY TECHNOLOGY AREAS: Other (Underwater Acoustics)

KEYWORDS: Telesonar, Underwater Modem, Digital Communication

ENVIRONMENTALLY ADAPTIVE SONAR TECHNOLOGIES

Andrés Larraza, Associate Professor
Kevin B. Smith, Associate Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To examine Navy relevant applications of the phenomenon of time-reversal acoustics. This phenomenon takes advantage of the incorporation of waveguide effects into the acoustic field to adaptively remove the influence of the environment through re-transmission of a time-reversed transmission. Considered as part of this project were enhancements to active sonar detection algorithms and underwater acoustic communication systems.

SUMMARY: In FY00, several activities took place under this project. Numerical algorithms were employed to study and compare the fundamental aspects a two-way communication scheme using time-reversal acoustics (TRA) and a one-way communication scheme using match-filtering techniques. Numerical work also was done on modeling the effectiveness of TRA applied to active sonar systems to enhance detection of submerged targets. Both, the sonar technology and the communications algorithms were implemented in the long tank in SP 017, providing real data to assess the effectiveness of the TRA and match-filtering approaches to underwater acoustic communication systems, and to environmentally adaptive sonar technologies.

PUBLICATIONS:

Larraza, A. and Smith, K.B., "Underwater Acoustic Communications Using Time-Reversal Acoustics and Match-filtering Techniques," *Proceedings of the 1st Workshop em Acústica Submarina,* Instituto de Pesquisas de Marina, Rio de Janeiro, Brazil, 8-10 November 2000.

Heinemann, M., Larraza, A., and Smith, K.B., "Experimental Studies of Applications of Time–Reversal Acoustics to Non-coherent underwater communications," *Journal of the Acoustical Society of America.*

Smith, K.B., Abrantes, A.A.M., and Larraza, A., "Examination of Time-Reversal Acosutics in Shallow Water and Applications to Non-coherent Underwater Acoustics Communications," *Journal of the Acoustical Society of America.*

PRESENTATIONS:

Larraza, A. and Smith, K.B., "Experimental and Numerical Studies of Underwater Acoustic Communication Using Time Reversal Acoustics," ONR Environmentally Adaptive Sonar Technologies (EAST) Peer Review, Applied Research Laboratories, University of Texas, Austin, TX, 8-11 February 2000.

Larraza, A., Smith, K.B., and Shipley, M., "Time Reversal Acoustic Methods Applied to Active Sonar and Underwater Communications," ONR Active Sonar Signal Processing Peer Review, University of Washington, 22-24 August 2000.

THESES DIRECTED:

Winter, T., "Numerical Evaluation of Active Sonar System Processing Using Time-Reversal Acoustics Methods," Masters Thesis, Naval Postgraduate School, March 2000.

Heinemann, M., "Experimental Studies of Applications of Time-Reversal Acoustics to Non-coherent Underwater Communications," Masters Thesis, Naval Postgraduate School, March 2000.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Modeling and Simulation

KEYWORDS: Underwater Acoustic Communication, Littoral Environments, Time-Reversal Acoustics

DEVELOPMENT OF A SEISMO-ACOUSTIC SONAR FOR THE DETECTION OF BURIED MINES IN THE SURF AND NEAR-SURF ZONES

Thomas G. Muir, Research Professor
Steven R. Baker, Associate Professor
Department of Physics
Clyde L. Scandrett, Associate Professor
Department of Mathematics
Sponsor: Office of Naval Research

OBJECTIVE: To develop and investigate the feasibility of the use of a sonar system using guided seismo-acoustic interface waves to detect buried mines in the surf and near-surf zones. This project is supported by ONR Code 322W. NIFR funds were used to partially support Professors Baker and Scandrett. Objectives for their work were to: 1) develop a low-cost, multiple input and output channel data acquisition and analysis system; 2) build up source and receiving arrays of seismic transducers; and 3) theoretically model the seismic array by means of a time domain finite difference model which could be used for a variety of physical settings and input responses.

SUMMARY: The hardware portion of a 32-input-channel, 32-output-channel data acquisition and analysis system was built using 16 ganged, professional audio PC sound cards, to be controlled under MATLAB. For the first time, 16 PC sound cards have been integrated into a single system. Some integration problems were encountered, but these were either solved by replacing hardware or were worked around. A problem with card-to-card synchronization, when running under MATLAB, remains to be solved.

We have made arrangements to borrow at least 5 waterproof shakers from the Navy, for use in a source array. We have designed and begun to build a set of 16 3-axis seismometers, to be deployed as a receiving array. Both these arrays will be integrated with the data acquisition/analysis system.

A 3D second order in time and space finite difference code has been developed and written for determining the time dependent displacements of an elastic half space in the vicinity of a source (or sources) and buried inhomogeneities. A new dipolar radiation condition, which handles body and Rayleigh waves, has been designed for use in truncating the numerical domain but is yet to be made fully stable.

PUBLICATIONS:

Sheetz, K., Guy, J., Baker, S., and Muir, T., "Seismic Sonar: The Spatial Coherence of Interface Waves in Surf Zone Sediments," *Proceedings of the 4th International Symposium on Technology and the Mine Problem*, Naval Postgraduate School, Monterey, CA, 13-16 March 2000.

Sheetz, K., Guy, J., Baker, S., and Muir, T., "Seismic Sonar: Beamforming in the Sand," *Proceedings of the 4th International Symposium on Technology and the Mine Problem*, Naval Postgraduate School, Monterey, CA, 13-16 March 2000.

THESES DIRECTED:

Sheetz, K., "Advancements in Buried Mine Detection Using Seismic Sonar," Masters Thesis, Naval Postgraduate School, December 2000.

Plager, W.L., "Mine Burial in the Surf Zone," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments

KEYWORDS: Seismic Sonar, Rayleigh Waves, Mine Detection, Surf Zone, Mine Countermeasures

SENSOR FUSION FOR TERRAIN CATEGORIZATION AND TARGET CLASSIFICATION

Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: Center for Reconnaissance Research

OBJECTIVE: The proposed research is to study the utility of data from National Technical Means (NTM) for Terrain Categorization (TERCAT). Data from visible, IR, and radar systems will be acquired in modes available to operational users, and analyzed according to the techniques currently in use for the interpretation of spectral imagery. Techniques in multi-temporal analysis will be added to current work.

SUMMARY: Analysis was completed on multi-system fusion, and high accuracy rates were obtained in scene classification.

THESIS DIRECTED:

Lisa, M.T., "Terrain Categorization Using Multispectral and Multitemporal Imagery," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Environmental Monitoring, Remote Sensing

AURORAL X-RAY INFRARED IMAGING SATELLITE

Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: Secretary of the Air Force

OBJECTIVE: Develop visible imager for the Naval Postgraduate School small satellite; proceed to PDR.

SUMMARY: The project was concluded at the design stage.

THESIS DIRECTED:

Robison, M., "Prototype Design of NPSAT Visible Imager," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Environmental Monitoring, Remote Sensing

CMO R&D TECHNICAL ASSISTANCE

Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: Defense Intelligence Agency

OBJECTIVE: The proposed effort is to support the central MASINT Organization in it's research and development efforts, particularly in the area of Spectral imagery and high frame rate non-imaging infrared systems. Technical development of the Cobra Brass F System, exploration of Cobra Brass E data and development of a UV Spectral Imager are supported.

SUMMARY: Significant progress was made with the Cobra Brass studies, including work in target tracking and aerosol discrimination. Work on a new UV spectrometer has begun.

THESIS DIRECTED:

Sukols, N.E., "Non-imaging Detection and Tracking of Mobile Targets," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Environmental Monitoring, Remote Sensing

SENSOR FUSION FOR TERRAIN CATEGORIZATION

Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: Navy Tactical Exploitation of National Capabilities (TENCAP) Office

OBJECTIVE: The proposed research is to study the utility of data from National Technical Means (NTM for Terrain Categorization (TERCAT). Data from visible, IR, and radar systems will be acquired in modes available to operational users, and analyzed according to the techniques currently in use for the interpretation of spectral imagery.

SUMMARY: Analysis was initiated on multi-temporal studies utilizing NTM systems.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Environmental Monitoring, Remote Sensing

IR IMAGING SATELLITE STUDY

Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: Study implementation of micro-bolometer focal plane technology for LWIR Spectral Imagery on a small satellite.

SUMMARY: A design study for a multi-spectral, LWIR sensor was completed, and delivered to the sponsor.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: IR Imaging, LWIR Spectral Imagery

MASINT RESEARCH IN SPECTRAL AND TEMPORAL SIGNATURES

Richard C. Olsen, Associate Professor
Department of Physics
Sponsor: Secretary of the Air Force

OBJECTIVE: The proposed effort is to support the central MASINT Organization in its research and development efforts, particularly in the areas of Spectral Imagery and High Frame Rate Non-Imaging Infrared Systems. Technical development of the Cobra Brass F System, exploitation of Cobra Brass E Data, and development of AUV Spectral Imager are supported.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Environmental Monitoring, Remote Sensing

RADIANT BRASS EXPLOITATION

Richard C. Olsen, Associate Professor
Philip L. Walker, Research Associate Professor
Department of Physics
Sponsor: Navy Tactical Exploitation of National Capabilities (TENCAP) Office

OBJECTIVE: Develop a method for using satellite data to predict the performance of aircraft mounted FLIRs for desert operation.

SUMMARY: This project was funded for $50K starting 1 May 2000. The project has 3 components. The first is to find a method of using satellite and meteorological data to determine atmospheric turbidity. The second is to test the method. The third is to relate satellite-derived turbidity to FLIR performance. The first two components are being worked in collaboration with Professor Durkee, NPS Meteorology and personnel at NAWC, China Lake. Ground-based equipment needed for validation of satellite retrieval of atmospheric optical depth is being operated at China Lake 24x7. This means the satellite operators can take their data at times most convenient to them. No satellite data has yet been received for analysis. It is expected that this situation will change shortly. Professor Durkee has offered to be a conduit for satellite data. He has been actively negotiating with the providers for processed data. Collaboration with Boeing has been discussed. They have volunteered to help obtain unprocessed satellite data. Meteorological information needed to extract turbidity from optical depth is to be generated using numerical weather prediction programs. We were to work the third component of this project using FLIRs mounted on F-18 being flown on training missions. That did not work out. Another approach is to try to piggyback on Predator UAV flights at Fallon. We will try that in late spring to early summer. Boeing is interested in arranging F-18 flights at China Lake.

DoD KEY TECHNOLOGY AREAS: Sensors

KEY WORDS: Environment, LIDAR, Transmission

WORKSHOP TO "BENCHMARK" THE EFFECTS OF SHALLOW WATER ENVIRONMENTAL VARIABILITY

Kevin B. Smith, Associate Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To co-organize the proceedings of a workshop on shallow water environmental variability influences on underwater acoustic propagation modeling. This workshop investigated the effects of environmental variability, i.e., range, depth, and azimuthal variability, on acoustic signal propagation, the accuracy of the applied propagation models, and considered some limited signal processing of the modeled acoustic fields. Funding was provided during FY00 to support the review and editing process of submitted research articles.

SUMMARY: The SWAM99 (Shallow Water Acoustic Modeling) Workshop was held in Monterey, CA, Sep 8-9 1999, hosted by Professor Kevin Smith at NPS and co-chaired by Alex Tolstoy of Scientific Solutions, Inc. Attendance was about 30-35 researchers. It was a very successful meeting with a number of issues addressed, questions raised, and follows on problems suggested.

During FY00, Professor Smith and Dr. Tolstoy managed the collection, reviews, and submissions of manuscripts from SWAM99 participants for a special issue of the *Journal of Computational Acoustics.* This special issue will serve as the proceedings of the workshop.

PUBLICATIONS:

Smith, K.B., "Convergence, Stability, and Variability of Shallow Water Acoustic Predictions Using a Split-Step Fourier Parabolic Equation Model," *Proceedings of the Shallow Water Acoustic Modeling (SWAM'99) Workshop,* 8-10 September 1999, *Journal of Computational Acoustics,* Vol. 9, No. 1, 2001 - Special Issue

of *Proceedings of the Shallow Water Acoustic Modeling (SWAM'99) Workshop,* 8-10 September 1999, (eds. Alex Tolstoy and Kevin B. Smith).

Tolstoy, A., Smith, K.B., and Maltsev, N., "The SWAM'99 Workshop - an overview," *Journal of Computational Acoustics,* Vol. 9, No. 1, 2001 - Special Issue of *Proceedings of the Shallow Water Acoustic Modeling (SWAM'99) Workshop,* 8-10 September 1999, (eds. Alex Tolstoy and Kevin B. Smith).

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Shallow Water Variability, Underwater Acoustic Modeling

REVERBERATION STUDIES IN EAST CHINA SEA

Kevin B. Smith, Associate Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this research was to develop a model capable of computing the influence of propagation on both interface and volume reverberation from a broadband pulse. Spatial correlations and statistics of the predicted reverberant signal were examined. The results from further analysis will be used to compare such predictions with data collected in the upcoming ASIAEx experiments. By understanding the role of the acoustic propagation in such signals, a clearer description of the underlying dominant scattering mechanisms should emerge.

SUMMARY: The theoretical development of the PE reverberation model was completed with the exception of the inclusion of density fluctuations in the sediment volume. This will be added during FY01. Both interface roughness and sediment sound speed fluctuations were computed based on characteristic spectral models of such perturbations. These were incorporated into the PE model, and solutions of the acoustic propagation for both CW and broadband pulse sources were generated. During this development portion, only a single realization for both the interface and volume fluctuations was used in order to concentrate on the processing algorithms. The rms fluctuation of the interface was set to 1m while the volume sound speed rms fluctuation was fixed at 15m/s. Both types of perturbations were included in all calculations, although the reverberation due to each was considered separately. Thus, it is possible that one type of perturbation may dominate the structure of both types of reverberation. Further examination of the individual effects will be examined in FY01.

From both CW and broadband calculations, vertical spatial correlations of the reverberation field were computed. Additionally, the statistical characteristics of the reverberation signal are being examined. Such results from future calculations will eventually be compared with measured data to determine the influence of propagation and, hopefully, help discriminate specific scattering mechanisms.

PUBLICATION:

Smith, K.B. and Lit-Siew, L., "Broadband Parabolic Equation Modeling of Acoustic Bottom Interface and Volume Reverberation in Shallow Water," *Proceedings of 5th European Conference on Underwater Acoustics,* Lyon, France, 10-13 July 2000, pp. 1171-1176.

PRESENTATION:

Smith, K.B. and Lit-Siew, L., "Broadband Parabolic Equation Modeling of Acoustic Bottom Interface and Volume Reverberation in Shallow Water," 5th European Conference on Underwater Acoustics, Lyon, France, 10-13 July 2000, pp. 1171-1176.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Shallow Water Reverberation, Parabolic Equation Modeling

MESOSCALE MODELING FOR ATMOSPHERIC TURBULENCE, PHASE II

D. L. Walters, Professor
Department of Physics
D. K. Miller, Research Assistant Professor
Department of Meteorology
Sponsor: Secretary of Air Force

OBJECTIVE: To adapt state of the art of large mesoscale numerical models, MM5 and COAMPS for computing electro-optical parameters for National Technical applications.

SUMMARY: Refinements and errors in the Mellor y Yamada closure algorithm in the U.S. Navy Coupled Atmosphere Ocean Mesoscale Prediction (COAMPS) numerical model have been implemented so that the model can realistically predict optical turbulence. Two key results are that the National Weather Service ETA and U.S. Navy NOGAGS input data fields; produce larger changes in the model output that any of the versions of parameterization schemes that we have tried. Of the tests cases run to date, the ETA input data fields appears to provide results that are more consistent than the U.S. Navy Global NOGAPS model, but this conclusion may simply reflect differences in how the two global models handle certain situations.

THESIS DIRECTED:

Holdaway, A.R., "High Resolution Microthermal Balloon Measurements in Support of Adaptive Optical Programs," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments

KEYWORDS: Atmospheric Turbulence, Adaptive Optics, Mesoscale Models, Adaptive Optical Systems, Imaging Systems

ATMOSPHERIC OPTICAL TURBULENCE SENSOR

D. L. Walters, Professor
Department of Physics
D. K. Miller, Research Assistant Professor
Department of Meteorology
Sponsor: United States Air Force Starfire Optical Range

OBJECTIVE: To develop and deliver a high resolution acoustic sonar for profiling optical turbulence use at USAF Starfire Optical range.

SUMMARY: NPS developed a prototype acoustic sonar for profiling optical turbulence in FY-98. This instrument was successfully used at the Starfire Optical Range to show that a large 1.5 m optical telescope facility had to be moved to a position on top of a hill to operate satisfactorily during the day. The USAF asked NPS to build and deliver a similar instrument for permanent installation. To be used in an unattended mode by unskilled technicians, the instrument had to be redesigned. A new power amp and preamplifier with remote power was designed, fabricated and tested, and a new sonar phased array with enclosure was designed and fabricated. This sonar enclosure had to have an automated rain cover and rain sensor to close when precipitation occurs. This system was developed, fabricated, tested and delivered on time within budget to the sponsor.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments

KEYWORDS: Atmospheric Turbulence, Adaptive Optics, Adaptive Optical Systems, Imaging Systems

DEPARTMENT OF PHYSICS

2000
Faculty Publications and Presentations

PUBLICATIONS/PRESENTATIONS

JOURNAL PAPERS

Colson, W. B. and McGinnis, R. D., "The Free Electron Laser With Inverse Taper," *Nuclear Instruments and Methods in Physics Research,* 49-52 (2000).

Heinemann, M., Larraza, A., and Smith, K.B., "Experimental Studies of Applications of Time–Reversal Acoustics to Non-coherent Underwater Communications," *Journal of the Acoustical Society of America.*

Larraza, A. and Tucholski, E., "Acoustic Einstein-Hopf Drag on a Bubble," *Physics Review Letters,* Vol. 84, pp. 2378-2380, 2000.

Nelson, D.H., Walters, D.L., Mac Kerrow, E.P., Schmitt, M.J., Porch, C.R., and Petrin, R.R., "Wave Optics Simulation of Atmospheric Turbulence and Reflective Speckle Effects in CO^2 Lidar," *Applied Optics*, Vol. 39, p. 1857, 20 May 2000.

Potty, G.R., Miller, J.H., Lynch, J.F., and Smith, K.B., "Tomographic Mapping of Sediments in Shallow Water," *Journal of the Acoustical Society of America,* Vol. 108, pp. 973-986, 2000.

Smith, K.B., Abrantes, A.A.M., and Larraza, A., "Examination of Time-Reversal Acoustics in Shallow Water and Applications to Non-coherent Underwater Acoustic Communications," *Journal of the Acoustical Society of America.*

CONFERENCE PAPERS

Christodoulou, A., Lampiris, D., Colson, W.B., Crooker, P.P., Blau, J., McGinnis, R.D., Benson, S.V., Gubeli, J.F., and Neil, G.R., "Simulations of the TJNAF FEL With Tapered and Inversely Tapered Undulators," poster paper at the Twenty Second International Free Electron Laser Conference, Duke University, Durham, NC, August 2000.

Colson, W.B. and McGinnis, R.D., "The Free Electron Laser With Inverse Taper," poster paper at the Twenty Second International Free Electron Laser Conference, Duke University, Durham, NC, August 2000.

Colson, W.B., "Short-Wavelength Free Electron Lasers in 2000," poster paper at the Twenty Second International Free Electron Laser Conference, Duke University, Durham, NC, August 2000.

Larraza, A. and Smith, K.B., "Underwater Acoustic Communications Using Time- Reversal Acoustics and Match-filtering Techniques," *Proceedings of the 1st Workshop em Acústica Submarina,* Instituto de Pesquisas de Marina, Rio de Janeiro, Brazil, 8-10 November 2000.

McGinnis, R.D., Blau, J., Colson, W.B., Massey, D., Crooker, P.P., Christodoulou, A., and Lampiris, D., "Simulations of the TJNAF 10kW Free Electron Laser," poster paper at the Twenty-Second International Free Electron Laser Conference, Duke University, Durham, NC, August 2000.

Sheetz, K., Guy, J., Baker, S., and Muir, T., "Seismic Sonar: The Spatial Coherence of Interface Waves in Surf Zone Sediments," *Proceedings of the 4th International Symposium on Technology and the Mine Problem,* Naval Postgraduate School, Monterey, CA, 13-16 March 2000.

Sheetz, K., Guy, J., Baker, S., and Muir, T., "Seismic Sonar: Beamforming in the Sand," *Proceedings of the 4th International Symposium on Technology and the Mine Problem*, Naval Postgraduate School, Monterey, CA, 13-16 March 2000.

Smith, K.B., "Convergence, Stability, and Variability of Shallow Water Acoustic Predictions Using a Split-step Fourier Parabolic Equation Model," *Proceedings of the Shallow Water Acoustic Modeling (SWAM'99)*

Workshop, 8-10 September 1999.

Smith, K.B. and Lit-Siew, L., "Broadband Parabolic Equation Modeling of Acoustic Bottom Interface and Volume Reverberation in Shallow Water," *Proceedings of 5th European Conference on Underwater Acoustics,* Lyon, France, 10-13 July 2000, pp. 1171-1176.

Therrien, C.W., Kouteas, S.D., and Smith, K.B., "Time Delay Estimation Using a Signal Subspace Model," *Proceedings of the 34th Asilomar Conference on Signals, Systems, and Computers,* Monterey, CA, 29-31 October 2000.

Tolstoy, A., Smith, K.B., and Maltsev, N., "The SWAM'99 Workshop - An Overview," Special Issue of *Proceedings of the Shallow Water Acoustic Modeling (SWAM'99) Workshop,* 8-10 September 1999 (eds. Alex Tolstoy and Kevin B. Smith).

CONFERENCE PRESENTATIONS

Baker, S.R. and Scandrett, C.L., "Relation between the Diffraction Constants, the Reciprocity Parameter, and the Mutual Impedamce of a Pair of Compact Radiators: An Improved Pritchard Approximation," 140th Meeting of the Acoustical Society of America, December 2000. Abstract appears in *Journal of Acoustical Society of America,* 108, p. 2520 (2000).

Colson, W.B., "Flexible Capabilities of the LCLS FEL," SSRL/SLAC Linac Coherent Light Source Scientific Advisory Committee, Stanford University, Palo Alto, CA, March 2000.

Denardo, B., "Nonradiating Wave Sources," Joint Meeting of Northern California/Nevada Sections of the American Association of Physics Teachers, Stanford University, Palo Alto, CA, 7-8 April 2000.

Guy, M.J., Sheetz, K., Baker, S.R., and Muir, T., "Seismic Sonar: Beamforming in the Sand," Proceedings of the 4th Symposium on Technology and the Mine Problem, Naval Postgraduate School, CA, 13-16 March 2000.

Larraza, A. and Smith, K.B., "Experimental and Numerical Studies of Underwater Acoustic Communication Using Time Reversal Acoustics," ONR Environmentally Adaptive Sonar Technologies (EAST) Peer Review, Applied Research Laboratories, University of Texas, Austin, TX, 8-11 February 2000.

Larraza, A., Smith, K.B., and Shipley, M., "Time Reversal Acoustic Methods Applied to Active Sonar and Underwater Communications," ONR Active Sonar Signal Processing Peer Review, University of Washington, 22-24 August 2000.

Scandrett, C.L., Day, J.L., and Baker, S.R., "A Modal Pritchard Approximation for Computing Array Element Mutual Impedance," 140th Meeting of the Acoustical Society of America, December 2000. Abstract appears in *Journal of Acoustical Society of America,* 108, p. 2637 (2000).

Sheetz, K., Guy, M.J., Baker, S.R., and Muir, T., "Seismic Sonar: the Spatial Coherence of Interface Waves in Suficial Sediments," 4th Symposium on Technology and the Mine Problem, Naval Postgraduate School, CA, 13-16 March 2000.

TECHNICAL REPORTS

Calvano, C., Harney, R., Wickersham, D., Farsaris, I., Malone, P., Ruley, D., York, N., "The Surface Warfare Test Ship," Naval Postgraduate School Technical Report, NPS-ME-00-001, January 2000.

Harney, R., "Ducking the Punch or Absorbing the Blow? Letting the Anticipated Threat Drive Future Warship Design," Naval Postgraduate School Technical Report, NPS-JW-00-008, January 2000.

Harney, R., "Fighting Dirty? Sustaining Operations in an NBC Environment," Naval Postgraduate School Technical Report, NPS-JW-00-009, January 2000.

Harney, R., "The Enemy's Access Denial System: Potential Competitor Exploitation of U. S. Military Vulnerabilities," Naval Postgraduate School Technical Report, NPS-JW-01-014, December 2000.

McGinnis, R.D., Thomson, R.W., Jr., Short, L.R., Herbert, P.A., Lampiris, D., Christodoulou, A., Colson, W.B., M.D. Shinn, M.D., Neil, G.R., Benson, S.V., Gubeli, J.F., Evans, R., and Jordan, K.C., "Free Electron Laser Material Damage Studies," Naval Postgraduate School Technical Report, NPS-PH-01-001, 2000.

OTHER

Harney, R., *Combat Systems Vol. 1: Sensor Functional Characteristics* Monterey, CA, Naval Postgraduate School, 545 pp., October 2000. Internally published book used in TSSE and SEI courses.

DEPARTMENT OF PHYSICS

Thesis Abstracts

DESIGN AND CONSTRUCTION OF A SOLAR POWERED THERMOACOUSTIC REFRIGERATOR

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Thomas J. Hofler, Department of Physics

This thesis describes the design, construction, and testing of a solar thermal powered thermoacoustically driven thermoacoustic refrigerator. This device uses an 18 inch diameter Fresnel lens to concentrate sunlight at 500°C directly onto the hot end of a heat driven prime mover stack, thereby eliminating the need for a hot heat exchanger. The one inch diameter prime mover and refrigerator stacks are located at opposite ends of a 12 inch long half-wave resonator pressurized to six atmospheres absolute with helium and argon, and operating at 600 Hz. The prime mover is capable of producing peak sound pressure levels of up to 5.5% of the resonator's ambient mean pressure, while the refrigerator has produced a maximum of four Watts of cooling power with an ultimate cold temperature of 5°C and a temperature span of 18°C. This refrigerator requires no external power to operate, and uses solar voltaic cells to run electric cooling fans to reject heat from the ambient heat exchangers.

DoD KEY TECHNOLOGY AREA: Environmental Quality

KEYWORDS: Thermoacoustic Refrigerator, Thermoacoustic Prime Mover, Solar Thermal Powered

AMPLITUDE AND TEMPORAL JITTER ASSOCIATED WITH THE NPS ACTIVE MODE-LOCKED SIGMA LASER

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Electro-optic techniques for analog-to-digital conversion (ADC) are being developed for wideband signal collection and analysis. They have the capability of being used for direct signal reception and ADC at an antenna. A fundamental requirement for these designs is a high-frequency optical pulse train with uniform amplitude and pulse spacing. A mode-locked fiber laser can provide pulse rates and pulsewidths suitable for these high bandwidth applications. In this thesis an accurate method for calculating and characterizing both the amplitude and timing jitters of the NPS active mode-locked sigma laser was designed and demonstrated. The method utilizes a wide bandwidth photodetector and a microwave spectrum analyzer toobtain data for analysis. Labview 4.0 software was used to extract and store the data displayed on the spectrum analyzer. Matlab 5.1 software was then used to analyze the Labview data and to perform calculations for the amplitude and temporal jitter. Measurements were made for a microwave sweep oscillator and a cw generator, then again with the fiber laser operating with each signal source. Final measurements were taken with variable laser diode pump powers by varying the controller currents. Results show that the calculation of the laser jitter is not dependent on the upper limit of the noise power integral calculation above 10 kHz; however, the jitter is highly dependent on the value of the lower frequency limit and decreases dramatically as the lower limit is increased. Laser amplitude jitter was found to decrease by 30% and timing jitter by 0.85 ps when the laser was operated with the cw generator instead of the sweep oscillator. Also, it was found that as pump power was increased, laser timing jitter decreased.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Mode-Locked Laser, Sigma Laser, Amplitude Jitter, Temporal Jitter

ACOUSTIC TRANSIENT TDOA ESTIMATION AND DISCRIMINATION

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Master of Science in Engineering Acoustics-September 2000
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Murali Tummala, Department of Electrical and Computer Engineering
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This thesis examines acoustic transient discrimination and Time Difference of Arrival (TDOA) estimation for the purposes of estimating the position of a submarine in a sonabuoy field. Transient discrimination, for this thesis, is the process of telling different transients apart. Two algorithms are evaluated. One method is based on higher order statistics while the other is based on signal subspace techniques. Extensive simulations using synthetic transients were conducted to establish the performance of each algorithm in terms of discrimination and TDOA estimation. It was found that the bispectral algorithm gave better TDOA estimation at low SNRs while the subspace algorithm gave better TDOA estimation at high SNRs. For discrimination, it was found that the subspace algorithm gave consistant false alarm rates at all SNRs while the false alarm rate for the bispectral algorithm grew with increasing SNR.

DoD KEY TECHNOLOGY AREAS: Sensors, Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation

KEYWORDS: Transient, TDOA, Discrimination, Bispectrum, Subspace

PERFORMANCE ANALYSIS OF IRTOOL AND COMPARISON TO LWKD MARINE BOUNDARY LAYER PROGRAM

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This thesis evaluates the ability of the IRTOOL computer simulation program to predict mirages. Using identical input conditions taken from the MAPTIP experiment database, predicted Minimum Mirage Range (MMR) and Maximum Intervision Range (MIVR) from both the IRTOOL and IRBLEM models were extracted and compared with the measurements recorded in the database. By comparison of the algorithms it was found that discrepancies in IRTOOL mirage prediction could be ascribed to the input function for significant ocean wave height, which gave values much greater than measured or used in IRBLEM. For a significant wave height close to the measured value the IRTOOL predictions were in very close agreement with observation and with IRBLEM. IRTOOL predictions were in all cases within 2.7 km and in most cases within 1.3 km of the measurements for all ranges varying from about 7-26 km. The strong temperature gradient predicted by the model within a few meters of the water surface, uncertainties in the measured range, and the variation of 0.8 to 2°C in Air Sea Temperature Difference are sufficient to account for the observed deviations. Differences between predictions of different models are discussed.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Refraction, Marine Boundary Layer, Atmosphere, IRTOOL, IRBLEM, Mirage, MAPTIP

MODIFICATION AND VERIFICATION OF DESIGN SIMULATION FOR THERMOACOUSTIC RESEARCH SOFTWARE

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Second Reader: James V. Sanders, Department of Physics

This thesis attempts to improve, prepare for release, and verify the accuracy of the expert system code entitled "Design Simulation for Thermoacoustic Research" (DSTAR) created previously by LT Eric Purdy. DSTAR allows a unique new approach for the rapid design and simulation of thermoacoustic devices utilizing a Microsoft Windows™ compliant interface to construct any given thermoacoustic model at runtime. The approach to simulation involves the solution of a one-dimensional acoustic wave equation simultaneously with an energy flow equation from one end of the specified device to the other, including additional lumped elements. The resulting solution is available as both a graphical and text-based output. In order to prepare for release, significant additions to the engine code and interface were completed. Additionally, theoretical results obtained by the DSTAR system code were compared to actual measured values in order to demonstrate potential engineering design applicability.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Thermoacoustic Simulation, Numerical Model

OPTIMIZATION PROCEDURE FOR ELECTRIC PROPULSION ENGINES

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This thesis addresses the optimization of all types of space electrical propulsion thrusters. From the Langmuir-Irving payload mass fraction formulation, a "dual-optimum" solution is defined, yielding a minimum overall mass for a specified payload consistent with minimum transfer time. This solution fixes the ideal payload mass ratio (m_{pl} / m_o) at a value of 0.45, establishing the ratios of effective exhaust velocity (v / v_c) and incremental change of vehicle velocity ($\Delta u / v_c$) to characteristic velocity at 0.820 and 0.327 respectively. The characteristic velocity (v_c) includes thrust time as well as engine efficiency (η_t) and specific power (α). A range of mass ratios from 0.35 to 0.55 is used in order to allow the system designer some flexibility while remaining close to optimal. Nine examples are presented which demonstrate that mission profiles can be optimized by profile-to-thruster matching. A comprehensive list of currently available electric propulsion engines is provided. This list details important parameters such as the specific power, which "sizes" an engine in terms of power provided to the thruster at the cost of additional mass. Allowance is also made for a fuel tank mass penalty, and examples show that this can also noticeably influence the optimum design.

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Space Vehicles

KEYWORDS: Space Propulsion, Electric Propulsion, Ion Engines, Hall Thrusters, Optimum Specific Impulse, Minimum Thrusting Time

EFFECTS OF SHIPBOARD COMPARTMENT FUEL FIRE AND FIRE EXTINGUISHING ON RF SIGNAL PROPAGATION IN THE 2.4 GHz ISM BAND

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The objective of this research was to quantify the effects of fuel fire and the follow-on fire extinguishing actions on wireless shipboard communications in the 2.4 GHz ISM band. Directional and non-directional antennas with horizontal and vertical polarization, and a PC-controlled scalar network analyzer, were used onboard ex-USS SHADWELL to measure the attenuation of 2.4 - 2.485 GHz signals transmitted through diesel and heptane fire, water mist created by the fire extinguishing system, and subsequently developed steam. A MATLAB code has been used to analyze the data statistically.

The attenuation for directional antennas exhibits relatively small variations with time and frequency, but fire and the follow-on fire-extinguishing phases create severe non-stationary frequency selective fading for non-directional antennas. Therefore standard communication techniques effective against frequency selective fading (non-stationary but slowly varying with time) are recommended for use with communication systems intended for shipboard indoors use. Even in normal conditions, without fire, water mist, or steam, it was determined that frequency selective fading would be a problem for non-directional antennas used in shipboard compartments and thus a system with anti-fading capability should be considered for shipboard use.

DoD KEY TECHNOLOGY AREA: Other (Shipboard Wireless Communications)

KEYWORDS: Instrumentation Scientific Medical (ISM) Band, Radio Frequency (RF) Propagation, Attenuation, Fire Extinguishing System, Plasma, MATLAB

SHALLOW WATER BATHYMETRY AT LAKE TAHOE FROM AVIRIS DATA

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Pierre-Marie Poulain, Department of Oceanography

One of the United States Navy Oceanographic community's roles is to keep an accurate worldwide database of oceanic bathymetry. In the littoral zones, much of the data is out of date or is unavailable. Stuffle et al. (1996) utilized a method addressing shallow water areas using the Hyperspectral Digital Imagery Collection Experiment (HYDICE) sensor on a small region in Lake Tahoe. As a follow-on, this work used a different sensor, the Airborne Visible/InfraRed Imaging Spectrometer (AVIRIS) sensor, and covered a much larger area on the opposite side of the lake. Principle components analysis (PCA) of the region of interest (ROI) revealed nine spectrally unique water classes. *A priori* knowledge of one bottom type in this ROI allowed insertion of a known bottom reflectance spectrum into a derived computer algorithm that, using also diffuse attenuation coefficients from HYDROLIGHT and reflectance just below the water surface derived from AVIRIS data, allowed computation of the bottom depth. Results compared within 30% of depth from a USGS bathymetric chart. This method holds much promise in clear waters, and next needs to be tested in the coastal ocean environment.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: AVIRIS, Hyperspectral, Bathymetry, Lake Tahoe, Optical Properties of Water

DESIGN, CONSTRUCTION, AND OPERATION OF AN ELECTROMAGNETIC RAIL GUN TEST BENCH

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Second Reader: Andrés Larraza, Department of Physics

For over two decades, the United States Army has conducted research in the field of electromagnetic launch railguns. With the advent of electric propulsion ships, the Navy is now considering the use of electric power to launch projectiles in support of maritime land attack. Bore wear is the most significant challenge for a naval railgun program. The interface between the armature and rails is the most stressed point of a railgun because it transitions to liquid under high current densities. This liquid interface causes rail and projectile material to redistribute unevenly and produces rail degradation. The focus of this thesis is to test different interface materials to minimize damage to the rail and armature during firing. A railgun test bench with a 4-inch long rail was designed, constructed, and operated to investigate rail wear and rail-armature interface dynamics. Various combinations of tungsten, copper, and silver alloys were tested for rail and armature materials. The least degradation of rail and projectile was observed with a silver-tungsten projectile and copper-tungsten rails: 10% loss in projectile mass for a current density of approximately 200 kA/cm^2. Indium at the interface protected the rails and projectile from damage at current densities under 45 kA/cm^2.

DoD KEY TECHNOLOGY AREAS: Conventional Weapons, Directed Energy Weapons

KEYWORDS: Electromagnetic Railgun, Electromagnetic Launch, EML Rail/Armature Interface

EVALUATION OF TACTICAL DECISION AID PROGRAMS FOR PREDICTION OF FIELD PERFORMANCE OF INFRARED SENSORS

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The diversity of infrared system performance prediction models currently used by different services conflict with the concept of 'joint operations' where all services must share the common resources to survive. In this respect this study presents an analysis and a comparison of two operational performance models, the U.S. Army's ACQUIRE and the infrared module of the Navy/Air Force Tactical Decision Aid (TDA), WinEOTDA. Differences in the modeling of underlying physical principles, input parameters, and treatments are analyzed. A comparison of the predicted detection ranges is made using a data set collected in the Gulf of Oman as the meteorological input. Suggestions are sought for the modification of the codes that will lead to the same outputs. Finally the possibility of adopting one of the codes as a standard TDA is analyzed. For the same scenario inputs and with a user-defined sensor model WinEOTDA predicted longer ranges for 100% of the time. WinEOTDA was observed to be more accurate in predicting detection ranges than ACQUIRE because of the improved target modeling.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation, Battlespace Environment

KEYWORDS: Tactical Decision Aids, FLIR92, SeaRad, ACQUIRE, WinEOTDA, TAWS

DESIGN AND CONSTRUCTION OF MEDIUM RESOLVING, POWER SCANNING, GRATING SPECTROMETER

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A scanning Ebert-Fastie spectrometer was designed and built for the Optical Physics and Sensors Laboratory of the Naval Postgraduate School. Optical design was done with two commercially available optical design software packages, OSLO LT by Sinclair Optics, Inc., and Optica by Wolfram Research, Inc. Several components for the spectrometer were designed and built at the Naval Postgraduate School Physics Department machine shop to include grating mount, motor mount, entrance and exit slits, gearbox, and spacers. Electronic interfaces included the motor, motor controller, and personal computer to control the diffraction grating angle, and a detector, data logger, lock-in detection system, and personal computer to record data. Data was measured from a Fe hollow cathode source to demonstrate proper operation. The recorded spectral lines were graphed in Microsoft Excel and tentatively identified as those tabulated in the published literature. Future work includes optimization of the resolving power and of the fore optics. Upon completion, the spectrometer will prove to be a very useful instructional aid in the optics and optoelectronics classes taught at the school, and as a medium resolving power visible and near ultraviolet instrument for future student thesis research.

DoD KEY TECHNOLOGY AREAS: Chemical and Biological Defense, Sensors

KEYWORDS: Spectrometer, Ebert-Fastie, Optics, Detector

EXPERIMENTAL STUDIES OF APPLICATIONS OF TIME–REVERSAL ACOUSTICS TO NON-COHERENT UNDERWATER COMMUNICATIONS

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Master of Science in Engineering Acoustics-March 2000
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The most difficult problem in shallow underwater acoustic communications is considered to be the time-varying multipath propagation because it impacts negatively on data rates. Computationally intensive and complex signal processing algorithms are required to compensate for symbol overlapping. This thesis presents results of a tank scale experiment to test Time-Reversal Acoustics (TRA) approach for high data rate binary transmissions. TRA can environmentally adapt the acoustic propagation effects of a complex medium. Our results show the suitability of the TRA approach in underwater acoustic communications. The results also show good focusing properties at an intended target location. The focal region extends over a few wavelengths, outside of which scrambling of the message occurs, offering natural encryption. Range shifts of the focal region could be achieved by frequency shifting. We found that the time focusing is aperture–size independent, but the spatial focusing is aperture–size dependent. Overall, we showed that our algorithm can accomplish a fast, secure, and stable communication scheme with low computational complexity.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Time Reversal Acoustics, Acoustic Communications, Acoustic Signal Processing

ACOUSTIC LOCALIZATION OF TRANSIENT CAVITATION EVENTS WITHIN THE VOLUME OF A SUBMARINE PROPULSOR USING A CROSSED-LINE ARRAY

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The development of a computer program that is capable of localizing transient cavitation events within a scale-model submarine propulsor, for the Naval Surface Warfare Center Acoustic Research Detachment, is presented. The program focuses a 21-element, crossed-line array, by applying exact phase weights in the frequency domain and evaluating the resultant coherence across all of the sensors in the time domain. Localization is determined by a comparison of normalized coherent summations from many different points within a volume enclosing the source.

The program is general, in that the method used is capable of conducting near-field localization using any array, provided the sensor locations are well-known. The source is assumed to be a spherical spreading source with a direct path to the array. A method of rejecting portions of the time series that are contaminated by reflected paths is incorporated. An evaluation of the method using synthetic data is included.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Surface/Under Surface Vehicles - Ships and Watercraft, Other (Submarine Stealth)

KEYWORDS: Acoustic Localization, Array Focusing, Submarine Transient Cavitation, Transient Localization

APPLICATIONS OF THERMAL HYPERSPECTRAL IMAGERY FOR SPECIFIC MATERIAL IDENTIFICATION

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Second Reader: Alan A. Ross, Navy Tactical Exploitation of National Capabilities (TENCAP) Chair

Thermal infrared spectral imagery provides the opportunity to perform material identification on targets. The Aerospace Corporation's SEBASS High Altitude Research Project (SHARP) collects thermal imagery data in both midwave infrared (MWIR) and longwave infrared (LWIR) regions of the electromagnetic spectrum. This thesis explored the ability to perform specific material identification of targets from SHARP acquired LWIR data from the DESERT RADIANCE III exercise conducted in Yuma, Arizona in February 1999. Data were atmospherically compensated using both an in-scene method (ISAC) and an empirical line method (ELM). The ELM was needed due to the lack of in-scene blackbodies, which limited the performance of ISAC. After calibration, an inverse minimum noise fraction rotation was used to correct a noticeable calibration error in the data. Alpha residual and emissivity normalization methods were used to separate emissivity from temperature. Both alpha residual and emissive data sets were analyzed using the spectral angle mapper algorithm. Spectral angle results were poor for alpha residuals, therefore only the emissive data was further examined using the spectral matched filter algorithm and the K-Means classification method. Only results from the spectral matched filter demonstrated an ability to positively identify materials based on specific thermal emissivity.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments

KEYWORDS: Remote Sensing, Hyperspectral, Thermal Imagery, Specific Material Identification, SHARP, DESERT RADIANCE III, Spectral Imagery

CONSTRUCTION AND QUANTIFICATION OF A TOROIDAL BUBBLE APPARATUS

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A toroidal bubble is a vortex ring with a gas core in a liquid. Current interest in toroidal bubbles is partially due to the discovery that small toroidal bubbles can occur in the cavitation collapse of a spherical bubble near the surface of a solid. This can occur near a propeller blade, causing both damage and acoustic emission. Another motivation is that dolphins generate a rich variety of large vortex bubbles. The objectives of this thesis are the construction of an apparatus that generates large toroidal bubbles in a tank of water, and the establishment of the parameter space in which toroidal bubbles occur. The apparatus employs a variable electrical input, interchangeable solenoid valve, interchangeable needle valve, and pressurized nitrogen gas. The tank is an acrylic cylinder with diameter one foot and height four feet. It is observed that whether or not a toroidal bubble forms is highly stochastic. This is studied by varying several parameters of the apparatus. Preliminary results of possible acoustic emission are presented. Future work with the apparatus is discussed, including digital photography of toroidal bubble formation and the effect of ensonification on the motion.

DoD KEY TECHNOLOGY AREA: Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: Toroidal Bubble, Vortex Ring, Acoustic Emission, Fluid Dynamics

TURBULENCE PROFILES AND OUTER LENGTH SCALE DETERMINATION IN THE ATMOSPHERE USING BALLOONS

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Turbulence in the atmosphere drives the formation of temperature inhomogeneities that scatter and diffract propagating electromagnetic waves, adversely affecting laser weapons and high-resolution optical systems. Military operations require reliable turbulence profiles for the development and validation of turbulence prediction models.

This research investigated the false turbulence contribution caused by well-known temperature steps in the vertical profile of the atmosphere, especially in the stratosphere. The homogeneity and isotropy requirements of structure functions were used to develop a technique to remove the false contribution to the temperature structure constant, C_T^2.

Both 1.54 cm and 5.82 m vertical resolution profiles with 0.001 to 0.01 K temperature resolution were collected from a balloon flight. Steps of 0.1 to 1 K in the vertical temperature profile produce abrupt changes in the mean temperature that obscure the measurement of the actual turbulent fluctuations. Removing these anomalies exposed the underlying C_T^2 distribution. Application of the new technique for several sampling intervals revealed a Kolmogorov inertial subrange extending from ~25 cm to ~10 m. The potential of this technique to compute the isoplanatic angle, θ_0 , coherence length, r_0 , and Greenwood frequency, f_g , reliably by using inexpensive balloons should benefit airborne and space-based laser programs.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Directed Energy Weapons, Modeling and Simulation

KEYWORDS: Adaptive, Atmosphere, Laser, Optics, Propagation, Turbulence

IMPACT ANALYSIS OF A BIOMECHANICAL MODEL OF THE HUMAN THORAX

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The biomechanical response of a finite element model of the human thorax and a protective body armor system was studied under impact loading from a projectile. The objective of the study was to create a viable finite element model of the human thorax. This objective was accomplished through the construction of a three-dimensional finite element model in DYNA3D, a finite element analysis program. The model was validated by comparing the results of tests of body armor systems conducted on cadavers to results obtained from finite element analysis. A parametric study was undertaken to determine the essential components of the model. The results from this investigation determined that the path of force propagation from a body armor system to the thorax upon bullet impact is directly through the vest to the sternum and then through the skeleton to the rest of the body. Thus, any parameters that affect the components in this pathway were essential to the model. This included the muscles, their geometries, material properties, and viscosity, as well as the Young's modulus of the sternochondral cartilage and the bones themselves.

DoD KEY TECHNOLOGY AREAS: Clothing, Textiles, and Food, Modeling and Simulation, Other (Biomechanical)

KEYWORDS: Finite Element Analysis, Human Thorax Model, Impact Analysis

A PROJECTILE FOR A RECTANGULAR BARRELED RAIL GUN

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The Physics Department at the Naval Postgraduate School is developing a concept to overcome the problems that keep present rail guns from being practical weapons. The rails must be replaced often if the rail gun operation is to be continuous. Replacing the rails in present rail gun configurations is time consuming. The Physics Department's design concept uses a rectangular barrel as part of the solution to the problem of replacing the rails. The projectile will require flat surfaces to maintain electrical contact with the flat rails and aerodynamic stabilization because of the lack of angular momentum. This thesis develops one possible model of a projectile for a rectangular barreled rail gun, which could be used to replace the standard five-inch gun found on most warships. The proposed projectile is successfully modeled as a five inch projectile with flat areas planed onto opposite sides and long chord, short span fins attached in a cruciform configuration. The computer programs used to develop the projectile model are included to allow evaluation of alternate configurations.

DoD KEY TECHNOLOGY AREAS: Conventional Weapons, Modeling and Simulation

KEYWORDS: Projectiles, Rail Guns, Computer Modeling

ANALYSIS OF THE WATERHAMMER CONCEPT AS A MINE COUNTERMEASURE SYSTEM

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Second Reader: John D. Pearson, Chair of Mine Warfare

The purpose of this thesis is to provide an analysis of the Waterhammer concept design. Waterhammer is a device intended to generate repetitive shock waves to clear a path through the very shallow water region for amphibious operations. These repetitive shock waves are intended to destroy obstructions and mines alike.

This thesis analyzes the energy budget of the deflagration processes and the basic principles of shock waves and acoustic saturation. When the source amplitude is increased to very high levels, acoustic saturation sets in, a state in which the amplitude of the received signal approaches a limiting value, independent of the source amplitude. Acoustic saturation thus will set physical constraints in the design of Waterhammer. Furthermore, as the pulse propagates in the shallow water environment, reflections from the water's surface and bottom floor will spread the energy in the water column thus reducing the energy density. These combined effects can affect the intended performance of Waterhammer. The results of the analysis in this thesis lead to the conclusion that Waterhammer may not be viable in its present concept design.

DoD KEY TECHNOLOGY AREAS: Conventional Weapons, Surface/Under Surface Vehicles-Ships and Watercraft, Manufacturing Science and Technology (MS&T)

KEYWORDS: Waterhammer Performance, Acoustic Saturation Limits, Nonlinear Effect in Water Due to Very High Source Levels

QUANTITATIVE ENERGY DISPERSIVE X-RAY SPECTROMETRY USING AN EMISPEC VISION SYSTEM

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The purpose of this work was to investigate the use of an Emispec Vision System to analyze energy dispersive x-ray spectra (EDS) obtained with the Topcon 002B transmission electron microscope (TEM) in the Materials Science Laboratory at the Naval Postgraduate School.

A series of tests performed with a standard NiO sample revealed that the TEM column and EDS detector were operating in a satisfactory fashion. NiO spectra acquired with different sample tilt-angles were used to test the Emispec software. An improved setup configuration, in which accurate quantification is obtained with the sample at zero tilt-angle, was developed.

Quantification tests performed with TiO_2, Cu-Al_2O_3 and alumina-YAG (with 2.5% TiO_2) samples confirmed the accuracy of the new software setup. Line profiles across the alumina-YAG interfaces were also recorded to verify the performance of the Emispec system for spectrum profile acquisition and to investigate the Ti distribution at the interface of the alumina-YAG heat-treated sample.

DoD KEY TECHNOLOGY AREA: Materials, Processes, and Structures

KEYWORDS: Transmission Electron Microscopy, Energy Dispersive X-Ray Spectra, EDS Quantitative Analysis

PARABOLIC EQUATION MODELING OF BOTTOM INTERFACE AND VOLUME REVERBERATION IN SHALLOW WATER

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A reverberation model based on the parabolic approximation is developed that includes sediment interface and volume perturbations. A multiple forward/single backscatter approximation is made, and the structure of the solution is found to depend on the two-way propagation with a scattering strength scaling dependent on the local properties of the perturbation. The model is implemented for continuous wave (CW) signals to predict mean reverberation pressure levels and for broadband pulse signals to generate complex reverberation structures in the time-domain. The spatial correlation and statistical properties of these predicted signals are then analyzed in an attempt to extract information on the underlying characteristics of the perturbation. Preliminary analysis suggests that reverberation due to the volume perturbations decorrelates more rapidly over depth than the reverberation due to interface fluctuations, although the differences appear small. Additionally, the statistical character of the reverberation structure due to the interface appears as a relatively flat spectrum, while the spectrum of the volume reverberation tends to appear colored. Attempts to correlate these characteristics with the structure of the perturbations is ongoing.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Shallow-Water Sound Propagation, Reverberation, Bottom Interface, Bottom Volume, Spatial Perturbations, Sound Speed Perturbations, Peak Correlations, Time/temporal Series, Range Series, MMPE, MMPEREV

TERRAIN CATEGORIZATION USING MULTISPECTRAL AND MULTITEMPORAL IMAGERY (U)

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Alan A. Ross, Navy Tactical Exploitation of National Capabilities (TENCAP) Chair

Abstract is classified.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Sensor Fusion, Multitemporal, Terrain Categorization, Imagery Intelligence

DESIGN AND COST-BENEFIT ANALYSIS OF A MINI THERMO-ACOUSTIC REFRIGERATOR DRIVER

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A miniature thermoacoustic refrigerator is being developed for the purpose of cooling integrated circuits below their failure temperature when used in hot environments. This thesis describes the development of an electrically powered acoustic driver that powers the thermoacoustic refrigerator. The driver utilizes a

flexural tri-laminar piezoelectric disk to generate one to two Watts of acoustic power at 4 kHz in 15 bar of He-Kr gas mixture.

This thesis also provides a cost analysis of the Mini TAR and a comparison with other cooling methods in terms of cost and benefits. It estimates the unit cost of a Mini TAR and compares it with other existing microchip coolers in terms of cost and benefits.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Electronics

KEYWORDS: Thermoacoustics, Refrigeration, Acoustic Driver, Piezoelectric Driver, Cost and Benefit Analysis

HIGH SPEED MARINE CRAFT THREAT: BUOYANCY AND STABILITY REQUIREMENTS FOR A SUB-LAUNCHED WEAPON SYSTEM

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Military intelligence has researched various scenarios in which the submarine is the only platform available to engage hostile waterborne infiltration forces. Torpedoes are meant for large ships and cruise missiles are strategic weapons not to be wasted on small craft. Therefore, the submarine does not have a weapons capability to engage and destroy high-speed marine craft (HSMC) that would be used for coastal infiltration.

The most practical scenario would utilize a torpedo stow for a weapon system that would be tube launched, thus ensuring the maximum cruise missile capability of the submarine with a minimal sacrifice to its anti-surface and anti-submarine capabilities. The maintaining of submarine stealth will be paramount, therefore, an off-hull launcher is desired. The weapon needs to be highly discriminative due to high shipping traffic in the coastal environment. In all, the major factors associated with the design and employment of a sub-launched weapon system for engaging HSMC are the threat, the missile, the launcher and the deployment method.

In a hostile coastal environment, there are numerous targets ranging from surface threats to air threats. Missile design is dependent on the threat and can be varied for different scenarios. However, the launcher and deployment of a tube launched weapon system are only restricted by the dimensions of the torpedo tube and the buoyancy and stability of the designed launcher. These parameters can be quantified and modeled. This thesis focused on designing a weapon system, SEABAT, to meet the basic buoyancy and stability requirements. The results of the SEABAT design prove its feasibility as a torpedo tube launched weapon system.

DoD KEY TECHNOLOGY AREA: Conventional Weapons

KEYWORDS: High Speed Marine Craft, Buoyancy, Stability, Submarine Launched Weapon System

THE POTENTIAL IMPACT OF HYPERSPECTRAL IMAGERY ON AMPHIBIOUS WARFARE PLANNING

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Military image analysts primarily use panchromatic and radar images to aid situational awareness in preparing a mission plan. Although analysts rely on these two formats, there are situations where these two sensors are unable to detect potential threats, i.e., buried mines. The Department of Defense has proposed

using a hyperspectral sensor to detect threats that otherwise may not be detected by existing sensors. In order to determine the utility of hyperspectral imagery for mission planning, a task analysis was conducted at two Joint Intelligence Centers to measure image analysts' preferences to infrared, radar, panchromatic, and hyperspectral imagery during an amphibious planning process. The results showed that the image analysts were most confident using panchromatic imagery for the majority of the planning tasks; however, the analysts exhibited uncertainty for other tasks, such as detecting buried mines. Further analysis showed that image analysts could reduce their uncertainty in detecting buried mines and producing bathymetric maps by using hyperspectral imagery. Although hyperspectral imagery reduced uncertainty during mission planning, operators report that this imagery is confusing. To integrate hyperspectral imagery in mission planning, image analysts must be trained to interpret a hyperspectral scene and understand how to exploit its' spectral characteristics.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Sensors, Visual Information Processing, Hyperspectral Imagery, Spectral Imagery, Image Interpretation, Amphibious Planning

OPERATION AND CALIBRATION OF THE NPS ULTRAVIOLET IMAGING SPECTROMETER (NUVIS) IN THE DETECTION OF SULFUR DIOXIDE PLUMES

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The Naval Postgraduate School's Ultraviolet Imaging Spectrometer (NUVIS) is a hyperspectral sensor with a spectral response of 300 to 375 nanometers. This thesis research concentrates on the operation and calibration of NUVIS in the detection of effluent sulfur dioxide (SO_2) plumes. NUVIS is capable of detecting and quantifying SO_2 emissions in the form of effluent smokestack plumes by exploiting SO_2's unique UV absorption signature. Laboratory comparison UV spectra of SO_2 were recorded and used to calculate curves of growth for four different SO_2 spectral features. Laboratory results were employed to analyze field data taken of a coal-burning power plant. Analysis of this plume data yielded a mean plume SO_2 mixing ratio of 365 $\pm$ 200 ppm, in agreement with the *in situ* stack value of 400 ppm. Further assessment of NUVIS indicates that its lower limit for SO_2 detection in typical field applications is approximately 70 ppm.

DoD KEY TECHNOLOGY AREAS: Chemical and Biological Defense, Environmental Quality, Sensors

KEYWORDS: Ultraviolet, Hyperspectral, Spectral Imaging, Spectrometer, Sulfur Dioxide, Pollution, Remote Sensing, Environmental Monitoring

OBSERVATIONS OF QUASI-NONRADIATING WAVE SOURCES IN ONE DIMENSION

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A nonradiating wave source is one that drives waves over a region of a medium, where no waves propagate outside the region due to complete destructive interference at the boundary. This thesis describes the first observations of an acoustical source of this type. Physical observations are made with a current-carrying wire that is transversely driven by several types of magnetic field distributions. The wire glows as a result of the current, and the wave pattern can be observed due to the cooling caused by the motion of the wire.

The predicted standing wave response in the source region is confirmed. Numerical simulations of a one-dimensional mass-and-spring lattice show that dissipation, nonuniformity, and nonlinearity each cause radiation to escape from the source region. The radiation amplitude relative to the standing wave amplitude is substantially reduced for sources that are distributed over a region rather than lumped over the same region. In addition, it is possible to make adjustments to the drive parameters to substantially minimize the radiation.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Nonradiating Wave Sources)

KEYWORDS: Nonradiating Waves, Noise Cancellation

TARGET DETECTION AND SCENE CLASSIFICATION WITH VNIR/SWIR SPECTRAL IMAGERY

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Second Reader: Alan Ross, Navy Tactical Exploitation of National Capabilities (TENCAP) Chair

Spectral imagery provides a new resource in remote sensing, which can be used for defeating camouflage, concealment and detection, as well as terrain categorization. A new sensor, the Night Vision Imaging Spectrometer (NVIS), provides VNIR/SWIR (0.4-2.5 m) spectra, which are used to study such applications. NVIS has a nominal GSD of 0.5-1.5 meters in operational modes utilized for this work, which make the data well suited for studying mapping and classification algorithms. Data taken at Ft. A.P. Hill on April 29, 2000 are studied here.

A Principal Components Transformation was performed on the NVIS data. From this new data set, target spectra were collected for use in classification algorithms. The NVIS data was converted from radiance to reflectance in two different ways: Empirical Line Method and Internal Average Relative Reflectance. Using this data, various standard algorithms were performed. It was found that while none of the algorithms correctly classified all of the selected targets, the Mahalanobis Distance and Mixture Tuned Matched Filter^{TM} algorithms were the most successful.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Sensors

KEYWORDS: Hyperspectral, NVIS, Remote Sensing, Imagery, Electro-Optical Sensing

EXPERIMENTAL INVESTIGATION OF SINKING A BUOYANT BODY IN WATER WITH BUBBLES

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The introduction of gas bubbles into a liquid decreases the average density, and thus decreases the buoyant force on a floating body. This thesis investigates the critical average density required to sink a buoyant body in water with rising bubbles. A volume of bubbly water is created in a clear acrylic tube of inner diameter 30 cm and height 60 cm, that is closed at the bottom and open at the top. An array of diffusers at the bottom produces 2 mm diameter bubbles that are uniform over the cross section of the tube. A 10-cm diameter hollow steel ball whose average density is varied from 0.70 to 0.99 g/cm^3 is employed as the buoyant body. A theory of the critical density for sinking is developed, and predicts that the average fluid

density is greater than the ball density for sinking. The experimental data, which include a quantitative error analysis, agree well with the theory for average ball densities from 0.94 to 0.99 g/cm^3, but show a definite trend of fluid densities that are smaller than those predicted for ball densities varying from 0.70 to 0.94 g/cm^3.

DoD KEY TECHNOLOGY AREA: Other (Fluid Dynamics)

KEYWORDS: Water, Density, Specific Gravity, Volume Fraction, Bubbles, Buoyancy, Nonnewtonian Fluid

INFLUENCE OF IGNITION ENERGY, IGNITION LOCATION, AND STOICHIOMETRY ON THE DEFLAGRATION-TO-DETONATION DISTANCE IN A PULSE DETONATION ENGINE

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The feasibility of utilizing detonations for air-breathing propulsion is the subject of a significant research effort headed by the Office of Naval Research. Pulse Detonation Engines (PDE) have a theoretically greater efficiency than current combustion cycles. However, pulse detonation technology must mature beginning with research in the fundamental process of developing a detonation wave. This thesis explores various ignition conditions which minimize the deflagration-to-detonation transition distance (X_{DDT}) of a single detonation wave in a gaseous mixture.

Specifically, the minimum X_{DDT} was determined for different Ethylene and Oxygen/Nitrogen gaseous mixtures under varying ignition energy (0.33-8.31 Joules), mixture equivalence ratios (0.6-2.0), and ignitor locations. To conduct the experiments a 6 feet long, 3 inch diameter tube combustor, support equipment, and operating software was built. Four independent test scenarios were investigated and trends developed to determine the minimum X_{DDT} while reducing oxidizer blend ratios.

Results show that X_{DDT} significantly depends on mixture equivalence ratio (φ) and was minimized at φ ? 1.1. No dependence on ignition energies greater than 0.5 Joules was observed. A further reduction in X_{DDT} was observed with the ignitor located one combustor diameter from the head wall. These results will be useful in future designs of pre-detonators for larger PDEs.

DoD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

KEYWORDS: Detonation, Pulse Detonation Engine, Deflagration-to-Detonation Transition, DDT

PROTOTYPE DESIGN OF NPSAT VISIBLE IMAGER

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The objective of this work was to design and construct a prototype imager for the NPS remote sensing satellite. This project is a low-earth orbiting satellite designed to image the earth in VNIR and LWIR at a resolution of 100–200 m.

The specific imager design considered here is the VNIR instrument, designed to image the daylit earth and atmosphere, as well as the relatively dim aurora (northern lights) at multiple discrete wavelengths. This project defined the desired wavelengths to be: 427.8 nm, 470.9 nm, 557.7 nm, 630.0 nm, 636.4 nm, and 844.6 nm.

A Kodak 763 X 512 CCD was implemented into a push-broom scanner design appropriate for our mission. Design optics are for a nominal F/2, 90 mm Leica lens. The prototype was completed and demonstrated to operate.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronics

KEYWORDS: Satellite, Imager, Aurora, Optics

MEASUREMENT OF FUEL ADDITIVE EFFECTS ON THE SOOT MASS LOADING IN OXYGEN/KEROSENE EXHAUST PLUMES

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Measurements of the soot mass loading in the exhaust of a small liquid rocket engine burning gaseous oxygen with kerosene and kerosene with additive mixtures have been made. The rocket engine was operated over a high soot-producing regime, to simulate the film-cooling region of an actual system, which covered an oxygen-to-fuel ratio (O/F) range of 0.6 to 1.3 and produced a nearly uniform plume distribution. Using a dual fuel tank system, the fuel source was switched during the runs to allow both kerosene and kerosene with additive measurements to be conducted during the same run to ensure nearly identical engine operating conditions. A multi-wavelength optical transmission technique was used to determine the amount of soot present and utilized the transmission ratio of six wavelengths from the near UV to the visible through the plume of the engine. The experimental technique was analyzed to determine the potential error introduced when the transmission values were extremely low (<5%) and what potential effect any organic absorbers (PAHs) may have had on the transmission ratios for the near UV wavelengths. Experimental results show that the addition of as little as 1% by mass of an additive can significantly reduce the amount of soot present in the engine exhaust, and therefore alter the associated IR radiation from the plume.

DoD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

KEYWORDS: Soot Measurement, Kerosene/Oxygen Liquid Rocket Engines, Additive Effects

SENSOR FUSION FOR TERRAIN CATEGORIZATION

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Spaceborne multispectral imaging for terrain classification has been used successfully to identify types of crops and ground cover for agricultural and land management purposes. The information derived from combining multiple sensors operating in different spectral bands into a single image has proven more valuable than that derived from a single band. Although multispectral imaging has not traditionally been associated with military reconnaissance satellites, the ability to automatically identify terrain type has military applications in battlefield characterization and target location. This thesis constructs a multispectral image by combining data from different sensors, and then uses this image for terraincategorization, or TERCAT. One military location in Southern California, San Clemente Island, was imaged using both civilian and National Technical Means (NTM) spacecraft. The civilian images were merged and analyzed using commercial imagery analysis software, producing classification maps of high

quality and compared with the results of the same process performed on the NTM data. The military utility of TERCAT products was explored, with emphasis on the intelligence value of the products.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Sensor Fusion, Terrain Categorization, Imagery Intelligence

DC CHARACTERIZATION OF EFETs GROWN ON BULK GaAs AND OVER BUFFER LAYERS OF LOW TEMPERATURE GROWN GaAs(Be)

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This thesis is part of a larger project that is attempting to address the drastic decline of foundries producing radiation hardened electronics for mil-aerospace applications. Wafer substrates containing certain buffer layers are known to improve the radiation tolerance of circuits built on them. Manufacturers potentially can use these substrates to build radiation tolerant devices with minimal or no changes to the design of a COTS device. This research documents the *DC* characteristics of standard Vitesse *EFETs*. Using a computer model built with Silvaco software, predictions for the *DC* operation of Vitesse *EFETs* built on a substrate with layers of *AlGaAs* over *LT GaAs(Be)* are made. Finally, an equation expressing the fermi level as a function of *Be* doping in *LT GaAs(Be)* is developed.

DoD KEY TECHNOLOGY AREAS: Electronics, Other (Radiation Effects)

KEYWORDS: Electronics, Radiation Hardened Electronics, Gallium Arsenide

NON-IMAGING DETECTION AND TRACKING OF MOBILE TARGETS

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In August, 1999, observations with a non-imaging satellite revealed an aircraft (not in afterburner) flying over the ocean. Although this initial detection was made quite by chance, a specialized sensor configuration was devised, and several additional aircraft observations were performed. The precise parameters required for such remote detection are still unclear due to the processing and analysis limitations of current system algorithms. Nevertheless, the successful collections made thus far do provide valuable insight into the phenomenon behind these observations. Furthermore, they point to specific hardware and software shortcomings which may be improved in the near future. This thesis includes a full explanation of the sensor and processing systems, a compilation of accomplished collections, and a thorough analysis of data. It explains the current status of this emerging capability and identifies the steps that are necessary to make remote aircraft detection and tracking into a tactical tool in the future.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Sensors

KEYWORDS: Aircraft Detection and Tracking, Space Sensors

MAGNETIC FIELD-INDUCED ABSORPTION OF SHORT ULTRA-INTENSE LASER PULSES

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Self-generated magnetic fields up to 10^9 Gauss have been predicted in overdense plasmas irradiated with ultra-intense laser light pulses. It was found that the laser absorption can be significantly enhanced by the oscillation of electrons across these fields. There is then a very large Lorentz force, which can strongly accelerate electrons into the plasma and can lead to generation of harmonics in the reflected light. It was shown that large magnetic fields can be significantly amplified to even larger values by the pressure of the light pulse. Potential applications are discussed. All data used in the simulations was unclassified.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Lasers)

KEYWORDS: Laser, Plasma, Ultra-Short Ultra-Intense Laser Pulses, Magnetic Fields

TRANSIENT LOCALIZATION IN SHALLOW WATER ENVIRONMENTS WITH A VERTICAL LINE ARRAY

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Second Reader: LCDR Mitchell Shipley, USN, Department of Physics

Several algorithms based on autocorrelation matching of multiple hydrophone elements in a vertical line array have been developed to localize a broadband transient signal. An earlier developed frequency-domain autocorrelation matching (FACM) algorithm was based on autocorrelation matching of only a single hydrophone. The success and robustness of this algorithm in the presence of environmental mismatch was the motivation to adapt it to include the additional information of multiple hydrophones. The new algorithms developed were based on joint autocorrelation matching, specifically depth- and frequency-domain autocorrelation matching (ZFACM), wavenumber- and frequency-domain autocorrelation matching (KzFACM), and an incoherent summation of the FACM results of all the elements in a vertical line array (IFACM). These algorithms were tested in simple, shallow water environments with and without mismatch in the specification of acoustic parameters (e.g., bathymetry and sound speed). The results suggest that the use of the additional information from multiple elements does improve both the accuracy and robustness of the localizations. Furthermore, the IFACM and the KzFACM algorithms produced similar results that appeared to perform slightly better than the ZFACM algorithm in the presence of mismatch. However, the relative performance of the algorithms appeared to be sensitive to the environment and placement of the source and receivers in the waveguide.

DoD KEY TECHNOLOGY AREAS: Sensors, Signal Processing

KEYWORDS: Joint Autocorrelation Matching, Depth- and Frequency-Domain Autocorrelation Matching, Wavenumber- and Frequency-Domain Autocorrelation Matching

EVALUATION OF RANGE COMPENSATION IN THERMAL IMAGING OF SHIPS USING THE EOPACE DATA BASE

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An ever-present problem in analyzing thermal images for target signatures is the influence of atmospheric effects in the signature observed at significant range. The compensation for these effects, mostly atmospheric absorption and scattering and path radiance requires accurate knowledge of the meteorological parameters for the area involved at the time of the measurements.

Based both on infrared image files taken during the Electro-Optical Propagation Assessment in Coastal Environments (EOPACE) experiment together with the EOPACE environmental data base and on the SeaRad propagation code to generate radiance, a range compensation algorithm is proposed in this thesis. Applying SeaRad output adjusted for the sky path radiance, an 11 by 11 matrix of the apparent sea temperatures is constructed in which each row corresponds to a different zenith angle and therefore range, and each column to a different sea apparent black body temperature. By interpolation all sea pixels in the image are range compensated. The ship pixels are range compensated by imposing continuity in the sea ship interface. The magnitude of scene temperature correction required is of the order of -2.3 ± 1.7 °C which is comparable to the precision of the recorded data.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors, Modeling and Simulation

KEYWORDS: Infrared Radiation, Radiance, Atmospheric Propagation, Range Compensation, Thermal Imaging

EVALUATION OF IMPROVEMENTS TO AN UNDERWATER ACOUSTIC PROPAGATION MODEL BASED ON THE PARABOLIC EQUATION

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Second Reader: James V. Sanders, Department of Physics

This thesis examines two implementations of the parabolic equation approximation to the acoustic wave equation aimed at removing three errors inherent to the wide-angle parabolic equation (WAPE) model. First, the selection of the range-step size used by the split-step Fourier algorithm affects the convergence of the solution. Second, in certain ocean environments WAPE incorrectly computes the down-range transmission loss. Finally, WAPE does not reproduce the standard normal mode basis set as defined by normal mode theory. A double-precision implementation of the WAPE (DP-WAPE) is developed to evaluate the dependence of solution convergence on the numerical precision of the model. Finally, an implementation that is insensitive to the choice of the reference sound speed (COIPE) is evaluated for its ability to reduce or remove the latter two of these three errors. The stability of the WAPE solution was found to be unaffected by the DP-WAPE implementation. The range-step dependence is inherent to the split-step algorithm. The COIPE corrects the transmission loss anomaly and satisfactorily reproduces the standard normal mode basis set.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Underwater Acoustics)

KEYWORDS: Underwater Acoustic Propagation, Parabolic Equation Approximation, Modal Decomposition

APPLICATION OF THE ROBUST SYMMETRICAL NUMBER SYSTEM TO HIGH RESOLUTION DIRECTION FINDING INTERFEROMETRY

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To reduce the number of phase sampling comparators in a direction finding (DF) interferometer antenna, a new array based on a robust symmetrical number system (RSNS) is described. The RSNS is used to decompose the spatial filtering operation into a number of parallel sub-operations that are of smaller computational complexity. Each sub-operation (interferometer) symmetrically folds the phase with folding period equal to $2Nm_i$ where N is the number of channels that are used and m_i is the channel modulus. A small comparator ladder mid-level quantizes each folded phase response. Each sub-operation only requires a precision in accordance with that modulus. A much higher DF resolution is achieved after the N different RSNS moduli are used and the results of these low precision sub-operations are recombined. The parallel use of phase waveforms increases the antenna resolution without increasing the folding rate of the system. The new antenna is constructed and tested in an anechoic chamber, and the results are compared with the experimental results of a previously tested optimum symmetrical number system (OSNS) array. Although the dynamic range of the RSNS is somewhat less than the OSNS, the inherent Gray code properties make it attractive for error control in phase sampling interferometry.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare

KEYWORDS: Robust Symmetrical Number Systems, Optimum Symmetrical Number Systems, Phase Sampling Interferometery, Direction Finding, Ambiguity Resolution

EXAMINATION OF TIME-REVERSAL ACOUSTIC APPLICATIONS TO SHALLOW WATER ACTIVE SONAR SYSTEMS

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The ability to employ effectively an active sonar system in the littoral regions is of great interest to the United States Navy. Time-varying multi-path propagation introduces significant problems that must be overcome in the employment of shallow water active sonar. The phenomenon of time-reversal acoustics (TRA) has provided hope for a solution to this problem by undoing much of the multipath spreading without the need to have knowledge of the environment in these littoral regions. When an active sonar return is time-reversed and retransmitted, this second signal focuses in time and space back at the original source location. This thesis investigates the phenomenon of TRA as it applies to an idealized shallow water environment. Numerical modeling was performed for a variety of source and target apertures and ranges. Results demonstrate a significant enhancement in received active sonar signal strength due to the TRA acoustic field focusing effect. Furthermore, the signal strength enhancement remains significant even when the source to target range changes between active sonar transmissions. The results presented in this thesis demonstrate that the use of TRA may provide substantial signal-to-noise ratio improvements over current active sonar systems. Further modeling and real world experiments could ultimately lead to the development of a practical active TRA sonar system.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation

KEYWORDS: Time-Reversal, Acoustics, Active Sonar

AN ANALYSIS OF RE-ACQUISITION AND IDENTIFICATION SENSORS FOR VERY SHALLOW WATER MINE COUNTERMEASURES (VSW MCM) WARFARE

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The Naval concepts Operational Maneuver from the Sea (OMFTS) and Ship to Objective Maneuver (STOM) will not succeed unless mines and obstacles can be located, identified and cleared from the amphibious approaches. The US Navy's Mine Warfare Plan and the Navy Investment Strategy for Development of Unmanned Underwater Vehicle Systems in Support of naval Very Shallow Water and Explosive Ordnance Disposal Mine Countermeasures Missions have defined specific strategies for achieving a very shallow water mine clearance capability. This thesis examines the potential for various technologies (sensors) to support very shallow water minefield clearance in the re-acquisition and identification of mines and obstacles. First, the mission is defined and current capabilities are reviewed. Second the requirements for the Very Shallow Water Mine Countermeasures mission are examined from the point of view of a notional concept of operations, the operating environment, and required performance characteristics, and, criteria are developed to evaluate potential detection and identification systems. Finally, detection and identification technologies are examined and evaluated against derived criteria. The results are two tables that can be used together as a tool to determine optimum combinations of sensors based upon mission priorities (precise identification, object location, neutralization, area survey) and vehicle capability (incremental energy available for sensors, payload capacity, mission portability, mission duration).

DOD KEY TECHNOLOGY AREAS: Sensors, Surface/Under Surface Vehicles - Ships and Watercraft, Conventional Weapons, Other (Mine Countermeasures)

KEYWORDS: Electro Optics, VSW MCM, EOD, AUV, STOM, OMFTS, Mine Hunting, UUV

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