JUSTIFICATION OF ESTIMATES FOR FISCAL YEAR 1986 SUBMITTED TO CONGRESS

FEBRUARY 1985

DARPA

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

CAL YEAR 1986

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: 61101E
USDR&E Mission Area: 530

Title: Defense Research Sciences
Budget Activity: 1. Technology Base

A. RESOURCES (PROJECT LISTING): ($ in Thousands)

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Costs
	TOTAL FOR PROGRAM ELEMENT	111,913	80,700	92,600	97,900	Continuing	N/A
MS-1	Materials Sciences	14,340	12,500[a/]	17,900	21,375	Continuing	N/A
ES-1	Electronic Sciences	20,863	16,800[b/]	16,175	18,450	Continuing	N/A
DRH-1	Systems Sciences	12,891	12,815	14,925	14,075	Continuing	N/A
CCS	Computer and Communications Sciences						
CCS-1	Intelligent Systems	18,303	[c/]	-0-	-0-	-0-	103,893
CCS-2	Advanced Digital Structures and Network Concepts	19,512	18,645	24,800	24,200	Continuing	N/A
CCS-3	Modernization Technology	8,698	10,200	9,400	9,400	Continuing	N/A
UDR-1	Unconventional Detection Research	7,627	5,350[d/]	-0-	-0-	-0-	41,420
UDR-2	Power Source and Extra Hypervelocity Technology	-0-	-0-	5,000	5,400	Continuing	N/A
DRT-1	Target Penetration Research	1,235	2,200	2,100	2,600	Continuing	N/A

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Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Costs
DRG-1	Geophysical Research	3,104	2,190	2,300	2,400	Continuing	N/A
DRS-1	Space Nuclear Power	5,340	e/	-0-	-0-	-0-	5,340

a/The Laser Countermeasure Materials Development Program was funded by the Strategic Defense Initiative Organization (SDIO) in FY 1985 under Program Element 63224C, Survivability, Lethality, and Key Support Technology. In FY 1986 and future years this program will be funded in this program element.

b/The Gallium Arsenide Technology Program and the Optical Components Program were funded by SDIO in FY 1985 and all future years funds are also being requested by SDIO in Program Element 63220C, Surveillance, Acquisition, Tracking and Kill Assessment.

c/The Intelligent Systems Project for FY 1985 and out years was switched from this Program Element to 62301E, Strategic Technology, Project ST-11, Intelligent Systems, in accordance with Congressional guidance in the FY 1985 Defense Appropriations Act.

d/The Hypervelocity Technology Program was transfered from UDR-1 to SDIO in FY 1985 under Program Element 63222C, Kinetic Energy Weapons. In FY 1986 and future years this program will continue to be funded by SDIO. The remaining programs accomplished in project UDR-1 have been sufficiently successful to transition them to project TT-3, Naval Warfare, in Program Element 62702E, starting in FY 1986.

e/The Space Nuclear Power Project was funded by SDIO in FY 1985 and all future year funds are also being requested by SDIO in Program Element 63224C, Survivability, Lethality and Key Support Technology.

SUMMARY

Title: Defense Research Sciences
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FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Costs
2,300	2,400	Continuing	N/A
-0-	-0-	-0-	5,340

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B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED:

Materials Sciences. This project explores new materials, processes, structures, and device concepts, and demonstrates innovative solutions for overcoming materials-related limitations or barriers to advancements in: rapid-solidification technology; improved propulsion engine materials; metal-matrix composites; ceramics and ceramic matrix composites; laser countermeasure materials; synthesis of stronger and more heat resistant polymers and adhesives; solid lubrication; materials response at high strain rates; and radar absorbing materials and structures.

Electronic Sciences. This project explores new concepts in electronic materials, devices, and device fabrication with the goal of demonstrating their feasibility to provide new technical options for implementing future electronic systems. Strong emphasis is placed on pursuit of unique combinations of performance, survivability, and cost required of DoD systems. Technologies pursued include: digital integrated circuits, millimeter wave and optoelectronic circuits of submicron feature size utilizing either compound semiconductors or silicon; electro-optical (especially infrared) sensors; optical computing and processing materials and devices, monomolecular and electronically active polymer films; and special devices and materials of particular interest to DoD.

System Sciences. The object of this program is to carry out highly innovative, small scale, interdisciplinary systems research leading to improved effectiveness of Armed Forces personnel in accomplishing their mission responsibilities. This program is organized around four research areas: technology for the development of command and control software systems; systems for land based travel; systems for autonomous navigation; and development of the advanced biochemical technology base for novel material applications to broad defense/intelligence strategic and tactical problems.

Computer and Communications Sciences. This program supports basic research in information processing and computer communication technology to provide a technological base for the development of future intelligent, network-based, military systems and for improved productivity through automation. The focus is on basic concept development, and includes the development and exploitation of advanced concepts in robotic software and automation technology design systems, advanced system network concepts, and Very Large Scale Integration (VLSI) architecture and design. A modernization technology effort is providing

experimental computer resources to improve research productivity at the forefront of computer science, and developing advanced VLSI design systems, advanced control and manipulation techniques and increased defense manufacturing productivity through the use of advanced automation techniques.

Experimental computer resources are being provided to major universities in order to upgrade their resources to adequately support their DoD research. This portion of the program will continue through FY 1988.

Power Source and Extra Hypervelocity Technology. The objectives of this project are to investigate new materials, processes, structures and demonstrate innovative solutions for overcoming materials related limitations or barriers to advancements in: direct chemical to electrical energy conversion, extremely high power density electrical charge storage and extra hypervelocity projectile/armor impact phenomena. There is a need to greatly improve the performance of: airborne and ground vehicle prime electrical power sources that will permit reduced thermal, acoustic and air inlet radar signatures; high power density electrical charge storage components that can be utilized by a number of advanced weapon system and vehicle concepts requiring high power, short duration sources; and projectile-launching weapon systems, supersonic air vehicles, advanced reentry bodies and advanced heavy armor targets.

Target Penetration Research. This project supports basic research activities in the areas of penetration mechanics, high-performance materials, shaped charge jetting phenomena, and advanced warhead concepts. Also included in the program are theoretical studies of chemical hydrodynamics and combustion/explosion phenomena. Useful results of these various studies are applied to on-going related activities in exploratory development.

Geophysical Research. The Nuclear Monitoring Program conducts research and development to enhance U.S. capabilities for monitoring nuclear explosion events. The program also provides technical information needed for developing sound national policy for negotiations on treaties limiting nuclear testing and provides technical support for U.S. participation in treaty-related international activities. Negotiations for a comprehensive test-ban treaty (CTBT) created the need for detailed technical information concerning monitoring stations internal to the USSR, high frequency propagation, and on-site inspection procedures. In the event that a CTBT were to be signed U.S. security would require the highest possible level of monitoring capability to verify the the Soviet's were or were not employing

evasive techniques. This capability rests on a foundation of basic seismological geophysics which is extended and maintained through DARPA funding of university research. This basic research also leads directly to improvements in the U.S. ability to estimate the yields of Soviet underground explosions and thus to evaluate their weapons program and to verify compliance or non-compliance with the Threshold Test Ban Treaty.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY: There were no significant changes between the FY 1985 and FY 1986 Descriptive Summaries except as listed below.

Electronic Sciences. The $5.6 million increase in FY 1986 funding is due to the inclusion of all optical signal processing efforts in this program element. Originally this work was part of the Strategic Computing program, but due to its fundamental research nature and wide applicability to future DoD systems this transfer was implemented.

Systems Sciences. The increase in this funding in FY 1986 is a result of increased emphasis being placed on the biochemical technology program based on government and industrial interest, including the Small Business Innovative Research program.

Computer and Communications Sciences. Project CCS-3, Modernization Technology is intended to provide state-of-the-art equipment for computer science research in universities and to support research efforts in defense productivity.

Power Source and Extra Hypervelocity Technology. Initial research on this program was funded in FY 1984 in project TT-5. The Extra Hypervelocity Technology program builds on fundamental results of the Hypervelocity Technology program started late FY 1984 and the Electromagnetic Launcher program (TT-5) which was transferred in FY 1985 to the Strategic Defense Initiative Organization. Initial research in the Ultracapacitor program was funded in project UDR-1 during FY 1985.

Geophysical Sciences. In FY 1986, the total funds for basic research under the Geophysical Sciences project are estimated to be $1.1 million less than the amount reported in the FY 1985 Descriptive Summary. This reflects a change in priorities.

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D. OTHER APPROPRIATION FUNDS: None.

E. RELATED ACTIVITIES:

Materials Sciences. DARPA programs in metal matrix composites, rapid solidification technology, advanced ceramics, and high temperature polymers and adhesives are coordinated with other service efforts and other agencies through a number of committees and interagency groups, including: National Science Foundation, Interagency Materials Coordinating Committee; Interagency Working Group on Ceramics for Heat Engines; Interagency Committees on Rapid Solidification and Metal Matrix Composites.

Electronic Sciences. The Services have programs developing specific infrared sensor devices. The DARPA program is focused on demonstration of new "silicon-like" materials growth, processing, and characterization for infrared sensor arrays, principally on the material mercury cadmium telluride. The DARPA programs in optical processing complement the algorithm and architecture programs of the Air Force Office of Scientific Research with efforts in material and device development. The Services have initiated, under a coordinated effort through the Under Secretary of Defense for Research and Engineering (USDR&E), exploratory and advanced development efforts in Very-High-Speed-Integrated-Circuits (VHSIC). The research effort in submicron device and materials technology complements the USDR&E program by addressing long range problems in design and fabrication of materials and devices that operate at or very near their physical limits and are fabricated in high vacuum via in-situ combinations of beam processing steps. A number of efforts are funded cooperatively with the Air Force, Navy, and Army Offices of Research, Air Force Wright Aeronautical Laboratories Materials Division, and the Naval Electronic and Air Systems Commands. Cooperative research efforts with the National Science Foundation at universities concerning use of synchrotron radiation, submicron structures, and crystal growth research are in progress.

Systems Sciences. These efforts are coordinated with Army Research Institute, Battlefield Information Systems program; Defense Mapping Agency; Army Intelligence Center and School; the U.S. Army Armor Center, Department of the Army; the U.S. Army Tank Automotive Command, the Air Force Rome Air Development Center;

the Air Force Wright Aeronautical Laboratories, and the U.S. Army Engineering Topographic Laboratories. Chemical ultrasensor research is closely coordinated with the Army and complements the latter's efforts by focussing on long range materials processing, integration, and device design concept issues.

Computer and Communications Sciences. The multi-Service effort on Very High Speed Integrated Circuits (VHSIC) is focused on very high speed technology and complements the DARPA program which is addressing architecture and design concepts for very large scale systems. The National Science Foundation (NSF) has a basic research program in submicron structures which is being coordinated with the DARPA program. DARPA maintains close technical liaison with DCA on new computer communications protocols and advanced network concepts. NSF and the military services are also providing sorely needed computer equipment to research institutions and some industry vendors are offering sizeable discounts to universities. NSF, the National Aeronautics and Space Administration, the Office of Naval Research, the Air Force Systems Command, the Naval Material Command, and the Army Research Office also support research in robotics. The Defense NATO Network Program Office carries out new team efforts on network architecture. Coordination with users and other sponsors of related research is maintained through joint programs, workshops, conferences, meetings between program managers, site visits, choice of contracting agent, and published research.

Power Source and Extra Hypervelocity Technology. The Solid Oxide Fuel Cell development is directly related to Service efforts in improving conversion efficiency of prime electric power sources. This program is coordinated directly with the Air Force Wright-Aeronautical Laboratories (AFWAL) and the Department of Energy (DOE) as the agents and close consideration is maintained with AFWAL and DOE efforts. Basic ultracapacitor technology is based upon a proprietary concept with employs mixed solid metal oxide materials and is related to concepts and techniques being evolved in the joint Air Force Solid Oxide Fuel Cell development. In the Extra Hypervelocity Technology program, the current effort is to explore velocity regimes and investigate the important military consequences of extra hypervelocity techniques. The supporting technology in the Strategic Defense Initiative such as compact power sources and power conditioning will be directly applicable to this effort.

Target Penetration Research. Armor/anti armor research is coordinated with the Army and Navy via annual joint program reviews.

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USDR&E Mission Area: 530

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Geophysical Sciences. Complementary research is conducted by the National Laboratories of the Department of Energy. The topics of seismic wave propagation and of earthquake source mechanisms are also of fundamental scientific interest and are of importance for earthquake hazard reduction. For these reasons research on these topics is also supported by the National Science Foundation and by the Nuclear Reactor Commission. Since most of this work is routinely published, coordination with DARPA's work may be achieved by careful reading of the open literature and attendance at professional meetings.

F. WORK PERFORMED BY:

Materials Sciences. Effort is distributed among performers as follows: 50% industry, 20% universities and 15% in-house government laboratories and 15% federally funded research development centers. The major performers are: GTE Sylvania, Towanda, Pennsylvania; General Electric Company, Schenectady, New York; United Technologies Research Center, East Hartford, Connecticut; Rockwell Science Center, Thousand Oaks, California; BDM Corporation, McLean, Virginia; Lanxide Corporation, Newark, Delaware; Babcock and Wilcox, Lynchburg, Virginia; Special Metals, New Hartford, New York; Hughes Aircraft Company, El Segundo, California; University of Michigan, Ann Arbor, Michigan; University of Massachusetts, Amherst, Massachusetts; Carnegie-Mellon University, Pittshurgh, Pennsylvania; Rice University, Houston, Texas; Massachusetts Institute of Technology, Cambridge, Massachusetts; University of Texas, Austin, Texas; University of Washington, Seattle, Washington; Stanford University, Stanford, California. In-house laboratory efforts are performed at the Naval Research Laboratory, Washington, District of Columbia; Air Force Wright Aeronautical Laboratories/Materials Laboratory, Dayton, Ohio; Naval Weapons Center, China Lake, California; and the National Bureau of Standards, Gaithersburg, Maryland.

Electronic Sciences. Approximately 48% of this work is performed by industry, 34% by universities, 10% by government laboratories, and 8% by FCRCs. The top industrial performers include: Rockwell International Science Center, Thousand Oaks, California; Honeywell Research Center, Bloomington, Minnesota; Texas Instruments, Dallas, Texas; McDonnell-Douglas, Huntington Beach, California; and Santa Barbara Research Center, Santa Barbara, California. The top university performers are: Stanford University, Palo Alto, California; Massachusetts Institute of Technology, Cambridge, Massachusetts; Cornell University, Ithaca, New York; Case-Western Reserve, Cleveland, Ohio; Pennsylvania State University, University Park, Pennsylvania; University of California, both Berkeley and San Diego,

California; and the University of Southern California, Los Angeles, California. In-house performer is the Naval Research Laboratory, Washington, District of Columbia. Lincoln Laboratory, Bedford, Massachusetts is the FCRC performer.

Systems Sciences. 60% industry and 40% universities. Major performers include: Science Applications, Inc., Tucson, Arizonia; Advanced Information and Decision System, Mountain View, California; Analytic Sciences Corporation, Reading, Massachusetts; General Research Corporation, McLean, Virginia; Ohio State University, Columbus, Ohio; University of Wisconsin, Madison, Wisconsin; Massachusetts Institute of Technology, Cambridge, Massachusetts; Stanford University, Palo Alto, California; University of Utah, Salt Lake City, Utah; and Widegren Communications Corporation, San Jose, California.

Computer and Communications Sciences. 81% university, 11% industry, and 8% in-house. The major performers are Bolt, Beranek, and Newman, Cambridge, Massachusetts; California Institute of Technology, Pasadena, California; Carnegie-Mellon University, Pittsburgh, Pennsylvania; Columbia University, New York City, New York; Massachusetts Institute of Technology, Cambridge, Massachusetts; MIT Lincoln Laboratory, Lexington, Massachusetts; Rand Corp., Santa Monica, California; Stanford University, Stanford, California; University of California, Berkeley, California; University of California, Los Angeles, California; University of Maryland, College Park, Maryland; University of Rochester, Rochester, New York; University of Southern California, Information Sciences Institute, Marina Del Rey, California; and Yale University, New Haven, Connecticut.

Power Source and Extra Hypervelocity Technology. Effort on the Solid Oxide Fuel Cell is distributed as follows: 83% is provided to a national laboratory and 17% is industry. The major performers are Argonne National Laboratory, Argonne, Illinois and Gould Defense System, Inc., Cleveland, Ohio. Industry provides 100% of the ultracapacitor effort. The prime contractor is the BDM Corporation, McLean, Virginia. The Extra Hypervelocity Technology program is distributed 70% industry, 20% universities and 10% in-house government. Major performers are General Research, Inc., Santa Barbara, California; Physics International, San Leandro, California; Westinghouse R&D, Pittsburgh, Pennsylvania; Southwest Research Institute, San Antonio, Texas; University of Dayton, Dayton, Ohio; University of Texas, Austin, Texas; Los Alamos National Laboratory, Los Alamos, New Mexico; and the Army Armament Research and Development Center, Dover, New Jersey.

Target Penetration Research. Zernow Technical Services, San Dimas, California; Lawrence Livermore National Laboratory; Livermore, California; Los Alamos National Laboratory, Los Alamos, New Mexico; and the Army Armament Research and Development Command, Dover, New Jersey.

Geophysical Sciences. All of this work is performed by universities. These include: University of Arizona, Tucson, Arizona; University of California, Berkeley, California; California Institute of Technology, Pasadena, California; Georgia Institute of Technology, Atlanta, Georgia; Harvard University, Cambridge, Massachusetts; Massachusetts Institute of Technology, Cambridge, Massachusetts; Pennsylvania State University, University Park, Pennsylvania; St. Louis University, St. Louis, Missouri; Southern Methodist University, Dallas, Texas; University of Southern California, Los Angeles, California; University of Texas, Richardson, Texas; Columbia University, Palisades, New York; and University of Colorado, Boulder, Colorado.

G. PROJECTS LESS THAN $7 MILLION IN FY 1986:

Power Source and Extra Hypervelocity Technology (NEW START). The Monolithic Solid Oxide Fuel Cell is potentially the largest single advance in direct chemical to electric energy conversion yet achieved. By utilizing a major innovation of an ion-conducting ceramic electrolyte and electron-conducting ceramic electrode and cell interconnects it appears possible to convert gasified fossil fuels directly to electrical energy at efficiencies over sixty percent. In addition, through advances in the technology of sub-miniaturized ceramic and component fabrication it now appears possible to produce an extremely compact power unit with energy and power densities exceeding those of gas turbines.

The ultracapacitor concept was demonstrated under laboratory conditions during FY 1984. During FY 1985 engineering parametric studies, technical and economic analyses, materials research and capacitor subscale module characterization and fabrication are conducted. Experimental modules that produce 1 KW to 10 KW power are tested in FY 1985. In FY 1986 a major system preliminary design for a 200 KW system will be conducted. The Ultracapacitor Development program to completion includes completion of subscale module testing and design review of the 200 KW capacitor. Pending successful design review, a detailed design, fabrication and operational evaluation of a prototype 200 KW module will be conducted which provides energy and power densities suitable for airborne weapon applications.

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Title: Defense Research Sciences
Budget Activity: 1. Technology Base

During FY 1985, the emphasis in this program will shift to the extra hypervelocity regime. The primary objectives will be to develop the enabling technologies for extremely high velocity launchers and to explore impact physics at pressure and energy density levels at which impact fusion may be possible. Initial development of launcher technology will be undertaken in FY 1986. During FY 1987 and out, experimental launchers will be fabricated and impact physics experiments will be undertaken.

Target Penetration Research. Program accomplishments in FY 1984 included (1) establishment of the performance potential of two advanced warhead concepts applicable to lightweight torpedoes for anti-submarine warfare, (2) development of improved materials processing techniques for producing lightweight, high-strength ceramics and cermets, and (3) evaluation of the performance of porous metals and certain super-plastic alloys. In FY 1985, work on advanced underwater warheads is concentrated on enhancing lethality using special supplemental devices, and also in improving warhead effectiveness modelling capabilities. In addition, on-going materials development and evaluation efforts for both armor and munitions applications are being continued, and a new thrust is being initiated to develop improved materials for kinetic energy penetrators. In FY 1986, the first full-scale testing of advanced underwater warheads is anticipated, coupled to continuing torpedo design activities. All materials development and evaluation work will be continued, with some transfer of technology to service laboratories expected. DARPA participation in the underwater warhead program is expected to end after FY 1987, with the transitioning of remaining work to the Navy. Materials development studies for armor/anti-armor applications are expected to remain a part of this continuing program in future years, although the specific goals of such efforts will likely change somewhat to address problems identified in advanced development work.

Geophysical Sciences. In FY 1984 a large scale seismic tomographic analysis of earth structure revealed for the first time an accurate picture of lateral variations in the earth. This will lead to more accurate locations of seismic events which is of use for directing the use of satellites and on-site inspections. The improved earth structure should also lead to more accurate yield estimates by means of magnitude from long-period Rayleigh waves. By use of improved instrumentation it was found that high-frequency noise levels at quiet sites are much lower than was thought here-to-fore. This implied that decoupled explosions could perhaps be detected at lower yields than previously thought possible. Patterns of body wave magnitude were discovered which could be contoured on the surface of the globe.

This implied that there is a limit to the precision with which yields can be determined with standard seismic methods. This has important implementations for the verifiability of a Threshold Test Ban Treaty and for the methods which should be used to estimate precise yields.

In FY 1985 tomographic research is continuing in order to better outline the 3-dimensional structure of the earth and to gain the location and yield-estimation benefits discussed above. Research is being funded to outline the geographical distribution of low noise sites; and to understand the source of the existing noise. These tasks should help predict the locations of low noise sites. Patterns in body waves are being studied to understand the cause of the patterns: propagation through varying earth structure or release of tectonic strain. Analysis of the tectonic strain release which affects surface wave yield estimates is underway using long-period body waves. This will give us confidence in bias estimates between Soviet and U.S. test sites. Close-in monitoring of underground tests at the Nevada Test Site is helping to resolve issues of non-linear propagation under moderate strain, of source spectra, and of tectonic strain release. Earthquakes are being monitored at close distances to see if their source spectra have significant differences from those of explosions. Theories of complex earthquakes are being developed. Such earthquakes may have source spectra similar to those of explosions. Theoretical approaches to 3-dimensional scattering and propagation are being developed to compare to model studies and to finite difference calculations. These studies are of importance in developing regional discriminants which are the only discriminants which may be used for weak decoupled explosions.

The university research program is funded on a two-year cycle. Thus, the work which will be performed in 1986 is a continuation of that underway in 1985, which is discussed above.

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Project: MS-1
Program Element: 61101E
USDR&E Mission Area: 530

Title: Materials Sciences
Title: Defense Research Sciences
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The objectives are to explore new materials concepts, and seek solutions to problems which require specially tailored materials such as amorphous metals, metal matrix and ceramic matrix composites, high temperature polymers and adhesives, easily processed ceramics, materials resistant to laser irradiation, solid lubricants for ceramics, and radar absorbing materials/structures. The full exploitation of rapid solidification powder technology will make possible a 300°C increase in operating temperature limits for turbine-blades, hence higher specific thrust and lower specific fuel consumption for advanced cruise missile and tactical aircraft engines. New aluminum alloys emerging from this technology will challenge higher-cost titanium alloys and composite materials for achieving weight, cost, and fuel reductions in advanced aircraft and missiles. Metal-matrix composite research is addressing new fabrication technologies for achieving high stiffness and high strength structural alloys, and new methods combining the advantages of rapid solidification metallurgy with metal matrix composite technology. Low temperature processing of materials offers the possibility of producing new composite classes, or of improving the quality or production speed of materials such as rocket propellants. New techniques in polymer, polymer composite and adhesive processing will lead to lightweight structures designed for longer life at higher temperature. Potential DoD applications include structural members and coatings for high performance aircraft and composite structures for space. Novel ceramic processing approaches including explosive compaction and chemical synthesis techniques to produce low cost, reliable ceramics and ceramic matrix composites for structural and optical applications are being evaluated. The laser countermeasures materials (LCMM) program is examining specific materials and/or combinations of materials to defend strategic systems from space-based laser radiation. A comprehensive experimental program has indicated ways to harden existing materials. Research in the fundamentals of solid lubrication of ceramics is providing options for lubrication of high temperature engines and satellites where conventional approaches cannot be employed. Processing routes for polymers and ceramics using electromagnetic energy (e.g. microwaves) are being investigated. Research on radar absorbing materials and structures is exploring the use of advanced materials and concepts to meet the future DoD system requirements. Efforts are also examining the production of the behavior of materials subjected to high strain rates.

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2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: In FY 1984, significant advances were made in materials research efforts covering a wide range of materials systems including metals, ceramics, polymers, semiconductors and composites. For example, progress has been made in understanding the factors which must be controlled in the explosive compaction of ceramics. In addition, chemical synthesis routes to ceramic bodies using exothermic reactions have been used to produce bodies that are 95 percent of theoretical density with 100 percent reaction yield. In the polymer blends research, several promising polymer systems have been selected and synthesized.

Significant reduction of the threshold for optical switching/limiting has been demonstrated in various materials, including liquid crystals and semiconductors used in power and energy limiting applications, semiconductor charge injection switches, and free carrier absorption devices; research programs in other promising nonlinear optical materials concepts for optical sensor protection have been initiated.

Based upon accurate testing techniques, ablative materials combinations developed in the laser countermeasures program have shown considerably improved resistance to laser irradiation. Since first surface reflectivity becomes the only parameter whose change can improve performance, it is now possible to predict optimal performance and therefore maximum hardening capability.

A comprehensive state-of-the-art review by leading experts in the field of material modelling and large-scale computer code development was conducted. Results were used to guide future programs designed to predict the behavior of materials under high strain rates.

b. FY 1985 Program: Research to establish a fundamental understanding of the processes of explosive compaction and chemical synthesis of ceramics is continuing. In addition, several new efforts to examine novel processing approaches to ceramics are being initiated. These include a program to form single crystal infrared domes to net shape and a method for using supercritical fluids to build up

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ceramic matrix and carbon carbon composites. A new program to examine the fundamentals of the solid lubrication of ceramics is establishing a technical basis from which concepts can be selected for a variety of DoD needs including high temperature bearings, bearings for satellites, and bearings and seals for cryocoolers and rocket turbo pumps. The initial effort is focusing both experimentally and theoretically on the surface interactions between a ceramic and a lubricant.

The theoretical and experimental approaches to the blending of polymers is continuing. Promising polymers combinations are being blended based on theoretical predictions of optimum conditions and the physical properties of the resulting polymer systems are being measured. A new program is aimed at establishing novel chemical, mechanical and evaluation approaches for improved high temperature polymeric adhesives. The goal of this effort is adhesives capable of withstanding 370°C. Another new effort is examining the use of electromagnetic energy (e.g. microwaves) for the processing or synthesis of unique polymers.

An effort combining physics and materials science to examine novel approaches in the design of radar absorbing structures is beginning this year. Initial research is focusing on an assessment of advanced DoD requirements.

Research on rapid solidification processing of alloys will emphasize welding of rapidly solidified powdered aluminum alloys. Metal matrix composite research will include studies on graphite/magnesium composites for space structures and reinforcing light alloys with silicon carbide particulates.

The theoretical work involving wave propagation in random media, which is applicable to a variety of defense problems ranging from ocean acoustics to radio waves in the ionosphere, is being completed and transferred to the services. The effort to develop improved mathematical constitutive models for use in large-scale computer simulation programs is being expanded, with new work concentrating on studies of materials behavior at high strain rates and micromechanics of deformation.

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The Laser Countermeasure and the Electro-Optic Sensor Protection programs are now being conducted by the Strategic Defense Initiatives Organization (SDIO).

c. FY 1986 Planned Program and Basis for FY 1986 Request: The fundamental efforts in explosive compaction and chemical synthesis of ceramics will end in FY 1986. Results from these programs will be used to establish priorities for an applications follow-on program. Work will continue on establishing the feasibility of the novel approaches to ceramic processing. The solid lubrication of ceramics program will continue to explore the fundamental interactions between a ceramic and a solid lubricant. Advanced ceramic and lubricant compositions will be suggested, formulated and tested. The research on polymer blending will focus on the selection of one or two promising systems which will then be optimized to yield new high performance polymer systems. The research on high temperature adhesives will continue to optimize several adhesives for elevated temperature use in advanced military systems. Several materials systems with unique potential in radar absorbing capability will be identified, fundamental processing limitations will be established and efforts to circumvent those limitations will commence. Research on rapid solidification processing will essentially finish in FY 1986. Metal matrix composite research will emphasize reducing processing costs and improving fracture toughness. The effort to develop improved constitutive models for use in large scale computer simulation will continue with model development and validation work aimed at understanding the response of materials to high rates of deformation.

d. Program to Completion: The feasibility of novel concepts for ceramic and ceramic composite fabrication will be determined and those that are promising will be transitioned to exploratory development programs. Advanced ceramic and solid lubrication formulations will be evaluated and transitioned to development programs for bearings, seals, etc. Research on high temperature polymers, high temperature adhesives, electromagnetic energy processing, and radar absorbing structures will continue, with emphasis on developing fundamental knowledge leading to improved materials for military systems. Studies on metal-matrix composites will continue through FY 1988 with a goal of producing strong, tough, lightweight structural components for airframes, missiles and space applications.

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e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones
Early FY 1985	Early FY 1985	RS aluminum alloy superplastic forming demonstrated
Early FY 1985	Early FY 1985	Demonstration of rapidly solidified metal matrix composite powder technology
Early FY 1985	Early FY 1985	Demonstration of feasibility of cryogenic processing of polymeric binders
Mid FY 1985	Mid FY 1985	Demonstrate the capability to explosively form flat ceramic plates
Late FY 1985	Late FY 1985	Production of high purity aluminum nitride

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Last Year's Reported Plan	Current Plan	Milestones
--	Early FY 1986	Develop theory to predict fracture toughness in metal matrix composites
--	Late FY 1986	Weldability of rapidly solidified aluminum alloys demonstrated
--	Late FY 1986	Demonstrate blended polymer system with optimum physical and chemical properties
Late FY 1985	N/A	Prototype dynamic mesh filter fabricated and tested
Late FY 1987	N/A	Demonstration of concepts for protection of unaided eye

f. Explanation of Milestones Changes: The last two milestones related to the Electro-Optic Sensor Protection Program, which transferred to the Strategic Defense Initiatives Organization (SDIO) effective in FY 1985. These milestones are not applicable to this project and were inadvertently reflected in the DARPA FY 1985 Descriptive Summaries.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ES-1
Program Element: #61101E
USDR&E Mission Area: 530

Title: Electronic Sciences
Title: Defense Research Sciences
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The objective of this project is to explore and demonstrate device, material, and material processing concepts which will provide: (1) new technical options for implementation of future electronic and optical systems and functions for information gathering and processing; and (2) substantial increases in performance, survivability, reliability, and availability of electronic components and monolithic, high functional throughput circuits at reduced cost per function. Specific areas of electronic and optical materials device and manufacturing research include revolutionary new approaches to produce large area infrared sensor materials and devices for strategic and tactical systems; innovative processes, device design concepts, and computer-based process design aids for submicron feature size integrated circuits; compound semiconductors; electronic and optical polymers; monomolecular thin film structures; photorefractive materials and device development for achieving spatial light modulation; and nonlinear optical effects for optical computing.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: Two inch diameter liquid encapsulated Czochralski (LEC) grown crystals of cadmium telluride were obtained for the first time. Careful analysis of heat flow mechanisms overcame long standing obstacles of crystal shape control ("flash-out") and core-hollowing. High quality, thin films of mercury cadmium telluride were realized on large, high band-gap substrates by molecular beam epitaxy (MBE).

Gallium arsenide (GaAs) integrated circuit technology reached a new record for complexity in the US by the fabrication of fully functional one kilobit memory chips. This advance resulted from having completed the scaling of the entire GaAs fabrication technology from two inch diameter wafers to three inch wafers and solving the problems associated with applying direct-step-on-wafer (DSW) lithography to the one-micrometer gate length GaAs device technology. A substantial improvement in the yield versus the complexity trade-off curve also resulted, with six percent yield obtained for these approximately 2300 gate chips.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ES-1
Program Element: #61101E
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Title: Electronic Sciences
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Budget Activity: 1. Technology Base

Initial theoretical and experimental results on charge collection in gallium arsenide (GaAs) due to high energy protons and cosmic rays were obtained as part of the joint DARPA/Defense Nuclear Agency Single Events Program. These measurements showed that the funneling phenomena is greatly reduced in GaAs semi-insulating substrates as compared to silicon. The combination of hydroplane polishing and a new cutting technique for obtaining GaAs wafers resulted in a reduction of damage induced near-surface, deep-trap density by two orders of magnitude. These measurements were carried out by electrolyte photoluminescence, a newly developed characterization technique that increases both sensitivity and spatial resolution for determining deep trap densities.

Thermodynamic calculations led to the discovery of new alloy systems that have low vapor pressure and good wetting properties on source needles used in focussed-ion beam systems. These alloys demonstrated over fifty hours operating lifetime in the focussed ion beam column. Both boron and arsenic beams were obtained from the newly developed alloy systems. This removes the major difficulty that has kept focussed ion beams from being utilized in the fabrication of silicon microcircuits.

The Stanford University Process Emulation Model (SUPREM), used by over 250 industrial and government laboratories, was released in its third edition in a new, robust version. Significant progress was also made towards achieving version 4 which will be a two-dimensional process model, and initial investigations into producing a GaAs version of SUPREM were begun.

Chlorine incorporation occurring in the overgrowth needed to produce the millimeter wave Permeable Base Transistor (PBT) was identified as the performance reducing step. Substituting metal-organic chemical vapor deposition (MO-CVD) in place of vapor phase epitaxy (VPE) has eliminated the problem and allowed the fabrication of PBTs with maximum frequency of operation above 100 gigahertz.

The attempt to fabricate a high speed spatial light modulator (SLM) resulted in a breakthrough that has raised expectations of increasing the framing speeds of such modulators from the 10 to 100 hertz range to better than 100 kilohertz. This breakthrough resulted via the realization and demonstration of

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a new phototransistor-type light detector based on the punch through effect in a MOSFET (metal-oxide-semiconductor-field-effect-transistor) device.

b. FY 1985 Program: Materials and device efforts directed towards achieving millimeter wave, three terminal devices are continuing. Emphasis is placed on utilization of velocity overshoot to achieve the carrier velocities required to implement such devices. Specific device structures under investigation are the Permeable Base Transister (PBT), Vertical Field Effect Transistor, Ballistic Injection and Drift Transistor, and the Opposed Gate-Source Transistor (OGST).

Research on growth and processing of large area mercury cadmium telluride (HgCdTe) infrared sensor material is continuing its emphasis on the molecular beam epitaxy method. Investigation of depositing device quality layers on dissimilar substrates is underway. A selection is being made between the use of CdTe or other materials for large area substrates for epitaxial growth of HdCdTe. Infrared detector and multi-layer superlattice devices of CdTe, HgTe and HgCdTe are being prepared and evaluated. These layered structures are prepared by molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MO-CVD). Research on the growth of mercury manganese telluride (HgMnTe) and related compounds to study and exploit their infrared and magnetic properties is being expanded.

The program to fabricate spatial light modulators (SLMs) should yield the first device, that meets the DARPA program goals, upon completion of the first microchannel SLM. The goals are a 1 kilohertz frame rate, a 1 second storage time, 1 million resolvable elements, 30 decibel phase dynamic range, and a 1000:1 contrast ratio. The program will continue with two other fabrication efforts; one for a deformable membrane modulator and one employing silicon on an electro-optic ceramic.

The optical materials program, to create improved photorefractive materials for light modulation and nonlinear materials for optical switching, will continue to expand. Exploration of monomolecular film applications and ionic polymer conductors is underway. Organic polymeric materials will be incorporated into device structures to determine operating characteristics. The reactive atmospheric

processing technique to produce striation-free barium titanate crystals will either prove to be workable or be dropped from the program. Characterization will begin on the liquid crystalline polymers as well as on the new disubstituted divinyl diacetylene polymers.

In support of all the above activities new analytic instrumentation programs have been initiated. The emphasis is on improving both the elemental sensitivity for detection of unwanted contaminants and increased spatial resolution to determine dopant fluctuations.

c. FY 1986 Planned Program and Basis for FY 1986 Request: Device designs that have yielded successful demonstrations of millimeter-wave operation will be directed towards monolithic implementations that contain both the active and passive devices to result in monolithic mm-wave phased array modules. Monomolecular Langmuir-Blodgett films will be applied to novel materials and device structures to evaluate the passivation potential of these films. New analytic instrumentation technology to increase the sensitivity of elemental analysis will continue. High vacuum, in-situ fabrication of submicrometer integrated circuits by combining various beam processing concepts in one interconnected system will be initiated; initial emphasis will be on demonstrating the low particle counts that are required for tenth micron technologies and the compatibility of various beam processing technologies. Research on low resistance submicron interconnect technology will be expanded. The selected mercury cadmium telluride/substrate combination will be advanced to the demonstration of a large pixel focal plane. Other candidate infrared imaging large focal plane technologies will be evaluated in parallel.

Research efforts in superlattices for increased performance of digital, analog and special purpose components such as infrared detectors, high performance solar cells for space systems, and better nonlinear optical materials for optical switching will be initiated. Specifically, research on new device types such as heterojunction bipolar transistors (HBT), high electron mobility transistors (HEMT), and on large optical switching arrays for optical computing that employ bi-stable elements, changeable holographic facets, and/or tunable non-linear gratings will be initiated. The development of novel analog systems for addressing sophisticated pattern recognition problems will be expanded.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ES-1
Program Element: #61101E
USDR&E Mission Area: 530

Title: Electronic Sciences
Title: Defense Research Sciences
Budget Activity: 1. Technology Base

Continuing efforts include: novel materials growth concepts that yield compound semiconductors with low dislocation densities; processing technology for submicrometer feature sized digital and analog circuits; three terminal device research for millimeter-wave amplifiers; growth and characterization of narrow bandgap materials for infrared focal plane arrays; and exploration of electronic and optical polymers for unique properties of significance to DoD applications.

d. Program to Completion: Research efforts exploring the feasibility of specific new concepts in devices and materials within the Electronic Sciences Project generally have a duration of three to six years. New efforts will be expanded in technology applications of monomolecular films, superlattices, electronic polymers, and three dimensional circuit structures. Exploration of revolutionary in-situ, high vacuum integrated circuit fabrication will be required to keep the lead in electronics from evaporating since conventional processing technology cannot be pushed in an evolutionary manner to tenth micrometer dimensions. Exploration of magnetic semiconductors will expand. The submicron materials and device physics effort will continue in FY 1987 and beyond due to the far-reaching operational significance which accompanies success, and the extreme technical challenge involved. Efforts in extremely high frequency device and material structures will continue beyond FY 1987 due to their emerging importance in super-computation, and secure communications as well as electronic warfare (EW).

e. Milestones: The milestones reported in the FY 1985 Descriptive Summary have been completed or are expected to be completed on schedule:

Last Year's Reported Plan	Current Plan	Milestones
Mid FY 1985	Mid FY 1985	Demonstration of signal amplification at 100 gigahertz in new transistor structures

FY 1986 RDT&E DESCRIPTIVE SUMMARY

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Program Element: #61101E
USDR&E Mission Area: 530

Title: Electronic Sciences
Title: Defense Research Sciences
Budget Activity: 1. Technology Base

Last Year's Reported Plan	Current Plan	Milestones
Late FY 1985	Late FY 1985	Demonstration of device quality Langmuir-Blodgett films for electro-optical waveguides
--	Late FY 1985	Successful fabrication and demonstration of high speed two-dimensional spatial light modulation
--	Mid FY 1986	Evaluation of particle count in vacuum processing environment
--	Mid FY 1987	Demonstration of the compatibility of all necessary beam processing techniques for complete device fabrication

f. Explanation of Milestone Changes: There are no changes in milestones from the FY 1985 Descriptive Summary.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #DRH-1
Program Element: #61101E
USDR&E Mission Area: 530

Title: System Sciences
Title: Defense Research Sciences
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The goal of this project is to develop the systems sciences that form the basis for technological aids to augment the performance of Department of Defense personnel. Problems that have been addressed include: distributed group decision making and group communication; analysis of imagery data; design of control systems for adaptive suspension and other complex vehicles; and the development of advanced bio-chemical technology to allow large scale production of biological materials and structures with novel physical and chemical properties leading to the enhanced performance of man-made devices and systems.

One technical initiative is in command and control information systems. This effort involves: developing a new technological approach for the utilization of interactive graphics to aid in tactical planning and tactical operations; the development of a "remote presence" system for reconnaissance and other applications providing stereo vision and binaural sound; and the development of heuristic, analytic, and electronic techniques to aid in the increasing problem of high resolution synthetic aperture radar image analysis and tactical use.

A second initiative is in the area of adaptive vehicle technology. This effort will provide new controls and capabilities for land-based travel over previously inaccessible terrain using a new control system that anticipates the future path using a laser terrain mapper, relieves the operator of responding to the details of that terrain, and adapts the suspension of the land based vehicle to accommodate to the terrain. Preliminary data to date demonstrates major mobility improvements, e.g., a doubling of maximum speed of travel over rough terrain.

A third initiative is in the area of autonomous land navigation. This effort will provide a capability for a vehicle to plan and execute a cross-country traverse of up to 50 kilometers. The navigation system will plan a route using digital terrain data and will consider mobility characteristics and operational constraints. Using on-board sensors, it will update the database, perform local obstacle

avoidance, and replan as necessary. Applications for an autonomous ground vehicle include reconnaissance, target designation, and various support missions.

The fourth initiative develops and exploits the area of advanced biochemical technology. This effort involves: development of ultrasensitive/ultraspecific chemical monitoring devices for both strategic and tactical application; development of methods for the in-situ production of visco-elastic biopolymers for enhanced marine vehicle speed, stealth, and sensor performance; and the fabrication of novel, stable, biological structures for broad-band electromagnetic defense.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: In FY 1984, the 56 kilobits per second production prototype video codec was completed. The shared graphics work station, a means for communicating shared interactive graphics, was extended to include hard copy as an input media and completed. A design study on a low-cost video teleconferencing system incorporating the 56 kbps color codec, the shared graphics workspace, and low-cost customer premise satellite earth stations was completed, and a system was fabricated.

A "remote presence" system incorporating stereo video and binaural sound was demonstrated using a teleoperated vehicle and a fiber optic tether.

In the area of adaptive platforms for land-based travel, the design for a full-scale hexapod vehicle was completed. This vehicle will weigh 2,268 kilograms, stand 2.13 meters high and will be 4.27 meters in length. It will be capable of moving over rough terrain, non-negotiable by conventional wheeled or tracked vehicles at a speed of 13 kilometers per hour. It will go up 100% slopes, cross-slope on a 100% grade, climb over 1.83 meter high obstacles, and cross 2.13 meter wide ditches. In FY 1984, fabrication of all major components was completed. The vehicle control system, including a unique laser terrain mapper, was tested. Final assembly of the hexapod was initiated. The work on control of a three-dimensional monopod was completed and extended to a quadruped. A high energy density composite flywheel energy storage system was demonstrated.

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Project: #DRH-1
Program Element: #61101E
USDR&E Mission Area: 530

Title: System Sciences
Title: Defense Research Sciences
Budget Activity: 1. Technology Base

As an aid to the analysis of high resolution synthetic aperture radar imagery, algorithms for relating image characteristics to scatterer characteristics, expert system heuristics, and feature extraction techniques were completed in FY 1984. New broad area search procedures were developed and initial evaluation showed the potential for greatly improved false alarm/hit rate statistics over current systems.

Advanced biochemical technology research focused on material production and characterization, and early concept evaluation. Accomplishments include the production of monoclonal antibodies against a variety of surrogate molecular species; development of synthetic strategies for the rational functionalization of individual elements in multi-element microelectrode arrays and demonstration of molecule-based transistors and diodes; discovery of anomalous effects of adsorption on the direct current conductivity of organic semiconductors under pressure and demonstration that the specific binding of antibody-antigen like reagents may produce an extended effect on charge transport properties of these materials; formation of stable enzyme-molecular leash reaction elements and their incorporation on solid-supports; development of stable lipsome structures for molecule-based signal amplification; and successful demonstration of electrode passivation for field emitter tips in room temperature liquid media.

b. FY 1985 Program: There are four major components to the FY 1985 program. First, the effort in command and control teleconferencing is being finalized with the demonstration of a low-cost video teleconferencing system incorporating the 56 kilobits per second color codec and the shared graphics workspace. In contrast to the best existing video teleconferencing systems that require 1.5 megabits per second, the new system uses economical communications (about one-tenth the cost of current systems), the communications are easily encrypted, and, perhaps most importantly, can function in times of crisis where bandwidth will be limited.

Second, the first fielded concept demonstration adaptive suspension platform is being completed and evaluated. This approach makes possible new tactics and all weather operation now precluded and is designed to ease inventory problems (many different vehicles for many different missions) and training problems experienced by military personnel. The coupled M-113 vehicle system is completed and is being

evaluated, and transferred. The first autonomous vehicle demonstration, road following, will take place in FY 1985. In this demonstration, the vehicle navigates up to 20 kilometers on a road at speeds up to 10 kilometers per hour. Research will continue on the vision, sensor, and planning sub-systems for the autonomous navigation system.

Third, ultrasensor research is emphasizing evaluation of ultratrace target loss, noise, and component reliability. Attention is focussed on efforts to minimize non-specific adsorption and the potential for reagent cross-reactivity. Work with viscoelastic biopolymers should continue Phase I efforts. Efforts will concentrate on achievement of critical polymer yields and quality levels, elaboration of general structure-function guidelines, planning of Phase II recombinant deoxyribonucleic acid (DNA) research, and identification of critical issues for Phase II immobilized cell research. Work with recently discovered novel biological structures will emphasize efforts to enhance electrical conductivity and structural stability.

Fourth, prior work in developing aids, heuristics and algorithms to aid in the analysis of high resolution synthetic aperture radar imagery is being combined in a concept demonstration capability for image analysis. The impact will be to remove a major bottleneck in new imagery collection systems, namely that the technology for the collection of imagery far outstrips existing capability for the manual analysis of images due to limitations in the number and capability of military personnel.

c. FY 1986 Planned Program and Basis for FY 1986 Request: Research will continue across a broad spectrum of innovative investigations in systems sciences, including development, demonstration and evaluation of analytic aids for high resolution synthetic aperture radar image analysis; development of techniques to enhance "remote presence" for operators of remote vehicles; field demonstration and evaluation of an adaptive suspension hexapod vehicle including a high density energy storage unit, hydraulics, laser terrain mapper, and hierarchical control algorithms (the vehicle will be modified in late FY 1986 to operate in dynamically stable modes incorporating the dynamic balance concepts used in the three-dimensional monopod and quadruped systems); continued research on the control of quadruped vehicles; the use of biological materials for the development of ultra-sensitive tactical and strategic chemical detection systems; development of novel bio-polymeric materials with significant mechanical

Project: #DRH-1
Program Element: #61101E
USDR&E Mission Area: 530

Title: System Sciences
Title: Defense Research Sciences
Budget Activity: 1. Technology Base

properties allowing enhanced marine vehicle speed, stealth, and sensor performance; development of novel biological structures with broad-band electromagnetic absorption and scattering properties; and the demonstration of an autonomous land navigation technology in which a vehicle traverses a 20 kilometer obstacle course.

d. Program to Completion: Future program content will be determined by research results, technology options and operational problems arising in this critical area.

e. Milestones: The milestones reported in the FY 1985 Descriptive Summary for FY 1984 have been completed on schedule.

Last Year's Reported Plan	Current Plan	Milestones
Early FY 1985	Early FY 1985	Demonstration of low-cost video-teleconferencing system
Late FY 1985	Mid FY 1985	Autonomous vehicle road-following demonstration, 5 kilometers per hour
Late FY 1985	Late FY 1985	Initial estimates of polymer yield/quality from photosynthetic, methylotrophic, and hydrogen oxidizing organisms
--	Early FY 1986	Quadruped operated at gallop gait

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Program Element: #61101E
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Title: System Sciences
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Last Year's Reported Plan	Current Plan	Milestones
--	Early FY 1986	Integrated broad area search, vehicle classification force inferencer, imager/analysis demonstration
--	Mid FY 1986	Hexapod tested to design limits
--	Mid FY 1986	Enhanced "remote presence" system demonstrated
--	Late FY 1986	Autonomous vehicle obstacle-avoidance demonstration
Late FY 1985	Mid FY 1987	Demonstration of synthetic aperture radar (SAR) image analysis system

f. Explanation of Milestone Changes: The demonstration of the SAR image analysis system was moved from late FY 1985 to mid FY 1987 because further refinement and evaluation of system components is required prior to system integration. Demonstrations of subsystems will now be performed instead during the period mid FY 1985 to late FY 1986, followed by system integration and demonstration by mid FY 1987.

The autonomous vehicle road following demonstration was moved from late FY 1985 to mid FY 1985 because reevaluation of the technology indicates that this milestone can be accelerated.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #CCS-2
Program Element: # 61101E
USDR&E Mission Area: 530

Title: Advanced Digital Structures & Network Concepts
Title: Defense Research Sciences
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The objective of this project is to develop the fundamental technology in advanced digital structures and system and network concepts for future distributed military information processing systems. Design methodologies and computer aided design tools are being developed for Very Large Scale Integrated technology which will reduce projected design time and cost over present methods and produce designs of the quality and robustness required for DoD applications. Design systems are being developed which permit the designer to start with a high-level description of the desired chip architecture, and interact with a computer to refine his design, develop test procedures and finally rely on the computer to create a suitable layout on the material substrate. Chips will be designed and fabricated to explore innovative architectures, including highly parallel structures, restructurable logic, signal processing applications and real-time symbolic processing.

System and Network concepts are being explored for use in future Communications, Command & Control architectures which will lead to survivable systems which are easier and faster to use than is currently possible. User interface techniques are being developed which simplify access to distributed resources and anticipate the intent of the user. Concepts for partitionable systems are being developed whereby a system can continue to function at a useable level of capability as multiple separate pieces after being split or prior to merging into an integrated system. Techniques are being developed to facilitate resource sharing among computers and provide easy construction of tailored service units by the user. Diagnostic tools and methodologies are being explored to allow for the rapid isolation of and recovery from network and host failures, and to provide dynamic reconfiguration of resources in response to hostile environmental conditions or overload situations.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: The complimentary metal oxide semiconductor design capability has been tested at 3 micron geometries and is being extended to accommodate Very

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #CCS-2
Program Element: # 61101E
USDR&E Mission Area: 530

Title: Advanced Digital Structures & Network Concepts
Title: Defense Research Sciences
Budget Activity: 1 Technology Base

Large Scale Integrated/Very High Speed Integrated Circuits (VLSI/VHSIC) geometries of 1.2 microns. Advanced design tools were implemented on low cost microprocessor-based work stations. These tools are to be used for the design of VLSI circuits having in excess of 100,000 transistors beginning in FY 1985. Languages and design methodologies to insure functional correctness have been developed. Design methods incorporating algorithms that operate in linear time and memory space are being developed in the areas of layout analysis and simulation. New VLSI-based computer architectures have been implemented coupling the best attributes of application, object-oriented, and functional languages to physical structure such as data flow, pipelined, and other parallel structures. Highly parallel, fine mesh machine architectures were investigated.

Experiments have been conducted to assess the effectiveness of internet fault detection, and isolation and recovery mechanisms. Analytical models of the reliability and performance of multi-net systems have been investigated. Research on cooperative interactive systems has addressed issues of robust communication, explanation of system capability and tailoring of the system to individual needs. A voice annotation capability was added to the multi-media message system for document editing, and a feature-based voice capability for large vocabularies was shown to be feasible. Experiments were conducted to dynamically migrate distributed processes across hosts, and experimentation with dynamic resource reservation techniques were conducted. An automated network management strategy was designed, and the concept of partitionable software systems was explored.

b. FY 1985 Program: Design capabilities for small geometry complimentary metal oxide and gallium arsenide semiconductors are being developed and tested. Circuits having in excess of 100,000 transistors are being designed for implementation of advanced computing architectures. Wafer level circuits having a complexity of over one million transistors are being explored. Advanced computer architectures implementing high level application oriented languages are being investigated. Highly parallel, fine mesh machine architectures are being demonstrated. Work is continuing on scaling design methods to accommodate reduced geometries, higher performance, and increased complexity.

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The cooperative interactive system components are being integrated. Research in the use of voice to support interactive user interfaces is continuing with the use of both feature-based and template-based approaches. A distributed kernel for partitioned software systems is being developed and partitioned system operation is being demonstrated. Special programs called agents are being developed to assist the user in using partitioned systems and in dealing with unfamiliar operating systems. Network partition recovery is being demonstrated; experiments with dynamic resource reservation are continuing and resource reservation concepts will be extended to the internet system. Automated network management techniques for performance tracking, fault detection and isolation, and degradation detection are being integrated into an experimental internet monitoring and control system. Design of an initial automated resource management system is beginning. Protocols for efficient use of high bandwith local area networks are being investigated.

c. FY 1986 Planned Program and Basis for FY 1986 Request: Very Large Scale Integrated (VLSI) architecture and design efforts aim to develop an integrated capability for the design, fabrication, and test of integrated circuits containing in excess of a million gates. Efficient design systems for negative metal oxide, complimentary metal oxide and gallium arsenide semiconductors will be demonstrated. Designs will be scaled to submicron dimensions. Innovative architectures and testing procedures for use with VLSI will be developed. Design tools will be developed to support advanced automation techniques for combined electronic and mechanical piece-part assemblies. Research in cooperative interactive systems will provide a methodology for building information services which share a natural, easy-to-use interface that is consistent across different systems. User interfaces will be provided that maintain the underlying consistency of a workstation environment while customizing that same environment for specific users using a semantic model of available functions and data. Work in combining natural language and graphics presentations will begin. Capabilities will be developed to incorporate continuous speech as an integral component of user interfaces. The use of automated techniques for monitoring, control and operation of the internetwork environment will be demonstrated. Network partition recovery techniques will be made more robust and evaluated. Partitionable software systems will be

developed which permit portable operation as well as surviving unscheduled network disruptions. The automated resource management system will be completed and tested under real-time dynamic load conditions. Network based system concepts and techniques will be developed and investigated in the context of advanced Command, Control, and Communication system architectures.

d. Program to Completion: This is a continuing program. Advanced silicon compiler technology will be developed and this design technology will be extended to other design disciplines.

Mechanical design systems will be coupled with existing flexible manufacturing systems to demonstrate demand manufacturing of mechanical components. Emphasis will be placed on integrating total system designs to facilitate manufacture and support of total systems. Experimentation in advanced computing architectures will continue with major emphasis placed on rapid prototyping of very high performance special purpose machines. Very Large Scale Integrated architecture and design efforts will focus on development of integrated capabilities for the design, fabrication, and test of integrated circuits containing in excess of one million gates and for the rapid prototyping of systems containing circuits of this complexity. Research in speech will produce connected-word speech systems that can perform simple functions such as data base retrieval and machine operating system commands. Intelligent user interfaces will combine natural language and graphic outputs to the user and user models that anticipate work session scenarios will be implemented. Operating and network management systems will result in robust, survivable systems that continue to provide local utility in the face of major global outages.

e. Milestones:

Last Years's Reported Plan	Current Plan	Milestones
Late FY 1984	Mid FY 1985	Demonstrate multi-processor containing 1000 processors.

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Title: Advanced Digital Structures & Network Concepts
Title: Defense Research Sciences
Budget Activity: 1 Technology Base

Last Years's Reported Plan	Current Plan	Milestones
Mid FY 1985	Mid FY 1985	Demonstrate Very Large Scale Integrated circuits containing 1 million transistors.
Mid FY 1985	Mid FY 1985	Demonstrate Very Large Scale Integrated/Very High Speed Integrated Circuits CMOS design capability.
Late FY 1985	Late FY 1985	Demonstrate automated resource management techniques.
Late FY 1985	Late FY 1985	Demonstrate one company-level simulation network; begin second local area simulator network.
Late FY 1986	Late FY 1986	Demonstrate Gallium Arsenide design capability.
--	Late FY 1986	Demonstrate combined English/graphics user interface capabilities.
--	Late FY 1986	Demonstrate, via simulation, algorithms for data reconstitution with mininal error and minimal communications between models.
--	Late FY 1986	Demonstrate demand manufacture of Integrate Circuits components based on functional specification.
--	End FY 1987	Develop design techniques for integrated systems.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #CCS-2
Program Element: # 61101E
USDR&E Mission Area: 530

Title: Advanced Digital Structures & Network Concepts
Title: Defense Research Sciences
Budget Activity: 1 Technology Base

f. Explanation of Milestone Changes: Construction of a multiprocessor having over 1000 processors was delayed to allow production engineering of circuits to achieve the necessary yield and reliability.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: # CCS-3
Program Element: #61101E
USDR&E Mission Area: 530

Title: Modernization Technology
Title: Defense Research Sciences
Budget Activity: 1 Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: This project is aimed at strengthening the capabilities of U.S. universities to provide critical fundamental research in information processing by providing, and maintaining a base of modern computing resources. In addition, it is focused on developing computer techniques for normal robotics and for automated system design. The modenization area was highlighted by the Defense Science Board as a critical area for investment if the U.S. technology leadership in information processing is to be maintained. Existing equipment, which in some cases is almost twenty years old, is being upgraded from large time-sharing systems to powerful single-user workstations configured in local networks. Experimental computer resources such as symbolic processors with large address space and high resolution graphics displays are being provided to U.S. universities performing DoD research to stimulate innovation in the fields of artificial intelligence, Very Large Scale Integrated architecture, software technology, design systems, robotics and automated manufacturing. In the area of productivity, efforts are continuing to explore ways in which information processing can close the gap between the generation of ideas and their concrete realization in the form of visual models, physical objects, or mechanical systems. Research in robotics is focused on developing automated systems that can be instructed in high-level languages, determine goals to be accomplished, plan the specific steps to meet these goals, and carry out the necessary actions. To meet these objectives, highly developed perceptual and spatial reasoning systems must be integrated with mechanical effectuators. Other efforts involve development of systems for describing and transforming shape, motion, and structural information, the synthesis of complex mechanical structures, and the recognition and representation by computers of 3-dimensional scenes which can be derived from sensor information. Additionally, high-resolution graphics systems will be used to aid in the description of complex objects and to provide a graphical representation of objects described by information structures. Design and implementation of real-time controllers for effective spatial manipulation of physical objects will be pursued and techniques will be explored to improve the productivity of scientific researchers by providing automated assistance for manual tasks which are tedious, time-consuming and error-prone.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: # CCS-3
Program Element: #61101E
USDR&E Mission Area: 530

Title: Modernization Technology
Title: Defense Research Sciences
Budget Activity: 1 Technology Base

2. PROGRAM ACCOMPLISHMENTS AND FUTURE PROGRAMS:

a. FY 1984 Accomplishments: The experimental computer resource modernization effort placed state-of-the-art equipment at a total of ten universities, along with appropriate maintenance. Equipment included symbolic processing machines with large address spaces and high-performance graphic capabilities, file servers, network gateways, and local network hardware. A real-time controller for advanced manipulators with the interfacing of the controller to a tactile sensing robotic hand has been demonstrated. Work was initiated on the development of a spatial reasoning system, autonomous navigation processes, and real-time 3-D scene understanding, including stereo perception, laser ranging, and optical flow. The results of research in describing shape has been applied to the prototyping of single objects based on their mathematical description. An effort in the use of beta-splines to represent and modify geometric shapes has been initiated.

b. FY 1985 Program: State-of-the-art computing resources are being provided and maintained at critical research laboratories, and research efforts in the area of robotics are continuing. Spatial reasoning is being applied to a follow-on effort to implement spatial representation in a low-cost mobile robot that is capable of roaming a shop floor and emptying scrap and part bins while also filling stock bins. Work in robotic control and manipulators is continuing and new work on robotic planning and scheduling and robotic instruction is being initiated. Techniques for autonomous passive navigation based on landmark and obstacle recognition are being developed. Tradeoffs in tactile sensing techniques and methods of control of grasping devices are being investigated with regard to accuracy and grasp stability.

c. FY 1986 Planned Program and Basis for FY 1986 Request: Key universities will continue to be supplied with advanced computer resources and supporting maintenance. By this time the price/performance ratio of symbolic computers will substantially decrease as new competitors enter the market. In this year, most of the resources will go to locations that have not been major recipients of equipment in the recent past. More complex tasks will be assigned to the factory floor-roving robot. Work in robotic perception, manipulation, and control will progress to the

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: # CCS-3
Program Element: #61101E
USDR&E Mission Area: 530

Title: Modernization Technology
Title: Defense Research Sciences
Budget Activity: 1 Technology Base

point where fine discriminatory tasks such as bin picking and parts insertion will be able to be performed. Advancos in robotic planning will focus on high-level instruction of robots.

d. Program to Completion: Provision of advanced computer resources to universites will continue, and robotic technology efforts will accelerate. Techniques in robotic instruction will be developod and demonstrated in unplanned scenarios. Development of the workshop robot that reasons about spatial quantities, representations of objects, and maneuvers in and manipulates its environment will be completed. Cooporative robotic techniques will be explored and developed.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones
Mid FY 1985	Mid FY 1985	Continue computer resource modernization.
Late FY 1985	Late FY 1985	Prototype user-mediated robotic planning system.
--	Mid FY 1986	Demonstration of manipulator parts insertion
--	Late FY 1986	Initial demonstration of a mobile shop robot.
--	Mid FY 1987	Demonstration of robotic planning for autonomous navigation.
--	Late FY 1987	Develop techniques for high-level robotic instruction.

f. Explanation of milestone changes: Not Applicable.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62101E
USDR&E Mission Area: 530

Title: Technical Studies
Budget Activity: 1. Technology Base

A. RESOURCES: ($ in Thousands)

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Cost
	TOTAL FOR PROGRAM ELEMENT	$1,200	$1,500	$1,800	$2,000	Continuing	N/A

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED: This program provides independent, topical, in-depth studies and analyses in support of the Office of the Under Secretary of Defense for Research and Engineering (OUSDR&E), and its various component offices. Each year the most urgent subjects are chosen by the directors of Command, Control and Communication, Strategic and Theater Nuclear Forces, Tactical Warfare, Research and Advanced Technology and others. The Institute for Defense Analyses (IDA) provides in-depth answers to current and anticipated future problems assisting the decision makers to make more rational judgements and decisions.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY: No FY 1985 Descriptive Summary was provided for this program element, as the funding request was well below the $7,000K level established by the FY 1985 guidance.

D. OTHER APPROPRIATION FUNDS: None.

E. RELATED ACTIVITIES: The work performed under this program element is related to and contributes data to the program management activities of OUSDR&E. Specific offices that have been supported include those of the Deputy Under Secretaries, Defense Research and Engineering (DUSDR&E) for: Command, Control, Communications and Intelligence; Acquisition Management; Research and Advanced Technology; Tactical Warfare Programs; and Strategic and Theater Nuclear Forces.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62101E
USDR&E Mission Area: 530

Title: Technical Studies
Budget Activity: 1. Technology Base

F. WORK PERFORMED BY: This research is performed by the Institute for Defense Analyses (IDA), Arlington, Virginia (FFRDC, 100%).

G. PROJECTS LESS THAN $7 MILLION IN FY 1986:

In FY 1984, IDA performed tasks in areas related to strategic systems; major tactical air and land warfare systems and issues; naval warfare problems; problems in the management of basic and applied research related to defense technology and issues associated with resource allocation management in the Department of Defense.

IDA performed several analyses, generally with work deadlines having to do with the President's Strategic Defense Initiative. One, for the Director of the Joint Staff, concerned the policy implications of deployment of a feasible near-term system. Another, for the Strategic Defense Initiatives Office, provided basic input regarding available technologies in the near and mid-term to assist in the design of a pilot architecture.

IDA performed a comparative analysis of U.S. and Soviet ASAT systems, with particular reference to countermeasures that might be employed by either side.

In the area of computers and computing technology IDA assisted in the development of a strategy for increasing the rate at which emerging computer technologies are adapted by the Services to military applications. It was also the principal resource to DoD in the assimilation into the department of Ada, the new, high-order computer language now mandated for all mission-critical systems. A principal application in which IDA played a key role was the application of Ada to the Worldwide Information System (WIS).

IDA assistance to the International Programs and Technology Office of USDR&E continued in the area of Export Control. Major contributions were made to the highly successful Coordinating Committee (COCOM) meetings in 1984 which culminated in adoption of rules favored by the U.S. for export of computer technology to eastern bloc nations.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62101E
USDR&E Mission Area: 530

Title: Technical Studies
Budget Activity: 1. Technology Base

Continuing work at Institute for Defense Analysis (IDA) on upper-stage alternatives for the Space Shuttle resulted in recommendations that are judged to have the potential of saving $30 million per launch.

Research into basic materials at IDA took several forms, including a critique of the U.S. industrial base to supply certain critical materials (such as polyacrylontrile-base carbon fiber) independently of foreign sources. A study of the current state of tribology (study of lubrication and wear) technology as it relates to military systems produced a set of recommendations now being followed through by DARPA.

In the field of tactical warfare programs IDA concluded a major study of the interaction of NATO and Warsaw Pact counterair campaigns. This study has played and will continue to play an important part in helping the U.S. and NATO develop appropriate force postures and weapons systems to defeat the Warsaw Pact air threat thru the 1990's. Important work was also done in a major program concerned with attack of Warsaw Pact forces in the area behind the immediate battle area. This relates to the Emerging Technologies (ET) initiative of Secretary Weinberger to the NATO allies. This work will form the basis for a general appreciation of what kinds of systems in what combinations can be effective in stalling WP (mainly Soviet) follow-on forces before they can reach the battle area. It will also develop general measures of how increments of new forces and systems can be traded off with older kinds of forces.

Further IDA work in tactical warfare included an evaluation of alternative mixes of scout and attack helicopters, development of a simpler, more reliable control plan for Central European airspace in war, assistance in the development, execution and evaluation of joint war games under the auspices of Commanders in Chief, U.S. Army and U.S. Air Force in Europe, and others.

Assistance by IDA in the area of defense management was provided in a variety of forms, including a major study of the application of new technology to the problems of improving the reliability and maintainability of weapons and support systems. Other work included study of the relationship of overhead costs to total costs in aircraft manufacturing, the effect of various forms of competition on ultimate costs, and an evaluation of the Defense Economic Modeling System.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62101E
USDR&E Mission Area: 530

Title: Technical Studies
Budget Activity: 1. Technology Base

Continuing work at IDA on the adaptation of new technology to DoD training requirements, and measuring the cost-effectiveness of alternative training regimes, was well-received and resulted in a number of policy recommendations.

In FY 1986 several efforts are continuing from FY 1984 to FY 1985. These will include work on defense technology base problems, including advanced materials, electro-optical sensors, the issue of "nuclear winter," and non-imaging infrared processing. Further studies will be performed concerning the attack of follow-on forces in the European land battle. Export Control, security of supply for the defense mobilization base, and the security of DoD computer systems will also receive continuing work.

New programs in 1986 will deal with antiradiation missile technologies, alternatives in land-based battlefield nuclear systems, ASW at lower source noise levels, countermeasures for anti-armor munitions, and others. In general, these programs create a body of expertise that is able to respond rapidly to the operating offices in OUSDR&E when the need arises.

Although the FY 1986 and FY 1987 study program is not fully formulated, it is believed that it will be a continuation of the technical studies initiated earlier for the offices of the Deputy Under Secretaries for Research and Advanced Technology, Tactical Warfare Programs, Strategic and Theater Nuclear Forces, and Command, Control, Communications and Intelligence. The emphasis will be placed on issues deemed most important at that time. It is planned and expected that the emphasis will be in at least the following areas:

1. Basic materials research, especially materials of interest to SDI.

2. Continuing work on advanced conventional warfare systems and concepts on support of Secretary of Defense emerging technologies (ET) initiatives.

3. Continuing work on Central European air-space control, identification of ground control units and related C^3 issues.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62101E
USDR&E Mission Area: 530

Title: Technical Studies
Budget Activity: 1. Technology Base

4. Continuing work in support of Deputy Under Secretary of Defense (IPN) in the area of export control.

5. Continuing work on the application of new technology to improve reliability and maintainability of weapon systems.

H. PROJECTS OVER $7 MILLION IN FY 1986: Not applicable.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #61103E
USDR&E Mission Area: 530

Title: University Research Initiative (NEW START)
Budget Activity: 1. Technology Base

A. RESOURCES: ($ in Thousands)

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Costs
	TOTAL FOR PROGRAM ELEMENT	0	0	$ 6,250	$ 12,500	$ 25,000	$ 43,750

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED: This project pursues new university based research initiatives in sciences and technologies of demonstrated or potential long term significance to the Department of Defense (DoD). The focus is on interdisciplinary research thrusts of three year duration which promise unique and innovative technological breakthroughs for use in the design and fabrication of future DoD systems. Specific technical areas to be addressed include: growth of new bulk single crystal and thin film multilayer semiconductor and electro-optic structures; application of expert systems (machine and artificial intelligence) to the design and fabrication of complex parts and materials; innovative chemical synthesis of new ceramics; surface chemical effects in friction, lubrication, and wear; advanced materials and devices from biology; university interdisciplinary centers for composites research and, data storage concepts and media. Each initiative addresses funding for equipment and instrumentation as well as faculty, graduate fellowships and research assistantships and materials necessary to execute the project.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY: Not Applicable. This is a new start in FY 1986.

D. OTHER APPROPRIATION FUNDS: Not Applicable.

E. RELATED ACTIVITIES: Defense Research Sciences (DRS) within Army, Navy, Air Force and DARPA provides broad support to the engineering and science disciplines of long term significance to the Department of Defense. This project will strengthen the DRS efforts substantially by supporting

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #61103E
USDR&E Mission Area: 530

Title: University Research Initiative (NEW START)
Budget Activity: 1. Technology Base

comparatively large ($1M-$2M/year/contract), specific multi-disciplinary efforts which exploit emerging, high leverage scientific opportunities, fill gaps in the existing national research and development program, meet threats of foreign domination of a science or technology, and address urgent defense needs.

F. WORK PEFORMED BY: This project will be performed by universities selected on a competitive basis.

G. PROJECTS LESS THAN $7 MILLION IN FY 1986: This project explores defense relevant, innovative materials research concepts in a sufficiently early stage of development that are best addressed through focussed, interdisciplinary, university based research initiatives. Each initiative will cover one or more efforts of up to three years duration, will include funding for necessary instrumentaion, and provide post-doctoral and graduate assistantships as well as other necessary support to implement its research plan. Specific initiatives are selected on the basis of the opportunity to exploit emerging, high leverage scientific opportunities which address urgent defense needs, fill large gaps in the national research and development program, and meet threats of foreign domination. Initiatives planned for starts in FY 1986 include: semiconductor and electro-optic bulk single crystal and multilayer thin film growth; application of expert systems to the design and fabrication of complex parts and materials; advanced materials and devices from biology; electronic data storage technology; and university interdisciplinary centers for composites research.

In FY 1986 this project will be announced and described to the academic community through Commerce Business Daily notices and briefings to the research community at conferences and other appropriate meetings. Short draft planning proposals will be sought from which a government technical evaluation team will select the best for small awards to partially support costs of preparing formal proposals. It is anticipated that at least one award will be made in four or more of the initiative areas described above. Initial funding will emphasize acquisition and/or design and fabrication of state-of-the-art ecuipment necessary for the research efforts, and establishment of necessary research assistantships/ fellowships. Subsequent years also will maintain an equipment support level (25-33 percent of

Program Element: #61103E
USDR&E Mission Area: 530

Title: University Research Initiative (NEW START)
Budget Activity: 1. Technology Base

annual funding) to provide for maintenance and updating. Proposal selection criteria will include: originality and potential impact of proposed research including the degree of interdisciplinarity; demonstrated quality of research staff and graduate students as evidenced by prior and on-going research achievements, especially in materials research pertinent to the proposed effort; university commitment to the research area as evidenced by facility investment, faculty tenure track appointments, and research support from other sources; the extent to which industrial interactions are evident; and viability of a long term plan to develop support for continuation of the effort as the DARPA effort nears completion.

A second competitive round seeking research efforts in the initiatives described above will be executed in FY 1987. Additional initiative areas will be considered such as mechanical behavior of composite materials, synthesis of new materials with tailored electromagnetic properties, chemistry of highly energetic materials, ultraviolet and visible laser-material interactions, and integrated optoelectronic circuit design and processing. Research efforts initiated in FY 1986 will complete purchase and/or construction and installation of instrumentation and equipment phases and achieve full level of research operations by the end of FY 1987. Research accomplishments will be forthcoming from these efforts beginning in mid FY 1987.

H. PROJECTS OVER $7 MILLION IN FY 1986: Not Applicable.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Technology
Budget Activity: 1. Technology Base

A. RESOURCES (Project Listing): ($ in Thousands)

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional To Completion	Total Estimated Costs
FY 1986	TOTAL FOR PROGRAM ELEMENT	207,734	165,750	254,400[a/]	315,100[a/]	Continuing	N/A
ST-1	Advanced Strategic Concepts & Strategic Technical Analysis	5,599	3,850	4,800	4,400	Continuing	N/A
ST-2	Space Surveillance & Advanced Optics	17,457	-0-	-0-	-0-	-0-	185,682
ST-3	High Energy Laser Technology	63,983	-0-	-0-	-0-	-0-	402,590
ST-4	Strategic Deterrent	6,863	-0-	-0-	-0-	-0-	37,334
ST-5	Strategic Delivery Vehicles	14,904	16,309	10,000	21,900	Continuing	N/A
ST-6	Warning Technology	13,805	10,400	-0-	-0-	-0-	96,391
ST-7	Special Applications Technology	15,198	6,791	10,000	25,600	Continuing	N/A
ST-8	Space Object Identification	1,875	-0-	-0-	-0-	-0-	39,016
ST-9	Submarine Laser Communications	18,952	34,900	28,500	5,700	-0-	N/A
ST-10	Strategic Computing	49,098	72,000	142,000	150,000	Continuing	N/A
ST-11	Intelligent Systems	-0-	21,500	25,400	32,100	Continuing	N/A

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Technology
Budget Activity: 1. Technology Base

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional To Completion	Total Estimated Costs
ST-12	Quantum Electro-Optics	-0-	-0-	23,500	41,000	Continuing	N/A
ST-13	Strategic Air Cruise Missile Defense	-0-	-0-	10,200	34,400	Continuing	N/A

a/ Parts of the efforts included in this program element, are included in FY 1985 and the outyears as part of the President's initiative in Strategic Defense and future year funds are being requested in several of the program elements making up that initiative.

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED: This Program Element in FY 1986 funds a comprehensive research and development program directed toward the development and application of advanced technologies associated with advanced strategic system concepts; strategic communications and signal processing; submarine laser communications; strategic computing; intelligent systems; electro-optics; advanced radar techniques; and hypersonic flight systems.

The Advanced Strategic Concepts and Technical Analysis Project objectives are to identify and thoroughly evaluate advanced strategic system concepts and system technologies in order to define critical technological issues and establish experimental efforts which are: to provide a basis for defining and evaluating the implications of technology on future weapons system designs and capabilities; to develop new initiatives that could significantly alter military effectiveness; to assess the implications of new technology on strategic policy and conversely the technological implications of new strategic policy; and to support the Office of the Under Secretary of Defense for Research and Engineering in establishing feasibility and priorities on present and proposed R&D programs and to technically evaluate the technological and capability implications of various treaty provisions. This project through its Advanced Strategic Analysis Task provides basic analytical feasibility for new strategic technology programs both within DARPA and for OUSDR&E, while the new initiatives effort provides seed funding for advanced strategic concepts and technology through both analysis and experiment.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Technology
Budget Activity: 1. Technology Base

The Strategic Delivery Vehicle Project in FY 1986 will integrate emerging aircraft materials, propulsion, fuels and aerodynamics technologies into the design of an advanced air vehicle capable of either sustained, endo-atmospheric hypersonic (mach 25) cruise or single stage to orbit operations. The phenomena which currently limit supersonic and hypersonic air breathing propulsion systems will be investigated and advanced technologies applied to reduce or eliminate current limitations.

The Warning Technology project consists of Detection of Aircraft - HI-CAMP (TIARA) (transitions to Program Elements 63226E, Project EE-17 in FY 1986); Precision Pointing - (Teal Emerald) (transitions to Project ST-12 in FY 1986); and Detection from Space (transitioned to the President's Strategic Deterrent Initiative (SDI) program in FY 1985 Program Element 63220C). Detection of Aircraft includes the determination of the Infrared (IR) signatures of: (1) strategic aircraft (primary target) and cruise missiles; (2) intercontinental and submarine launched ballistic missiles; (3) ground and sea targets; and (4) the natural and perturbed backgrounds against which these targets are observed from a spaceborne or airborne IR surveillance sensor. This program will provide the data base for the design of advanced space surveillance systems and will guide the development of the technology base. Detection from Space consists of the development of the core technology for space-based, multi-mission radar concepts.

The Special Application Technology Project in FY 1986 consists of two major thrusts: Strategic Communications and the Acoustic Charge Transport (ACT). Strategic Communications is composed of several elements, the primary one being a vertical Very Low Frequency (VLF)/Extremely Low Frequency (ELF) transportable communication system. This is a balloon supported vertical dipole antenna that can be transported to provide a post attack survivable VLF/ELF Emergency Action Message (EAM) delivery system to the nuclear submarine fleet.

The Acoustic Charge Transport (ACT) Program utilizes a newly-discovered solid state microcircuit technique which promises to revolutionize much of the signal processing done in military communications, radar, signal intercept, and reconnaissance systems. The process will lead to a class of radiation-hard Gallium-Arsenide microcircuit signal processors which are many orders of magnitude smaller and faster than digital processors currently envisioned, yet have sufficient accuracy to compete for many of their applications. ACT devices are similar in concept to charge-coupled device (CCD) and surface acoustic wave (SAW) devices in use today, but are capable of achieving bandwidths and dynamic operating ranges which overcome most limitations of SAWs and CCDs. The Acoustic Charge Transport Device program is structured to transition ACT technology from a concept to system-ready devices as quickly as possible.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Technology
Budget Activity: 1. Technology Base

The DARPA/Navy Submarine Laser Communications (SLC) Project is developing the technology necessary for providing critical underwater communications using blue-green lasers. The specific payoffs of this technology would be: (1) providing critical messages to Fleet Ballistic-Nuclear Missile Submarines (SSBNs) at depth without compromising the submarine's natural covertness, thus helping to ensure the SSBN force's continued high level of survivability; (2) increased robustness and survivability of the Command, Control and Communications (C3) system well into the post-attack period; (3) allowing the Nuclear Submarine (SSN) to work most effectively in its own environment while providing threat and target intelligence information to it in real time; and (4) controlling a broad variety of pre-placed underwater assets, such as minefields and acoustic arrays.

The Strategic Computing Project is an effort to develop and demonstrate super intelligent computers for application to critical problems in Defense. It draws directly on the basic research results from the Intelligent Systems Project (ST-11), and augments them to provide specific future defense capabilities using advanced computer technology.

The Intelligent Systems Project undertakes fundamental investigations into the limits of the digital computer's capabilities for intelligent processing in selected areas of military relevance. The results of this basic research are to be exploited in the Strategic Computing Project (ST-10).

The objective of the Advanced Quantum Electro-Optics Project is to develop optical technologies to make possible a broad range of new military capabilities.

Strategic Air Cruise Missile Defense is a new project that consolidates previous efforts under project ST-1. The project objectives are to identify and to develop techniques for surveillance of high survivability performance vehicles (HSPVs) by exploiting the natural environment. Potential threat vehicles include aircraft, cruise missiles or satellites. Mission functions addressed include surveillance (acquisition, track, identification), targeting and kill assessment.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY:

Advanced Strategic Concepts and Strategic Technical Analysis - FY 1985 funding did not change but FY 1986 funding decreased due to reduced requirements relating to transferred Strategic Defense Initiative (SDI) efforts.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Technology
Budget Activity: 1. Technology Base

Space Surveillance and Advanced Optics - No change has occurred in FY 1985 and FY 1986 funding as all funds have been transferred to the Strategic Defense Initiative Organization in PE 63220C.

High Energy Laser Technology - FY 1985 and FY 1986 funds for Blue Green Laser Technology and Exploratory Laser Research have been transferred to the Submarine Laser Communications Project ST-9.

Strategic Deterrent - FY 1985 and FY 1986 funds have been eliminated due to the completion of the Impactor Technology program and the transition of the Ballistic Intercept Missile (BIM) program from a technology effort to a demonstration program funded in FY 1986 as a new project in PE 63226E, EE-16.

Strategic Delivery Vehicles - FY 1985 and FY 1986 funding has decreased due to: the completion of DARPA funding for the High Power Transmission portion of the Heavy Lift Helicopter program the transfer of the Advanced Cruise Missile Program to PE 63226E, Project, EE-19; and the transfer of the Convertible Engine Technology development into a new joint DARPA/NASA initiative titled Adaptive Control Engine. The FY 1986 funds will initiate a new thrust in advanced air vehicle design called Copper Canyon.

Warning Technology - FY 1985 funding has decreased and FY 1986 funding eliminated due to the transition of the Highly Calibrated Airborne Measurement (HI-CAMP) program (TIARA) to a demonstration program funded in PE 63226E Project, EE-17 and the transfer of precision pointing technology to a new project, ST-12.

Special Applications Technology - FY 1985 and FY 1986 funding has doubled due to an increase in Acoustic Change Transport (ACT) technology development funds in order to investigate ACT phenomenology, prepare accurate analytical models of the ACT process for performance prediction; and design, fabricate, test and evaluate related ACT devices and components.

Space Object Identification (TIARA) - The project was completed in FY 1984 and there is no change with last year's submission.

Submarine Laser Communication - FY 1985 and FY 1986 funding has increased due to the inclusion of the Blue-Green Laser Technology and Exploratory Laser Research programs from Project ST-3.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Technology
Budget Activity: 1. Technology Base

Strategic Computing - FY 1985 and FY 1986 funding has not changed.

Intelligent Systems - This is a new project due to Congressional redirection of Project No. CCS-01 from PE 61101E, in FY 1985.

Advanced Quantum Electro-Optics - This is a new project starting in FY 1986.

Strategic Air Cruise Missile Defense (SACM) - This is a new project starting in FY 1986 utilizing basic efforts funded in FY 1985 in Project ST-1 to identify and develop techniques for surveillance of a high survivability performance air vehicles.

D. OTHER APPROPRIATION FUNDS: Not applicable.

E. RELATED ACTIVITIES: (Projects with FY 1986 Funding)

The Advanced Strategic Concepts and Technical Analysis project relates directly to programs of the Office of the Under Secretary of Defense for Research and Engineering, the Air Force Aeronautical Systems Division, the Army Ballistic Missile Defense Advanced Technology Center, the Air Force Space Division, the Air Force Rome Air Development Center, and the Naval Ocean Systems Center.

The Strategic Delivery Vehicles Project in FY 1986 is being conducted jointly with the U.S. Air Force and is directly related to current Air Force Space Division requirements and programs to develop vehicles for aerospace operations.

The Special Applications Technology Project is related to programs of the Directorate of Space Systems and Command, Control Communications at Headquarters Air Force, the Air Force Rome Air Development Center, the Defense Communications Agency, the Minimum Essential Emergency Communications Program (MEECP), the Naval Electronic Systems Command, and the Office of Naval Research.

For the Submarine Laser Communications Project there are several supporting Navy program in areas such as blue-green laser technology and optical oceanography. Other major technology areas, such as space optical systems and atmospheric compensation, are coordinated with ongoing Air Force, Navy, and DARPA

programs through a variety of formal and informal mechanisms including joint use of facilities, personnel, and contracting agents.

In Strategic Computing the Defense Software Technology Initiative will augment this effort by developing single processor software environments based on the Ada Programming language and by providing Ada Programming Support Environments to support conventional software practices. The Very High Speed Integrated Circuit program is addressing special purpose VLSI chips for military signal processing applications. The S-1 multiprocessor system under development by the Navy and Department of Energy is exploring one approach to multiprocessor architecture potentially useful for superspeed computer applications. National Bureau of Standards will support maintenance and dissemination of speech databases developed under this program to the research community at large and will support multiprocessor system architecture benchmarking activities. The Services, National Security Agency, and Central Intelligence Agency have all initiated Artificial Intelligence (AI) Centers that offer the potential of contributing technology to, and using the technology developed by the generic AI component of this effort. The Supercomputer Research Division of Institute for Defense Analyses, established by DoD, will assist in the evaluation of selected multiprocessor system architectures.

The National Science Foundation, the National Institute of Health, the National Aeronautics and Space Administration, the Office of Naval Research, the Air Force Office of Scientific Research, the Naval Research Laboratory, the Naval Electronic Systems Command, the Defense Mapping Agency, Rome Air Development Center, the Army Engineering Topographic Laboratory, and Air Force Avionics Laboratory also support artificial intelligence research. These efforts address image understanding, expert systems technology, industrial automation, analytical chemistry, immunology, natural language understanding, deep-space and undersea probes, information fusion, and management decision aids. Techniques developed in this project have widespread applicability throughout the Defense Department. Close coordination with prospective users is maintained through workshops, site visits, the choice of contracting agents, and joint programs. Examples of joint programs include the image understanding and natural language database interface work being performed in conjunction with the Defense Mapping Agency and the image understanding for port monitoring work conducted with the Central Intelligence Agency and Office of Naval Research. In the area of software generation, the Ada Joint Projects Office (AJPO) is funding work in software engineering and a new government Software Engineering Institute is to be developed. DARPA's work in new-generation software development involves more advanced research and complements the other software engineering work described above.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Technology
Budget Activity: 1. Technology Base

Advanced Quantum Electro-Optics: The portion of this effort which is developing advanced space imaging technology will be fully coordinated, through technical interchange meetings, with related Air Force programs currently ongoing at Rome Air Development Center, Air Force Space Division and Air Force Space Command.

The Strategic Air Cruise Missile Defense effort will focus on ongoing DARPA surveillance efforts, such as, Teal Ruby and HI-CAMP. The program will be run with the help of a steering committee with Army, Navy and Air Force participation to coordinate internal service programs.

F. WORK PERFORMED BY: (Projects with FY 1986 Funding)

Advanced Strategic Concepts and Strategic Technical Analysis: All of the project efforts are conducted by industry. The major contractors are: General Research Corporation, Santa Barbara, California; Toyon Research, Santa Barbara, California; Analytical Decisions, Inc., Arlington, Virginia; Directed Technologies Inc., McLean, Virginia, and MIT Lincoln Laboratory, Lexington, Massachusetts.

Strategic Delivery Vehicle Project: 80% Industry, (18%) Government laboratory and (2%) Government in-house. Contractors include the following: The Marquardt Company, Van Nuys, California; Aerojet General Corp., Sacramento, California; General Applied Science Laboratories, Inc., Westbury, New York; Dupont Aerospace, Long Beach, California; and Science Application International, Princeton, New Jersey. In-house support is provided by the Aeronautical Systems Division, Wright-Patterson AFB, Ohio.

Special Application Technology: The University of Illinois and Electronic Decisions Incorporated, Urbana, Illinois, perform 65% of the work with the balance done by Pacific-Sierra Research Corporation of Santa Monica, California.

Submarine Laser Communications: (85%) Industry, (2%) universities, and (13%) government in-house laboratories. Contractors include: Hughes Aircraft Company, Los Angeles, California; McDonnell Douglas Astronautics Company, St. Louis, Missouri; GTE Sylvania, Mountain View, California; Lockheed Missiles and Space Company, Palo Alto, California; AVCO, Everett, Massachusetts; Northrop Corporation, Palos Verdes Peninsula, California; Rockwell International, Canoga Park and Thousand Oaks, California; Adaptive Optics Associates, Cambridge, Massachusetts; Eastman Kodak, Rochester, New York; Sanders Associates, Nashua, New

Hampshire; Lawrence Livermore National Laboratory, Livermore, California; and Lincoln Laboratory, Lexington, Massachusetts. The university work is being done by the University of California's Scripps Institute of Oceanography and the University of Arizona's Optical Science Center. In-house effort is being funded at the Naval Ocean Systems Center, San Diego, California; Naval Research Laboratory, Washington, D.C.; and Rome Air Development Center, Rome, New York.

Strategic Computing: 43% University, 43% Industry, and 14% In-House. The major performers are Bolt Beranek and Newman, Cambridge, Massachusetts; Carnegie-Mellon University, Pittsburgh, Pittsburgh; Columbia University, New York City, New York; Martin-Marietta Corp, Denver, Colorado: Massachusetts Institute of Technology, Cambridge, Massachusetts; MIT Lincoln Laboratory, Lexington, Massachusetts; National Bureau of Standards, Gaithersburg, Maryland; Naval Ocean Systems Center, San Diego, California; Rockwell International, Thousand Oaks, California; Stanford University, Stanford, California; Texas Instruments, Inc., Dallas, Texas; Thinking Machines, Inc., Cambridge, Massachusetts; University of Maryland, College Park, Maryland; and University of Southern California, Information Sciences Institute, Marina Del Ray, California.

Intelligent Systems: 35% Industry, 58% University, 7% In-House. Major performers are Bolt Beranek and Newman, Cambridge, Massachusetts; Carnegie-Mellon University, Pittsburgh, Pennsylvania; Columbia University, New York City, New York; Environmental Research Institute of Michigan, Lansing, Michigan; ESL, Inc., Mountain View, California; Hughes Research Lab., Malibu, California; Kestrel Institute, Palo Alto, California; Massachusetts Institute of Technology, Cambridge, Massachusetts; Rutgers University, New Brunswick, New Jersey; Rand Corp., Santa Monica, California; SRI International, Menlo Park, California; Stanford University, Stanford, California; University of California, Berkeley, California; University of Massachusetts, Amherst, Massachusetts; University of Rochester, Rochester, New York; University of Southern California, Los Angeles, California; and Yale University, New Haven, Conneticut.

Advanced Quantum Electro-Optics: It is anticipated that 60% of this effort will be conducted by industry, 30% by universities and 10% by government laboratories, in house.

The Advanced Air Defense project is currently in source selection based on an industry briefing and survey. Over 160 contractor submittals are being evaluated.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Technology
Budget Activity: 1. Technology Base

G. PROJECTS LESS THAN $7 MILLION IN FY 1986:

Advanced Strategic Concepts & Strategic Technical Analysis - This project supports the Office of the Under Secretary of Defense for Research and Engineering (Strategic and Tactical Nuclear Forces) (OUSDR&E (S&TNF)) in establishing feasibility and priorities on present and proposed R&D programs and to technically evaluate the technological and capability implications of various policy and treaty provisions. This effort in FY 1985 and FY 1986 provides basic analytical feasibility for strategic programs for OUSDR&E (S&TNF) and frequently assists them in addressing current or potential issues raised by Congress. Because of the diverse nature of this program, the technical objectives vary from task to task. OUSDR&E (S&TNF) determines the specific task objectives.

This project also defines and evaluates the implications of technology on future weapons system designs and capabilities; to develop new initiatives that could significantly alter military effectiveness; and to assess both the implications of new technology on strategic policy and the technological implications of new strategic policy.

FY 1984 accomplishments include OUSDR&E (S&TNF) directed studies in bomber modernization issues; strategic air defense penetration; and bomber force sustainability. New initiatives in FY 1984 included DARPA directed studies in technologies for the Rapid Deployment Force; hybrid bistatic radar concepts; joint theater counter strike technology, imprecisely located target detection; analog cryptography; and meteor burst electronic warfare. FY 1985 efforts include the imprecisely located target detection study; and the initiation of air vehicle target detection called Advanced Air Defense which is being transferred in FY 1986 to a new project number ST-13.

Support in FY 1985 continues for OUSDR&E (S&TNF) in evaluating the impacts and technology needs for survivability, endurance and effectiveness of strategic forces. Two continuing efforts will assess modernization of the airbreathing leg of the TRIAD (and associated weaponry) and wartime endurance of strategic forces.

FY 1986 objectives will be identical to those in FY 1985. Specific efforts will be selected on the basis of highest potential payoff and relative importance of strategic issues addressed.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Technology
Budget Activity: 1. Technology Base

The research and analyses conducted in this project are normally completed within one-to-two years. Those that are successful are either transitioned to the Services or to new DARPA thrusts. As new technology, new concepts or new military problems arise, technical analyses and evaluation will be initiated to determine feasibility or operational military potential.

Warning Technology - During FY 1984 detailed mission planning was accomplished in the Detection of Aircraft (HI-CAMP) program (TIARA) with several test missions flown to validate design and performance. The HI-CAMP II system was successfully flight tested and initial operational flights were flown. The sensor and the gimbal platform were integrated into the aircraft and the engineering arrays were upgraded. Operational flights were conducted against target aircraft, helicopters, rehearsals for TEAL RUBY, F-14 aircraft takeoff from airfield and carrier ships and Army targets. Many of these flights were funded by the Air Force and Navy. A US-Canadian cooperative flight series was also made with Canadian and US targets over Canadian arctic backgrounds. In Detection from Space, fabrication of the New (approximately) six-foot square, space-fed lens continued and a new lens test fixture was completed. Fabrication and test of monolithic phase-shift chips were completed and production of controllable modules for use in the array lens test was begun. The first fully monolithic, single chip X-band transceiver was successfully fabricated and evaluated.

In FY 1985 HI-CAMP II equipment will be fully operational and the flight measurement program will continue. This program will be closely coordinated with the TEAL RUBY experiment mission planning and will perform TEAL RUBY rehearsal missions including radiometric and navigation experiments. In FY 1986 the HI-CAMP program transitions to project EE-17, PE 63226E.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: ST-5
Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Delivery Vehicles
Title: Strategic Technology
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The goals of this program are to investigate the technological feasibility of a powered vehicle capable of horizontal take-off and landing. Such a vehicle would have a significantly larger payload fraction. Potential applications include manned strategic bomber and reconnaissance platform with very high survivability and rapid response strike/supply missions. Areas of investigation will include computational fluid mechanics, hypersonic laminar boundary flow, engine inlet shock wave structure and other fields related to design of an integrated airframe/propulsion configuration with the required performance.

2. Program Accomplishments and Future Programs: The technical objective is to determine the feasibility of new methods of propulsion for air vehicles that would have military application in the 20th century. Critical issues include those associated with an efficient engine cycle selection, an engine combustor, inlet and nozzle design for minimum losses. Significant new advancements which may impact these areas include advanced materials, high energy density fuels and computational fluid mechanics. The latter area utilizes the culmination of more than 20 years research and development in numerical methods and computer hardware to solve the governing flow equations.

a. FY 1984 Accomplishments: During FY 1984 the critical technology issues were identified and planning activities conducted to define the analytical and experimental programs needed to address each issue. Both turbine cycles were examined. Material strength and endurance were characterized through component demonstration tests. High temperature oxidation protection coatings were also demonstrated. A fuel test of combustion efficiency was successfully completed and vehicle configuration survivability analyses were utilized to generate vehicle structural requirements.

b. FY 1985 Program: During FY 1985, full Navier Stokes computational fluid mechanics codes are being exercised on CYBER and CRAY supercomputers to establish correlation with existing experimental data. Testing activities include limited wind tunnel investigations and critical propulsion concept experiments. A system cycle is to be chosen for further examination if studies indicate feasibility.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: ST-5
Program Element: #62301F
USDR&E Mission Area: 530

Title: Strategic Delivery Vehicles
Title: Strategic Technology
Budget Activity: 1. Technology Base

During FY 1985, the program is proceeding into a 24-month component and subsystem validation phase to demonstrate feasibility of the critical engine components, fuel compatibility and critical vehicle structures and aerodynamics.

c. FY 1986 Planned Program and Basis for FY 1986 Request: The selected cycle will be subjected to more detailed analysis and test. Various wind tunnel facilities will be utilized to explore potential flight regimes. Vehicle studies will be conducted to insure proper propulsion integration.

d. Program to Completion: Depending upon the results of earlier phases, DARPA will consider extending the generic propulsion technology activities so as to achieve some type of propulsion concept demonstration.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones
--	Late FY 1985	Conduct critical technology experiments.
--	Late FY 1985	Select advanced propulsion cycle.
--	Mid FY 1986	Review detailed advanced cycle design/analysis test data.
--	Late FY 1986	Examine engine/airframe integrated concepts.

f. Explanation of Milestone Changes: Not Applicable.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-7
Program Element: #62301E
USDR&E Mission Area: 530

Title: Special Application Technology
Title: Strategic Technology
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986

1. Project Description: The Special Applications Technology project will exploit recent advances in signal processing techniques for, spread spectrum and low probability of intercept (LDI) communications, very wideband signal intercept receivers, vertical VLF/ELF communications technologies, AM internetting. Until recently contraints of cost, speed, capacity and the need for conversion from analog to digital formats have hampered exploitation of spread spectrum and LPI communications. The recent breakthrough in the Acoustic Charge Transport (ACT) process, a hybird analog/digital device technology, makes possible small, low cost, low power microelectronic components for advanced large dynamic range, large processing gain, extremely wide bandwidth, radiation hard, radar and signal processing systems. Signal processors using ACT devices will replace current digital array processors with single-chip analog devices of greater capability. The VLF/ELF, (Aerostat supported ELF/VLF Transmitter, ASET) transportable communication system is a system supporting the Fleet Ballistic Missile (FBM) force. AM Internetting uses the AM radio broadcast stations to establish a network capable of surviving an Electromagnetic Pulse attack. Voice capabilities from AM internetted stations are achievable without normal programming interference by applying advanced modulation schemes and advanced voice encoder equipment. To support strategic communications, monolithic array module technology is being developed to provide low cost satellite terminals.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: ACT fabrication and test facilities were established that include a metalization capability, photolithographic processing and inspection equipment and the standard and custom instrumentation needed to perform DC, microwave and ultrasonic testing on experimental ACT devices. The conceptual feasibility of using an ACT tap-delay line as the basis for a number of advanced signal processing components was established. Detailed configuration designs and operational concept for the VLF/ELF program continued. Additional characterization data was obtained on the discrete device.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-7
Program Element: #62301E
USDR&E Mission Area: 530

Title: Special Application Technology
Title: Strategic Technology
Budget Activity: 1. Technology Base

The baseline process for the devices was developed to the point where the feasibility has been established. Materials and processing approaches (vapor phase epitaxy and molecular beam epitaxy) have been initiated to fabricate both GaAs FETs and High Electron Mobility Transistor (HEMT) devices. A brassboard space signal processing software to support a demonstration of ground station processing was begun. This and related signal processing efforts transferred to the Strategic Defense Initiative during 1984.

b. FY 1985 Program: Experimental Acoustic Charge Transport (ACT) monolithic devices are being fabricated and tests are being conducted to validate fabrication processes and device parameters estimated to be achieveable from theoretical models. A capability to design, model, optimize, fabricate and test prototype ACT devices is being evolved. Development of a basic interface module is being initiated by implementing high speed processing of either analog or digital signals. This device will be combined with the ACT tap-delay line to form an analog/digital interface (ADI) component. Development of four other ACT devices needed to form an analog/digital array processing component is being initiated. Detailed VLF/ELF designs at subsystem level and parts/equipment procurement is beginning. Work on EHF devices is continuing.

c. FY 1986 Planned Program and Basis for FY 1986 Program: Fabrication and test of a proof-of-principle ACT ADI and related interface and control circuitry will be completed. Feasibility models of an analog memory and vector processing devices will be completed and tested. Application efforts to demonstrate these devices in practical military systems will be initiated. Fabrication, assembly and checkout of electrical and mechanical VLF/ELF subsystems will be conducted.

d. Program to Completion: After completion of the ACT ADI analog memory and vector processing feasibility demonstration, integrated monolithic vector processor will be designed, fabricated and tested during FY 1988. Monolithic integration of optimized ACT devices with control and support circuitry to form a practical Analog/Digital Array Processor (ADAP) component will be completed and transferred to the Services for use in appropriate radar and communication signal processing subsystems. Joint DARPA/Service programs to use ACT devices in military communication, radar, and signal receiver

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Project: #ST-7
Program Element: #62301E
USDR&E Mission Area: 530

Title: Special Application Technology
Title: Strategic Technology
Budget Activity: 1. Technology Base

systems will be carried out. VLF/ELF experimentation including field strength and pattern measurements will begin. Investigations of transportability and set up times will be made at the completion of the fixed site tests.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones
--	Mid FY 1985	Initiate Acoustic Charge Transport (ACT) Analog/Digital Interface (ADI) analog memory and vector processor feasibility device development. Initiate VLF/ELF detailed subsystem design.
--	Late FY 1986	Complete fabrication, test and evaluate Acoustic Charge Transport (ACT) feasibility model devices. Continue development of EHF devices.
--	Late FY 1986	Initiate development of optimized ACT devices and Analog/Digital Array Processor (ADAP) feasibility model device.
Mid FY 1985	Early FY 1987	Initiate demonstration Vertical VLF/ELF Communications System.
Mid FY 1987	Late FY 1987	Conduct VLF/ELF transmission test; demonstrate transportability of the VLF/ELF communication system.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-7
Program Element: #62301E
USDR&E Mission Area: 530

Title: Special Application Technology
Title: Strategic Technology
Budget Activity: 1. Technology Base

Last Year's Reported Plan	Current Plan	Milestones
--	Early FY 1988	Complete development of optimized ACT devices and evaluate ADAP feasibility model device.
--		Complete development of optimized monolithic ADAP for incorporated as component in selected systems applications.

f. Explanation of Milestone Changes: The VLF/ELF milestones slipped due to inordinate procurement delays in getting the major contract awarded through the Navy Agent.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-9
Program Element: #62301E
USDR&E Mission Area: 530

Title: Submarine Laser Communications
Title: Strategic Technology
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The DARPA/Navy Submarine Laser Communications (SLC) Program is developing the technology necessary for providing critical underwater communications using blue-green lasers. The specific payoffs of this technology would be: (1) providing critical messages to Fleet Ballistic-Nuclear Missile Submarines (SSBNs) at depth without compromising the submarine's natural covertness, thus helping to ensure the SSBN force's continued high level of survivability; (2) increased robustness and survivability of the Command, Control and Communications (C^3) system well into the post-attack period; (3) allowing the attack Nuclear Submarine (SSN) to work most effectively in its own environment while providing threat and target intelligence information to it in real time; and (4) controlling a broad variety of pre-placed underwater assets, such as minefields and acoustic arrays.

The specific objectives of the DARPA/Navy SLC program are: (1) complete the development of satellite-based laser transmitter and submarine optical receiver technology to provide the Navy with a basis for deciding whether to embark upon full scale system development by FY 1988; (2) jointly with the Navy to conduct aircraft-to-submarine experiments, first with a green laser transmitter and later with blue; and (3) continue the long range development of advanced optical technology to provide potential for block replacements for the baseline system which might increase reliability, decrease cost and weight, or improve operational utility. A major portion of the long range effort is a technology base development program in tunable medium power solid-state lasers with Lawrence Livermore Laboratories.

Submarine Laser Communication System Concepts: On the basis of recent technical breakthroughs, and in order to provide broad area coverage, to increase availability, and to make an SLC system survivable, a satellite-based laser transmitter has been chosen as the baseline system approach. The baseline technologies involve a Xenon Chloride laser transmitter and a Cesium atomic resonance filter receiver.

The downlink beam would be expected to travel from the satellite through clouds to a large diameter spot on the water.

The message would be transmitted to a spot, then the beam is stepped to a new spot, and the message retransmitted. The process could continue until the entire operating area were covered. This procedure would reduce the average data rate accordingly.

SLC may permit radically new and effective ways of controlling the sea and projecting power using our stealthiest asset, the submarine. It can provide a timeliness lacking in all current submarine communication systems and provide a freedom from operational constraints that may multiply the effectiveness of our submarine force by a large factor.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: In August 1984 a Memorandum of Agreement was concluded between the Navy and DARPA for the "Joint Development of a Satellite-to-Submarine Laser Communication System." It covers those developments necessary to make an informed decision to start full scale development of an operational system by FY 1988. Those elements were: 1. the development of a blue light space qualifiable laboratory transmitter - this was to be solely a DARPA effort; 2. the joint development of filter for experimental use on a submarine to receive blue light signals; 3. the joint conduct of experiments and exercises; 4. and the jointly funded, but Navy directed, development of operational and system concepts.

An operational experiment was conducted with a green Airborne laser and a birefringence receiver off San Clemente Island in May and June 1984. Perfect communications were established to the submarine USS Dolphin in dirty water at noon. Signal to noise improvements are anticipated when blue transmitters and the atomic resonance filter are available. This translates to an increase in communication depth or a decrease in laser transmitter weight and cost. These changes are over and above those achieved by the

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Project: #ST-9
Program Element: #62301E
USDR&E Mission Area: 530

Title: Submarine Laser Communications
Title: Strategic Technology
Budget Activity: 1. Technology Base

SLCAIR-84 experiment. The large amount of data collected has given us confidence that our understanding of the environmental effects (clouds, atmosphere, ocean water) is correct and that our future projections of performance will be accurate. Two blue laser candidates were tested. One produces an ability to operate for over 100,000,000 pulses without failure; a major technology issue for the satellite-borne transmitter reliability since, at 40 pulses per second data rate, it will transmit approximately one billion pulses per year.

Major contracts were awarded: to develop the space qualifiable laser test transmitter ($21.2M for 30 months to Lockheed/Northrop); and to develop a first phase atomic resonance receiver ($1.3M each for 15 months to GTE and McDonnell Douglas). Contracts were also awarded for long range development of a promising solid-state blue laser concept, for diode-pumped laser development, and for detector development to be used to support the resonance filter efforts. Lawrence Livermore National Laboratories initiated a long range development of solid-state laser transmitter technology applicable to both laser communications and in support of the SLC effort.

b. FY 1985 Program: Continuing efforts under the Joint Navy/DARPA Memorandum of Agreement are being conducted to adapt the green laser transmitter, used in the 1984 Submarine Laser Communication Airborne experiment (SLCAIR-84) and to develop a blue transmitter for future operational demonstrations. The designs for the laboratory technology transmitter test module (LTM) are to be completed and fabrication is to commence.

A selection of the best atomic resonance filter approach is being made and the actual submarine receiver is being fabricated. Research efforts to improve the detection sensitivity of this filter even further is concluding.

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At a lower level, an effort to explore the potential improvements to the baseline system offered by solid-state laser is underway at Lawrence Livermore labs and shorter-ranged projects are being funded with several contractors and Universitites. These technologies are three to five years behind the LTM Xenon Chloride work, but give promise of further improvements in operational utility of a SLC system as follow-on replacements for the first deployed satellites.

A continuing effort is being conducted to determine the environmental factors that affect a SLC system. In particular, a test of the green transmitter through thick Oregon clouds is being conducted. During this test an Air Force C-135 is to detect the signals within the clouds as well.

c. FY 1986 Planned Program and Basis for FY 1986 Request: In Mid FY 1986 the joint DARPA/Navy Project will be conducted. A green laser transmitter modified for operation in a P-3 aircraft will communicate to an SSN. Environmental and propagation data will be taken, and a demonstration will be made. By late FY 1986 the submarine-qualified atomic resonance filter receiver will be nearing completion, as will be an experimental airworthy blue laser for further experiments and demonstation. These will use the frequency of blue light planned for the first operational satellite system.

The space qualifiable laboratory transmitter technology Test Module (LTM) will be fabricated and under test by late FY 1986. Successful development will provide the Navy with adequate assurances that a full scale development is warranted on the basis of this baseline technology.

An assessment of a practical underwater remote control receiver will be completed in early FY 1986 and fabrication of an experimental model will begin. This should demonstrate the ability of an SLC system to control mines, under water vehicles, sonobuoy fields, torpedoes, etc.

An effort to fabricate and install sunlight detectors in attack submarines to measure ocean optical conditions where submarines actually operate should be complete by late FY 1986. The data collected in FY 1986 and later years will confirm and expand our current understanding of the way an SLC system will work. It will also serve as a forerunner of the device which, by measuring how much sunlight has

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Title: Submarine Laser Communications
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penetrated the ocean, will tell a submarine Commanding Officer what his maximum laser communication depth is at any time. The submarine will then be able to choose to be at a depth where SLC messages can reach it without any effort on its part, or to be below that depth and communicate using the current periodic and operationally confining radio frequency methods.

Solid-state laser transmitter candidates will be emerging that may provide potential block replacement of the first operational system, but they are expected to still be well behind the baseline XeCl system.

d. Program to Completion: FY 1987 will bring the end of DARPA's direct involvement in Submarine Laser Communications as the program is transferred to the Navy. The demonstration of aircraft-to-submarine communication using blue light and the atomic resonance filter will be completed. The final test data from the space qualifiable transmitter will be provided to the Navy for their competition for the full scale development project. DARPA will continue to pursue medium power laser and receiver technology which will have applicability to Submarine Laser Communications, but will also have utility elsewhere. By FY 1988 the Navy will control the SLC program entirely.

e. Milestones: The conditions aircraft-to-sub communications experiment cited in the FY 1985 Descriptive Summary was completed on schedule.

Last Years Reported Plan	Current Plan	Milestones
Mid FY 1985	Mid FY 1985	Blue output from XeCl laser
Late FY 1985	Mid FY 1986	First communications test with SLCAIR-84 equipment

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Project: #ST-9
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Title: Submarine Laser Communications
Title: Strategic Technology
Budget Activity: 1. Technology Base

Last Years Reported Plan	Current Plan	Milestones
Late FY 1986	Late FY 1986	Blue laser, atomic resonance filter
Mid FY 1986	Late FY 1986	Laboratory Transmitter Module complete
Mid FY 1985	Late FY 1986	Laboratory atomic resonance receiver(s) complete
Mid FY 1986	Early FY 1987	Submarine test receivers complete
Early FY 1987	Late FY 1987	At-sea tests
--	Early FY 1988	Navy decision to field a satellite-to-submarine communication system.
--	Early FY 1988	DARPA completes transition of SLC program to U.S. Navy.

f. Explanation of Milestone Changes: Milestone changes result from unanticipated delays in initiating contracts for the space qualifiable laser and atomic resonance filter receiver as well as program restructuring as a result of negotiating a joint development agreement with the Navy.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-10
Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Computing
Title: Strategic Technology
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: This project is developing advanced machine intelligence technology and demonstrating its application to specific Defense problems. Innovative computer architectures will be prototyped and several experimental high performance multiprocessor computers will be doveloped along with software to support vision, speech understanding, expert systems and natural language man-machine interfaces. Very large scale integrated systems and fabrication technology will be developed to enable rapid prototyping of state-of-the-art integrated circuits and multi-processor systems, including new wafer-scale and optoelectronic systems for packaging and interconnection. Large scale design and automated assembly and testing will be pursued. Emulation systems will be explored and developed to enable alternate systems architectures to be rapidly investigated and evaluated. Multiprocessor machine architectures which may be efficient for both symbolic computation and for large scale numeric applications will be explored. System support software for very high performance computing such as multiprocessor operating systems and microprogramming tools will be developed. Specific defense applications of this technology will include such important military problems as control of an autonomous land vehicle, fleet battle management, and a pilot's associate. Other computationally intensive applications such as signal interpretation, logistics scheduling, and data fusion will also be explored.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: The Strategic Computing Program was inaugurated with initial emphasis on optoelectronics, multiprocessor system architectures, advanced machine intelligence software and a supporting infrastructure. Construction of a 64-node, high-performance emulation facility was initiated. Proliminary optoelectronic efforts included chip-to-chip and board-to-board interconnections as well as a 4 to 1 optical multiplexer. Fast turnaround support for printed circuit boards was developed and 1.25 micron CMOS structures were fabricated using the MOS Implementation System (MOSIS). Machine Intelligence requirements for Defense AI applications were investigated and an RFP was issued for multiprocessor system architecture development. A programmable systolic computational array was designed and a small piece of the array constructed and

and demonstrated on front-end processing for real-time computer vision. Development of a compact Lisp machine for use in military concept demonstrations was started. A prototype butterfly multiprocessor containing 128-nodes was completed. A fine-grain connection machine employing thousands of a small processors is being developed. Development of a tree-structured multiprocessor suitable for exploitation in expert systems was initiated. Competitive research efforts for vision, speech, natural language, and expert systems were structured to meet program technology objectives; competitive selections were made in all areas and contracts are being awarded. Lisp machines have been procured to support the research efforts. Collaboration between application contractors and technology developers has been emphasized as contracts are awarded. The autonomous land vehicle effort was started, along with supporting vision research work that provides the "eyes" for the vehicle. An effort in fleet battle management involving CINPACFLT and the carrier U.S.S. Carl Vinson was started; detailed plans for the Pilots Associate Application are being defined. The overall program involves cooperating university, industrial, and government researchers. Liaisons to the DoD Services and Agencies and other Government organizations were also formed to maximize technology transition. Contacts have been established with NBS and with the ALVEY program in England the 5th Generation program in Japan and the ESPRIT program in Europe to develop standard benchmarks and performance evaluation techniques.

b. FY 1985 Program: Real-time customization and repair of large scale integrated circuits having near 1 micron design rules are being demonstrated using beam processing techniques. Automated printed circuit board and interconnect technology are being integrated into MOSIS; techniques are being developed for integration of wafer scale VLSI systems including the associated process, device, and packaging concepts. Initial board to board optoelectronics interconnections are being demonstrated. Circuit and system level simulation software is being developed for multi-board systems of VLSI components. New integrated circuit fabrication services and system kits are being made available through MOSIS including 1.25 micron CMOS lambda scaled designs, initial wafer scale interconnection, and standard buses. Efforts are being initiated to develop advanced coarse mesh and fine mesh machine architectures. Development of the emulation facility is continuing and is being used to emulate a tagged token data flow architecture. Fine and coarse grain tree machine architectures are being prototyped using advanced VLSI fabrication services via MOSIS. A prototype 10-cell programmable systolic array machine is being demonstrated

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Title: Strategic Computing
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Budget Activity: 1 Technology Base

along with a multiprocessor software workbench. Work on the compact lisp machine is continuing and development of a high-performance Lisp machine is being initiated. A prototype connection machine with 16,000 processors is being completed and demonstrated for use in symbolic processing. The 128 processor butterfly is being benchmarked and will be made available to the research community through the ARPANET. Supporting operating systems and software environments are being undertaken for the butterfly, systolic array, and software workbench architectures; new architectural concepts, programming languages, system software, and design and analysis tools are being developed to support the effective use of multiprocessors. Benchmarks for multiprocessor systems are being developed through cooperation with NBS. New-generation software systems are being built to capture and integrate emerging technology in the areas of vision, speech, natural language, and expert systems. Real-time vision software to support a simple road following task is being completed and will be installed in the autonomous land vehicle. Designs for an evolutionary advanced expert system and natural language interface that provides automated English responses are being completed. The Common Lisp and Ada languages are being use as standard system implementation languages for the program. The work in the autonomous land vehicle is ahead of schedule and heading for an early road following demonstration in CY 1986; the battle management application is focusing on a combined ashore and afloat scenario with the U.S.S. Carl Vinson and CINCPACFLT participation. The interface to the pilot's associate application is being specified and expert systems are being defined for all three application.

c. FY 1986 Planned Program and Basis for FY 1986 Request: MOSIS will be augmented to provided access to the Gallium Arsenide Pilot line, wafer scale interconnects and additional system kits. "Through the air" optoelectronic interconnect techniques will be investigated and low latency storage system techniques explored. Approaches for rapid VLSI System prototyping from chips to chassis will be evaluated with a goal of one month implementation time. The compact Lisp Machine chip will be completed. Butterfly multiprocessors will be made available for research on multiprocessor software applications. The dataflow emulation facility will be upgraded to include a new, higher performance interconnection network, larger scale emulations of the tagged token dataflow architecture will be carried out, and the results used to design an initial tagged token dataflow machine. An object oriented multiprocessing environment will be demonstrated on the

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Budget Activity: 1 Technology Base

software workbench. Advanced signal processing capabilities will be demonstrated using the programmable systolic array. The connection machine will be upgraded to 64,000 processors, demonstrated, and advanced software development tools will be completed to support its use in symbolic processing. The design of a 1,000,000 processor connection machine will be started, based on the results of the smaller scale prototypes. Initial demonstrations of the results of the competitive multiprocessor system architecture projects will be completed. A second round of competitions will be started. A 100 word noisy speech recognition system will be demonstrated in the Pilot's Associate application. A 1000 word continuous speech understanding system will be tested in non real-time on a lisp machine. Additional road following software will be tested on the Autonomous Land Vehicle; initial obstacle avoidance vision software will be completed and low-level vision algorithms will be exploited on the programmable systolic array for application to the vehicle. New-generation natural language and expert system technologies will be demonstrated forincorporation in battle management application areas. Designs will be completed for parallel execution of these systems. The battle management application will focus on natural language interactions and the development of expert systems for force requirements, capabilities assessment and strategy evaluation. The Pilot's Associate application will focus on connected word speech in the cockpit and development of expert systems to support tactical mission requirement and knowledge of the aircraft itself.

d. Program to Completion: Work on multiprocessor system architectures and software will continue leading to the development of a new generation of systems with 3 to 4 orders of magnitude increase in performance. Infrasturcture support for the program will be expanded to upgrade the experimental environment to include the new multiprocessor system architectures and advanced VLSI capabilities. New-generation machine intelligence systems will be delivered on multiprocessor systems and tested. Efforts will continue to focus on continuous speech understanding, image modeling and object recognition, knowledge acquisition, explanation, natural language understanding, and multiprocessor exploitation. Emphasis will continue to be placed on transfer and realization of technology in demonstration applications. Test and evaluation standards will continue to be refined. Concept demonstrations of the Land Vehicle, Pilot's Associate and Battle Management System will be carried out for a series of increasingly complex scenarios.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-10
Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Computing
Title: Strategic Technology
Budget Activity: 1 Technology Base

e. Milestones:

Late Year's Reported Plan	Current Plan	Milestone
Early FY 1985	Early FY 1985	Demonstration of an expert system for threat assessment.
Late FY 1984	Mid FY 1985	Speech Understanding system design completed.
Late FY 1985	Late FY 1985	Beam Processed, customized IC interconnection demonstrated.
--	Late FY 1985	Demonstrate road-following for Autonomous Land Vehicle application.
Mid FY 1986	Early FY 1986	Initial Emulation Facility operational.
--	Late FY 1986	Demonstrate Obstacle Avoidance on Autonomous Land Vehicle.
Late FY 1986	Late FY 1986	Design of low cost symbolic processing machine completed.
--	Late FY 1986	Demonstrate fully operational dataflow emulation facility.
Late FY 1986	Early FY 1987	Initial data flow emulator completed.
Mid FY 1987	Mid FY 1987	Innovative multi-processor architectures demonstrated with speed potential of 1000 times current supercomputer speeds.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-10
Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Computing
Title: Strategic Technology
Budget Activity: 1 Technology Base

Late Year's Reported Plan	Current Plan	Milestones
--	Mid FY 1987	Demonstrate connected word speech for the Pilot's Associate.
Early FY 1986	Late FY 1987	Initial automated computer assembly and testing demonstration.

f. Explanation of Milestone Changes: The competitive award for a Speech Understanding System was selected in FY 1984 but due to contractual delays will not be awarded until early FY 1985. The emulation facility contract was not signed until the end of FY 1984. The automated computer assembly and testing effort is being deferred until after the rapid prototyping methodology is completed. However the Printed Circuit board automation over the ARPANET was initiated earlier than originally planned and completed a year ahead of schedule.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: ST-11
Program Element: #62301E
USDR&E Mission Area: 530

Title: Intelligent Systems
Title: Strategic Technology
Budget Activity: 1 Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The Intelligent Systems, Project CCS-01, under the Defense Research Sciences Program Element no. 61101E, was transferred at the beginning of FY 1985 to the Strategic Technology Program Element no. 62301E and designated Project no. ST-11. The Intelligent Systems project focuses on fundamental investigations into the limits of the digital computer's capability for intelligent processing with the ultimate goal of making it possible for computers to assist and/or relieve military personnel in complex as well as routine decision-making tasks which are information or personnel intensive, tedious, dangerous, or rapidly changing. The specific objective of this research project is to advance the frontiers of the field of artificial intelligence, thereby providing a foundation of scientific principles for the development of a next generation of intelligent systems that will solve current and future DoD problems. To meet this objective, the research in this program explores new ways of representing and using knowledge in computers in order to perform tasks that require symbolic reasoning of sufficient complexity that one would ascribe intelligence to a human who performed them. Continuing research efforts include reasoning processes, knowledge acquisition and representation, image understanding, intelligent user interfaces, cooperative problem solving in distributed environments, fundamental architectures for expert systems, learning activities, the intelligent management of knowledge and information, and new generation software.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: Work in FY 1984 was conducted under Project CCS-1 known as Intelligent System as part of the Defense Research Science Program Element no. 61101E. Knowledge-based techniques for explicit instantiation of knowledge were infused into image understanding processes. The ACRONYM vision system was applied to a new task domain. ACRONYM also served as the foundation for a port monitoring task undertaken as a separate effort. Increased emphasis was placed on reasoning with uncertainty and efforts were initiated to address the data fusion problem. Expert systems technology utilizing the blackboard paradigm was investigated as a means of attacking more complex problems. Initial steps were taken to integrate different types of knowledge representation systems so as to overcome weaknesses inherent to a particular type of

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: ST-11
Program Element: #62301E
USDR&E Mission Area: 530

Title: Intelligent Systems
Title: Strategic Technology
Budget Activity: 1. Technology Base

system. Work in the acquisition of knowledge for natural language systems has been applied to a Defense Mapping Agency database, and was installed as an experimental tool for that agency. Distributed problem solving techniques were applied to represent uncertainty and propagate its effects in control of Robot Piloted Vehicles. Applications of knowledge engineering techniques were demonstrated in prototype expert systems that emphasize intelligent user interfaces and multiple uses of a single knowledge base. Information fusion and reasoning with uncertainty were applied to an intelligence domain. The data intensive planning effort focussed on laboratory and research planning and exploring the use of constraints to detect deviations from plans. Efforts were undertaken to produce correct and efficient programs from specifications.

b. FY 1985 Program: Basic research in machine reasoning is continuing with transfer of advances in this area to the more applied domains of expert systems technology and natural language. The Meta-Representation System that is being designed to reason about and control its own problem-solving activity is being enhanced by incroporating probabilistic reasoning and by constructing a knowledge-based consultant that will give advice about appropriate representations and inference methods. Improved problem solving systems are being developed to provide reasoning at several levels of abstraction in order to improve methods of constraining search. Reasoning about facts is being extended by formalizing the representation of those facts into a knowledge base, and by developing a priority scheme to guide automatic use of the facts. Knowledge acquisition research is being extended to general problems of induction to assist in building, expanding and correcting knowledge bases. The blackboard software environment BB1 is being extended as a general problem solving framework by enabling the scheduler to infer heuristic patterns that occur during software use and to encode these new heuristic patterns in a new control regime. Research in supporting complex queries for photointerpretation is being extended by improving hierarchical representations in order to constrain search. Image understanding research will improve the 3D MOSAIC system by integrating techniques for monocular and stereo image analysis and spatial reasoning that is being used to build and verify 3D scene models. Research in improving generic representation methods for natural language and planning assistance is being utilized to enhance the KL-TWO system by developing a hybrid approach for representing knowledge and for reasoning from such knowledge; the system will be enhanced to support plan development in a complex domain when no appropriate

pre-selected plan exists. A complex simulated environment for machine learning experimentation is being developed and used to discover principles and heuristics for intelligent action involving vision, speech and manipulation. The SOAR (Small Talk on a Reduced Instruction Set) computer system is being utilized to develop methods that permit expert systems to improve performance as a result of experience gained during use, and to permit them to effectively work on new subgoals where the system has little prior knowledge of the problem. Two new research efforts in knowledge management and new generation software are being inaugurated in FY 1985. Projects are getting underway with development efforts that incorportate intelligent functions to manage database retrieval systems, instantiation of modeling systems for rapid prototyping of software systems.

c. FY 1986 Planned Program and Basis for FY 1986 Request: Significant advances in depth mapping will result from maturation of image understanding techniques such as optical flow and stereo analysis for cultural structures. Techniques will be extended for using rule-based methods for knowledge-based control of low level scene analysis. The MAPS image-to-map correspondence system will be extended to aid decision support tasks for rule-based photointerpretation systems, and techniques for hierarchically and symbolically representing digital maps will be developed. A stereo algorithm based on scanline research will be developed and utilized to control the search problem in three-dimensional space with the objective of formulating a uniform algorithm of stereo reconstruction. The KNIFE image understanding system will be enhanced to solve problems in image segmentation, feature extraction, material identification, and feature classification by combining a database of recognition rules with recursive segmentation thus enabling software to find and label scene features. Research in developing tools for automatic algorithm design will be extended to include areas such as dynamic programming. A flow graph parsing algorithm will be applied to analysis of programs to develop a general knowledge acquisition and software design system. Work will continue to develop and formalize domain-independent control techniques such as the conjunct-ordering heuristic method. Research in machine learning will be extended by developing problems solvers that explore the space of alternative actions to discover short cuts and to note regularities; the general and domain specific heuristics aquired in this process will then be employed by expert systems to assist in directing search. A learning system for acquiring rules of Very Large Scale Integrated fault diagnosis will be demonstrated and the system will be extended to include capabilities for

analyzing and generalizing from the users' actions. The text analysis system, RESEARCHER, will be enhanced to oxtract and merge information from multiple sources; further development willincorporate knowledge-intonsive explanation-based learning to speed the generalization process whena complete domain model is available. Knowledge acquisition efforts will combine learning techniques with user interaction capabilities. Logic programming will be used as a basis for representing queries to expert systems in order to improve the speod of execution and quality of content for generating explanations. Speech understanding research will enhance the feature-based approach to spooch recognition by improving acoustic-phonetic labeling techniques for continuous speech and by developing a word hypothesizer incorporating prosodic and broad phonetic category labels. Rosearch in intelligont databases will extend to query language development and to tools for dessign of intelligent database models, distributed database systems, and interactive graphic editors for data browsing and graphical schema design. Applicability of structuring learning systems which directly assimilate new knowledge in the course of its use will be investigated as advances are made in better knowledge representation methods. Discovery techniques will be explored using structured logic procedures. Small scale prototypes of the new software and system development models will be extended and usod as a basis for initial evaluation of software alternatives. In addition to models such as visual programming, transformational programming, and deductive programming, new models such as inferential programming, kowledge-based program synthesis, and new knowledge-based optimization techniques will be developed to support production quality refinement of rapidly developed prototypes. A deductive system software development approach using a functional programming language and automated reasoning tools will be demonstrated.

d. Program to Completion: The basic research program will continue to explore artificial intolligence problems that are of fundamental importance to DoD. Very difficult research aroas such as commonsonse reasoning, learning and discovery will begin to find limited applica'ion in more applied areas such as expert systems and natural language. Knowledge acquisition and knowledge representation will continue to be of great interest because of their importance to achieving the next evolutionary step in capabilities for applied artificial intelligence. Work will also continue in areas such as cooperatlve problem solving. reasoning with uncertainty, image

Project: ST-11
Program Element: #62301E
USDR&E Mission Area: 530

Title: Intelligent Systems
Title: Strategic Technology
Budget Activity: 1 Technology Base

undorstanding, expert systems, and natural language becauso of their overwhelming importance in solving critical military problems. Research in planning and user modoling will become ripe for exploitation in command and control domains. Research to develop methods for computers to discover knowledge and learn new rules will enable development of more robust expert systems. The structure and formalism of database technology will be morged with the powerful representation and control models used in artificial intelligence in order to produce knowledge management methods that efficiently support complex quory processing and sharing of information among distributed processors. Significant advances in planning systems will result from discoveries in automated loarning and discovery methods. Knowledge baso representation advances will result in better query optimization methods for data access and in improved methods to represent goals used for planning systems. Research will continue to focus on those problems in intelligent data management that are of fundamental importance in developing large, distributed command and control systems. Research will continue to focus on those problems in intelligent data management that are of fundamental importance in developing large, distributed command and control systems. The most promising new-generation software development models will be rapidly prototyped using the new-generation experimental environmont that is being developed under the IA37T project and prepared for medium- to large-scale experimental uso to measure performance of the alternative models. The result of this effort will be new-generation of software and system development methods which will exploit artificial intelligence technologies and new multiprocessor systems architectures.

e. Milestones:

Late Year's Report Plan	Current Plan	Milestones
Late FY 1985	Late FY 1985	Demonstration of a prototype, interactive knowledge acquisition capability.
Late FY 1985	Late FY 1985	Demonstration of artificial intelligence techniques in a distributed sensor network testbed.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: ST-11
Program Element: #62301E
USDR&E Mission Area: 530

Title: Intelligent Systems
Title: Strategic Technology
Budget Activity: 1 Technology Base

Late Year's Report Plan	Current Plan	Milestones
Early FY 1986	Early FY 1986	Dovolopment of an expert system tutor for electronic equipment fault diagnosis.
Early FY 1986	Mid FY 1986	Demonstration of explanation capabilities for expert systems that relate fundamental causes for system actions.
--	Late FY 1986	Demonstration of generation of single rule synthesis for Very Large Scale Integrated design fault diagnosis.
--	Late FY 1986	Design of a system for generating plans and monitoring their execution.
--	Early FY 1987	Demonstration of an intelligent aid for determining map to image correspondence.
--	Mid FY 1987	Demonstration of intelligent optimization of data base query.
--	Mid FY 1987	Demonstration of a system for generating programs in a specific domain from high-level specifications.

f. Explanation of Milestone Changes: Not Applicable

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-12
Program Element: 62301E
USDR&E Mission Area: 530

Title: Advanced Quantum Electro-Optics (NEW START)
Title: Strategic Technology
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The objective of the Advanced Quantum Electro-optics program is to develop optical technologies to make possible a broad range of new military capabilities including ultra long range space imaging from the ground, phased array laser radars, and spaced-based counter aircraft. This new effort will focus on developing advanced methods and technologies for compensating large, segmented ground based receiving telescopes against the effects of atmospheric turbulence on the incoming wavefront.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: New Start in FY 1986.

b. FY 1985 Program: New Start in FY 1986.

c. FY 1986 Planned Program and Basis for FY 1986 Request: In FY 1986, this program will build on recent breakthroughs in atmospheric compensation technologies. Methods will be developed and coupled with ground based telescopes fully compensating for the effects of atmospheric turbulence. This effort will provide a critical adjunct to the existing Air Force GEODSS program which can detect objects at these ranges but cannot provide these objects. The technologies for compensating the pulsed ground based laser for the effects of atmospheric turbulence are being developed by the Strategic Defense Initiative Organization. This effort will develop laser radar technology including integrated optical processing technology based on holography and linear and nonlinear processes such as stimulated Brillouin scattering. This capability will depend on the development of new technologies to provide image compensation over extended path lengths through the atmosphere. In FY 1986, this program will be focused on developing concepts and component technologies, and testing of these components and concepts in subscale laboratory experiments. Advanced holographic grating fabrication techniques, low cost replication techniques by plastic embossing and large aperture modular construction from wafers will be included in this program.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-12
Program Element: 62301E
USDR&E Mission Area: 530

Title: Advanced Quantum Electro-Optics (NEW START)
Title: Strategic Technology
Budget Activity: 1. Technology Base

d. Program to Completion: Field experiments will be conducted jointly with the military services, primarily the Air Force, to determine bounds on imaging performance in an operational environment. These technologies will then be transitioned to the military services for further development.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestone
--	--	Field experiments to verify predictions of models in operational environment

f. Explanation of Milestone changes: Not applicable.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-13
Program Element: #62310E
USDR&E Mission Area: 530

Title: Strategic Air and Cruise Missile Defense
Title: Strategic Technology
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: This project is for efforts previously funded under project ST-2 that were consolidated under the new initiative Strategic Air and Cruise Missile (SACM) Defense. The SACM program objectives are to identify and the develop techniques for surveillance. Potential threat vehicles are primarily cruise missiles. Mission functions addressed include surveillance (acquisition, track, identification), targeting and kill assessment. The SACM Program will develop system concepts, associated technologies, and an architecture to provide the building blocks for advanced strategic surveillance capability. The objective is to achieve order-of-magnitude sensitivity improvements compared to existing surveillance systems. A two phase program is planned. In the first phase, promising new sensor concepts will be identified and analyzed. An architecture task will also be initiated in Phase I to develop the framework for evaluating multiple phenomenology sensor systems. The architecture efforts would include tasks for scenario and model development for evaluating overall system concepts; threat development/projection; concepts for energy spectrum (sensor) management; and, concepts for C^3 and data fusion. This new initiative will include efforts from major system studies to developments of key technology components such as ultra high performance for advanced high speed processors. The program will be based on advanced technologies such as TEAL RUBY, HI CAMP, Long Range Interceptor Experiment and new phenomenologies.

2. Program Accomplishments and Future Programs: These are new efforts. The SACM program resulted from a DARPA sponsored surveillance architecture effort during FY 1983 and FY 1984 which was accomplished in house with other government agency support. This effort reviewed all the major advanced surveillance technologies that could support future surveillance system needs. The program will evaluate all advanced surveillance concepts and platforms and how to integrate them.

a. FY 1984 Accomplishments: The surveillance architecture was completed and new ideas solicited. A program structure was established to run the program.

b. FY 1985 Program: The SACM Phase I effort is starting in FY 1985 with evaluation of new ideas/proposals. Efforts will include architectural models on the primary mission of Continental

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-13
Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Air and Cruise Missile Defense
Title: Strategic Technology
Budget Activity: 1. Technology Base

United States (CONUS) air defense and fleet defense and other secondary missions such as theater surveillance and advanced targeting. System concepts will be developed on new techniques such as multisensor systems as well as traditional surveillance concepts. Most of the effort this year will be on investigation of new techniques, development of comparative tools and establishment of a technical steering committee. The advanced arrays for target detection will be developed and the HBR system engineering will be performed for possible demonstrations in the late 1980's including distributed aperture radar experiment planning and utility assessment.

c. FY 1986 Planned Program and Basis for FY 1986 Request: The SACM phase I survey of new innovative techniques and system concepts will be completed with the most promising techniques selected for further technology and concept development. These systems will also be evaluated using the architectural mission models that will iterate the initial system concepts into the most effective integrated network to achieve significantly improved surveillance capability. The advanced ultra high performance Large Scale Integrated (LSI) chip will be developed in small test arrays and the demonstration and measurement test program for the HBR program will be developed. The HBR signal processor with antenna and receiver test articles will be developed for target detection.

d. Program to Completion: An advanced surveillance sensors architecture will be developed. The high risk, new innovative surveillance technologies will be developed and tested.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones
--	Mid FY 1985	Initiate architectural model development
--	Late FY 1985	Sensor concepts/technology development

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #ST-13
Program Element: #62301E
USDR&E Mission Area: 530

Title: Strategic Air and Cruise Missile Defense
Title: Strategic Technology
Budget Activity: 1. Technology Base

Last Year's Reported Plan	Current Plan	Milestones
--	Mid FY 1986	Initial SACM concept evaluation
--	Early FY 1986	Select Phase II concepts and technologies

f. Explanation of Milestone Changes: Not applicable.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62707E
Mission Area: #530

Title: Particle Beam Technology
Budget Activity: 1. Technology Base

A. RESOURCES ($ in Thousands):

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Costs
	TOTAL FOR PROGRAM ELEMENT	$30,900	$17,400	$21,500	$15,500	Continuing	N/A

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED: This program supports basic research and technology development to determine the scientific feasibility of particle beam weapon concepts which have the advantages of near speed-of-light delivery, rapid retargeting, and deep target penetration with a variety of kill mechanisms. The major objective of this effort is to demonstrate stable, predictable propagation of a relativistic electron beam within the atmosphere for potential point defense applications. Through FY 1984, this program also supported research on the production of high brightness neutral particle beams for potential space applications. In FY 1985, the neutral particle beam program and certain elements of the charged particle beam program directed toward research of spaced based electron beam weapon concepts were transferred to Program Element 63221C and became part of the new Strategic Defense Initiative program.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY: In FY 1984, this Program Element included development of particle beam technology potentially useful for ballistic missile defense in space. In FY 1985 and the outyears, those projects are being continued under the President's initiative on Strategic Defense. The decrement reflected in this year's estimate of the required FY 1986 funding reflects a breakthrough in induction linear accelerator technology which was applied during FY 1984 to achieve operation of the Advanced Test Accelerator (ATA) at performance levels exceeding design goals. This technical achievement, within the accelerator, removed the requirement for a major planned modification to the ATA in FY 1986 and resulted in substantial cost savings for FY 1986.

D. OTHER APPROPRIATION FUNDS: None.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62707E
Mission Area: #530

Title: Particle Beam Technology
Budget Activity: 1. Technology Base

E. RELATED ACTIVITIES: In FY 1980 the Under Secretary of Defense for Research and Engineering approved the Particle Beam Technology Program plan which, beginning in FY 1981, consolidated the DoD particle beam efforts under the overall technical direction of DARPA. Under this plan, DARPA assumed responsibility for both charged and neutral particle beam feasibility experiments. The Military Departments were responsible for advancing those technologies which are essential in order to rapidly develop particle beam weapons once they are proven feasible. In FY 1983, the transition to Army support began for the neutral particle beam program. In FY 1983-84, the neutral particle beam feasibility experiment was jointly supported by the Army and DARPA. For FY 1985 and the outyears, the joint Army/DARPA neutral particle beam program will be continued as a part of the President's initiative on Strategic Defense, with funds requested under Program Element 63221C.

F. WORK PERFORMED BY: This effort is performed by in-house activities (5%), by federally funded research facilities (85%) and by industrial contractors (10%). In-house participants include: the Naval Surface Weapons Center, Silver Spring, Maryland; and the Naval Research Laboratory Washington, D.C. Federally funded research facilities include the Lawrence Livermore National Laboratory, Livermore, California; the Los Alamos National Laboratory, Los Alamos, New Mexico; and Sandia National Laboratories, Albuquerque, New Mexico. Industrial contractors include Science Applications, Inc., Palo Alto, California; SRI International, Menlo Park, California; Avco Everett Research Laboratory, Everett, Massachusetts; Mission Research Corporation, Santa Barbara, California; B. K. Dynamics, Inc., Rockville, Maryland; C.S Draper Laboratories, Cambridge, Massachusetts; McDonnell Douglas Research Labs, St. Louis, Missouri; and Pulse Sciences, Inc., Oakland, California.

G. PROJECTS LESS THAN $7 MILLION IN FY 1986: Not Applicable.

H. PROJECTS OVER $7 Million IN FY 1986:

1. Project Description: Charged particle beam concepts are being considered for applications in a variety of advanced weapon systems. The reason for interest in these concepts is the expectation that particle beams can deliver large amounts of energy at close to the speed of light and lethally deposit it deep within a target with high coupling efficiency.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62707E
Mission Area: #530

Title: Particle Beam Technology
Budget Activity: 1. Technology Base

The key issue for development of charged particle beam concepts is the capability to propagate electron beams in the atmosphere. Theoretical models for electron beam propagation have been developed and have been verified by low-energy experiments at sub-atmospheric densities. However, until now, no electron accelerators of sufficient energy and current had been developed in the United States which would permit critical propagation experiments to be performed at full atmospheric densities. Such experiments are essential. Therefore, a major objective of the Particle Beam Technology Program is to develop the required high-energy accelerator and to demonstrate the feasibility of predictably propagating powerful electron beams to distances of military interest. Construction of the Advanced Test Accelerator (ATA), which was initiated by DARPA at Lawrence Livermore National Laboratory (LLNL) in FY 1979 with the objective of providing such an electron beam, was mechanically completed in the second quarter of FY 1983. The Experimental Test Accelerator, which represents the front-end of the ATA, is being operated at LLNL as a testbed for continued evaluation of the ATA design and to perform low-energy propagation experiments.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: In FY 1984, the Advanced Test Accelerator (ATA) was operated for the first time at performance levels which exceeded design goals. Achievement of this major program milestone was a direct result of a breakthrough in linear induction accelerator technology. Previously, these instabilities had limited the maximum current that could be accelerated to the full energy with the ATA. Attempts to accelerate beam currents without laser guiding resulted in large transverse oscillations on the beam which made the resulting electron beam useless for propagation experiments.

In FY 1984, a new pulsed power module for linear induction accelerators was also demonstrated at a repetition rate using the magnetic switching technology developed in previous years. Finally, experiments on channel tracking were continued at Los Alamos National Laboratory, the Naval Research Laboratory and at Sandia National Laboratory. These experiments provided further corroboration of upgraded theoretical beam propagation models.

b. FY 1985 Program: In FY 1985, the laser guiding experiments on the Advanced Test Accelerator (ATA) are continuing and the beam propagation line, with its transition from vacuum to atmospheric density, is being completed. The laser guiding channel in the ATA beam line is being upgraded and being given a repetitive pulse capability to allow multiple pulse propagation tests.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62707E
Mission Area: #530

Title: Particle Beam Technology
Budget Activity: 1. Technology Base

c. FY 1986 Planned Program and Basis for FY 1986 Request: The emphasis of the program will shift to multiple pulse propagation. Both lead pulse stability and channel tracking of subsequent pulses in the pulse train are necessary conditions for electron beam propagation over useful ranges. The decrease in planned FY 1986 resources for this program element from last year is made possible by the breakthrough accelerators which has solved the critical technical beam stability issue in the accelerator. Resources planned to address this issue in FY 1986 are no longer required and substantially cost savings in the FY 1986 program resulted.

d. Program to Completion: In FY 1987 and beyond, the feasibility of the continuous pulse train mode of propagation will be determined. This propagation mode has the potential to provide the possibility of nuclear keep out. Following the successful demonstration of the technology, the charged particle beam program will be transitioned to the Navy for further development.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestone
--	--	Install atmospheric beam line

f. Explanation of Milestone Changes: The approximate six month slip in the major milestones for the charged particle beam program was caused by the aforementioned instability induced limitations in maximum beam current in the Advanced Test Accelerator (ATA). These technical issues have now been successfully resolved with the ATA and the program is now proceeding according to the new schedule.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62707E
Mission Area: #530

Title: Particle Beam Technology
Budget Activity: 1. Technology Base

E. RELATED ACTIVITIES: In FY 1980 the Under Secretary of Defense for Research and Engineering approved the Particle Beam Technology Program plan which, beginning in FY 1981, consolidated the DoD particle beam efforts under the overall technical direction of DARPA. Under this plan, DARPA assumed responsibility for both charged and neutral particle beam feasibility experiments. The Military Departments were responsible for advancing those technologies which are essential in order to rapidly develop particle beam weapons once they are proven feasible. In FY 1983, the transition to Army support began for the neutral particle beam program. In FY 1983-84, the neutral particle beam feasibility experiment was jointly supported by the Army and DARPA. For FY 1985 and the outyears, the joint Army/DARPA neutral particle beam program will be continued as a part of the President's initiative on Strategic Defense, with funds requested under Program Element 63221C.

F. WORK PERFORMED BY: This effort is performed by in-house activities (5%), by federally funded research facilities (85%) and by industrial contractors (10%). In-house participants include: the Naval Surface Weapons Center, Silver Spring, Maryland; and the Naval Research Laboratory Washington, D.C. Federally funded research facilities include the Lawrence Livermore National Laboratory, Livermore, California; the Los Alamos National Laboratory, Los Alamos, New Mexico; and Sandia National Laboratories, Albuquerque, New Mexico. Industrial contractors include Science Applications, Inc., Palo Alto, California; SRI International, Menlo Park, California; Avco Everett Research Laboratory, Everett, Massachusetts; Mission Research Corporation, Santa Barbara, California; B. K. Dynamics, Inc., Rockville, Maryland; C.S Draper Laboratories, Cambridge, Massachusetts; McDonnell Douglas Research Labs, St. Louis, Missouri; and Pulse Sciences, Inc., Oakland, California.

G. PROJECTS LESS THAN $7 MILLION IN FY 1986: Not Applicable.

H. PROJECTS OVER $7 Million IN FY 1986:

1. Project Description: Charged particle beam concepts are being considered for applications in a variety of advanced weapon systems. The reason for interest in these concepts is the expectation that particle beams can deliver large amounts of energy at close to the speed of light and lethally deposit it deep within a target with high coupling efficiency.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62707E
Mission Area: #530

Title: Particle Beam Technology
Budget Activity: 1. Technology Base

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G. PROJECTS LESS THAN $7 MILLION IN FY 1986: Not Applicable.

H. PROJECTS OVER $7 Million IN FY 1986:

1. Project Description: Charged particle beam concepts are being considered for applications in a variety of advanced weapon systems. The reason for interest in these concepts is the expectation that particle beams can deliver large amounts of energy at close to the speed of light and lethally deposit it deep within a target with high coupling efficiency.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62707E
Mission Area: #530

Title: Particle Beam Technology
Budget Activity: 1. Technology Base

A. RESOURCES ($ in Thousands):

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Costs
	TOTAL FOR PROGRAM ELEMENT	$30,900	$17,400	$21,500	$15,500	Continuing	N/A

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED: This program supports basic research and technology development to determine the scientific feasibility of particle beam weapon concepts which have the advantages of near speed-of-light delivery, rapid retargeting, and deep target penetration with a variety of kill mechanisms. The major objective of this effort is to demonstrate stable, predictable propagation of a relativistic electron beam within the atmosphere for potential point defense applications. Through FY 1984, this program also supported research on the production of high brightness neutral particle beams for potential space applications. In FY 1985, the neutral particle beam program and certain elements of the charged particle beam program directed toward research of spaced based electron beam weapon concepts were transferred to Program Element 63221C and became part of the new Strategic Defense Initiative program.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY: In FY 1984, this Program Element included development of particle beam technology potentially useful for ballistic missile defense in space. In FY 1985 and the outyears, those projects are being continued under the President's initiative on Strategic Defense. The decrement reflected in this year's estimate of the required FY 1986 funding reflects a breakthrough in induction linear accelerator technology which was applied during FY 1984 to achieve operation of the Advanced Test Accelerator (ATA) at performance levels exceeding design goals. This technical achievement, within the accelerator, removed the requirement for a major planned modification to the ATA in FY 1986 and resulted in substantial cost savings for FY 1986.

D. OTHER APPROPRIATION FUNDS: None.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62702E
USDR&E Mission Area: 530

Title: Tactical Technology
Budget Activity: 1. Technology Base

A. RESOURCES (PROJECT LISTING): ($ in thousands)

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Costs
	TOTAL FOR PROGRAM ELEMENT	103,436*	107,400*	102,000*	$130,000*	Continuing	N/A
TT-1	Target Acquisition and Engagement	-0-[a/]	-0-	-0-	-0-	-0-	-0-
TT-2	Weapons Technology and Concepts	-0-[a/]	-0-	-0-	-0-	-0-	-0-
TT-3	Naval Warfare	35,942	40,700	31,680[b/]	34,650[b/]	Continuing	N/A
TT-4	Advanced Armor Technology	5,276	5,200	5,200	5,200	Continuing	N/A
TT-5	Target Acquisition and Weapons Technology	52,887	37,300	41,620	55,150	Continuing	N/A
TT-6	Tactical Directed Energy Technology	-0-	-0-	15,000	25,000	Continuing	N/A

* Total includes classified projects not identified herein.

a/ Projects TT-1 and TT-2 are consolidated in TT-5.

b/ The Advanced Undersea Vehicle Program is continuing in FY 1986 and the outyears as Project No. EE-18 in DAPPA Program Element 63226E, Experimental Evaluation of Major Innovative Technologies.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62702E
USDR&E Mission Area: 530

Title: Tactical Technology
Budget Activity 1. Technology Base

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED: This program element is dedicated to the advancement of concepts and technologies that will serve as the basis for the development of the next generation of tactical systems. The program goal is to advance non-nuclear, tactical, combat capabilities to counter the expanding tactical threat with emphasis on high payoffs, reasonable costs, and realistic manpower constraints. The major development objectives are: (1) improving target acquisition and engagement technology; (2) advancing fire control, seeker, and command and control technology; (3) advancing warhead, munition and propulsion technology; (4) improving armor technology; and (5) enhancing ocean surveillance, targeting and control technologies.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY: The total funding for FY 1985 is $2.0 million less than the request for that fiscal year included in the FY 1985 Descriptive Summary. This reduction is the net effect of a slight increase in the Naval Warfare project and a reduction in the Target Acquisition and Weapons Technology project. The Naval Warfare increase is due to the addition of the new Mini-GPS Receiver program and the Target Acquisition and Weapons Technology reduction is caused by a schedule slip in the Millimeter Wave Autonomous Sensor program and a redefinition of the Critical Node Targeting program.

The total request for FY 1986 is $29.0 million less than last year's request for that fiscal year included in the FY 1985 Descriptive Summary. This reduction is the net effect of decreases in the Naval Warfare and Target Acquisition and Weapons Technology projects and the addition of a new Tactical Directed Energy Technology project. The Naval Warfare decrease reflects the transfer of the Advanced Undersea Vehicle program to Project No. EE-18 in Program Element 63226E, offset by added funding for the new Mini-GPS Receiver program. The Target Acquisition and Weapons Technology decrease reflects the Critical Node Targeting program redefinition, the transfer of the Electromagnetic Gun program to Program Element 63222C and the within program element transfer of classified programs to another project.

D. OTHER APPROPRIATION FUNDS: None.

E. RELATED ACTIVITIES: Overall coordination of efforts is maintained with representatives of the Office of the Undersecretary of Defense for Research and Engineering, the offices of the service assistant secretaries responsible for research and advanced development, and the corresponding service

headquarters staff offices. In addition, direct coordination of activities with appropriate service laboratories is maintained through means such as technical interchange meetings and conferences.

Specific Naval Warfare project coordination mechanisms are as follows: The Systolic Array Processor program is coordinated through the Naval Electronics Systems Command (NAVELEX) and the Naval Sea Systems Command (NAVSEA) and a Memorandum of Understanding (MOU) has been signed with these organizations. Similarly, the ARIADNE Program is also coordinated with NAVELEX which is jointly sponsoring the development of certain aspects of the required technology base. The Advanced Conformal Submarine Acoustic Sensor program is being pursued as a joint venture by DARPA, the Office of Naval Research, and the Office of the Chief of Naval Operations (Submarine Warfare) and an existing Memorandum of Agreement (MOA) governs the effort. The Mini-GPS Receiver Program is being run in coordination with the Global Positioning System Special Project Office and with support from the United States Marine Corps.

Advanced Armor Technology project activities are coordinated with the Army Armament Research and Development Center, Army Ballistic Research Laboratory, Army Mechanics and Materials Research Center, Naval Surface Weapons Center (White Oak), and Naval Surface Weapons Center (Dahlgren).

In the Target Acquisition and Weapons Technology project, the Critical Node Targeting program is being developed and funded jointly with the Air Force. The Surveillance Radar program is a joint development with the Army in which the Marine Corps maintains a close liaison. The all-Digital Radar is being developed and funded jointly with the Army Missile Command and the Air Force Rome Air Development Center. In the Advanced Ramjet Munition Technology program, the Army is jointly funding the ramjet-powered rod penetrator munition (PAMROD) and 40 mm Tubular Projectile developments. The Ramjet Combustion Phenomenology study is a joint effort with the Naval Weapons Center, China Lake and the Army Ballistics Research Laboratory. The Boron Solid Fuel Ramjet Flight demonstration is a jointly-funded project with the Navy. The Advanced Warhead Technology program includes the joint-funded Bridge Road and Tunnel (BRAT) and Penetration Augmented Munition (PAM) developments with the Army. In the Advanced Warhead Technology program, the Marine Corps is jointly funding the Shoulder-Launched Multi-Purpose Assault Weapon Hyperboloid Charge Development. The Autonomous Infrared Sensor Technology program and the Millimeter Wave Sensor program are coordinated within the three services through the Joint Deputies for Laboratories and under the auspices of the Advanced Target Recognizer Working Group. The Uncooled Sensor

program is jointly funded with the Army Night Vision and Electro-optical Laboratory and the Army Missile Command. DARPA is also an active member of the DoD Anti-Armor Master Plan Steering Group and Working Group.

Plans for the new Tactical Directed Energy Technology project are coordinated through frequent technical interchange meetings with representatives from the three services' tactical directed energy programs.

F. WORK PERFORMED BY: Approximately 85% of the work of the Naval Warfare project is carried out by industry and 15% by DoD in-house agencies. Industrial contractors involved in research programs under this project are: Bolt, Beranek and Newman, Inc., Arlington, Virginia and Cambridge, Massachusetts; Cambridge Acoustical Associates, Inc. Cambridge, Massachusetts; AMRON Corporation, Fairfax, Virginia; McDonnell-Douglas Astronautics Company, Huntington Beach, California; General Dynamics Corporation, San Diego, California; General Electric Company, Syracuse, New York; Westinghouse Electric Corporation, Baltimore, Maryland; Tetra-Tech Inc., Arlington, Virginia and Pasadena, California, and Raytheon Company, Portsmouth, Rhode Island. The in-house effort is performed by the Naval Ocean Systems Center, San Diego, California; the Naval Underwater Systems Center, New London, Connecticut and Newport, Rhode Island; the Naval Ship Research and Development Center, Carderock and Annapolis, Maryland; the Naval Oceanographic Research and Development Activity, Bay St. Louis, Mississippi; the Naval Research Laboratory, Washington, D.C.; the Naval Civil Engineering Laboratory, Port Hueneme, California; and the Office of Naval Research, Washington, D.C.

About 54% of the Advanced Armor Technology project work is contracted to industry and 24% to Federally funded research and development centers. The remaining 22% of the work is performed by non-profit and in-house laboratories. Principal contractors are Aerojet Ordnance Manufacturing, Downey, California; Aeronautical Research Associates of Princeton, Princeton, New Jersey; Battelle Columbus Laboratories, Columbus, Ohio; California Research and Technology, Dublin, California; Geo-Centers, Inc., Suitland, Maryland; Newton Corp., Upper Falls, Massachusetts; Honeywell Inc., Minneapolis, Minnesota; Lawrence Livermore National Laboratory, Livermore, California; Physics International, San Leandro, California; and the Reynolds Metals Company, Richmond, Virginia. Additional work on a cooperative effort is being carried out by Allied Corporation, Morristown, New Jersey and the U.S. Army Armament Research and Development Center, Dover, New Jersey.

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Program Element: #62702E
USDR&E Mission Area: 530

Title: Tactical Technology
Budget Activity 1. Technology Base

In the Target Acquisition and Weapons Technology project, 62.6% of the work is performed by contractors, while universities account for 32.9% and the remaining 4.5% is performed in-house by government laboratories. The top ten performers are the University of Texas, Austin, Texas; Systems Planning Corp., Arlington, Virginia; Rockwell International Corporation, Los Angeles, California; the Massachusetts Institute of Technology Lincoln Laboratory, Cambridge, Massachusetts; ERIM, Ann Arbor, Michigan; Chemical Systems Division of United Technologies, San Jose, California; CACI, Federal Incorporated, Arlington, Virginia; The BDM Corporation, McLean, Virginia; General Atomics, La Jolla, California; and General Dynamics Corp., San Diego, California.

It is anticipated that approximately 50% of the new Tactical Directed Energy Technology project work will be conducted by industry, 40% by in-house Government laboratories and 10% by universities. The program will be initiated by competitive means and the contractors are not known at this time.

G. PROJECTS LESS THAN $7 MILLION IN FY 1986: The armor/anti-armor project is expected to continue in subsequent years with specific objectives evolving to address emerging challenges in this critical technology area.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #TT-3
Program Element: #62702E
USDR&E Mission Area: 530

Title: Naval Warfare
Title: Tactical Technology
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The objective of the Naval Warfare project is to investigate new technologies and system concepts which would significantly enhance the maintenance of effective surveillance, targeting, and control of surface and subsurface ocean areas. The earlier emphasis on surveillance of the Soviet submarine forces has been expanded to address a wider range of ocean warfare issues for both surface and submerged targets and the development of more capable weapon system concepts to meet the expanding Soviet threat. The project emphasizes the performance of key experiments validating critical technology elements or system concepts prior to Navy transition. Major initiatives currently being pursued include: (1) the Integrated Anti-Submarine Warfare (ASW) Sensor Technology program to demonstrate advanced acoustic and non-acoustic sensor system concepts for blue water or Arctic region detection and localization of submarines (2) the ARIADNE (TIARA) program (formerly the Long Haul Array Program) to investigate the application of fiber optic cabling and telemetry techniques for strategic or tactical undersea surveillance; (3) the Systolic Array Processor program which seeks to develop novel digital architectures for providing the enhanced signal processing capacity needed in real-time multi-channel processors for towed and conformal array applications; and (4) the Mini-GPS Receiver program, which will develop a cigarette package-sized Monolithic Microwave Integrated Circuits (MMIC) and Very Large Scale Integrated (VLSI) Global Positioning System (GPS) receiver.

The Naval Warfare project is also seeking to expand involvement in the "end game" of anti-submarine warfare (ASW) and the larger issue of ocean warfare in general. Major tactical ASW and ocean warfare research programs include: (1) the Advanced Conformal Submarine Acoustic Sensor (ACSAS), which is intended to establish the basis for a new class of hull-mounted attack submarine sonars; (2) the Advanced Undersea Vehicle (AUV) (TIARA) program in which aerospace technologies are being applied to the design of a small unmanned submersible.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments:

Advanced Autonomous Array (A^3) (TIARA): FY 1984 was the final year of DARPA involvement with A^3. Emphasis is being placed on final transition to the Naval Electronic Systems Command, which is

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USDR&E Mission Area: 530

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considering both a vertical array embodiment of the basic sensor and its application in battle group Anti-Submarine Warfare (ASW) defense. Several small ancillary studies on data communication options using remote sensors similar to the A^3 are also being completed, and an additional sea test is considered likely.

ARIADNE (TIARA): Development of the undersea hardware continued, including sea water batteries, and Repeater/Multiplexer/Connectors (RMC). The design of the RMC's was completed and work begun on breadboard models. Sea water battery notional designs developed by the Naval Ocean Systems Center (NOSC) were tested for extended duration deployments in deep water. Multiple sources and designs for fiber optic undersea cable were acquired. Survivability testing began in deep and shallow water as well as in pressure tanks and abrasion devices. Based on the results of the last year's efforts, signal processing techniques were selected and initial coding begun.

Systolic Array Processor: The first design/fabrication iteration for the Very Large Scale Integrated (VLSI) systolic chip was completed late in FY 1984, and the acoustic data pre-processor fabricated for final testing at that same time.

Non-Acoustic ASW: The FY 1984 accomplishments for this effort were reported under Project UDR-1. During FY 1985, this project transfers to naval warfare tactical technology.

Arctic Surveillance: Air deployment techniques for dropping the buoy from an aircraft and penetrating ice were designed and tested.

Advanced Conformal Submarine Acoustic Sensor (ACSAS): Efforts emphasized experimental tests on scale model bodies to understand the phenomena of flow noise and structural noise propagation. Further pop-up tests were conducted to test the performance of various polymer hydrophone arrays, sail configurations, and structural modifications. To examine the effect of structural body modifications on the propagation of structural noise, tests continued using 1/15 scale models which incorporate alternative outer body configurations for measurement of acoustic structural noise when the body was subjected to controlled excitation at various frequencies.

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Advanced Undersea Vehicle (AUV) (TIARA): Following successful completion of the individual technology demonstrations, fabrication and check out of each of the hardware subsystems was completed. Software development proceeded in a simulation laboratory, and components were individually verified and integrated into a unified software package. A conceptual design of an advanced undersea vehicle was completed. A 15-25% reduction in required propulsion power was demonstrated in wind tunnel tests. Concepts for more capable systems were studied.

Mini-GPS Receiver: A 30-month effort was started in FY 1984 to develop a cigarette pack sized GPS receiver with full function capability. This will be the first development incorporating Monolithic Microwave Integrated Circuits (MMIC).

b. FY 1985 Program:

ARIADNE (TIARA): Repeater/Multiplexer/Connector (RMC) designs are being completed and the first three prototypes from each of two developers will be delivered and tested. The results of these tests will lead to planned optical improvements. Based on the results of the first year tests, second versions of cable will be developed and delivered. Air deployment of cables and repeaters is being demonstrated. A one year test of sea water batteries is being conducted, and specifications for commercial manufacture of sea water batteries drawn up and a test bed developed. The data distribution system for the fiber optic cable output is being designed and implemented.

Specific algorithms for signal and information collection and processing architecture are being developed along with a feasibility demonstration testbed design.

Systolic Array: Final systolic chip sets are being manufactured and incorporated into an adaptive beamformer system that will first be validated in the laboratory and then used in a major sea test for real time processing of the outputs of an advanced development model towed array. Adaptive performance is being compared with theoretical expectations.

Advanced Conformal Submarine Acoustic Sensor (ACSAS): Major testing of various system components are the primary effort in FY 1985 with substantial building on the results of earlier tests. A significant

effort during this year will be the completion and testing of a completely new front end for the KAMLOOPS vehicle, whose design and shape will be the result of analytic studies and testing during the previous two years. During the FY 1985 testing, compatibility with other components and the performance capabilities of the hull coating and outer decoupler candidate designs will be evaluated and documented to arrive at an optimal system design.

Advanced Undersea Vehicle (AUV) (TIARA): The integration of the individual subsystems is being completed. Testing of circuits and sensors is continuing. Technology requirements are being identified for a number of candidate AUV missions where advances are needed prior to vehicle design and fabrication. A technology development plan is being formulated with technology demonstrations identified.

Mini-GPS Receiver: A Mini-GPS breadboard is being evaluated before preceeding with the full brass-board construction.

Non-Acoustic ASW: Preparation for a definitive experiment using a transmitter and several candidate receiving systems will be completed. The image digital processing capability is being improved and an intensive analysis effort undertaken.

c. FY 1986 Planned Program and Basis for FY 1986 Request:

ARIADNE (TIARA): Preparations will be undertaken in FY 1985 and FY 1986 for deployment. A six node testbed will be integrated and deployed in two sea tests. Two competitive designs for an information processing system based on a rule-based expert system for broadband and narrowband target detection will be completed and one selected for implementation. This program should transfer to the Navy at the end of FY 1986.

Systolic Array: The combination of processor and sensor will be further tested to assess the system capability for tactical applications, and specific transition opportunities will be identified. This program will be completed during FY 1986.

Advanced Conformal Submarine Acoustic Sensor (ACSAS): This program is scheduled to be completed in FY 1987. Efforts remaining to be completed include component sea tests and KAMLOOPS verification tests in FY

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1986 and Large Scale Vehicle tests in FY 1987 and beyond. Management transition of the program from the Office of Naval Research to the Naval Sea Systems Command will occur at the end of FY 1986.

Advanced Undersea Vehicle (AUV) (TIARA): This program has been transferred to PE 63226E, project #EE-18.

Mini-GPS Receiver: Final completion of the brassboard will be completed in the spring of 1986. The Marine Corps will be paralleling the DARPA effort with an engineering design model (EDM) and specification which will get underway upon success of the brassboard.

Integrated Non-Acoustic ASW: The efforts conducted within the non-acoustic ASW project will be continued within this project. An in-depth study of current and future requirements will be completed. A threat quantification workshop will be held. Single sensor analysis of the candidate phenomenology sensors will be completed. An integrated system definition and technology assessment will be completed. The sensor platform will be selected for an experiment to be conducted in the Georgia Straits, Hawaii, Northern Alaska and U.S. coastal waters.

d. Program to Completion:

Integrated ASW: The system design review will be completed.

e. Milestones: The milestones cited in the FY 1985 Descriptive Summaries with completion dates through Mid FY 1985 have been completed or are expected to be completed on schedule.

Last Year's Reported Plan	Current Plan	Milestones
ARIADNE (TIARA):		
Late FY 1984	Late FY 1985	Development of fiber optic telemetry link
Late FY 1986	Late FY 1987	Potential system demonstration

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Last Year's Reported Plan	Current Plan	Milestones
Systolic Array Processing:		
Mid FY 1984	Mid FY 1985	Manufacture and test chips in processor.
--	Late FY 1985	Sea test of systolic beamformer.
Arctic Surveillance:		
Early FY 1985	Early FY 1985	Deploy ICE PICK in operational demonstration.
Advanced Conformal Submarine Acoustic Sensor (ACSAS):		
Late FY 1984	Mid FY 1985	KAMLOOPS test series with new bow and array
--	Mid FY 1986	Pressure/shock tests on structural design.
--	Late FY 1986	Integrated system testing.
Late FY 1986	Late FY 1987	Potential full scale demonstration test.
Ocean Tactical Targeting (TIARA):		
Early FY 1985	Early FY 1985	Integration of sensor cueing and feedback algorithms work station
Mid FY 1985	Mid FY 1985	Conduct controlled real-time operational impact demonstration

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Project: #TT-3
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USDR&E Mission Area: 530

Title: Naval Warfare
Title: Tactical Technology
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Last Year's Reported Plan	Current Plan	Milestones
Advanced Undersea Vehicle (TIARA):		
--	Mid FY 1985	Pressure test composite hull design
--	Late FY 1985	Demonstration autonomous navigation logic
--	Late FY 1985	Complete advanced technology developmment plan
Mini-GPS Receiver:		
--	Mid FY 1985	Initiate brassboard development
--	Mid FY 1986	Complete brassboard

f. Explanation of Milestone Changes: ARIADNE (TIARA): Navy and DARPA have been negotiating an enhanced two phase program: a technology effort through FY 1986, and a Navy system feasibility demonstration in FY 1987 and FY 1988. This has altered the milestones as shown. Systolic Array Processing: Small slip in prototyping milestones was due to re-definition of processor requirements for beamforming. The FY 1985 sea test milestone has been added to make explicit a planned-for-system demonstration. Advanced Conformal Submarine Acoustic Sensor: As a result of extensive analytical work and an appraisal of potential future support, it was decided that much stronger emphasis should be placed on an experimental approach to answering critical technical questions about the performance of very large hull-mounted conformal arrays in a flow noise environment. This has required a substantial recasting of the program plan to include a larger test series, more experimental hardware, and resulting changes in milestones. The delay in the new KAMLOOPS bow is due to more extensive structural modifications than previously anticipated and has, in turn, pushed subsequent milestones outward. Ocean Tactical Targeting (TIARA): Small slip in first milestone caused by delay in letting prime contract. Mini-GPS Receiver: This was a new start, and no milestones have appeared previously.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: TT-5
Program Element: #62702F
USDP&E Mission Area: 530

Title: Target Acquisition and Weapons Technology
Title: Tactical Technology
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The Target Acquisition and Weapons Technology project is designed to help offset expected enemy numerical advantages in deployed weapons and systems through the increased lethality and effectiveness of U.S. fielded systems. Targeting and sensor system technologies are the focus of the Critical Node Targeting, and the Surveillance Radar programs. The Surveillance Radar Technology program is jointly developing with the Army a self-contained miniaturized airborne radar for short-range battlefield surveillance from a Remotely Piloted Vehicle (RPV). The Surveillance Radar program is also developing reduced-tolerance imaging techniques to permit high-resolution radar imaging without the stringent (and expensive) aircraft motion compensation normally required. Taken together these technologies will provide for lower-cost airborne battlefield surveillance with greatly enhanced capability to detect and classify targets. Sensor and algorithm technologies for fire and forget munitions and other highly specialized applications are being developed in the Autonomous Infrared (IR) Sensor Technology, the Uncooled IR Sensors, and the Millimeter Wave Autonomous Sensor programs. The Autonomous Infrared Sensor Technology program is structured to provide a technology base for future infrared seekers and sensors associated with tactical operations such as advanced missiles, projectiles and attack helicopter sensors. A government standard database and evaluation standards will be developed with which to gauge the performance of advanced algorithms and perform comparison of sensor techniques. The program is jointly managed and funded by DARPA and the Army, with active participation from the Air Force and Navy. The Uncooled IR Sensor program is developing two-dimensional imaging arrays of pyroelectric and other room temperature sensor techniques that sense infrared energy. A primary application for uncooled infrared imaging is in potentially low cost high production volume sensors such as missile seekers and projectiles. The Millimeter Wave Autonomous Sensor program is forging the technological base for a new generation of precision-guided adverse weather weapon seekers, forward-area surveillance radars, and fire control radars. Advanced weapons, weapons lethality, propulsion and warhead technologies are being explored in the Advanced Ramjet Munition Technology and the Advanced Warhead Technology programs. The Advanced Ramjet Munitions Technology program features the development of advanced solid fuel ramjet propulsion, special munition concepts and fundamental ramjet combustion phenomenology analysis. The Advanced Warhead Technology program features the joint DARPA/Army development of the Bridge Road and Tunnel and Penetration Augmented Munition demolitions as an integral

Project: TT-5
Program Element: #62702E
USDR&E Mission Area: 530

Title: Target Acquisition and Weapons Technology
Title: Tactical Technology
Budget Activity: 1. Technology Base

part of the generic application of Multi-stage Conventional Munitions (MCM) technology. MCMs result in explosive energy being deposited in the structure as opposed to today's conventional C-4 based demolitions capability.

2. Program Accomplishments and Future Programs: The Cruise Missile Defense and Assault Breaker Programs were completed in FY 1984 and transitioned to the services for further development. The Electromagnetic Gun program was transferred to the Strategic Defense Initiative Organization.

a. FY 1984 Accomplishments: Research accomplishments during FY 1984 for Target Acquisition and Engagement and Weapon Technology were reported under projects TT-1 and TT-2, respectively. This research was combined during FY 1985 and continued through initiation of this project, TT-5.Conceptual design of the miniaturized RPV Surveillance Radar was completed. Detailed design and fabrication was initiated.

A major analysis effort to determine capabilities of selected integrated sensor suites against a series of Critical Node Targets was completed. The system surpassed all expectations during preliminary tests.

Detailed surveys of infrared databases and evaluation technology were completed in the Autonomous Infrared (IR) Sensor Technology program. Potential radar techniques were assessed and target algorithms were evaluated.

Preliminary uncooled IR imagery showed very promising results. One prototype imaging arrays was developed.

Collection of the interim Millimeter Wave Autonomous Sensor database was completed. Promising algorithms were selected for evaluation on the signature data processing facility and fabrication of the experimental testbed sensor continued.

Feasibility studies, preliminary materials testing, and design stress analysis studies were completed on the 105mm ramjet powered, rod penetrator munition (RAMROD) under the Advanced Ramjet Munitions Technology program. In preliminary tests, the projectile demonstrated auto-ignition and muzzle velocities. Significantly improved lethality was achieved against a broad spectrum of aircraft and armor targets. A

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Title: Target Acquisition and Weapons Technology
Title: Tactical Technology
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major redesign of the extended range 8" Howitzer artillery projectile was completed and the stress analysis effort was also finished. Testing of design changes has been completed and flight test projectile fabrication has begun.

Under the Advanced Warhead Technology program, analysis of the interaction of the forward shaped charge with limestone, granite and varieties of reinforce concrete was begun. Assessment of the follow-through charge propulsion mechanism interaction with the forward shaped charge was begun. The Shoulder-Launched Multi-Purpose Assault Weapon wall breaching hyperboloid charge development was initiated.

b. FY 1985 Program: The joint Air Force/DARPA design definition study for a testbed and test program continues as a part of the Critical Node Targeting program.

In the Surveillance Radar program, hardware development of the miniaturized Remotely Piloted Vehicle (RPV) radar is being completed. Analysis of Reduced-Tolerance Imaging techniques continues.

In the Autonomous Infrared (IR) Sensor program, multi-sensor instrument data is provided to algorithm development teams. Evaluation of algorithms is conducted using standardized evaluation principles. A standard sensor database is provided for algorithm evaluation. Synthetic imagery database is completed.

In the Uncooled Sensor program, three candidate design configurations of a pyroelectric element imaging arrays are being evaluated in the laboratory.

In the Millimeter Wave Sensor program, research on the phenomenology of high resolution Millimeter Wave target discrimination techniques continues. Alternative discrimination algorithms are examined and optimized. Design and fabrication of a testbed collection sensor continues. Development of new target detection/classification algorithms is initiated.

In the Advanced Ramjet Munitions Technology program, RAMROD component testing is accomplished under high g loadings. RAMROD projectile testing of auto-ignition, ramjet boost-sustain function, aeroballistic stability, and structural integrity is conducted. In the Metalized Boron Fuel Intregral Rocket Ramjet

Project: TT-5
Program Element: #62702E
USDR&E Mission Area: 530

Title: Target Acquisition and Weapons Technology
Title: Tactical Technology
Budget Activity: 1. Technology Base

effort three advanced boron fuels and a state-of-the-art hydrocarbon fuel are tested at the Naval Postgraduate School, under common conditions to determine the best fuel for a flight demonstration later in FY 1985.

The Advanced Warhead Technology program, Penetrated Augmented Munition (PAM) preliminary design is completed. Technology investigations (computer and experimental) of the Bridge Road and Tunnel Munition (BRAT) forward and main charges, fuzing, timing and propulsion components are conducted. The Shoulder-Launched Multi-purpose Assault Weapon (SMAW) hyperboloid charge concept is demonstrated and transitioned to Naval Surface Weapons Center (NSWC) Dahlgren for further development.

c. FY 1986 Planned Program and Basis for FY 1986 Request: Critical Node Targeting design definition studies for a testbed will be completed and fabrication of the required sensors and integration hardware and software initiated. Selection of promising techniques, optimized for targeting critical battlefield nodes, will be made and development of receiver hardware and software will be initiated.

Components of the miniaturized Remotely Piloted Vehicle (RPV) Surveillance Radar will be integrated and flight-tested on a small stand-up aircraft and fabrication of the fully miniaturized signal processor will begin.

Efforts in the Autonomous Infrared Sensor Technology program will be designed to definitize emerging algorithm evaluation standards and define criteria for synthetic data with which to test algorithms. Test in the program facilities will be performed with real imagery. Multi-sensor data combining will be used in the development of high performance algorithms.

Uncooled Sensor program will demonstrate imagery from uncooled laboratory model cameras with adequate resolution and sensitivity for autonomous weapon and night sight applications. Based on results, demonstration of operational feasibility of one or two of the best approaches will be pursued in a joint DARPA/Army/Air Force program. Candidate applications include an air-to-ground munitions seeker, a fire and forget missile seeker and an air-to-air missile for anti-helicopter missions.

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Project: TT-5
Program Element: #62702E
USDR&E Mission Area: 530

Title: Target Acquisition and Weapons Technology
Title: Tactical Technology
Budget Activity: 1. Technology Base

Efforts in the Millimeter Wave Autonomous Sensor program will continue to optimize battlefield target detection/classification algorithms and autonomous sensor modeling. Testbed sensor fabrication will be completed and collection of a comprehensive database will be initiated. Contractors who have heretofore been using existing databases for algorithm development will begin using the new, higher-quality data.

Advanced Ramjet Munition Technology program efforts will include preliminary testing of RAMROD projectiles and structural integrity at high g-loadings using the M-68 105 mm gun. Dispersion and lethality testing of RAMROD will be initiated late in FY 1986 or early FY 1987 and the technology will be transferred to the U.S. Army. The tubular projectile Ramjet Combustion Phenomenology effort will begin free jet testing of solid fuel ramjet engines. Integration of experimental and modeling efforts under the Ramjet Combustion Phenomenology effort will be completed and transitioned to the Navy and Army in late FY 1986 or early FY 1987.

In the Advanced Warhead Technology program, the Penetrated Augmented Munition (PAM) system (designed as a special operator demolition) will be demonstrated and transitioned to the Army. The preliminary Bridge Road and Tunnel (BRAT) system design will be completed. Late in FY 1986 or early in FY 1987 the BRAT system will be demonstrated and further development will be undertaken by the Army. The Hydrostatic Shaped Charge Fragmentation concept will be demonstrated using an extended range, high lethality (up to 50% greater than current unitary artillery projectiles) artillery warhead. The Advanced Anti-Armor Rifle Grenade will be developed and demonstrated.

d. Program To Completion: In the Critical Node Targeting program, fabrication will be completed during FY 1987. Flight test evaluation will be initiated in the Continental United States (CONUS).

In the Surveillance Radar program, flight testing of the final version of the Miniaturized Remotely Piloted Vehicle (RPV) radar system is planned for late FY 1987. Experimental cruise-missile surveillance techniques will be evaluated in FY 1987 and FY 1988.

Under the Autonomous Infrared Sensor Technology program, performance capabilities and limitations of advanced autonomous active and passive infrared sensor/signal processing techniques will be provided to

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USDR&E Mission Area: 530

Title: Target Acquisition and Weapons Technology
Title: Tactical Technology
Budget Activity: 1. Technology Base

industry as results become available. Transition of system/sensor development data will be completed and a standardized database will be made available for industry sensor design and development efforts.

The Uncooled Sensor program will transition to the Army during FY 1987 with the demonstration of a prototype imager with high sensitivity, small pixel detectors and large imaging detector arrays. Advanced development and operational testing to determine operational practicability will be completed by the Army during FY 1988.

In the Millimeter Wave (MMW) Autonomous Sensor program, collection of a comprehensive high resolution MMW database will be completed during FY 1987. Reduction and analysis of this data will be completed and the data will be applied to optimize the MMW autonomous sensor design. Design optimization and evaluation will be completed during FY 1988, resulting in the definition of a new generation of fire-and-forget millimeter wave seekers and "smart" fire control radars.

Under the Advanced Ramjet Munition Technology program, the joint DARPA/NASA air turboramjet engine technology testbed will be evaluated over the full dynamic range for which the engine is to be designed in the NASA Langley wind tunnel during FY 1987/1988.

In the Advance Warhead Technology program, efforts will continue to evaluate and develop simple, high payoff concepts until program termination in FY 1990. Developed technologies will be transitioned to the Services as appropriate.

FY 1986 PDT&E DESCRIPTIVE SUMMARY

Project: TT-5
Program Element: #62702E
USDP&E Mission Area: 530

Title: Target Acquisition and Weapons Technology
Title: Tactical Technology
Budget Activity: 1. Technology Base

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones
Critical Node Targeting Program:		
--	Early FY 1986	MFTASCAN receiver test and evaluation.
--	Mid FY 1986	Receiver test and evaluation.
--	Late FY 1986	Application and evaluation of knowledge engineering and pattern recognition processing.
--	Early FY 1988	Testbed flight tests.
Uncooled Sensor Program:		
Mid FY 1985	Mid FY 1985	Image demonstration: Large Arrays, Small Pixels, Full Sensitivity.
Late FY 1987	Late FY 1987	Program transition to Service development programs.
Millimeter Wave Autonomous Sensor Program:		
Late FY 1986	Late FY 1987	Data collection will be completed.
Late FY 1986	Late FY 1987	Research phase will be completed.

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USDP&E Mission Area: 530

Title: Target Acquisition and Weapons Technology
Title: Tactical Technology
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Last Year's Reported Plan	Current Plan	Milestones
Mid FY 1987	Mid FY 1988	Seeker designs will be delivered.
Late FY 1987	Late FY 1988	Seeker designs evaluated.
Advanced Ramjet Munitions Technology Program:		
Mid FY 1984	Mid FY 1985	Critical component development and fabrication of RAMROD.
--	Early FY 1985	Ramjet lethality testing completion.
--	Early FY 1985	Tubular Ramjet combustion phenomenology effort initiated.
--	Late FY 1985	Smooth bore firing (175MM Gun) of RAMROD.
--	Late FY 1985	Air Turboramjet concept design study initiated.
Early FY 1986	Mid FY 1986	M-68 105MM high-g firing of RAMROD.
--	Mid FY 1986	Air Turboramjet Technology Demonstrator development will begin.
Early FY 1986	Early FY 1987	RAMROD dispersion and lethality test firing series.
--	Late FY 1987	Air Turboramjet demonstrator wind tunnel testing begins.
--	Mid FY 1988	Air Turboramjet wind tunnel testing completed.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: TT-5
Program Element: #62702F
USDR&E Mission Area: 530

Title: Target Acquisition and Weapons Technology
Title: Tactical Technology
Budget Activity: 1. Technology Base

Last Year's Reported Plan	Current Plan	Milestones
Advanced Warhead Technology Program:		
--	Mid FY 1985	Hyperboloid charge demonstration.
--	Mid FY 1985	Charge fragmentation concept definition.
--	Late FY 1985	Advanced anti-armor rifle grenade concept definition.
--	Late FY 1985	Charge warhead concept definition.
--	Late FY 1985	Penetrated Augmented Munition (PAM) preliminary design will be completed.
--	Late FY 1986	PAM demonstration.
--	Late FY 1986	Bridge Road and Tunnel (BRAT) preliminary design will be completed.
--	Late FY 1986	Advanced anti-armor rifle grenade will be demonstrated.
--	Late FY 1987	BRAT demonstration.
--	Late FY 1987	Charge initiative demonstrated.

f. Explanation of Milestone Changes: The twelve month delay in the Millimeter Wave Autonomous Sensor program is due to the difficulties in implementing the original testbed data collection sensor design.

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Project: TT-5
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Title: Target Acquisition and Weapons Technology
Title: Tactical Technology
Budget Activity: 1. Technology Base

The changes in the Advanced Ramjet Munition Technology program were caused by a nine-month delay in contracting for the RAMROD development; the need to understand the dynamics of solid fuel ramjet combustor operation under high spin conditions; and the start of the air-turboramjet technology investigation. The changes in the Advanced Warhead Technology program are based upon the further refinement of program objectives, the signing of a DARPA/Army Memorandum of Understanding for the PAM/BRAT development and the very late initiation of the program in FY 1984.

The changes indicated in the Critical Node Targeting program reflect a further definition of the program.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #TT-6
Program Element: 62702E
USDRE&E Mission Area: 530

Title: Tactical Directed Energy Technology (NEW START)
Title: Tactical Technology
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The objective of the Tactical Directed Energy Technology Project is to develop moderate power efficient for a broad spectrum of military applications.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: Not Applicable.

b. FY 1985 Program: Not Applicable.

c. FY 1986 Planned Program and Basis for FY 1986 Request: In FY 1986, DARPA will initiate a new directed energy project which will include the development of tactical applications. The performance limits of nonlinear optical processes which have the potential to insure near perfect beam quality from both visible and IR lasers will also be determined. The objective of the second portion of this project is to develop efficient extra high power microwave sources. This effort will exploit recent breakthroughs at Lawrence Livermore National Laboratory and utilize the Experimental Test Accelerator (ETA) to determine the feasibility of generating microwave pulses. Development of efficient high power sources at millimeter wavelengths will provide new options for advanced surveillance systems and anti-sensor microwave weapons.

d. Program to Completion: This is a continuing effort project.

e. Milestones: Not Applicable.

f. Explanation of Milestone Changes: Not Applicable.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62708E
Title: Integrated Command and Control Technology
USDR&E Mission Area: 530
Budget Activity: 1 Technology Base

A. Resources ($ in Thousands)

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Costs
TOTAL FOR PROGRAM ELEMENT		43,519	53,000	53,000	57,500	Continuing	N/A
IC-1	Distributed Information Systems	23,961	23,400	23,700	23,600	Continuing	N/A
IC-2	Advanced Command Control and Communications Technology	19,558	29,600	29,300	33,900	Continuing	N/A

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED: The objective of DARPA's research in Integrated Command and Control technology is to develop advanced information processing and computer-communications technology which provides a technology base for future command and control systems, and to demonstrate and evaluate them with the Services and our Allies in selected operational environments. A heavy emphasis is placed on the development of distributed communications and processing technologies to enhance survivability.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY:

1. Problems surfaced during the testing of the initial Low-cost Packet Radio prototypes resulted in redesign activities for portions of circuitry and packaging. This resulted in delays in the building of the quantity units required for development of the networking software and delivery to the testbeds. The delay is anticipated to be approximately six months in testbed delivery.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62708E
Title: Integrated Command and Control Technology
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2. Restructuring of the projects within the PE has resulted in funding level changes of the projects, with no change in the overall PE funding.

D. OTHER APPROPRIATION FUNDS: None.

E. RELATED ACTIVITIES: The internetting effort is coordinated with the Defense Communications Agency (DCA) and the Services. The Defense Data Network is utilizing the DARPA developed Internet protocols. Efforts to achieve interoperability of command and control are being coordinated with DCA, the Services, and a number of NATO countries. DCA, the Army Communications-Electronics Command (CECOM), the Naval Electronic Systems Command, and the Air Force Rome Air Development Center (RADC) are all conducting research in packet-switching based on the DARPA research results. RADC is also funding and coordinating efforts in distributed processing technology. The Strategic Command Control and Communications experiment is a joint effort with the Strategic Air Command (SAC), RADC and DCA. The Ft. Bragg testbed is a joint effort with the Army, with CECOM playing the lead role for the Army. The development of wideband packet satellite technology is being carried out jointly with the Experimental Integrated Switched Network effort of DCA and the Services. Development of security devices for the tactical environment is being carried out jointly with the National Security Agency and CECOM. Design tools are being developed by the Ada Joint Program Office and the Software Technology for Adaptable and Reliable Systems activity.

F. WORK PERFORMED BY: Universities 55%, Industry 41%, In-house 4%. The major performers are University of Southern California/Information Sciences Institute, Marina del Rey, California; Bolt Beranek and Newman, Cambridge, Massachusetts; SRI, Menlo Park, California; Stanford University, Stanford, California; Carnegie-Mellon University, Pittsburgh, Pennsylvania; Massachusetts Institute of Technology, Cambridge, Massachusetts; MIT Lincoln Laboratory, Lexington, Massachusetts; Hazeltine Corporation, Greenlawn, New York; University of California at Berkeley, Berkeley, California; Rockwell International, Richardson, Texas; Perceptronics, Woodland Hills, California.

G. PROJECTS LESS THAN $7 MILLION IN FY 1986: Not Applicable.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: # IC-1
Program Element: #62708E
USDR&E Mission Area: 530

Title: Distributed Information Systems
Title: Integrated Command and Control Technology
Budget Activity: 1 Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The objectives of this project are to develop and demonstrate technology for building geographically distributed information systems which can be secured, operate in real-time and be easily expanded to meet the increasing demand for information processing in DoD command, control and communications applications. Techniques are being developed to support secure distributed processing among computers on different packet networks. Mechanisms to control and regulate the performance of the internet environment are being developed. Distributed operating systems, message systems, data bases and programming environments are being developed, along with several applications which run in a distributed environment of personal workstations. Secure multimedia conferencing architecture, protocols and devices will be developed and validated in the internet system. Survivable distributed networks of acoustic and video sensors for tactical and cruise missile defense, using low-cost, unattended, communicating sensors, each with local processing, are being developed. An initiative in Artificial Intelligence AI-based software will use techniques from artificial intelligence to aid in the specification, development and maintenance of software systems. The use of wideband communications to support distributed command and control is being explored. Architectures and systems engineering tools for building evolutionary command and control systems will be developed and demonstrated in a secure multimedia conferencing application. The use of networking to provide distributed training systems for practicing very large team combat skills involving hundreds of personnel is also being developed.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: Techniques were developed to tightly integrate the host and communication resources in the internet environment and various structures were explored for higher level protocol standards. Name servers were developed and demonstrated on the ARPANET to locate internet resources. The wideband network was further integrated into the internet system by implementing "Type-of-Service" routing to automatically direct high volume, delay-insensitive traffic onto the wideband channel. Multi-user packet voice tests were completed and the packet multiplexing protocols evaluated. Network partition detection and recovery mechanisms were developed for installation in the internet for use by the SAC testbed (Project IC-2).

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: # IC-1
Program Element: #62708E
USDR&E Mission Area: 530

Title: Distributed Information Systems
Title: Integrated Command and Control Technology
Budget Activity: 1 Technology Base

An end-to-end remotely keyable encryption system based on the National Bureau of Standards (NBS) Data Encryption Standard (DES) was demonstrated in prototype form. Development of a certifiable end-to-end encryption system for the Ft. Bragg and SAC testbeds based on the Internet Private Line Interface (IPLI) continued. Work began to interface the IPLI's with packet radio technology for use in the testbeds. A system was developed to control user access to the ARPANET through Terminal Access Controllers (TACs). An experimental distributed operating systerm, together with an extensive collection of application tools, was enhanced to support a large (150-workstation) user community of software developers. A prototype distributed multimedia message system was implemented. The design was completed of an integrated language/system (Argus) for the creation of distributed programs, and an initial implementation demonstrated. Testing of the six node distributed sensor network has been completed, and new distributed tracking algorithms have been demonstrated which show order-of-magnitude improvements in tracking accuracy and computational efficiency.

Techniques for using artificial intelligence in developing software systems were explored. Techniques were also developed for reasoning about programs using fault analysis and programming language constraints. Program optimization based upon symbolic evaluation and simplification along with deadlock detection and avoidance for communicating processes were demonstrated. An annotation language (ANNA) was developed for Ada and techniques were developed for specifying Very Large Scale Integrated (VLSI) designs in a subset of Ada. A prototype Ada programming environment (ACTURUS) was developed that provided many capabilities found in LISP-like environments including support for rapid prototyping and program development.

A training simulator networking project called SIMNET was initiated to study the feasibility of interconnecting large numbers of simulators so that military personnel could practice team combat skills from their own bases and at very low cost. The goal is to develop the base technologies for large scale simulator networks where team practice can be accomplished regularly and intensively, particularly where parts of teams are stationed at many remote locations. Initial work identified the basic architecture for such networks and designed a testbed on which to test and evaluate this architecture as it evolves.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: # IC-1
Program Element: #62708E
USDR&E Mission Area: 530

Title: Distributed Information Systems
Title: Integrated Command and Control Technology
Budget Activity: 1 Technology Base

b. FY 1985 Program: The internet will become an effective distributed environment to support advanced software system development and high-level command control applications. Protocols will be developed to support distributed Communication and Control (C2) applications including multi-media conferencing. The wideband network is being used to demonstrate transmission of compressed packet video images. It will be integrated into the internet environment and used to support distributed command and control research requiring high bandwidth real-time communication. Network partition detection and recovery mechanisms are being evaluated in the internet system. The IPLI's are being certified for use with packet radios to provide network security for the Ft. Bragg and SAC testbeds. The TAC access control system is being installed on the ARPANET. The DES-based encryption device is being evaluated for compartmentation of a secure local network and will be used to achieve privacy on the ARPANET.

The multimedia message system is being enhanced for operational use in the Ft. Bragg testbed. The Berkeley version of the UNIX operating system is being extended to allow monitoring of the execution of distributed programs. Preliminary testing is being conducted of a distributed operating system whose nodes span a set of connected networks. The effect of process migration on performance is being measured in an experimental multicomputer system. A new concept based on specification of "resilient objects" is being explored for implementing fault-tolerant systems.

The testbed six-node distributed sensor network is being integrated into a robust, self-managing configuration including the self-locating packet radios and new video sensors. Knowledge-based distributed tracking in an acoustic-cued/video-tracked mode will be demonstrated. This will be a highly intelligent, accurate and robust tracking system, using all-passive (i.e., non-emanating) sensors, suitable for defensive weapon fire control. Development is being initiated of an evolutionary method for describing and evaluating the performance of C3 Systems architectures based on high-level functional descriptions. A rapid prototyping environment will be designed to support experimental development of new software and systems process models for medium and large-scale experimental use.

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Project: # IC-1
Program Element: #62708E
USDR&E Mission Area: 530

Title: Distributed Information Systems
Title: Integrated Command and Control Technology
Budget Activity: 1 Technology Base

The simulator networking research will produce a very low cost prototype simulator that will be mass produced for use as the gaming station on the network. This prototype will be finished in mid-FY 85 and a local area network of eight of these simulators will be tested in late-FY 1985.

c. FY 1986 Planned Program and Basis for FY 1986 Request: Techniques will be demonstrated for distributed real-time applications operating on the Internet system to support multi-media conferencing. New end-to-end communication services will be developed and demonstrated to support such applications. Interoperability of the Internet system with commercial systems will be demonstrated, including electronic mail and appropriate charging mechanisms.

The distributed sensor network will be used to explore distributed information query and retrieval using goal-directed smart processes that migrate through the distributed system collecting information and returning to the user. Distributed knowledge-based techniques will be developed for target recognition problems and for system diagnosis and control. A demonstration of the evolutionary systems development concepts will be performed by initiating development of secure multi-media conferencing. Prototype development of the new experimental environment will be started. Small-scale prototypes of the major subsystems will be developed and used as a basis for evaluating the designs. A prototype system framework will be developed as a collection of interfaces and support mechanisms to provide an integrated environment while maintaining modularity. In addition, the prototype development of an extensible data type system, object base, knowledge representation system, analysis and reasoning tools, wide spectrum language and graphic user interface will be started.

Two small local area networks of simulators, each located on widely separated military bases, will be connected by long haul networks. Tests will commence assessing the peformance of the local and long haul networking, particularly as it relates to the perception of time delays by the military personnel who are engaged in combat exercises over the networks.

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Project: # IC-1
Program Element: #62708E
USDR&E Mission Area: 530

Title: Distributed Information Systems
Title: Integrated Command and Control Technology
Budget Activity: 1 Technology Base

d. Program to Completion: The internet environment will become a tightly integrated network of networks. Interoperability with other protocol systems will be explored. Techniques will be developed and demonstrated for providing the required real-time data communication to support distributed command and control applications in an Internet environment. Techniques will be developed and demonstrated to permit a locally specified tradeoff between transparency and autonomy in a distributed operating system. Mechanisms will be developed which permit integrated operation of very large distributed systems with thousands of nodes. A distributed operating system will be developed and demonstrated in which support of nodes spread across an internetwork is included in the fundamental design of the system. A distributed system design approach will be developed in which the distributed and fault-tolerant nature of replicated objects is a basic property of the objects themselves, allowing the designer of a distributed application to proceed as if he were creating a simpler non-distriburted design. The distributed sensor network program will be completed with publication of a book describing the theoretical foundations and algorithmic and knowledge-based techniques developed and validated. The full evolutionary systems architecture and engineering method will be developed and demonstrated for secure multimedia conferencing in a Service testbed, including a knowledge-based self-awareness capability.

The new experimental software and system development environment will be completed. The most promising new software and system development methods will be rapidly prototyped using the new experimental environment and prepared for experimental use. New tools will be developed to support the use of multiprocessor system architectures.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestone
Late FY 1984	Mid FY 1985	Demonstrate prototype Ada-based Distributed Data Management System.

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Project: # IC-1
Program Element: #62708E
USDR&E Mission Area: 530

Title: Distributed Information Systems
Title: Integrated Command and Control Technology
Budget Activity: 1 Technology Base

Last Year's Reported Plan	Current Plan	Milestone
Early FY 1985	Early FY 1985	Certify manually rekeyed end-to-end encryption system for use at Fort Bragg.
Mid FY 1985	Under Consideration	Initiate installation of privacy devices on ARPANET.
Mid FY 1985	Mid FY 1985	Prototype simulator tested.
Late FY 1985	Mid FY 1985	Install TAC access control system on ARPANET.
Late FY 1985	Late FY 1985	Complete distributed operating system for multiple computers on high-bandwidth network.
Late FY 1984	Late FY 1985	Demonstrate prototype Ada-based Distributed Data Management System.
Late FY 1985	Late FY 1985	Local area network of simulators tested.
-------	Late FY 1985	Demonstrate multimedia message system in Fort Bragg testbed.
-------	Early FY 1985	Complete distributed monitoring facility and distributed object access mechanism for Berkeley UNIX.
Mid FY 1986	Mid FY 1986	Demonstrate interoperability of the internet with commercial networks.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: # IC-1
Program Element: #62708E
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Title: Distributed Information Systems
Title: Integrated Command and Control Technology
Budget Activity: 1 Technology Base

Late Year's Reported Plan	Current Plan	Milestone
Mid FY 1986	Mid FY 1986	Initial testing of long haul simulator network commences.
--------	Mid FY 1986	Demonstrate knowledge-based acoustic/video tracking.
--------	Late FY 1986	Demonstrate multi-media conferencing system.
Mid FY 1986	Mid FY 1986	Demonstrate interoperability of the internet with commerical networks.
	Mid FY 1986	Demonstrate multi-media conferencing system.
---------	Late FY 1986	Complete initial design of a prototype new-generation experimental environment.
---------	Early FY 1987	Develop Knowledge-base evolutionary systems architecture and engineering methodology.
---------	Late FY 1987	Complete initial prototype of new-generation experimental environment.

f. Explanation of Milestone Changes: Demonstration of a prototype Ada-based Distributed Data Management System is delayed due to the unavailability of a certified Ada compiler.

The TAC Access Control System will be completed several months ahead of schedule because planned additional debugging of the software will not be necessary.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: # IC-1
Program Element: #62708E
USDR&E Mission Area: 530

Title: Distributed Information Systems
Title: Integrated Command and Control Technology
Budget Activity: 1 Technology Base

A decision considering installation of privacy devices is delayed pending a policy determination considering policy on the ARPANET.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: # IC-2
Program Element: #62708E
USDR&E Mission Area: 530

Title: Advanced Command Control Communication Technology
Title: Defense Research Sciences
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The objectives of this project are to develop and demonstrate advanced command and control technology and transfer it to the Services. Survivable networks are being explored which can function in the presence of jamming, spoofing and the loss of communication resources, and techniques are being developed for utilizing and controlling large-scale communication networks consisting of thousands of nodes. Low-cost packet radios are being procured to support experimentation with large scale networks. A survivable communications network architecture for use in both a CONUS based application and a satellite network consisting of multiple, low-orbiting, low-cost satellites is being investigated. This system supports high bandwidth inter-node links communication based on packet switching technology. A methodology is being developed for rapid implementation of custom and semi-custom integrated circuits and mechanical parts which permits the physical separation of the design and fabrication processes, with a goal of reducing the development time for critical Defense components from completed design to finished project to a few weeks. A joint testbed program is being carried out with the Army at Fort Bragg, North Carolina, to develop distributed ADP applications for evaluation in an operational tactical environment, to evolve innovative system concepts for the use of computers in support of future Army requirements, and to develop doctrine for distributed processing in a Corps headquarters. A strategic command and control experiment is being conducted jointly with Defense Communications Agency (DCA) and the Strategic Air Command (SAC) to evaluate the use of packet radio technology, internetting and distributed data base technology as a basis for providing survivable communications and for rapid reconstitution of strategic communications following a major attack.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: Theoretical and experimental work on the control of large radio networks was continued with emphasis on the development of survivable network techniques, robust protocols and network-based C3 countermeasures. Initial integration and testing of the low-cost packet radio (LPR) was completed and required redesign initiated in preparation for delivery of 1000 experimental units. Network control algorithms were adapted to utilize the code

changing features of the Low-cost Packet Radio (LPR). The initial LPR software development was initiated. An architecture was developed for decentralized control of network based ADP resources in the battlefield in conjunction with the Army. A technical and program plan was developed jointly with the Army for the exploration of this architecture in the joint testbed at Fort Bragg, North Carolina. High power appliques were constructed for packet radios and they were shown to operate effectively at distances of 250 to 300 miles. Modifications to current internetwork protocols were designed to support network reconstitution and partitioned network operation. Extended range packet radios were installed on Strategic Air Command (SAC) aircraft to support network testing and experimentation. Design of a bomber recovery data base was completed and Strategic Planning Aids are being developed. Implementation was begun of a database management scheme which can restore the consistency of replicated databases after a network has been partitioned and reconstituted. Feasibility studies and preliminary architectural designs were completed for the airborne demonstration of the low-orbiting multiple satellite system. The Very Large Scale Integrated (VLSI) fast turnaround fabication service, called MOS Implementation Service (MOSIS), used commercial vendors to produce over 1700 designs submitted over computer networks by researchers representing over 80 organizations. Negative Metal Oxide Semi-conductor (NMOS), Complimentary Metal oxide Semi-conductor (CMOS), and Complimentary Metal oxide Semi-conductor/Silicon on Saphire (CMOS/SOS) fabrication was provided. A process description language called FABLE was developed to support automated control of foundry operations.

b. FY 1985 Program: Development of the initial version of software for low-cost packet radio is continuing. Performance enhancements are being explored along with access control and protection of network resources in the face of sophisticated threats. End-to-end network security devices (see Distributed Information Systems IC-1) are being integrated into the Fort Bragg and SAC testbeds. Experimentation involving multiple network partitions is being conducted using an airborne packet radio network, the ARPANET, and local area networks. Database partition recovery software is being completed and tested with the bomber recovery database. Initial testing of strategic planning aids is being performed. The Fort Bragg testbed is being fully configured with packet radios, packet switched multichannel radios, distributed computing and end-to-end security devices. Distributed command and control applications to be evaluated in the testbed are being designed and developed. Development of a low-cost high performance tactical end-to-end security

device is being initiated jointly with the Army and National Security Agency (NSA). Development of a prototype payload for airborne testing of the multiple satellite system is being initiated The MOSIS System will continue to accept researchdesigns and to provide NMOS and CMOS fabrication services utilizing newly developed wafer level screens. A common baseline foundry automation system will be demonstrated at research sites.

c. FY 1986 Planned Program and Basis for FY 1986 Request: The initial version of the Low-cost Packet Radio (LPR) software will be completed, tested, and installed in a number of testbeds including those at Fort Bragg and SAC HQ. Software development to support large survivable networks will be initiated. Techniques for dealing with sophisticated distributed threats against distributed command, control, and communication systems will be developed. Integration will be completed of all components of the SAC testbed and associated software, including the bomber recovery application, the internet reconstitution software and hardware, the partition-recoverable distributed database manager, the strategic planning aids, and the network security devices. After initial testing of the fully integrated testbed, a series of experiments will be conducted constituting a total system demonstration of the technology developed in the Strategic C3 Experiment. Capabilities demonstrated will include updating of replicated data bases, communications and database reconstitution, and distributed automated support for command and control functions such as aircraft recovery planning. The distributed command and control applications will be evaluated with the XVIII Airborne Corps and other users in the Ft. Bragg testbed. The tactical end-to-end security device will be competitively acquired. A demonstration of low cost multiple satellite communication will be carried out in the laboratory. The MOSIS System will provide compatible 3 micron and 1.2 micron CMOS processes to designers in the research community. Quality control procedures will be incorporated to enable use of the MOSIS for operational defense systems.

d. Program to Completion: A network management system for large scale survivable networks will be developed and evaluated. Position location and end-to-end security capabilities will be integrated into the network. An airborne demonstration of the low cost multiple satellite concept will be completed. The results of the total system demonstration for the Strategic C3 Experiment will be evaluated and documented. Distributed experiments in the Fort Bragg testbed

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Project: # IC-2
Program Element: #62708E
USDR&E Mission Area: 530

Title: Advanced Command Control Communication Technology
Title: Defense Research Sciences
Budget Activity: 1 Technology Base

involving low cost packet radios, tactical end-to-end security devices, and the distributed command and control applications will be completed and evaluated. The MOSIS will continue to be used tosupport VLSI fabrication of designs submitted over computer networks. The VLSI fast turnaround testbed will be automated to support management and control of a multi-use fabrication facility.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestone
Mid FY 1985	Mid FY 1985	Integrate security devices into packet radio networks at Fort Bragg and SAC.
Late FY 1984	Mid FY 1985	Demonstrate communication and database reconstitution.
Late FY 1984	Mid FY 1985	Software available for large survivable network testing.
Late FY 1985	Late FY 1985	Computer-aided fabrication demonstrated.
Mid FY 1986	Mid FY 1986	Initial Low-cost packet radio network delivered to testbeds.
Mid FY 1985	Mid FY 1988	Demonstrate low-cost multi-satellite communication in the laboratory.
----	Late FY 1986	Demonstrate total system operation in Strategic C3 Experiment at Offutt Air Force Base.
----	Late FY 1986	MOSIS supports compatible 3 micron and 1.2 micron CMOS fabrication.

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Project: # IC-2
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Title: Advanced Command Control Communication Technology
Title: Defense Research Sciences
Budget Activity: 1 Technology Base

Late Year's Reported Plan	Current Plan	Milestone
----	Late FY 1986	Mil Spec quality control demonstrated.
----	Late FY 1987	Automated foundry operation demonstrated.
----	Late FY 1987	Airborne demonstration of Multiple Satellite concept.
Mid FY 1986	Mid FY 1988	Demonstrate large scale survivable network.

f. Explanation of Milestone Changes:

Demonstration of capability for database reconstitution after a network partition slipped from late FY 1984 to mid FY 1985 due to delays in setting up a secure software development facility.

The development and testing of the survivable network software was held up for six months while the hardware underwent more detailed testing than originally planned.

The multiple satellite system prototype payload development will be delayed due to a decision to first apply the system concept to a network of Remotely Piloted Vehicles.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62712E
USDR&E Mission Area: 530

Title: Materials and Electronics Technology
Budget Activity: 1. Technology Base

A. RESOURCES (PROJECT LISTING): ($ in Thousands)

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Cost
	TOTAL FOR PROGRAM ELEMENT	$24,634	$28,200	$33,000	$46,000	Continuing	N/A
MPT-1	Materials Processing Technology	$18,339	$20,400	$27,000	$31,000	Continuing	N/A
MPT-2	Electronics Processing Technology	$ 6,295	$ 7,800	$ 6,000	$15,000	Continuing	N/A

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED: This program element develops novel materials, processes, structures and device technologies that will give new capability to future defense weapon systems. Examples are: application of rapidly solidified superalloys and metal single crystal technology to enable higher temperature operation of gas turbine engine components; development of ceramic and carbon/carbon composites for high temperature engine applications; advanced fabrication methods for structural materials; metal-matrix composites for space structures; strong ceramic fibers from polymer precursors for spacecraft and engine components; demonstration of high energy, high power density battery concepts for military applications; development of high temperature bearing concepts for cruise missile engines; and intelligent task automation for increased productivity and/or reliability of Defense systems needed for certain mission functions. In electronics, the emphasis is on the development of second generation gallium arsenide (GaAs) based solid state circuit technology for military applications; examples are: bipolar and enhancement/depletion mode gate arrays, computer aided design (CAD) systems, advanced material growth, and analog to digital converters. These efforts will provide significant performance advances for communications subsystems as well as extending the bandwidth of tactical Electronic Counter Measures (ECM) and Electronic Counter-Counter Measures (ECCM) subsystems.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62712E
USDR&E Mission Area: 530

Title: Materials and Electronics Technology
Budget Activity: 1. Technology Base

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY: The FY 1986 increase of $2M is due to the initiation of a new program including development of high temperature lubricants and bearings, ceramic and other high temperature composite materials, and electromagnetic processing of materials. Increases in these new efforts are somewhat offset by a decrease in support of research on advanced engine materials. A new initiative in FY 1987 will be the application of superlattice technologies, molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MO-CVD), to high speed, complex digital, analog, and optoelectronic integrated circuits. Core efforts also will be established for a range of additional materials research initiatives including exploitation of advanced bulk crystal growth technology and computer based manufacturing process simulations. These focused materials initiatives are envisioned to be 5-8 year duration university/industry/government development efforts which will provide the materials preparation and processing technology required to implement new systems concepts of the 1990's.

D. OTHER APPROPRIATION FUNDS: None.

E. RELATED ACTIVITIES: In MPT-1, carbon-carbon research and development programs are currently underway at the National Aeronautics and Space Administration (NASA) (for airframes) and the Air Force with the goal of 1370°C turbine inlet temperature operation. The DARPA Defense Sciences Office effort emphasizes oxidation protection technology and is coupled closely with the DARPA Tactical Technology Office Extended Long-Range Integrated Technology Evaluation (ELITE) program to demonstrate 1925°C inlet temperature capability for missile engines, to realize substantial specific fuel efficiency and thrust performance gains. Programs to develop high performance ceramic materials for gas turbine engine components are being conducted by all services, NASA, and the Department of Energy; plans and programs are reviewed by an Interagency Ceramics Coordinating Committee. The Air Force is providing a share of the funding for the Radial Wafer Blade Program. NASA and the Defense Nuclear Agency are joining DARPA in a coordinated program to exploit metal matrix composite technology for improved survivable space structures. The ceramics from polymers program is reviewed by an interagency steering committee established by DARPA for that purpose. Generally, the Services are sponsoring research related to unique manufacturing methods which are different than those being pursued by DARPA, and duplication of effort is

prevented by direct coordination through the Office of Under Secretary of Defense for Research and Engineering (OUSDRE), the Manufacturing Technology Advisory Group (MTAG), COMAT which is a committee under the aegis of the White House Office of Science and Technology Policy, and the Interagency Materials Group which is hosted by the National Science Foundation. The intelligent task automation program is related to, complemented by and coordinated with efforts by the Air Force Wright Aeronautical Laboratories, the National Bureau of Standards, Air Force Office of Scientific Research, Office of Naval Research, and the Office of the Director of Army Research. In MPT-2, developments in electronic materials, device concepts, and processing methods are coupled to the Services' programs through the DARPA agents, joint funding agreements, annual DoD-wide program reviews, and reviews with OUSDRE's Advisory Group on Electron Devices (AGED), to assure that no unnecessary duplication of effort occurs. First generation gallium arsenide technology development is managed by DARPA for the Strategic Defense Initiative Organization (SDIO).

F. WORK PERFORMED BY: In MPT-1, approximately 86 percent of the work is performed by industry, 8% by universities, and 6% in-house. The top industrial performers include: Pratt and Whitney Aircraft Group, West Palm Beach, Florida; General Electric Company, Schenectady, New York; AVCO Speciality Materials Division, Lowell, Massachusetts; Special Metals Corporation, New Hartford, New York; Kongsberg Vaapenfabrikk, Oslo, Norway; Dow Corning Corporation, Midland, Michigan; United Technologies Research Center, East Hartford, Connecticut; Dow Chemical Company, Walnut Creek, California; Minneapolis Honeywell, Rosedale, Minnesota; and Martin Marietta Aerospace, Denver, Colorado. The universities include: Massachusetts Institute of Technology, Cambridge, Massachusetts; University of Texas, Austin, Texas; Cornell University, Ithaca, New York; University of Michigan, Ann Arbor, Michigan; Stanford University, Palo Alto, California; and Carnegie Mellon University, Pittsburgh, Pennsylvania. The Naval Research Laboratory, Washington, D.C. performs in-house research related to rapid solidification technology. In MPT-2, approximately 90% of the work is performed by industry, 5% by universities, and 5% in-house. The top industrial performers are: Rockwell International, Thousand Oaks, California; McDonnell-Douglas, Huntington Beach, California; and Texas Instruments, Dallas, Texas.

G. PROJECTS UNDER $7 MILLION IN FY 1986: Not Applicable.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #MPT-1
Program Element: #62712E
USDR&E Mission Area: 530

Title: Materials Processing Technology
Title: Materials and Electronics Technology
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The objective of this project is to develop a variety of material systems and processes for use in high performance DoD applications. The specific programs include: the development of alloys for a dual alloy radial turbine concept; deformation processing of vacuum arc double electrode remelt (VADER) superalloys for advanced turbine applications; the development of advanced composite materials such as metal matrix, ceramic matrix and carbon carbon composites; the processing of ceramic fibers and whiskers; the feasibility demonstration of high energy, high power battery concepts; development of material systems for high temperature cruise missile bearings; intelligent task automation for increased productivity and/or reliability of Defense systems, and the development of a dual alloy radial turbine (DARPA DART Demonstrator) for demonstration of advanced materials under realistic gas turbine conditions.

DARPA has pioneered ceramic and carbon-carbon composites for turbines and other advanced power plants because these materials promise engine designs with reduced weight, increased performance, reduced dependence on costly and critical alloy materials, and the lower specific fuel consumption gained by operation at high temperatures. An effort is being undertaken to develop a coating system for carbon-carbon composites which will permit their use in engines at temperatures in excess of 1927°C. The technology for obtaining ceramic fibers and ceramic matrix composites through polymer processing is also being established. In this approach, silicon polymers formed at low temperature are converted into high temperature, oxidation resistant ceramic fibers. Coupled with these advanced fibers, the ceramic composites being developed will offer high strength, laser resistance and fracture resistance materials for a wide range of applications including spacecraft structures and power systems, engine components, infrared windows and radar absorbing materials. Other efforts are determining the critical parameters for scaling up the growth of single crystal silicon carbide whiskers for use in ceramic and metal matrix composites, and developing and demonstrating material systems for use in high temperature cruise missile bearings. The Intelligent Task Automation Program is aimed at establishing the technology base for advanced mechanical systems which are capable of sensory controlled motion. The purpose of the vacuum arc double electrode remelt (VADER) process is to scale up the remelt process to produce ingots for large

turbine components, develop fundamental understanding of factors governing the deformation behavior of high strength superalloys, apply the concepts to fabrication of a full size turbine disk, and perform a preliminary mechanical property assessment.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: In the ceramics from polymers program, the capability to spin ceramic fibers with mechanical properties equal to the Japanese fiber has been demonstrated. An examination of various ceramic matrix composite processing routes has led to several promising approaches for future work. Another program to examine the scale up of single crystal silicon carbide whiskers has been equally successful. Significant improvement in the understanding of the process has led to a 50% increase in reactor yield. A large scale reactor has been designed for scale up of the whisker growth. In the effort to develop oxidation protection for carbon-carbon composites, four coating concepts were selected, each employing multiple layers to inhibit oxygen and carbon diffusion, while still maintaining overall mechanical integrity. A dual alloy radial turbine (DART) rotor geometry with appropriate materials properties has been designed for the DARPA DART Demonstrator; a test rotor has confirmed the design.

Deformation processing of VADER processed superalloy by a multi-step forging has been successfully scaled up to a mid-scale turbine component disk shape with stress rupture properties several times greater than those from the state-of-the-art powder processing route for the alloy. In the intelligent task automation effort, robotic arm slew and touch was demonstrated for both stationary and moving targets in experiments which required position control, force control and end point sensing. Grasping of hard and fragile objects with a dexterous 3-fingered hand was demonstrated via simple rolling-type manipulations requiring two of the fingers. A six-degree of freedom force sensing finger was designed, built and calibrated for handling small parts needed in assembly. A 3-dimensional optical sensor was developed with dual resolution ranges, one for parts inspection and the other for acquisition.

b. FY 1985 Program: The thermal oxidative stability of the ceramic fibers made from polymer processing is being established. Optimization of the scale up of the fibers continues including

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Project: #MPT-1
Program Element: #62712E
USDR&E Mission Area: 530

Title: Materials Processing Technology
Title: Materials and Electronics Technology
Budget Activity: 1. Technology Base

examination of a variety of ceramic fiber compositions. The improved fibers being developed by this program are being incorporated into promising ceramic matrix composite approaches.

Continued improvements in the control of the silicon carbide whisker growing process are being made and incorporated into the scaled up reactor. This large production reactor is being used to develop the technology for producing large quantities of the whiskers inexpensively.

A new program is being initiated to develop battery concepts which have both high power density and high energy density. Among the concepts being examined are a sodium/sulfur cell and a dynamic cell using an alkali and an acid.

In the Intelligent Task Automation Program, the inspection robot task and the assembly robot project, which are jointly funded by the Air Force and DARPA, are completing Phase I activities. Technology base activities include the following: acoustic imaging, active touch sensing, improved actuations, composite materials for robots and compliant robotic structures.

A new program is examining the materials problems associated with operating bearings at the extreme temperatures of advanced cruise missile engines. The first phase of this effort is focusing on the definition of the operating environment and an assessment of the existing materials capabilities.

In the carbon-carbon oxidation protection program, the initial four coating concepts are being reduced to two approaches for continued development in reduction of gaseous diffusion and in coating mechanical integrity under dynamic conditions. Concurrent fabrication and testing of subelement rotors is underway for eventual coatings application.

Design of the DARPA Dual Alloy Radial Turbine (DART) Demonstrator is being completed, and DART rotors are under fabrication. Current efforts in the vacuum arc double electrode remelt process include completion of thermal and fluid flow models for the process, and incorporation of deformation mapping techniques to optimize deformation processing of full scale turbine components.

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Project: #MPT-1
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USDR&E Mission Area: 530

Title: Materials Processing Technology
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c. FY 1986 Planned Program and Basis for FY 1986 Request: In the Ceramics from Polymers Program, process optimization will continue in order to demonstrate the capability for producing ceramic fibers with a variety of chemical compositions. In addition, several approaches for making high temperature, high strength, fracture resistant ceramic composites will be established. Manufacturing routes to the promising fibers and composites will be transitioned to service man-tech programs. Based on continued understanding of the important parameters affecting the silicon carbide whisker process, the final design of the scaled up reactor will be selected and evaluated. By the end of the program, the reactor will be capable of producing pound quantities of whiskers which will be made available to other Government programs. Evaluation of carbon-carbon oxidation protection systems will continue with data being taken on static and dynamic oxidation protection, erosion protection, and mechanical compatibility within the coatings system. An optimum system will be selected for final development and application to a subelement turbine rotor for operational verification.

A total of five dual alloy radial turbine (DART) rotors will be fabricated and tested in the Demonstrator and examined for performance validation. The first (of three) DARPA DART Demonstrators will be fabricated and functional tests performed to determine temperature and pressure profiles in the hot section.

The programs to demonstrate the feasibility of high power, high energy density battery concepts will continue. A new effort will also be started to examine other high payoff approaches.

Processing of full-scale turbine components using the vacuum arc double electrode remelt process will be demonstrated and the mechanical properties of the components will be assessed.

The high temperature bearings program will continue to develop the materials technologies for operation in a turbine engine. A preliminary evaluation of concepts will be made. Phase II of the joint DARPA/Air Force project in intelligent task automation will continue. The composite robot effort will be extended to include the ammunition resupply module and the adaptive suspension vehicle program.

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Project: #MPT-1
Program Element: #62712E
USDR&E Mission Area: 530

Title: Materials Processing Technology
Title: Materials and Electronics Technology
Budget Activity: 1. Technology Base

Proof-of-concept effort will be initiated for coordinating flexible arms with end point control. Evaluation will be made of the potential military applications for a mobile, multiple arm robot system.

d. Program to Completion: This is an on-going program which will continue to assess DoD materials needs and to develop and demonstrate novel concepts to meet them. Some specific efforts which will be completed and/or transitioned are described below.

Selected ceramic fibers and ceramic matrix composites will be optimized and evaluated for applications of interest to DoD such as radar absorbing materials or space power structural components. Interface with and transition to the Services and other DoD offices will be of primary consideration. Final materials selections for high temperature bearings will be made and evaluated. Successful bearing approaches will be incorporated into on-going high temperature engine programs.

An optimal oxidation protection coating system will be applied to subelement carbon-carbon rotors for data development and performance verification under operational conditions. The program will end in FY 1987. The DARPA DART Demonstrator program will conclude in FY 1987 with testing of the DART rotors within a functional demonstrator, which will be in operation at a designated U.S. contractor facility. Consideration will be given to component replacement by carbon-carbon parts, in a transition to a high-temperature (1927°C) turbine stage.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones
Mid FY 1984	Early FY 1985	Spin ceramic fibers with physical properties equal to Japanese fiber and with superior oxidation resistance

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #MPT-1
Program Element: #62712E
USDR&E Mission Area: 530

Title: Materials Processing Technology
Title: Materials and Electronics Technology
Budget Activity: 1. Technology Base

Last Year's Reported Plan	Current Plan	Milestones
Late FY 1984	Early FY 1985	Feasibility demonstration of intelligent task automation subsystems for programmed assembly, and for inspection/verification
Early FY 1985	Early FY 1985	Initiate Phase II of joint Intelligent Task Automation Program (prototype development of selected demonstration)
Mid FY 1985	Mid FY 1985	Demonstrate feasibility of high performance ceramic matrix composites via polymer processing
- -	Late FY 1985	Pilot plant scale production of silicon carbide whiskers
- -	Late FY 1985	Delivery for final testing of DARPA Dual Alloy Radial Turbine (DART) Demonstrator rotors
- -	Early FY 1986	Preliminary selection of high temperature bearing concepts

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #MPT-1
Program Element: #62712E
USDR&E Mission Area: 530

Title: Materials Processing Technology
Title: Materials and Electronics Technology
Budget Activity: 1. Technology Base

Last Year's Reported Plan	Current Plan	Milestones
- -	Early FY 1986	Initiate work on mobile multiple-arm-robotic system
Mid FY 1986	Mid FY 1986	Develop superior oxidation resistant coatings for carbon-carbon composites
- -	Mid FY 1986	Apply flexible robot arm control scheme to ammunition resupply module
- -	Late FY 1986	Demonstration of high energy/power density battery concepts
- -	Late FY 1986	Selection of optimum 1927°C coating for carbon-carbon oxidation protection

f. Explanation of Milestone Changes: Ceramic fiber spinning to properties equal to Japanese was accomplished, however technical challenges caused a slip in the demonstration of improved oxidative stability. Feasibility demonstration of intelligent task automation subsystems did not slip, but rather the milestone date listed last year was incorrect due to mixing up calendar year with fiscal year timeframes.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: MPT-2
Program Element: #62712E
USDR&E Mission Area: 530

Title: Electronic Processing Technology
Title: Materials and Electronics Technology
Budget Activity: 1. Technology Base

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: Although this project is under $7M the project is being written due to its relevance to a wide range of Department of Defense's gallium arsenide (GaAs) programs. This essentially represents the "second generation" technology base for the major GaAs program being managed by DARPA for the Strategic Defense Initiative Organization (SDIO). Furthermore, it provides long range support to high speed technology needs in electronic warfare (EW). Second generation, GaAs based solid state electronics will be developed. These efforts include bipolar and enhancement/depletion mode gate arrays, computer aided design (CAD) systems, and analog to digital converters capable of 8 bit resolution at a one gigahertz sampling rate. Process and device modelling programs will be expanded to provide increased support to the integrated circuit design and fabrication programs.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: The complementary junction field effect transistor (CJFET) memory cell continued to provide impressive performance results due to the increased noise margin (resistance to memory errors) of this design: thirty-nine percent yield on a wafer for 256 bit memories and memory retention after being subjected to a 10 to the power 11 rads per second, 20 nanosecond long ionizing radiation pulse. Two 1000 gate arrays, one utilizing metal semiconductor field effect transistor (MESFET) technology and the other utilizing heterojunction current injection logic technology, were successfully fabricated, and advanced on-board signal processor (AOSP) parts implemented on these gate arrays are under evaluation. A robust two-dimensional device model for GaAs was released.

Utility of focused-laser photochemistry was successfully demonstrated by implementing both etching and deposition of conductors on a gate-array to produce a functional integrated circuit (IC). This demonstration represents a significant step in applying beam processing technology to custom IC fabrication.

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Project: MPT-2
Program Element: #62712E
USDR&E Mission Area: 530

Title: Electronic Processing Technology
Title: Materials and Electronics Technology
Budget Activity: 1. Technology Base

b. FY 1985 Program: Gallium arsenide (GaAs) component development will begin to target DoD's requirements for high speed components, for example, radar frequency memories for electronic warfare (EW), in addition to the previously emphasized needs for radiation hardness and low power. In the pursuit of increased speed, self aligned fabrication techniques for both conventional GaAs technologies and gallium aluminum arsenide (GaAlAs)/GaAs heterostructure technologies are being pursued. Improved sources for ion-beam processing will be developed by optimizing palladium-based alloy sources and expanding the theory of ion interactions with materials.

c. FY 1986 Planned Program and Basis for FY 1986 Request: Four thousand gate arrays will be implemented in both the heterojunction bipolar technology and the enhancement/depletion (E/D) technologies. Circuits that utilize at least eighty percent of the gate array will be automatically routed by the computer aided design (CAD) under development. Since second generation GaAs technologies require improved material, new materials growth technologies such as indium alloying and "electrodynamic gradient" horizonal Bridgeman growth will be pursued.

Device development efforts for a second generation, high speed GaAs device technology will continue. Process modeling, with the end goal of producing a GaAs version of the Stanford University Process Emulation Model (SUPREM), will be ready to begin comparisons with experimental results. Basic materials and processing improvements that are derived in the 61101E program element will be evaluated with respect to improving heterojunction devices. The capability to use focused beams of electrons, photons, and ions to locally modify integrated circuits will be demonstrated.

d. Program to Completion: This effort is continuing due to the exceptional importance of information and signal processing capabilities to defense systems. While material GaAs developments have emphasized radiation hardness the second generation will be applied to high speed DoD needs in electronic warfare. Packaging concepts, on both the chip and board level, for high speed components will be emphasized.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: MPT-2
Program Element: #62712E
USDR&E Mission Area: 530

Title: Electronic Processing Technology
Title: Materials and Electronics Technology
Budget Activity: 1. Technology Base

The developments of molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MO-CVD) systems have opened up a totally novel concept for semiconductor technologies-materials engineering. Artificially created superlattices can, in principle, be tailored to yield pre-determined bandstructures. Essentially a multi-dimensional materials space has been opened up with near infinite combinational possibilities that has to be intelligently investigated to uncover the probably limited, singularities that will significantly improve the capabilities of future electronic and optical devices. Initial efforts in the development of superlattices have revealed a lack in both theoretical understanding and experimental techniques. The program will combine theorists with established experimental groups to define desirable directions and resolve present uncertainties in predictive capabilities. The latter stages will bring in device physicists to design superlattice lasers, detectors, waveguides, non-linear filters, amplifiers and multi-component chips. On-going research programs are developing an opto-electronic processing capability whereas electronics handles the switching and optics handles the high speed transfer of multiplexed data. This program will develop the packaging technology necessary to incorporate this emerging capability into subsystems which can benefit from the noise immunity, wide bandwidth, Electro-Magnetic Pulse (EMP) immunity, and the ease of fanout offered by the optoelectronics.

e. Milestones: The milestones reported in last year's FY 1985 Descriptive Summary have been completed or are expected to be completed on schedule except as noted below:

Last Year's Reported Plan	Current Plan	Milestones
Mid FY 1984	Early FY 1985	Demonstration of a fully monolithic 8-12 gigahertz 3 watt gallium arsenide (GaAs) power amplifier with 18 db of gain.

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Project: MPT-2
Program Element: #62712E
USDR&E Mission Area: 530

Title: Electronic Processing Technology
Title: Materials and Electronics Technology
Budget Activity: 1. Technology Base

Last Year's Reported Plan	Current Plan	Milestones
Mid FY 1985	Mid FY 1985	Reduction of defect density in molecular beam epitaxy of gallium aluminum arsenide (GaAlAs) to less than $100/cm^2$.
Mid FY 1986	Mid FY 1986	A 4 kilobit complementary Junction Field Effect Transistor (JFET) gallium arsenide (GaAs) random access memory with .2 microwatt power dissipation per bit will be demonstrated.
End FY 1986	End FY 1986	GaAs analog to digital (A/D) converter with gigahertz sampling rate will be fabricated.

f. Explanation of Milestone Changes: The demonstration of a fully monolithic 3 watt, 8-12 gigahertz GaAs power amplifier with 18 db of gain is now scheduled for early FY 1985 rather than mid FY 1984. The delay was caused by late commitment of Navy funds on this joint DARPA/Navy program.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62714E
USDR&E Mission Area: 530

Title: Nuclear Monitoring
Budget Activity: 1. Technology Base

A. RESOURCES ($ in Thousands)

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Costs
	TOTAL FOR PROGRAM ELEMENT	$14,447	$18,500	$19,400	$20,300	Continuing	N/A

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED: The Nuclear Monitoring program conducts research and development to enhance U.S. capabilities for monitoring nuclear explosion events. The program also provides technical information needed for developing sound national policy for negotiations on treaties limiting nuclear testing and provides technical support for U.S. participation in treaty-related international activities. Negotiations for a comprehensive test-ban treaty (CTBT) created the need for detailed technical information concerning monitoring stations internal to the USSR, high frequency propagation, and on-site inspection procedures. In the event that a CTBT were to be negotiated U.S. security would require the highest possible level of monitoring capability to verify that the Soviets were complying with the provisions of such a treaty and not conducting clandestine tests under conditions designed to evade detection. Thus research is required to follow and extend the state of the monitoring art. The need for the nuclear monitoring program is further exemplified by the unexpected initiation of negotiations for an explosion yield threshold treaty in 1974, requiring the development (in a period of less than a year) of special monitoring provisions for the Peaceful Nuclear Explosion Treaty (PNET). The possibility of Soviet violations of the Threshold Test Ban Treaty yield limit has clearly brought to the forefront the need for improved monitoring of this treaty. At present, special technical statistical and on-site measurement efforts are required to provide policymakers with technical options for improving the verification of the explosion yield threshold treaty through unilateral efforts and those which might require additional negotiation with the Soviets. The program continues to support the technical activities

of the United Nations Conference on Disarmament. Other research efforts in this program are aimed at developing the sensors and advanced technology needed to detect the presence of nuclear materials at remote distances.

The FY 1986 Nuclear Monitoring program will continue the following programs: initiation of a cooperative effort with the Department of Energy, to design and test an advanced seismic array in Norway to establish the feasibility of installing such systems for verifying future test ban treaties; technical support of international cooperative measures for verifying future test ban treaties; development and testing of an advanced international seismic data center; fundamental seismological and geophysical research into the character of earthquake and explosion sources with particular emphasis on high frequency seismological studies and improving the capabilities to use seismic stations which may be installed in the Soviet Union under provisions of a future comprehensive or reduced threshold test ban treaty; testing of advanced methods to improve the accuracy of yield estimation; development of means for on-site measurements as an option for improved yield verification; and, the exploration of sensing technology and diagnostic techniques to remotely detect the presence of nuclear materials and to provide nuclear diagnostic characterization of detected nuclear materials.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY: In FY 1986, the total funds for the Nuclear Monitoring program $7M less than the amount reported in the FY 1985 Descriptive Summary. This reduction is due to revised plans for large scale demonstration of advanced seismic monitoring equipment and a reduction of research efforts in on-site inspection technology. Emphasis has been placed on expanding development of new, sophisticated, physically-sound methods to use stations internal to the USSR to discriminate earthquake from underground nuclear explosions, and to estimate the yield of underground nuclear explosions. Emphasis is also on the exploration of potentially promising non-seismic monitoring techniques.

D. OTHER APPROPRIATION FUNDS: Not Applicable.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62714E
USDR&E Mission Area: 530

Title: Nuclear Monitoring
Budget Activity: 1. Technology Base

E. RELATED ACTIVITIES: Complementary research is conducted by the National Laboratories of the Department of Energy and by the Air Force Technical Applications Center. These complementary efforts are coordinated through existing interagency agreements and periodic working level coordination meetings.

F. WORK PERFORMED BY: Eight percent of the work under this task is performed by universities, eighty percent by industrial contractors, and twelve percent by in-house laboratories. Major university contractors include: California Institute of Technology, Pasadena, California; Harvard University, Cambridge, Massachusetts; Columbia University, New York; University of Florida, Gainesville, Florida; Massachusetts Institute of Technology, Cambridge, Massachusetts, and University of Maryland, College Park, Maryland. Industrial contractors include Teledyne Geotech, Garland, Texas and Alexandria, Virginia; Sierra Geophysics Inc., Seattle, Washington; S-Cubed, La Jolla, California; Woodward-Clyde Associates, Pasadena, California; Lockheed Palo Alto Research Laboratory, Palo Alto, California; Science Applications, Inc., McLean, Virginia; Atom Sciences, Oak Ridge, Tennessee; TRW, Redondo Beach, California; Mission Research Corporation, Santa Barbara, California; and Pacific Sierra Research, Los Angeles, California. Participating in-house Government laboratories include the Naval Ocean Research and Development Activity, NSTL, Mississippi; the U.S. Geological Survey, Golden, Colorado; Lawrence Livermore National Laboratory, Livermore, California; and Sandia National Laboratories, Albuquerque, New Mexico.

G. PROJECTS LESS THAN $7 MILLION IN FY 1986: Not Applicable.

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The program objective is to improve the U.S. capability in yield estimation of the nuclear tests of other nations, to improve the detection, location, and discrimination of earthquakes and explosions, and to improve the U.S. capability to detect and analyze nuclear materials. The seismic aspects of the program are in support of Defense Department policy that verification of nuclear test ban agreements be adequately verifiable and to provide the fundamental research and development which is required to improve the operational requirements to detect Soviet nuclear tests and to estimate their yields. The project also provides the technical support to

Program Element: #62714E
USDR&E Mission Area: 530

Title: Nuclear Monitoring
Budget Activity: 1. Technology Base

international cooperative projects in which the U.S. is involved, such as those sponsored by the Conference on Disarmament.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: Yield Estimation. Laboratory experiments and finite difference calculations improved our ability to predict coupling of underground nuclear tests and to allow for effects of cratering and of detonation under mountains. Improvements were made in the estimation of the contamination by tectonic strain release of long-period signals from underground explosions. These efforts improved our capability to estimate Soviet yields. A thorough statistical study was completed which brought together the best available data and yield estimation procedures and developed a generally accepted method of answering questions of Threshold Test Ban Treaty compliance.

Data Acquisition. A high-frequency seismic array was installed in Norway in a joint effort with the Department of Energy and the government of Norway. The resulting data will greatly aid yield estimation and event detection and discrimination and will provide much needed data for additional research in these areas.

Discrimination of Earthquakes from Explosions. Several promising new teleseismic discrimination techniques which work on small magnitude events have been applied to events which could not be otherwise identified, with excellent results. Theoretical and empirical studies continued on the difficult problem of regional discrimination. A study was made of the ability of broad-band stations to counter the hide-in earthquake evasion technique.

Support of International Negotiations. Preparations were completed for support of a FY 1985 large scale seismic detection experiment conducted under the auspices of the United Nations, Conference on Disarmament, Group of Scientific Experts.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62714E
USDR&E Mission Area: 530

Title: Nuclear Monitoring
Budget Activity: 1. Technology Base

Nuclear Materials Detection. Research continued on development of new technologies for the detection and identification of nuclear tests.

b. FY 1985 Program: Yield Estimation. Laboratory experiments and finite difference calculations are continuing in order to understand coupling in jointed and fractured rock. Planning is underway for an underground test at the Nevada Test Site in a rock very similar to that at the Soviet Test Site. Finite difference calculations of cratering explosions should enable use of satellite observations of Soviet tests for yield estimation. Extensions of two-dimensional finite difference calculations to three dimensions are giving more accurate estimates of yield for shots under mountains.

Data Acquisition. Data from the small array in Norway are being analyzed in this first year of operation with an emphasis on the high frequencies which may be of use to detect decoupled explosions.

Discrimination of Earthquakes from Explosions. The new earthquake/explosion discrimination technique, studied in FY 1984 is being evaluated on several years of unidentified events. A new approach to discrimination by short-period first motion is also being tested on the same data set.

Laboratory and theoretical approaches to regional propagation are being emphasized in order to lay a firm foundation for empirical studies of discrimination and yield estimation. A careful study of the empirical data on cavity decoupling is underway.

Support of International Negotiations. This program has supported U.S. efforts to participate in a large scale test of an international monitoring system sponsored by the United Nations Group of Scientific Experts experiment. This experiment should provide, for the first time, a solid basis for measuring the verification capability such a system might provide and the resources required to set-up such a system.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62714E
USDR&E Mission Area: 530

Title: Nuclear Monitoring
Budget Activity: 1. Technology Base

Nuclear Materials Detection. A new initiative has begun on a detector with application to nuclear materials. Preliminary evaluation of different approaches to detection is also underway.

c. FY 1986 Planned Program and Basis for FY 1986 Request: In yield estimation we will evaluate the results of a DARPA initiated underground nuclear test at the Nevada Test Site in rock similar to that at the Soviet Test Site. This should lead to better estimates of the bias between Soviet and U.S. seismic magnitudes for events of the same yield. Supporting laboratory and finite difference calculations will deepen our understanding of these results making them more suitable for government decision making with respect to possible Soviet violations of the Threshold Test Ban Treaty. Installation will begin of a magnitude estimation system, based on DARPA research, by the Air Force which will give yield estimates directly from recorded waveforms. Discrimination will be enhanced by installation of an interactive graphics system which will implement short-period focal plane and first motion analysis, as developed by DARPA researchers, which can be used as a discriminant at the lowest magnitudes. For the smallest, shallow, perhaps decoupled, explosions only regional phases can be used as discriminants. Thus laboratory, theoretical, and empirical studies of regional discrimination will continue; as will studies on improved methods of decoupling. Data from Norway will be fully available and intensive analysis of this data should yield important discoveries in yield estimation, detection of very small events, and regional propagation, possibly even within the Soviet Union and especially at high frequencies where decoupling is inefficient. These insights will lead to the deployment of instruments at new sites selected to gather crucial detection or propagation information. Experiments will be performed to test further the evasion concept of hide-in-earthquake. DARPA will continue to support additional treaty-related studies as required by international negotiations.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62714E
USDR&E Mission Area: 530

Title: Nuclear Monitoring
Budget Activity: 1. Technology Base

d. Program to Completion: The research program has provided several options for improving the verification of the Threshold Test Ban Treaty and a comprehensive test ban treaty. The seismic research requirements in future years will be driven by negotiation options as they appear. We may anticipate that these programs in yield estimation, and in regional discrimination will be conducted at a level to support policy initiatives in this area. Because of the element of evasion the program is basically continuing since discrimination of weak signals from decoupled explosions as seen at regional distances would call upon the most advanced theoretical, experimental, and systems capabilities.

e. Milestones: The FY 1984 milestones reported in last year's Descriptive Summary were completed on schedule.

Last Year's Reported Plan	Current Plan	Milestones
Mid FY 1985	Mid FY 1985	Complete development of counter-evasion methods for complex evasion techniques.
Late FY 1985	Late FY 1985	Complete evaluation of small-scale chemical explosions source theory.
Late FY 1985	Late FY 1985	Complete U.S. participation in Conference on Disarmament technical data exchange experiments.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #62714E
USDR&E Mission Area: 530

Title: Nuclear Monitoring
Budget Activity: 1. Technology Base

Last Year's Reported Plan	Current Plan	Milestones
Late FY 1985	Late FY 1985	Test of Advanced Gamma-Ray Detector.
--	Late FY 1985	Test of high energy x-ray imaging methods.
--	Late FY 1985	Demonstration of analysis of air samples for the measurement of the ratios of the isotopes.
--	Mid FY 1986	Completion of construction of an advanced gamma ray radiation detector.
--	Late FY 1986	Statistical magnitude: advanced yield determination system completed and transferred to the Air Force.
--	Late FY 1986	Development of improved magnitude yield and discrimination regional parameters from theoretical calculations.
--	Late FY 1986	Demonstration of low-energy neutrino detection.

f. Explanation of Milestone Changes: There are no changes from last year's milestones.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #63226E
USDR&E Mission Area: 530

Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

A. RESOURCES (PROJECT LISTING): ($ in Thousands)

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Costs
	TOTAL FOR PROGRAM ELEMENT	281,456*	193,505*	175,249*	201,542*	Continuing	TBD
EE-2	TEAL RUBY Experiment	32,220	31,000	25,000	10,000	5,000	238,579
EE-3	Helicopter Technology Demonstration	21,700	19,900	21,400	13,260	0	96,722
EE-7	Space Acquisition, Tracking and Pointing Experiment - TALON GOLD	57,937	a/	a/	a/	a/	a/
EE-8	High Power Chemical Laser Ground-Based Demonstration - ALPHA	36,944	a/	a/	a/	a/	a/
EE-9	X-29 Advanced Technology Demonstrator	19,000	14,000	5,000	0	0	118,508
EE-12	Large Optics Demonstration Experiment - LODE	22,979	a/	a/	a/	a/	
EE-16	Long Range Aircraft Interceptor Experiment	0	0	8,000	20,000	100,000	128,000
EE-17	Detection of Aircraft (HI-CAMP)	0	0	4,010	3,100	5,000	12,110

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #63226E
USDR&E Mission Area: 530

Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Costs
EE-18	Advanced Undersea Vehicle	0	0	16,600	20,000	20,000	56,000
EE-19	Advanced Cruise Missile Technology	0	0	7,000	20,000	25,000	52,000

* Total includes classified projects not identified herein.

a/ The TRIAD Projects, EE-07, EE-08 and EE-12, are continuing in FY 1985 and the outyears as a part of the President's initiative in Strategic Defense and resources are being requested in Program Element #63221C, Directed Energy Weapons.

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED:

TEAL RUBY Experiment. (TIARA) This is a space experiment to demonstrate infrared detection of strategic aircraft from a space platform, measure target and clutter background signatures from space, and demonstrate advanced infrared mosaic detector technology. Expansion of the basic sensor missions is being investigated to include collecting signature measurements on other critical targets such as spacecraft, key tactical targets, ships and strategic missile plumes. The sensor and the associated USAF spacecraft are being built.

Helicopter Technology Demonstration (formerly X-Wing/RSRA): This program is a major innovation in Vertical Takeoff and Landing aircraft design which, by stopping the rotor in flight, combines the vertical lift efficiency of a helicopter with the speed, range, and altitude performance of a transonic fixed wing aircraft. Design analysis indicates an operational X-Wing vehicle would have approximately three times the speed, range, and altitude performance of a conventional helicopter with equivalent payload lifting capability. These characteristics enable a very broad operational applicability such as: more flexible sea-basing for the Navy for conducting long range anti-submarine warfare; over-the-horizon targeting of

surface and air targets; tactical jamming; close air support; and intra-theater self-deployment capability. Development and integration into a flight test vehicle of a high power transmission that will enable a significant increase in helicopter heavy lift capability is included in this project.

X-29 Advanced Technology Demonstrator: The X-29 Advanced Technology Demonstrator program is designed to develop and demonstrate advanced aerodynamics, structures and flight control technologies. This aircraft, made possible with advanced composite structure and a digital fly-by-wire flight control system, will be flight tested to investigate and quantify the technical benefits and performance capabilities of such an integrated advanced technology vehicle. Flight test will develop confidence in numerous

Long Range Aircraft Interceptor Experiment: The focus of this program is on the development of technology for a non-nuclear weapon that has potential for a dramatic advancement in anti-war warfare and features: (1) very short travel time for rapid force projection, (2) very large attack footprint which limits defense avoidance (or electronic countermeasures), (3) high mobility and flexible basing (air, ship or ground launch options), (4) difficult detection by the enemy that attack is under way, (5) high potential for covert use, particularly against an unsophisticated opponent, (6) large Radar homing sensor and large kinematic footprint, (7) multiple operating modes (home-on-jam, anti-radiation-homing, active search), and (8) mission flexible and adaptable as a fast reaction "gap filler" as new threats emerge or as unforeseen crisis situations arise.

Detection of Aircraft (HI-CAMP): (TIARA) Detection of Aircraft includes the determination of the Infrared (IR) signatures of: (1) strategic aircraft (primary target) and cruise missiles; (2) intercontinental and submarine launched ballistic missiles; (3) ground and sea targets; and (4) the natural and perturbed backgrounds against which these targets are observed from a spaceborne or airborne IR surveillance sensor. This project will provide the data base for the design of advanced space surveillance systems and will guide the development of the technology base. The HI-CAMP (Highly Calibrated Airborne Measurements Program) II effort was initiated in FY 1981 to provide the above IR signatures through airborne measurements aboard a U-2 aircraft and to support the mission planning and flight operations of the TEAL RUBY Experiment (Project EE-02). HI-CAMP II includes the development, fabrication and flight test of a new, improved version of the highly successful HI-CAMP I infrared sensor system. The HI-CAMP II sensor was developed to include: (1) a stabilized sensor platform (improved by a factor of ten), (2) a new

hybrid silicon detector/multiplexor chips (one for short and one for long wavelength), (3) the focal plane drive electronics, (4) modified platform and, (5) a new correlation tracker subsystem for tracking lower contrast targets. The improved gimbal system permits long atmospheric slant path observations.

Advanced Undersea Vehicle: The objective of this program is to develop and demonstrate advances in technology required for autonomous undersea vehicles.

Advanced Cruise Missile Technology: (TIARA) Improving Warsaw Pact cruise missile defenses require that future generations of these weapons possess substantially improved penetration capability and lethality. The Advanced Cruise Missile program is developing two major elements: advanced propulsion and vehicle and subsystem design concepts for greatly improved survivability, lethality and range-payload product. Critical component technologies have been successfully developed and program focus is transitioning to feasibility demonstration of an integrated vehicle.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY: (TIARA) Congress reduced the FY 1985 requested fundirg for this Program Element by $10 million. The decrease in the FY 1986 request is the result of the reduced requirement for TEAL RUBY and the delayed build up in other programs caused by the FY 1985 Congressional reduction.

D. OTHER APPROPRIATION FUNDS: Not applicable.

E. RELATED ACTIVITIES:

TEAL RUBY Experiment: (TIARA) The TEAL RUBY Experiment provides the transition of DARPA concept, technology and design data into a variety of future space systems being considered by the Air Force, Navy and Army. TEAL RUBY will provide global background data, target signature data (for band selection) and validation of the mosaic concept for the Air Force Advanced Warning System, the Navy Integrated Tactical Surveillance System (ITSS), Air Force Space Based Surveillance System (SBSS) and the Space Based Laser programs.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #63226E
USDR&E Mission Area: 530

Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

Helicopter Technology Demonstrator: The Helicopter Technology Demonstrator development is a derivative of Circulation Control Rotor work performed by the David Taylor Naval Ship Research and Development Center and also utilizes Army research into stopped rotor dynamics and control work. A joint DARPA/NASA convertible turbofan/shaft engine program has been conducted in a parallel effort to provide a new and more efficient propulsion system for this program. The heavy lift effort is jointly funded by DARPA/NASA/ARMY. The Memorandum of Agreement for this effort was signed on December 14, 1984. Related Army efforts include the CH-47D modernization and the ACH-XX (Advanced Cargo Helicopter, Experimental) programs.

X-29 Advanced Technology Demonstrator: A DARPA/Air Force Memorandum of Agreement has been signed for the Air Force Systems Command to act as the DARPA agent responsible for procurement and technical monitoring of the design and fabrication effort. The Air Force Program Office will also address the military utility of the numerous X-29 advanced technologies and their importance to the Services, advanced flight vehicle programs and especially the Advanced Tactical Fighter. The X-29 program exploits and extends research in the use of advanced composite materials, computer aided design, advanced aerodynamic and structural analytical design methods, and digital flight control design techniques previously conducted by the Air Force, Navy, NASA and industry. A DARPA/NASA Memorandum of Agreement has been signed for NASA Ames, Dryden Flight Research Facility to conduct the flight test phase of the X-29 program. Also, NASA Langley has conducted structural dynamic testing and high angle of attack and spin wind tunnel testing to determine the aerodynamic coefficients and stability derivatives to use in Air Force, NASA and contractor ground simulations of the planned flight vehicles. In order to more rapidly transition the X-29 technologies, DARPA has formed the X-29 Future Applications Committee composed of potential corporate and government users to receive real-time results from the program so that results and lessons learned can be factored into other programs.

Long Range Aircraft Interceptor Experiment: This work is related to programs of the Air Force Ballistic Missile Office, the Naval Surface Weapons Center, the Naval Undersea Systems Center, and the Naval Ocean Systems Center. A joint technology demonstrator flight test is being conducted with the Sandia National Laboratory.

Program Element: #63226E
USDR&E Mission Area: 530

Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

Detection of Aircraft (HI-CAMP): (TIARA) These efforts are directly related to other programs under the cognizance of the Under Secretary of Defense for Research and Engineering as well as those of the following service units: Air Force: Directorates of Space Systems and Command, Control, Communications; Aeronautical Systems Division; Rome Air Development Center; Space Division; Rocket Propulsion Laboratory; and Geophysics and Avionics Laboratories; Army: Missile Research and Development Command and Harry Diamond Laboratories.

Advanced Cruise Missile: (TIARA) The Advanced Cruise Missile Program is directly related to programs managed by the Joint Cruise Missile project office and the Air Force Aeronautical Systems Division, Deputy for Systems and Deputy for Development planning (the DARPA agent). The engine developments are related to small engine research at the Air Force Aeropropulsion Laboratory (one of the DARPA agents), the Army Tank and Automotive Command and the Naval Air Propulsion Center (one of the DARPA agents).

F. WORK PERFORMED BY:

TEAL RUBY Experiment: (TIARA) The TEAL RUBY effort is performed by industry (76%), government in-house laboratories (15%), and by a Federal Contract Research Center (FCRC) (9%). Rockwell International, Seal Beach, California, is the prime contractor on the TEAL RUBY sensor; support contractors are: Logicon, San Pedro, California; Magnavox, Torrance, California; MRJ, Fairfax, Virginia; Riverside Research Institute, Arlington, Virginia; and the Environmental Institute of Michigan, Ann Arbor, Michigan. The FCRC support is provided by the Aerospace Corporation, El Segundo, California. The program is managed by the Air Force Space Division, Los Angeles, California, with support in Naval areas of interest by the Naval Ocean System Center, San Diego, California. Target support is provided by the Air Force Geophysics Laboratory (AFGL), Hanscom Field, Massachusetts and operational support will be provided by the Air Force Satellite Control Facility at Sunnyvale, California.

Helicopter Technology Demonstrator: About 90% of the X-Wing program is being performed by industry. The prime contractors are Sikorsky Aircraft Company, Stratford, Conneticut and Boeing Aircraft Company, Seattle, Washington. 10% of the work is being conducted by the David Taylor Naval Ship Research and Development Center, Carderock, Maryland and the Army Aviation Research and Development Command, Ft. Eustis, Virginia. NASA Ames Research Center is supporting the program through wind tunnel testing and flight research.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #63226E
USDR&E Mission Area: 530

Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

X-29 Advanced Technology Demonstrator: Approximately 90% of the effort is being performed by industry, the principal contractor being Grumman Aircraft Corporation, Bethpage, New York. Approximately 10% is being performed in-house by the Air Force Systems Command and by numerous NASA centers. The NASA and Air Force percentage will increase to a much larger share as the flight test phase progresses. The technical agent responsible for program oversight is the Air Force Wright Aeronautical Laboratories, Flight Dynamics Laboratory, assisted by NASA Ames, Dryden Flight Research Facility and the Air Force Flight Test Center, Edwards AFB, California. The Navy has supported the logistics and technical development with engineering support form the Naval Air Test Center, Patuxent River, Maryland.

Long Range Aircraft Interceptor Missile: About 90% of the effort is conducted by industry. The major contractors are: Decision Science Applications, Arlington, Virginia; Analytic Services Company, Arlington, Virginia; Hughes Aircraft Company, Fullerton and Canoga Park, California; Raytheon Company, Lexington, Massachusetts; Lockheed Missiles and Space Company, Palo Alto, California; and Science Applications, Incorporated, La Jolla, California.

Detection of Aircraft (HI-CAMP): (TIARA) 95% of this work is performed by industry and 5% by government laboratories. Major industrial contractors are: Lockheed Missile and Space Company, Palo Alto, California; MRJ, Fairfax, Virginia; Photon Research, LaJolla, California; and ERIM, Ann Arbor, Michigan. Government laboratories include: Air Force Geophysics Laboratory, Hanscom Air Force Base, Massachusetts; the Naval Ocean Systems Center, San Diego, California; and the National Aeronautics and Space Administration. Federal Contract Research Center support includes that of the Aerospace Corporation, El Segundo, California and the Institute for Defense Analyses, Arlington, Virginia.

Advanced Undersea Vehicle: 90% of the effort is performed by industry and 10% by government laboratories. The major industrial contractors are Scientific Research Laboratories, Santa Barbara, California and Rockwell International, Anaheim, California. The government laboratories which support this project are the David Taylor Naval Ship Research and Development Center, Carderock, Maryland, and the Naval Underwater Systems Center, Newport, Rhode Island.

Advanced Cruise Missile Technology: (TIARA) Industry provides 98% percent and government in-house 2% of this effort. LTV Aerospace, Dallas, Texas is the prime contractor with engine demonstration support from the Institute for Defense Analyses, Arlington, Virginia.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #63226E
US DR&E Mission Area: 530

Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

G. PROJECTS LESS THAN $7 MILLION IN FY 1986: (TIARA) Detailed mission planning for the Detection of Aircraft (HI-CAMP) program was accomplished for FY 1984 and FY 1985 under Program Element 62301E, Project ST-6, and several test missions were flown to validate design and performance. In FY 1984, the HI-CAMP II system was successfully flight tested and initial operational flights were flown. The sensor and the gimbal platform were integrated into the aircraft and the engineering arrays were upgraded. Operational flights were conducted against target aircraft, helicopter, rehearsals for TEAL RUBY, F-14 aircraft takeoff from airfield and carrier ships and Army targets. One experiment was also conducted on an Atlas missile in support of the Strategic Defense Initiative. Many of these flights were funded by the Air Force and Navy. In FY 1985 the HI-CAMP II equipment will be fully operational and the flight measurement program will continue. This program will be closely coordinated with the TEAL RUBY experiment mission planning and will perform TEAL RUBY rehearsal missions including radiometric and navigation experiments. Flights are planned for other strategic missiles, special targets and deployment for NATO theater targets and backgrounds. The project will transition to Program Element 63226E, Project EE-17, in FY 1986 and will focus on support of the major DARPA/Air Force TEAL RUBY Satellite Experiment. HI-CAMP has the same primary spectral bands as TEAL RUBY but with higher ground resolution for analysis. HI-CAMP will be used to collect simultaneous truth background and target data during the TEAL RUBY experiment to help in experiment diagnostics and for calibration. Target missions will include aircraft, tactical and strategic missiles, ships, and tactical Army targets. Other missions will be flown for the Army, Navy and Air Force depending on the TEAL RUBY schedule.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-2
Program Element: #63226E
USDR&E Mission Area: 530 (TIARA)

Title: TEAL RUBY Experiment
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: DARPA initiated the TEAL RUBY Program in 1974 to demonstrate the feasibility of detecting strategic air vehicles using a space-based infrared sensor and to provide a future option for warning of bomber attack against North America or Naval Battle Groups. Detection of weak aircraft signatures against the strong earth background clutter required a large number of advanced technologies. The TEAL RUBY Space Experiment will use each focal plane zone containing detectors. Spectral filters were developed to demonstrate in a single focal plane. Although the filter was demonstrated successfully in the laboratory, it will not be included in the TEAL RUBY flight test to eliminate cost and schedule constraints. Measurements will be performed to validate performance. The sensor is designed with sufficient sensitivity to detect targets. Background measurements, required for the design of future operational sensors, will be made on a worldwide basis and under a variety of climatological and geographic conditions.

2. Program Accomplishments and Future Program: The qualification test program was completed resulting in a highly successful radiometric test in a space chamber. The test provided the first comprehensive system-level performance data. The responsivity, noise and uniformity levels for the different representative spectral zones of the focal plane were testbed. Since each zone has different requirements for optimum target and background measurements, these test results were key inputs for mission planning and software development. The test results were key inputs for mission planning and software development. The test results were within an average of 17 percent of expected results. A new radiometric chamber was calibrated and brought on-line to support this test. TEAL RUBY flight sensor component acceptance testing and sensor assembly was completed. The mission planning and operations software requirements were established and work on software design specifications, including software acceptance testing plans, started. Development of the Rockwell Mission Operations Center (MOC) and installation of the MOC Network Interface Data System, which will govern the interconnection with the Air Force Satellite Control Facility (AFSCF), proceeded including the delivery of the MOC computers. Planning for the baseline aircraft target and background experiments has been completed. In addition, formulation of the target aircraft operations plan with the Air Force Geophysics Laboratory (AFGL) was initiated. Integration and parts problems to correct design problems have caused some delays. Several additional missions were defined for other services and agencies including the Navy, Army and other Air Force agencies. These include the following: The software effort supporting the software and MOC has

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-2
Program Element: #63226E
USDR&E Mission Area: 530 (TIARA)

Title: TEAL RUBY Experiment
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

been receiving additional emphasis along with mission planning in preparation for launch. The software for mission execution, data processing and reduction is a major effort since the mosaic sensor data rate ard quantity of data exceeds conventional sensors. The data analysis software is based upon the experience and software generated by the DARPA Highly Calibrated Airborne Measurement Program (HI-CAMP) sensor and will provide the basis for advanced systems.

a. FY 1984 Accomplishments: Testing was completed on the qualification unit and the unit provided for integration with the P-80 Shuttle spacecraft in early FY 1984. The TEAL RUBY/P-80 spacecraft integration test program was accomplished using a qualification sensor while flight sensor acceptance testing was performed. The acceptance tests included functional and radiometric tests to verify the performance level and stability of the sensor. In the mission planning and software development area, the Critical Design Reviews (CDR) were completed except for one uplink program and the software coding was initiated. The integration and testing of the Rockwell Mission Operations Center (MOC) was started and the new mission computers were i stalled. Preparations proceeded for the following major future efforts: Flight sensor radiometric space chamber testing, software coding, spacecraft/ flight sensor integration and mission operations. The mission planning was completed for aircraft experiments.

b. FY 1985 Program: In FY 1985, the TEAL RUBY flight sensor is being tested in the radiometric chamber and then replaced with the qualification sensor currently on the spacecraft. The flight sensor for the final integration testing is being integrated and checked out with the complete satellite system going through vacuum chamber and functional testing in preparation for shipment to the launch facility. Rehearsals for planned missions and detailed experiment planning are being conducted including all non-aircraft missions. This is the major activity year as hardware test and integration is completed, software is developed and major operation rehearsals occur.

c. FY 1986 Planned Program and Basis for FY 1986 Request: The spacecraft system will be packaged and delivered. After insertion into final orbit, the TEAL RUBY sensor will be checked out in orbital experiment operations initiated. Experimental missions will be conducted for selected time periods, corresponding to orbital passage over targets and/or background areas of interest. Experimental segments or missions are generally categorized as: (1) target missions demonstrating on-board detection,

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-2
Program Element: #63226E
USDR&E Mission Area: 530 (TIARA)

Title: TEAL RUBY Experiment
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

and (2) background missions where multispectral radiometric data will be recorded. Priority in time sequence of experiment execution will be given background data. The Allied, Navy and other agency missions will be conducted after the first successful aircraft detection mission and will be fitted in between major aircraft deployment periods. All this planning will be established prior to launch and updated based on actual orbital data which will modify mission encounter periods. Focal plane operation will be monitored using a variety of temperature, signal and noise measurements. The estimated life of the TEAL RUBY sensor is limited by the supply of stored liquid cryogens. Each set of mission data will receive a "quick look" for feedback to subsequent missions to increase the efficiency of collection over the lifetime of the satellite. A final experiment evaluation report will follow mission completion by approximately six months.

d. Program to Completion: All reports will be completed. All the data will be processed into engineering research data tapes and put into a TEAL RUBY library for system designers.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones
--	Mid FY 1985	Flight sensor chamber test
		Launch of P-80 Spacecraft.
		Complete Orbital Operations.
		Complete Program.

f. Explanation of Milestone Changes: Program completion will be delayed to allow processing of all raw data tapes into an engineering library along with report documentation.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-3
Program Element: #63226E
USDR&E Mission Area: 530

Title: X-Wing/RSRA
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The X-wing vehicle will provide the Services with a vertical take off and landing circulation control rotating wing helicopter that converts to fixed wing mode for forward flight at significantly increased efficiency and speed (300-400 Knots). The X-Wing concept developed into an operational vehicle would have similar vertical takeoff/landing characteristics as conventional helicopters, i.e. low disk loading which results in low down draft but would approach the dynamic characteristics of a high performance fixed wing combat vehicle in the X-Wing stopped rotor configuration. Current helicopters have maximum forward speeds of approximately 225 knots and very low dynamic performance, i.e. turn rate, roll rates, rate of climb, etc. Thus, a factor of three or more improvement in efficiency and aerodynamic performance can be expected in the fixed wing mode. Fixed wing dynamic performance of the X-Wing can approach that of current high performance vehicles but far exceed the low speed performance of these same vehicles. The closest competitor is the Harrier which has limited dynamic performance in the low speed regime and has extremely high disk loading which is unacceptable for landing on unprepared landing zones. Thus, the X-Wing vehicle concept offers significant efficiencies over both regimes of either a pure helicopter or fixed wing high performance vehicle. Objectives of this program are to demonstrate the feasibility and practicability of the X-wing vertical takeoff and landing aircraft concept through design, fabrication and flight test of a demonstration vehicle representative of an operational size aircraft. During FY 1983, a joint DARPA/NASA X-Wing program on the Rotor Systems Research Aircraft (RSRA) was initiated with approximately equal funding from each agency. The NASA portion of the program is being conducted under the effort entitled: "Technology for Next Generation Rotorcraft" (within the Rotorcraft Systems Technology Program UPN 532), which began in FY 1984. The X-Wing/RSRA program is composed of the following major tasks: (1) design and analysis; (2) basic design data; (3) fabrication of a large (50-foot diameter) rotor system; (4) ground tests and software development; and (5) contractor and NASA flight tests on the RSRA. Contractor rotor system design activities are supported by David Taylor Naval Ship Research and Development Center and NASA in-house programs of subscale wind tunnel testing and analytic correlation. A sophisticated Mach-scaled dynamic model built by Boeing has been utilized extensively to provide basic design data, particularly in the conversion (rotating to stopped) mode. Completion of a joint DARPA/NASA/Army research effort to demonstrate feasibility of a high power combining transmission is an additional task.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-3
Program Element: #63226E
USDR&E Mission Area: 530

Title: X-Wing/RSRA
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

Successful development of a high power combining transmission in the Heavy Lift Helicopter (HLH) program has provided the critical technology for doubling U.S. helicopter heavy lift capability. The HLH project is intended to establish operational feasibility of the high power combining transmission technology through installation in an XCH-62 airframe, ground testing and in-flight performance evaluation. Initial HLH research resulted in successful achievement of a high power combining transmission capable of transmitting torque levels in excess of 80,000 inch-pounds, approximately double current capability.

2. PROGRAM ACCOMPLISHMENTS AND FUTURE PROGRAMS:

a. FY 1984 Accomplishments: During FY 1984, the detailed design and fabrication of most subsystems were completed. After critical design review, components entered into proof load, fatique, laboratory and ground tests. Major subsystems included blades, compressors, hub moment sensors, gear boxes, and flight control and computer hardware. A propulsion system testbed was designed for ground testing of the engine-transmission-rotor-control system. Subscale Rotor System Research Aircraft (RSRA) model testing for aerodynamic and stability refinements was also conducted. Most simulation facility hardware and software evaluations of the control logic were performed. The high power transmission combiner was assembled and successfully tested. The HLH transmission combiner was assembled and aft transmission tests were successfully completed. The tests demonstrated that the combining technique could support transmission of the required torque. These research accomplishments were achieved while the effort was included in Project ST-5 (PE 62301E).

b. FY 1985 Program: An advanced X-Wing rotor system is being fabricated and installed on the RSRA and testing of the propulsion system testbed, component qualifications tests, hub-sensor calibration and airframe shake testing will be completed. A specialized systems integration test facility is being used to evaluate the fly-by-wire control system. Following these activities, the airframe is tied down for integrated systems testing and the final flight control system software updated from sub-scale, full scale, and simulation test results. A 100-hour endurance test of the high power combining transmission is being completed. A 100-hour endurance test is being conducted on the combiner and forward transmission tests of the HLH transmission are being completed. Integrated transmission testing is to be completed and an engineering design review conducted for integration with the XCH-62 flight demonstration vehicles. This is being accomplished under Project ST-5.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-3
Program Element: #63226F
USDR&E Mission Area: 530

Title: X-Wing/RSRA
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

c. FY 1986 Planned Program and Basis for FY 1986 Request: Following successful flight safety review and tie-down testing during last quarter of FY 1985 and first quarter FY 1986 flight testing of the aircraft will be initiated. Flight testing objectives will include investigation of: (1) the in-flight aerodynamics associated with the circulation control boundary layer control system; (2) the capability of the pneumatic control system to provide flight control, vibratory airload suppression and gust control, particularly during conversion to fixed-wing flight; (3) the performance of the closed loop fly-by-wire stabilization and control system in all flight modes; (4) the structural and aeroelastic performance of the graphite composite fore/aft swept X-wing blades; and (5) an operational air speed/altitude envelope up to the limits of the Rotor Systems Research Aircraft airframe. High power transmission functional tests will be initiated. Major XCH-62 vehicle subsystems required to support test of the high power combining transmission will be fabricated, qualified and assembled. Rotor blade and fuselage fabrication and assembly will be completed. Final assembly functional tests will be initiated.

d. Program to Completion: Upon review of flight test data and successful demonstration of X-wing feasibility and practicability, the program will be transferred fully to NASA who will continue and complete experimental testing during FY 1987. Final XCH-62 (HLH) high power combining transmission functional testing and proof loading will be completed during FY 1987 using NASA and Army funds. Functional, proof loading and ground tests will be completed in late FY 1988. Tie-down testing will be conducted, a flight test readiness check will be completed and the first flight test will be accomplished during this same period. Flight testing will be completed during FY 1988-1989.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones
Late FY 1984	Farly 1985	Initiate propulsion system testbed.
--	Early FY 1985	100-hour XCH-62 Heavy Lift Helicopter (HLH) combiner and forward transmission tests.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-3
Program Element: #63226E
USDR&E Mission Area: 530

Title: X-Wing/RSRA
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

Last Year's Reported Plan	Current Plan	Milestones
Early FY 1985	Late FY 1985	Ground testing; flight clearance review; conduct first flight.
Mid FY 1985	Late FY 1985	Flight test data review.
--	Late FY 1985	Fabricate, qualify and assemble major XCH-62 (HLH) transmission subsystems.
Early FY 1986	Mid FY 1986	NASA receipt of aircraft.
--	Late FY 1986	Initiate final XCH-62 (HLH) assembly functional tests and proof loading.
--	Mid FY 1987	Complete airframe final assembly.
--	Late FY 1988	Complete functional testing, proof loading, ground tests and first flight test.
--	Late FY 1989	Complete flight testing.

f. Explanation of Milestone Changes: The FY 1984-1986 milestones are slightly revised (+6 months) to correspond to a slight slippage in the date of the DARPA/NASA Rotor Systems Research Aircraft critical design review.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-9 Title: X-29 Advanced Technology Demonstrator
Program Element: #63226E Title: Experimental Evaluation of Major Innovative Technologies
USDR&E Mission Area: 530 Budget Activity: 2. Advanced Technology Development

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The X-29 Advanced Technology Demonstrator (X-29 ATD) program has the potential for achieving major technical breakthroughs in air vehicle design which can be translated into significant operational performance improvements. Eight technologies will be developed and breakthroughs are anticipated in the areas of structures, aerodynamics, stability and control, and configurational design freedom. In the structures area, the composite wing covers are designed to solve the aeroelastic divergence phenomenon, a static structural instability experienced by forward swept wings (FSW), which has prohibited the exploitation of the FSW aerodynamic and configurational design advantages. The composite wings are designed to twist when loaded (aeroelastic tailored) to handle this phenomenon without the weight penalty associated with a metal FSW. Aeroelastic tailoring has important applications for aft swept wings as well, but in this application it is critical to program success. High confidence in this technology is a result of earlier large scale wind tunnel testing of two specific FSW designs. Aerodynamically, the X-29 ATD will demonstrate high aerodynamic efficiency throughout the entire flight regime. The aerodynamics of the FSW design and the favorable interaction of the canard and wing, also documented by extensive analysis and wind tunnel testing, provide greater useful lift at given angles of attack and allow higher angles of attack to be achieved before wing stall. As a result, significantly lower takeoff and landing speeds and substantially improved high angle of attack maneuverability are possible. The FSW configuration generates lower drag due to lift during transonic maneuvering flight and, through optimum deflection of the three control surfaces (canard, wing flaps and strake flaps), subsonic and supersonic trim drag can also be greatly reduced. The X-29 ATD is designed to be statically unstable to reduce supersonic trim drag. This unstable nature also permits greater maneuverability and results in a smaller and lighter vehicle. The vehicle is controlled with a full authority and fully moveable canard and is the first modern day aircraft so designed. A new digital fly-by-wire flight control system is used to optimally schedule the canard, strake flaps and rudder deflections and will be used to investigate advanced control designs to build confidence and reduce the risk in the design of future systems. Configurational design flexibility, available because of the FSW design, allows weight and/or volume to be varied significantly without serious controllability impact and enhances the design

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-9
Program Element: #63226E
USDR&E Mission Area: 530

Title: X-29 Advanced Technology Demonstrator
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

efficiency. These technical developments are important when considered individually, but when combined in this flight vehicle, they synergistically produce considerable operational performance improvement. Early analysis indicated that a forward swept wing (FSW) aircraft could be as much as 30% lighter than an equivalent aft swept wing aircraft. This weight reduction can be translated into equivalent range/payload or performance improvements and any weight reduction can be translated into a cost saving. In addition, the competing designs for this program were point designed for high transonic maneuverability yet had impressive short takeoff and landing capabilities even without sophisticated high lift devices. Such capabilities are due to the excellent low speed stability and control characteristics inherent in the FSW wing design. These performance improvements will be valuable to the Air Force in the design of advanced tactical fighters for which runway denial is an operational concern and to the Navy for operations from small ships. The development, evaluation and exploration of the X-29 technologies will reduce the time, risk and cost of any future tactical fighter development.

7. Program Accomplishments And Future Programs:

a. FY 1984 Accomplishments: All fabrication and ground testing efforts were completed during FY 1984 in preparation for flight testing. The structural proof loading of the Number One vehicle was completed and the static and dynamic test results matched the predicted values well enough to "close the loop" on the wing design. Composite structures can reliably be designed to predictably twist under load permitting the lightweight, yet stiff, structures to solve the FSW aeroelastic divergence. All systems were tested extensively and necessary modifications were made to meet safety and design goals and specifications. Instrumentation was activated and calibrated. The contractor, Air Force and NASA safety review processes were completed to clear the vehicle for flight. A significant program change and contract modification was made to conduct all flight testing to Edwards AFB and to initiate a joint government/contractor flight test program instead of conducting initial testing at the contractor's facility. This change delayed the first flight by four months but enhanced safety, provided test continuity and insured a more productive program.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-9
Program Element: #63226E
USDR&E Mission Area: 530

Title: X-29 Advanced Technology Demonstrator
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

b. FY 1985 Program: The aircraft was being shipped to Edwards and prepared for it's first flight and functional testing to be conducted by the contractor to insure the vehicle was ready for first flight and concept evaluation in December 1984. The NASA involvement is increasing as additional personnel prepare for the concept evaluation flight testing. NASA is being assisted by the Air Force Flight Test Center (AFFTC) engineers in generating and evaluating the military utility of the X-29 technologies and planning a possible expanded military test phase following the concept evaluation. Following the functional flights in early FY 1985, a joint government/contractor test program is being initiated. Recognized and accepted flight control limitations are restricting early testing. The full envelope capability is being installed in mid FY 1985. A nominal flight envelope is being explored to gain experience with the systems and then the full structural divergence envelope is being investigated after the full flight control system capability is installed. NASA is conducting the flight tests supported by the AFFTC and the Air Force Wright Aeronautical Laboratories Flight Dynamics Laboratory. Contractor support is also being continued. Test results are being made available to government and industry users as generated. Special meetings are being held to transition this information as early as possible.

c. FY 1986 Planned Program and Basis for FY 1986 Request: Flight testing will continue through FY 1986. The full aircraft design envelope will be investigated with research efforts focused on the advanced aerodynamic, structural and flight control technologies. A strong emphasis will be placed on developing the audit trail from design through flight test to validate the new technologies and create the database necessary to transition the X-29 technologies. Changes to the vehicles and control system are anticipated as experience is gained from testing to prepare for the follow-on military application testing. The program will be structured to focus on military applications and payoffs from the various X-29 technologies and how these relate to the advanced fighter requirements.

d. Program to Completion: The DARPA funded concept demonstration flight test program will be completed in FY 1986 with the experimental flight vehicles transitioned to the Air Force and NASA for continued testing. NASA will continue to investigate the X-29 technologies to build the technology base required for future exploration. It is anticipated that the X-29 aircraft or its systems may also

Project: #EE-9
Program Element: #63226E
USDR&E Mission Area: 530

Title: X-29 Advanced Technology Demonstrator
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

be modified to investigate other concepts for specific military applications. A major effort will be conducted to transfer the flight test information to the user community as it is generated. This is a long-range estimate based on success in meeting the technical and management milestones.

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones
Late FY 1984	Early FY 1985	First flight of the X-29 and completion of four test flights.
Early FY 1985	Mid FY 1985	Start concept demonstration flight test program.
--	Late FY 1985	Implement full envelope capability.
Mid FY 1986	Late FY 1986	Complete DARPA sponsored concept evaluation flight test program.
--	Early FY 987	Initiate NASA sponsored research and Service military application testing.

f. Explanation of Milestone Changes: The milestones cited in the FY 1985 Descriptive Summary with completion dates through FY 1986 are expected to be delayed four to six months. First flight was delayed from late FY 1984 to early FY 1985 (December 1984) because of the decision to move the first flight from the contractor's facility on Long Island to Edwards AFB to enhance safety and insure continuity of the test program. This will cause an extension of the flight test program from mid FY 1986 to late FY 1986.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-16
Program Element: #63226E
USDR&E Mission Area: 530

Title: Long Range Interceptor Experiment
Title: Experiment Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Descriptive: This effort in the Long Range Interceptor Experiment (LORAINE) transitions from the Strategic Technology program element 62301E, Project ST-4, in FY 1986. Focus of the LORAINE program has been on development of technology for a non-nuclear very long range anti-aircraft weapon. The development is intended primarily for Battle group and Continental United States (CONUS) air defense applications. By virtue of its speed the LORAINE could attack in a matter of minutes. By having a large search area the LORAINE minimizes the need for accurate pretargeting information, and coupled with its speed of reaction eliminates the need for update information in most scenarios. It is ideally suited to complement long range surveillance systems such as Over-the-Horizon (OTH) Radar and Space Infrared (IR) systems. These latter systems can be used to cue the LORAINE. LORAINE can also be used to provide the outer air defense for the Battle Group. In short, the LORAINE is the ultimate long range intercept weapon. The baseline reentry vehicle was developed by the Sandia National Laboratory.

2. Program Accomplishments and Future Programs: This is a new project in FY 1986 which continues work on the Long Range Interceptor Experiment (LORAINE) previously funded in PE 62301E, Project ST-4. Efforts are underway to resolve the demanding technical issues and operation. A nearly full scale LORAINE concept demonstration will be developed which will culminate in one or two intercepts under expected operating conditions. The program will include the development of the attendant cooling system; an appropriate prime power source; and, all the hardware miniaturization necessary to incorporate the LORAINE system. The detailed LORAINE intercept program plan is being developed.

a. FY 1984 Accomplishments: Construction of the SWERVE-III vehicle, instrumentation and experimental hardware continued. Initial difficulties were solved. The first set of experimental hardware, properly calibrated including the completed antenna array insert was delivered to Sandia. Sandia laid out plans for a precursor flight with dummy reentry vehicle in order to fully check out launch site and down range instrumentation.

b. FY 1985 Program: In FY 1985 a flight test is being conducted to verify electrical, mechanical, and thermal performance. Remaining work in the fiscal year includes analyses of flight data and planning for a full scale LORAINE intercept.

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FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-16
Program Element: #63226E
USDR&E Mission Area: 530

Title: Long Range Interceptor Experiment
Title: Experiment Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

c. FY 1986 Planned Program and Basis for FY 1986 Request: In FY 1986, development towards the full scale demonstration of the Long Range Interceptor Experiment (LORAINE) will be initiated. This will include major contracts for the components and supporting equipment. An integration plan and an experiment test plan will be developed to lead the program through an orderly series of experiments culminating in an intercept demonstration.

d. Program to Completion: This is a continuing program.

e. Milestones:

Development

Last Year's Reported Plan	Current Plan	Milestones
Late FY 1984	Mid FY 1985	Conduct sub-scale LORAINE test
--	Early FY 1986	Complete LORAINE flight test planning
Mid FY 1987	Mid FY 1987	Complete LORAINE integration.
Early FY 1988	Early FY 1988	LORAINE integration completed.
		LORAINE intercept of drone demonstrations.

f. Explanation of Milestone Changes: Initial milestones reported last year proved too aggressive. Schedule slippage has occurred due to late completion and integration.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #FE-18
Program Element: #63226E
USDR&E Mission Area: 530 (TIARA)

Title: Advanced Undersea Vehicle
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

H. PROJECT OVER $7 MILLION IN FY 1986:

1. Project Description: The objective of this program is to develop and demonstrate advances in technology required for autonomous undersea vehicles. Previous efforts were reported in Program Element 62702E and summary details are contained in Project TT-3. FY 1986 funds are to start with the closure of the technology and initiation of larger scale subsystem demonstrations.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: The FY 1984 portion of this program is reported in Program Element 62702E, Project TT-03.

b. FY 1985 Program: The FY 1985 portion of this program is reported in Program Element 62702E, Project TT-03.

c. FY 1986 Planned Program and Basis for FY 1986 Request:

Testing of subsystems for advanced undersea vehicles will continue through FY 1986 and demonstrations are planned. The objective is to develop technologies which if integrated together will enable a vehicle to sense its environment, takes actions not specifically planned, and carry out a task or mission as specified. The FY 1986 resources will be used to develop the individual technologies required to enable this capability. It is expected that a large percentage of the effort will be expanded on associated sensor systems. A testbed vehicle for integration and testing these technologies is planned in the outyears. However, no or little FY 1986 funds will be used for this program.

d. Program to Completion: This is a continuing program.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-18
Program Element: #63226
USDR&E Mission Area: 530 (TIARA)

Title: Advanced Undersea Vehicle
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones:
--	Early FY 1986	Begin advanced technology demonstrations
Late FY 1986	Late FY 1986	Complete critical on-going technology demonstrations
Early FY 1987	Early FY 1987	Determine if testbed vehicle is required
Late FY 1988	Late FY 1988	Demonstration of adaptive vehicle technologies

f. Explanation of Milestone Changes: Not applicable

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EF-19
Program Element: 63226E
USDR&E Mission Area: 530

Title: Advanced Cruise Missile Technology (NEW START)
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: The Advanced Cruise Missile Technology program is developing technologies applicable to next generation strategic and tactical missile systems. Major technical objectives are being pursued and the vehicle and engine design and subsystems needed to achieve a substantial increase in range-payload product are being developed. The increased engine thermal efficiency and configuration are expected to produce either long range or a reduction in volume and weight for conventional ranges. A secondary objective is to reduce reliance on strategic materials for production of the cruise missile vehicle.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: The Advanced Cruise Missile efforts were conducted in Program Element #62301E, Project ST-5 in FY 1984.

b. FY 1985 Program: These efforts are conducted in Program Element No. 62301E, Project ST-5 in FY 1985.

c. FY 1986 Planned Program and Basis for FY 1986 Request: Preliminary vehicle designs and model tests will be initiated. Individual engine and vehicle components will be fabricated and tested. Val'dation of full scale engine components will be initiated.

d. Program to Completion: In FY 1987 individual full scale engine components will be combined into a hot section for evaluation of performance. This effort will complete validation of full scale components suitable for a flight weight engine test program. Vehicle designs and model tests will be completed and the improvement in survivability assessed. Technology, configuration, and survivability analyses needed to support a decision to enter into development of a flight test vehicle will be completed during FY 1987. FY 1988 and FY 1989 funds represent the DARPA portion of a jointly funded flight test vehicle fabrication, test and evaluation program to be initiated during FY 1988 and completed during FY 1989.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-19
Program Element: 63226E
USDR&E Mission Area: 530

Title: Advanced Cruise Missile Technology (NEW START)
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

e. Milestones:

Last Year's Reported Plan	Current Plan	Milestones
--	Early FY 1985	Initiate development of full scale component developments.
--	Late FY 1985	Evaluation of engine components under fuel combustion conditions.
--	Early FY 1986	Preliminary vehicle design concept and model testing initiated.
--	Mid FY 1986	Individual full scale engine and vehicle component fabrication and testing initiated.
--	Mid FY 1987	Validation of full scale engine components suitable for flight weight engine completed.
--	Late FY 1987	Vehicle configuration design defined and model testing completed.
--	Late FY 1987	Decision to initiate development of flight test vehicle.
--	Early FY 1988	Initiate fabrication and integration of flight test vehicle subsystems.
--	Mid FY 1989	First flight test of full scale test vehicle.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Project: #EE-19
Program Element: 63226F
USDR&F Mission Area: 530

Title: Advanced Cruise Missile Technology (NEW START)
Title: Experimental Evaluation of Major Innovative Technologies
Budget Activity: 2. Advanced Technology Development

f. Explanation of Milestone Changes: The milestones shown above are different from those shown for this effort when it was included in Project ST-5 (Strategic Delivery Vehicles) in last year's FY 1985 Descriptive Summary. The changes are due to a further definition of the project and its establishment as a separate project.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #65112E
USDR&E Mission Area: 530

Title: Technical Analytical Support
Budget Activity: 6. Defensewide Mission Support

A. RESOURCES: ($ in Thousands)

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional to Completion	Total Estimated Cost
	TOTAL FOR PROGRAM ELEMENT	-	$14,700	-	-	-	$14,700

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED: This level-of-effort program funds special research and analytical services to the Office of the Secretary of Defense (OSD) and to DARPA. The program provides support to OSD planning, policy formulation and decision making processes, and to DARPA advanced technology programs through dedicated scientific and technical capabilities maintained by the Federally Funded Research and Development Center at the Rand Corporation. The broad objectives of the program are to ensure access by all OSD components to independent interdisciplinary research capabilities covering a broad range of relevant specialities, enhance mechanisms for technology transfer among OSD components, and institutionalize capabilities for analysis of issues that cut across the responsibilities of individual OSD components.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY: This is a new Program Element that began in FY 1985, established to encompass the Rand Corporation study efforts performed for OSD and DARPA as part of the expansion of Rand's existing Federally Funded Research and Development Center (FFRDC) status. The DoD has approved the expansion of Rand Corporation's FFRDC status to include work for both OSD and DARPA under this new PE. A detailed research program for FY 1985 is currently under review. The FY 1986 and outyear funding has been transferred from DARPA to OSD under PE 65112D.

D. OTHER APPROPRIATION FUNDS: None.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #65112E
USDR&E Mission Area: 530

Title: Technical Analytical Support
Budget Activity: 6. Defensewide Mission Support

E. RELATED ACTIVITIES: Rand Corporation currently has approved FFRDC status with the Air Force under Program Element #65101F "Project Air Force". The research efforts performed under this program are conducted to assist senior Air Force managers in the decision making process covering overall future Air Force actions. Research for other than Air Force, conducted under this program relates and contributes to a wide spectrum of DoD activities. To assure relevance and to prevent unnecessary duplication of effort, each newly proposed research effort is reviewed by the DoD agency. The results are also published and deposited with the Defense Technical Information Center for further dissemination to other authorized recipients.

F. WORK PERFORMED BY: All work will be performed by the Rand Corporation, Santa Monica, California. A Defense Advisory Group (DAG) is being established to provide policy guidance and allocate resources. The DAG will be chaired by the Under Secretary of Defense for Research and Engineering and co-chaired by the Under Secretary of Defense for Policy. User OSD organizations and DARPA will be members of the Defense Advisory Group.

G. PROJECTS LESS THAN $7 MILLION IN FY 1986: No funds were requested in FY 1984 for this Program Element. The efforts described herein have been funded in various other Program Elements for FY 1983 and FY 1984 and research results are shown for comparability. Analysis of proposed improvements in space-based surveillance capabilities demonstrated a need for better balance between performance and endurance and survivability requirements. An integrated model of the enlisted personnel force structure and associated analyses have contributed to the OSD reformulation of All Volunteer Force (AVF) policy directions. A reexamination of the implications of shifts in the paired relationships that comprise the US/USSR/PRC strategic triangle is assisting the reformulation of US policy. A methodology for cooperative distributive problem-solving in the domain of sensor Remotely Piloted Vehicles (RPV) was developed. Responding to a congressional inquiry, the Assistant Secretary of Defense (Health Affairs) asked for an evaluation of the feasibility of a closed enrollment system for the provision of DoD medical health services. Analyses of satellite survivability, millimeter wave communications and other matters relating to enduring command, control, communications, and intelligence systems are being used to improve strategic communication capabilities. An assessment of alternative policies towards west-east resource flows served as the basis for high-level conference on East-West economic relations and the Soviet defense posture. A Rand concept for an advanced non-nuclear weapon system with the potential to destroy

hard fixed targets at intercontinental ranges is currently being evaluated in an experimental program. A comprehensive picture of Soviet R&D in particle beam research was developed to serve as the basis for evaluating Soviet capabilities and for setting objectives for U.S. high-energy beam research. The congressionally mandated study on reducing the risk of unintentional nuclear war drew upon Rand analyses of various initiatives designed to increase confidence between the super powers. The work that Rand Corporation will provide for OSD and DARPA in FY 1986 and beyond has been transferred from DARPA, Program Element 65112E to OSD, Program Element 65112D. The Rand program will be guided in the future by the policies established by a special Defense Advisory Group (DAG) and coordinated with user OSD organizations and DARPA. Descriptive Summaries for Program Element 65112D for FY 1986 and beyond will be included in OSD RDT&E submissions.

H. PROJECTS OVER $7 MILLION IN FY 1986: Not applicable.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #65898E
USDR&E Mission Area: 530

Title: Management Headquarters (R&D)
Budget Activity: 6. Defensewide Mission Support

A. RESOURCES: ($ in Thousands)

Project Number	Title	FY 1984 Actual	FY 1985 Estimate	FY 1986 Estimate	FY 1987 Estimate	Additional To Completion	Total Estimated Cost
	TOTAL FOR PROGRAM ELEMENT	11,350	11,430	13,148	13,500	Continuing	N/A

B. BRIEF DESCRIPTION OF ELEMENT AND MISSION NEED: This program element provides funds for payment of salaries to civilian employees and for administrative support costs of the Defense Advanced Research Projects Agency (DARPA). This funding provides for the personnel compensation and benefits for civilians assigned to DARPA as well as costs for building rent and security, travel, supplies and equipment, communications, printing and reproduction. In addition, funds are included for reimbursing the Military Services for administrative support costs associated with contracts undertaken on the Agency's behalf.

C. COMPARISON WITH FY 1985 DESCRIPTIVE SUMMARY: The FY 1986 funding increase reflects additional administrative support costs at Service field activities associated with the administration of DARPA contracts. Management and administrative support costs for headquarters DARPA are approximately the same level as in FY 1985 and reflect the 5 percent pay reduction proposed by the President for FY 1986.

D. OTHER APPROPRIATION FUNDS: None.

E. RELATED ACTIVITIES: Not applicable.

F. WORK PERFORMED BY: Civilian and military personnel assigned to the Defense Advanced Research Projects Agency and by DARPA Agent personnel operating within the Military Services.

G. PROJECTS LESS THAN $7 MILLION IN FY 1986: Not Applicable.

FY 1986 RDT&E DESCRIPTIVE SUMMARY

Program Element: #65898E
USDR&E Mission Area: 530

Title: Management Headquarters (R&D)
Budget Activity: 6. Defensewide Mission Support

H. PROJECTS OVER $7 MILLION IN FY 1986:

1. Project Description: This project provides funds for normal management and support functions of the Defense Advanced Research Projects Agency (DARPA). The funding includes civilian personnel compensation and benefits, and costs for travel, building rent and security, supplies and equipment, communications, printing and reproduction. Funding is included for the reimbursement of administrative support costs associated with contracts undertaken on DARPA's behalf by the Military Services.

2. Program Accomplishments and Future Programs:

a. FY 1984 Accomplishments: Funding under this program element in FY 1984 supported management and administration for the RDT&E program assigned to DARPA. The majority of the funds were required for the pay of personnel who operate the Agency. Beginning in FY 1983, this project included funding to reimburse the various Service agents for cost associated with their administration of DARPA contracts. These funds were formerly budgeted in the technical program elements which fund the technology base programs.

b. FY 1985 Program: Continuation of the management and administrative support costs for DARPA is planned.

c. FY 1986 Planned Program and Basis for FY 1986 Request: The management and administrative support costs for headquarters DARPA will continued at approximately the same level as FY 1985. Reimbursement for the administrative support costs associated with the administration of DARPA contracts by our Service activities is expected to increase by $1.4 million in FY 1986 to the $4 million a year level.

d. Program to Completion: This is a continuing program.

e. Milestones: Not applicable.

f. Explanation of Milestone Changes: Not applicable.