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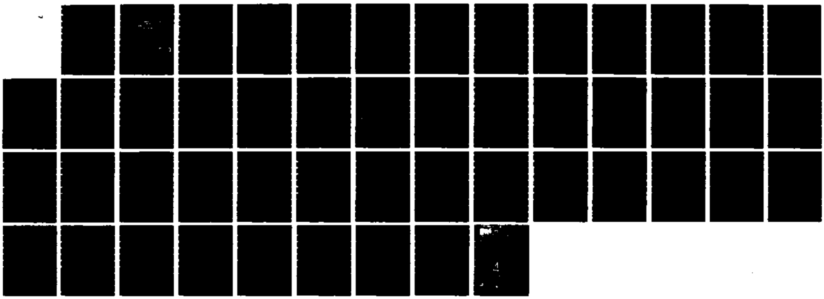

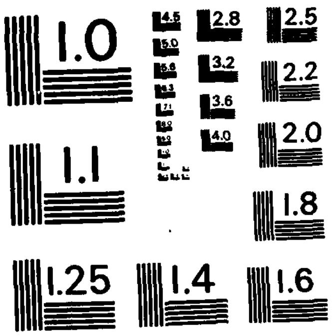

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THE DEPARTMENT OF DEFENSE STATEMENT ON THE SCIENCE AND TECHNOLOGY PROGRAM

by

DR. EDITH W. MARTIN
DEPUTY UNDER SECRETARY OF DEFENSE
for
RESEARCH AND ADVANCED TECHNOLOGY

BEFORE THE
SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT
OF THE
COMMITTEE ON ARMED SERVICES
OF THE
UNITED STATES HOUSE OF REPRESENTATIVES
98th CONGRESS, SECOND SESSION

21 MARCH 1984

Hold until released
by the Committee

THE DEPARTMENT OF DEFENSE

STATEMENT ON

THE SCIENCE AND TECHNOLOGY PROGRAM

by

Dr. Edith W. Martin
Deputy Under Secretary
of Defense
for
Research and Advanced Technology

before the

Subcommittee on Research and Development
of the
Committee on Armed Services
United States House of Representatives
98th Congress, Second Session

21 March 1984

→ This report discusses the following selected major FY 1985 Programs:

The FY 1985 Department of Defense Statement on The Science and Technology Program

from i

Mr. Chairman and Members of the Committee:

I. INTRODUCTION

I am grateful for this opportunity to testify in support of the Department of Defense Science and Technology (S&T) Program for FY 1985.

Today I want to describe to you our objectives for the DoD S&T Program, how I view the threat represented by the very large Soviet RDT&E effort, and how we plan to capitalize on the strength of our system -- our free industry, universities, in-house laboratories, allies, and the openness of our society -- to offset the Soviet advantages in numbers and resources.

Our major objective in the S&T Program is to provide the technology options for the mid-term and long-term solution of national security problems. It is not reasonable to expect our society to support a military buildup which would enable us to match the Soviets soldier-for-soldier or weapon-for-weapon. Instead we rely on our superior technology and most particularly on our ability to apply that technology to give us the necessary military advantage. But a few words of caution are required.

Superior technology can improve our military forces within reason, but in the last decade the Soviets have increased their RDT&E program from one comparable to ours to one about twice the size of ours and increasing more rapidly than ours. If this trend continues without an adequate response on our part, then eventually the Soviets will overcome our technological edge. This is true even when we consider the contributions to technology development made by the factors of our political and economic systems which have no Soviet counterparts: vigorous commercial research and development efforts, defense industry's independent research and development, and allies who are technologically advanced. Even the major contributions made by these unique resources cannot indefinitely compensate for the Soviet's two-to-one expenditure rate or, perhaps more threatening in the long-term, for the Soviet edge in education and training of scientists and engineers.

Nonetheless, as you can see from our program, we plan to continue our reliance on these unique strengths of our free democratic and capitalist society. Of the S&T Program, more than half is performed by industry, fourteen percent by universities and approximately one-third by DoD in-house laboratories. We have programs underway to increase participation by universities, particularly in the research portion of the program, and to strengthen their ability to support development of military technology by renewing their research instrumentation capabilities over the next few years. Additionally, we are initiating in the S&T program a major effort to develop technology applicable to the President's Strategic Defense Initiative.

In light of my foregoing remarks, it is not surprising that we are requesting the Congress to authorize and appropriate significantly greater funds for the S&T Program in FY 1985. Table 1 gives the summary of our FY

1984 program and our request for FY 1985. It includes Research (6.1), Exploratory Development (6.2), and Advanced Technology Developments (6.3A) of the three Military Departments and the Defense Agencies.

The FY 1985 S&T request reflects a major restructuring by the establishment of the Strategic Defense Initiative (SDI) within Budget Activity 2, Advanced Technology Development. The SDI required a major shift of funding from Budget Activity 1, Technology Base, and Budget Activity 3, Strategic Programs, plus lesser amounts from other accounts to establish this important national initiative. This distorts Table 1 FY 1984-85 comparison in terms of growth. However, the allocations between budget activities as shown in the FY 1985 S&T request is an accurate portrayal of the work being accomplished. The Strategic Defense Initiative will be more fully discussed in separate testimony.

There is no doubt that the technological superiority upon which we depend for our security is being challenged as never before. It is equally clear that our ability as a nation to meet this challenge will depend in large measure upon the maintenance of a vigorous, broadly-based, imaginative Science and Technology Program.

Our only hope of accomplishing this task is through the continuing superior achievements resulting from our academic, industrial, and government organizations with the continued support of your committee and the Congress.

Table 1

Science and Technology Program

(Dollars in Millions)

	FY 1984	FY 1985
Research		
Military Departments	730	796
Defense Agencies	110	104
Total Research	840	900
Exploratory Development		
Military Departments	1,446	1,598
Defense Agencies	757	729
Total Exploratory Development	2,203	2,327
Advanced Technology Development	1,386	3,421
TOTAL SCIENCE AND TECHNOLOGY	4,428	6,647

Notes: Numbers may not add due to rounding.

The significant difference between the total FY 1984 and FY 1985 is a result of creating the Strategic Defense Initiative in Budget Activity 2, Advanced Technology Development. Over $1,069 million was transferred from Budget Activity 3, over $317 million from Budget Activity 1, and lesser amounts from other accounts to Budget Activity 2.

The Exploratory Development and Advanced Technology Development growth is further distorted because of a redesignation of DARPA's P.E. 62711E, Experimental Evaluation of Major Innovative Technology from Exploratory Development to Advanced Technology Development (over $200 million involved).

II. MANAGEMENT ACTIONS

Technology development and technological change are not static processes. The contents of a sound program today become quickly outdated. Unexpected progress, changing political emphasis, varying military threats and many other factors require us to constantly reevaluate our position and reorient our efforts into those areas of high payoff potential. We now have taken or have underway a number of initiatives that improve our ability to plan and execute the S&T program.

A. Organization for Computers and Microelectronics

Microelectronics and computer technology are playing an ever increasing role in our defense systems. Strong management of our technology base research and development programs is needed in these rapidly advancing fields. We have created and are well along in staffing two new permanent offices: the Very High Speed Integrated Circuits and Electron Devices (VHSIC/ED) Directorate, and the Computer Software and Systems (CSS) Directorate. The Director of the VHSIC/ED office was appointed at the Senior Executive Service level almost a year ago. He is assisted by three deputy directors assigned by and representing each of the Military Departments.

Several staff elements were consolidated to create the Computer Software and Systems Directorate. The position of Director has been established at the Senior Executive Service level. Selection of an individual to fill this position is imminent. The Directorate responsibilities include the Ada Joint Program Office, the Software Technology for Adaptable, Reliable Systems (STARS) Joint Program Office and the Software Engineering Institute. Its objective is oversight of the military service programs in computers and software technology, and coordination of the Department's integrated approach to future generation military computers.

B. DoD-University Interface

A number of measures to strengthen the DoD-University interface have been taken this year. Foremost among these was the establishment of the DoD-University Forum as a formal advisory body to the Department of Defense. The Forum is co-chaired by the Under Secretary of Defense for Research and Engineering and by the President of Stanford University, and is composed of an equal number of DoD and university officials. The Forum is co-sponsored with DoD by three major higher education associations: The Association of American Universities, the National Association of State Universities and Land Grant Colleges, and the American Council on Education.

The role of the DoD University Forum is to provide for periodic consultations among senior university representatives and DoD officials on the full range of research-related needs and issues that affect the Department's ties with universities. It is an outgrowth of a 1982 Defense Science Board Task Force Study of University Responsiveness to National Security Requirements which recommended such a body to improve DoD's relationships with the nation's universities.

The Forum has established three working groups. The first working group is looking into the complex and sensitive issues pertinent to the question of how to balance the need for export controls for reasons of national security against the need of the university technical community for free and open dialogue. To assist the group in its deliberations, the Department participated in sponsoring a National Acad[illegible] of Science Panel on Scientific Communication and National Security (The [illegible]rson Panel). The report of the panel, which has also contributed t[illegible] [illegible]r Governmental efforts to address the issue of export control, laid the foundation for continuing discussions between the Department and the academic community.

The second working group examined DoD's needs in engineering and science education, and delivered a report examining the present environment in university science and engineering departments; assessed the effectiveness of existing DoD efforts to address these problems; and identified key leverage points on campus and in DoD which the Department might address. We are now working on implementation plans to deal with the major recommendations made by this working group.

The third working group was established to examine DoD's needs in foreign languages and area studies. It is also working closely with the Association of American Universities with whom we contracted to produce the study which was requested by the Department of Defense Authorization

Act of 1983. The Conference Report asks DoD to assess "... the requirement of the Defense Department and the intelligence community for a national research resource base which promotes the study and understanding of foreign languages and nations, in particular the Soviet Union, and which supports the unique requirements of the Army and other military intelligence users for high quality, informed research on matters of special interest which require such understanding." We expect to submit this report in the first half of 1984 as planned.

The Forum has become the focal point of our efforts to strengthen DoD-University relations, and we are pleased with the enthusiasm with which this activity has been received. The underlying motivation for these efforts is not only to strengthen the research and educational capabilities in support of national security, but springs from the realization that academia, government and industry are interdependently linked by our mutual efforts to ensure that our nation remains strong and productive.

C. Science and Technology Role in Export Control

The Department of Defense views with growing concern the extent to which the flow of U.S. technology to the Soviet Union facilitates Soviet military modernization. On the other hand, DoD recognizes that continued U.S. leadership in technology depends to a great extent on the health and vigor of the national research enterprise, which thrives best in an environment of free and open exchange of ideas and information.

Considerable resources have been invested in attempting to resolve this dilemma, both within and outside of the Department. Much has been accomplished, but significant long-term and continuing efforts are still required. We have maintained an open dialogue with the U.S. academic and industrial communities throughout this process, an activity which has resulted in a much greater awareness of the needs and concerns of all parties. Our continuing efforts in these areas have been formalized and will be directed by a Subpanel for Research and Development under DoD's International Technology Transfer Panel. This Subpanel, which I chair, addresses issues regarding technical guidelines and the exchange of technical information. It will also hear appeals from within and outside the Department on decisions made at lower levels, and will form working groups to address specific issues.

D. University Instrumentation Program

The ability of the academic sector to perform research that supports Defense goals is being seriously affected by research equipment obsolescence. In response to a national shortage of university research equipment, the Department of Defense initiated a five-year, $150 million University Research Instrumentation Program (URIP). Our program for the acquisition of university research equipment has the primary purpose of stimulation and support of basic research underlying the technology goals of the Department of Defense. Specifically, it provides funding for large items of equipment ($50,000 to $500,000 range) which will be used in research areas of priority concern to the military services. The instrumentation funds available in this program are in addition to the funding for normal university research contracts which may be used to purchase smaller equipment items.

The response of the university community to the URIP program has been overwhelming. In the first year, FY 1983, $30 million was awarded to over 80 universities in 33 states. Winners were selected from 2,500 proposals which requested a total of $645 million. Approximately 1,900 proposals have been received for the second phase of URIP and $60 million is planned for award through a single competition, the funding coming equally from the FY 1984 and FY 1985 Defense Research Sciences Program.

E. Independent Research and Development (IR&D)

Independent research and development (IR&D) is the technical effort a company selects and initiates internally in order to maintain its competitive position in a rapidly changing technological world. This is in contrast to the work specifically sought by the DoD, performed under contract or by other agreement. Through negotiation of the overhead on current contracts used to cover the company's research investment, DoD seeks to encourage innovative concepts that broaden and complement those being developed within the Department, to stimulate competition among contractors, and to contribute to the economic stability of Defense contractors by allowing them to develop a broad base of technical products.

The IR&D program is highly leveraged. Through annual review of the company technical plans and research results, DoD realizes use of all industries' IR&D while reimbursing only about one-third of the contractor's total IR&D expenses.

This past year we have taken management actions to insure that unnecessary duplication of research and development efforts does not occur under IR&D; the evaluation procedures for judging the technical quality of the IR&D efforts we support have been updated and clarified; and the intiative to improve the quality of IR&D through the university interaction plan has been implemented. A strong and healthy industry-university interaction will facilitate the flow of ideas from academia to industry, will make university researchers more cognizant of industry concerns and will better prepare students for the industrial environment.

F. Small Business Innovation Development Program

On July 22, 1982, the President enacted Public Law 97-219, the Small Business Innovation Development Act of 1982. The purpose of this Act is to stimulate technological innovation and to increase the use of small business in meeting Federal research and development needs. The Department of Defense has recognized that the strong high technology capabilities and experience of small business can make a valuable contribution to the R&D needs of DoD. This Act was modeled from a previous voluntary program, the Defense Small Business Advanced Technology (DESAT) Program. The DESAT program currently has 33 small business awards in effect. Small Business Innovative Research (SBIR) will become the primary DoD small business research and development program when the DESAT contracts are completed.

In Phase 1 of SBIR, 284 proposals were selected for funding from more than 2,900 proposals received by the Military Departments, the Defense Advanced Research Projects Agency and the Defense Nuclear Agency in response to the FY 1983 solicitation. The FY 1983 SBIR and DESAT funding will total approximately $20 million. In accordance with the legislative provisions of Public Law 97-219, DoD estimates that approximately $44 million in FY 1984 and $79 million in FY 1985 resources will be dedicated by this Act to small business R&D.

G. *In-House Laboratories*

The DoD in-house laboratories are the core of our Science and Technology Program, and efforts to improve their capability are receiving increasing attention from my office.

Implementation of recommendations identified by the report "USDRE Independent Review of the DoD Laboratories" and the recommendations of the recent ort of the White House Science Council - Federal Laboratory Revie 's in progress. Those recommendations dealing with issues relatir scientific and technical manpower have been receiving considerable attention within DoD as well as by the Office of Science and Technology Policy which is responsible for implementing the recommendations of the White House Science Council Report.

In my reorganization last year, the Office of Research and Technical Information was redesignated the Office of Research and Laboratory Management. This reorganization will give new impetus and renewed organizational focus to our goals for strengthening the DoD laboratory community. Thus far, I have been pleased with the office's approach of involving the Services' laboratory communities in a participatory process for developing action plans for improving the effectiveness of the in-house laboratories.

III. SELECTED FY 1984 TECHNICAL PROGRAMS

The S&T program covers a broad spectrum of projects of interest to DoD. The challenge is to invest in those areas where we can achieve the greatest return in terms of increased military capability. It is not practical to cover all endeavors in this statement; however, I will highlight a number of the programs underway.

A. Computer Software Initiative

An important ingredient of our science and technology based defense strategy is the use of "smart" weapons -- weapons which have sophisticated computers as integral components. In fact, computers have become essential to the military mission. Almost every defense system fielded today and virtually every military system planned contains a computer whose software provides a very high percentage of the functional capability of that system. Clearly, the future success of U.S. forces in defense or conflict will depend very heavily on the maturity of our computer technology and its applications.

Unfortunately, however, problems surrounding mission critical software are presenting serious limitations and portend severe future consequences unless action is taken. As pointed out by the Defense Science Board Summer Study of 1981, the opportunities to influence our defense posture as a result of improvements in the area of software are profound - but so too are the risks. No scientific or technical breakthrough in any one area will provide us all the opportunities available through software or solve all the problems. A coherent set of advances is necessary. The software initiatives of the Department of Defense are intended to affect the schedule, cost, performance, reliability, flexibility, and reuse of software. While a large portion of the effort addresses software technology development and application, attention is also given to relevant management and acquisition policies and practices. Currently, the DoD software initiative has three components: (1) Ada - the DoD high order programming language; (2) STARS - Software Technology for Adaptable Reliable Systems, which focuses on tools, techniques, etc. to support the automated software factory concept; and (3) SEI - the Software Engineering Institute which is an organization tasked with transitioning emerging technology into a form or baseline environment directly usable for the development and maintenance of defense systems.

Ada - Our first initiative in the software area was started in 1975. The intent was to attack the area of software where we would realize the quickest, most assured, and most widespread gains. That was the area of high order languages. The ultimate objective was to achieve a common high order programming language for DoD mission critical systems. The resulting language is Ada.

Substantial progress has been made in the Ada program. In 1983, Ada became both a military standard and an American National Standard, and we are now working toward international standardization. There are over 40 developments of Ada compilers and support systems in the free world. These are sponsored by governments, industry, and academia. The existence of these will aid our acceleration efforts. Also in 1983 we issued instructions on the use of Ada in all mission critical systems that enter advanced development in 1984 or that start full-scale engineering development after July 1, 1984.

STARS: Once the Ada programming language effort was soundly underway, DoD began to address other areas in which there were large gains to be made. The first of these was in the development of baseline Ada programming support environments. The intent was to provide a basic set of tools which would facilitate the development of Ada programs and subsequently to embellish that software suite with productivity enhancing aids. The two DoD efforts in this area are the Army/Navy Ada Language System (ALS and ALS/N) and the Air Force Ada Integrated Environment (AIE). A tremendous amount is being learned from these efforts about the form that future support systems should take.

As a direct result, the Department has been working jointly with industry to develop interface standards for Ada Programming Support Systems. These standards will facilitate the transportability of software tools across support systems produced by different companies. These standards are now under public review. A solid standard is expected by early 1985.

As shown in Chart 1 the Ada language and related tools only address a portion of the software life cycle activities. The STARS program is intended to augment these and complete the software development and evolution scenario.

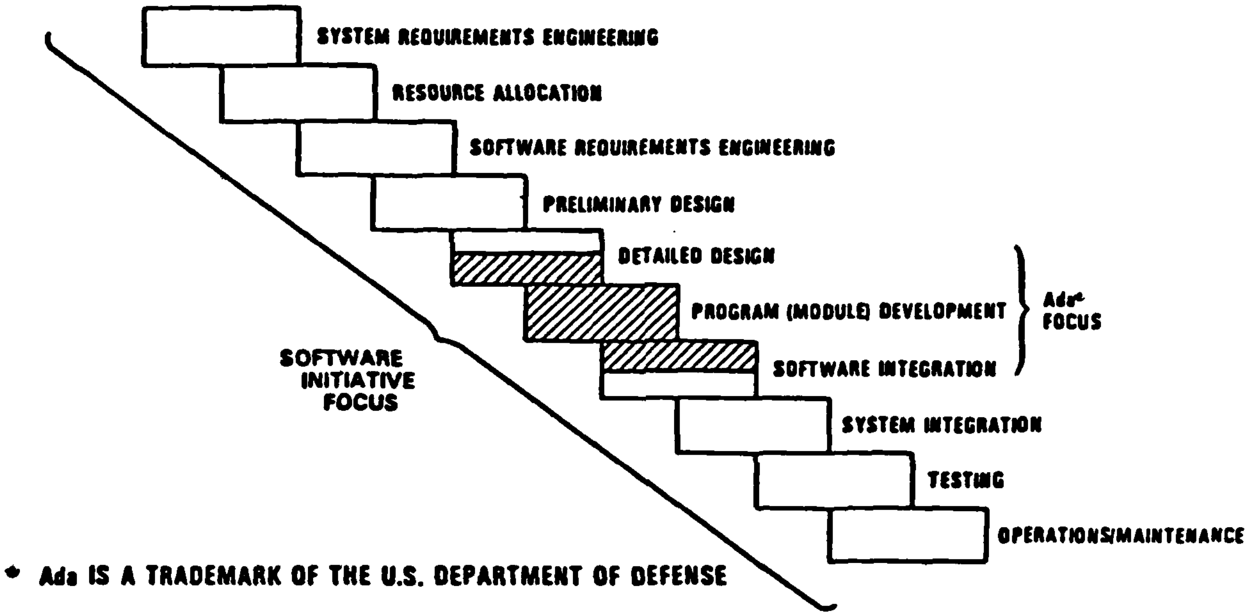
The fundamental objective of the STARS program is to reduce the labor-intensiveness of software development and evolution such that DoD can efficiently serve an increasing user base at affordable cost. STARS is a FY84 new start. It is a joint OSD and Service program managed by a joint Service program office.

The STARS program plan has received extensive review and has been endorsed by the National Academy of Sciences, the Institute for Electrical and Electronics Engineers (IEEE), the IEEE Computer Society, and the Electrtonic Industries Association among others. Service support is very strong. Industry indications are that the STARS program is greatly needed for the commercial sector as well as defense and that the STARS program will do for DoD and the U.S. software industry what VHSIC has and will do for DoD and the U.S. semi-conductor industry.

SEI: The third segment of our software initiative is the Software Engineering Institute (SEI). Software technology has been advancing very rapidly and a broad technical foundation for software engineering exists and will continue to grow under the Ada and STARS programs. For a variety of reasons, however, new software technology is not crossing the bridge into practice. The function of the SEI is to solve this technology transition

CHART 1

SCIENCE AND TECHNOLOGY PROGRAM



THE RELATIVE FOCUS OF ADA AND STARS WITH RESPECT TO THE SOFTWARE LIFE CYCLE problem. The SEI primary task will be dedicated to accelerating the transition of emerging software technology for use on our defense systems. The principal mechanism for this acceleration and transition will be via provision of an automated software factory, which will be developed in part under the STARS program and evolved and maintained under the auspices of the Institute.

The SEI is in the President's budget request. Our plan is to establish a new Federally Funded Research and Development Center (FFRDC) along the lines of MIT's Lincoln Laboratory formally linked with one of the top universities in the field of computers and computer science.

The DoD strongly feels that these three components of our software initiative will provide a solid foundation for future progress in this important area of military computers and software.

B. Very High Speed Integrated Circuits (VHSIC)

The VHSIC Program is the major DoD effort to develop and make accessable state-of-the-art electronic signal processing and integrated circuit technology which meets the requirements of military systems. VHSIC continues to receive the highest priority among the DoD technology programs and has begun to successfully produce some of the results for which the program was initiated.

The VHSIC Program approach is to develop two generations of advanced silicon integrated circuits or chips. The first generation chips, being developed in Phase 1, have internal feature sizes of 1.25 micrometers. During 1983, three of the six contractors having Phase 1 chips under development are in the final stages of design and fabrication. The demonstration "brassboards" which will be used to validate the effectiveness of the new technology in a military systems environment are also nearing completion at all of the contractors.

Important additions have been made to the overall VHSIC Program plan:

- A Yield Enhancement Program - to bring the cost of the individual VHSIC chips down to levels which make them affordable to use in a wide variety of system applications.

- An advanced X-ray lithography machine - to provide a submicron fabrication capability with a much higher production rate for future needs.

- A silicon materials improvement program - to ensure that the highest quality material is available for both development and production needs.

- A Technology Insertion effort - to support cooperative joint ventures with the managers of current DoD system programs. These efforts will provide increased mission capability and exploit the VHSIC technology to provide reliability and maintainability benefits for current and future systems.

- An Integrated Design Automation System (IDAS) - to cope with the immensely complex task of designing VHSIC-scale devices. Such an automated system is needed by the entire defense community to design VHSIC chips which now approach 500,000 transistors in complexity. In the next several years some of the VHSIC chips are expected to have more than 2,000,000 transistors.

VHSIC has had and will continue to have constructive interaction with both the silicon integrated circuit (IC) industry which manufactures integrated circuits and with the systems contractors who will use VHSIC technology in future defense systems. DoD's objective is to be at the leading edge in integrated circuit application and stimulate a national effort in this important technical area..

A second generation of VHSIC will be developed in Phase 2, based on silicon technology with the 0.5 micrometer feature sizes. Many of the techniques and most of the underlying knowledge needed for this technology have been emerging from university, industry, and DoD research efforts during the past two decades. This advance into the submicrometer region, where lithography is limited by the wavelength of light, is necessary in order to construct electronic signal processing systems of even greater capability. It will extend the beneficial application of VHSIC technology into the next century.

C. Research

The DoD Research (6.1) Program is made up of hundreds of projects, some are supporting long-range research to provide technological progress on an evolutionary basis, while others either have potential for revolutionary improvements in our future military capabilities or guard against possible improvements in our adversarys' position. Typical examples of areas we plan to emphasize this year include:

- Computer Sciences: DoD has long recognized the potential of computers in military systems and has pursued research in microelectronics and in computer science and engineering. Our current basic research into highly parallel architectures and algorithms is aimed at increasing computational speed so that we can consider more accurate models of physical phenomena. Our ability to do this will yield improvements in oceanographic and weather forecasting and on the prediction of flows used in the design of aircraft and ships. Increased speed will also permit the timely extraction of information from the growing data sets collected by advanced sensors. This year, semiconductor device research will be striving to attain ultra-high speed integrated circuits by focusing on high electronic mobility transistors and heterojunction bipolar transistors. In addition, existing devices (3-5 micrometer feature size) will be evaluated at the limits of their operating ranges in temperature, voltage, and device speed. The effort will determine how combat conditions affect the generation and detection of electronic signals.

- <u>Oceanography:</u> This broad research area addresses numerous problems of naval warfare. Of these, undersea warfare presents the greatest challenges, both in protecting friendly forces and in countering the enemy. The natural variability of the oceans influences the propagation and utility of signals used in detection, communications, and weapons guidance systems. These signals, both acoustic and nonacoustic, and our understanding of their ambient "noise" fields and variability, have long-term strategic significance with regard to determining the effectiveness of sea-based missiles. This year we will increase our efforts in marine bioluminescence. There are many questions to be addressed by the basic research program: What are the unique characteristics of bioluminescent organisms and in response to man-made disturbance, is it possible to use bioluminescence to rapidly assess the biomass, physiological state, and location of organisms that are producing the light?

- <u>Jet Engine Hot Section Research:</u> Research on jet engines will provide knowledge in a number of fundamental areas which if successful will result in substantially higher performance, more reliable jet engines. Major emphasis is being placed on prediction of turbulent reacting flows, chemistry and fluid mechanics of liquid and metal slurry spray combustion, durable ceramic-composite materials, and carbon-carbon material. Research will continue on new techniques which are essential in understanding combustion systems, airbreathing and rocket engines, and effective fuel utilization. Continuing research will be directed at the dynamics of high-speed turbulent steady-state flows and transient chemically reacting flows with emphasis placed on realistic modeling and characterization of the flow field processes. Physical and chemical reactions in exhaust plumes along with a number of radiation phenomena will be studied.

- <u>Biology and Medical Sciences:</u> Research on military disease, injury and health hazards provides the science base for DoD medical programs in combat casualty care, health hazard assessment of military weapon systems, militarily unique infectious disease and combat dentistry. Efforts are closely coordinated by the Services medical communities. In the recent past, new techniques for rapid assessment of microbiological safety of military rations were developed by DoD laboratory and university researchers. This year, research is planned for continued application of recombinant DNA technology and monoclonal antibodies essential for vaccines against Malaria, African Trypanosomiasis, Scrub Typhus, and diarrheal diseases. The application of nonspecific enhancers of immunity (immunomodulating agents) to the treatment and prevention of militarily important infectious disease will be studied. The potential military applicability of these compounds is especially great in the treatment of immunocompromised patients (i.e., irradiated or burned), the nonspecific treatment of fever illnesses, and the use of genetically engineered vaccines.

An important component of the DoD basic research plan to strengthen our overall posture in science and technology and to facilitate the application of the technology is a strong interaction among universities, Federal laboratories and industry. Our continued attention to this interaction is already paying off and has substantial long-range potential. Each of these performers of DoD research has its role and is making its contribution to our effort.

D. Materials and Structures

Our progress with the development of Metal-Matrix Composites (MMCs) for air and ground vehicles, missiles, and various items of ordnance equipment has been excellent. Several items, such as shipboard antennas, tracked vehicle shoes, long life submarine batteries, elements of aircraft empennage control surfaces, and helicopter transmission cases are in the demonstration and test phase. As examples, the MMC phased array shipboard antenna met all radiation requirements and was demonstrated to be fully survivable in the above ground high energy explosive test conducted by the Defense Nuclear Agency. MMC tracked vehicle components are undergoing actual vehicle endurance testing by the Marine Corps and the Army and a MMC F-15 aircraft tail section is being qualified for flight tests.

Also from this program an antenna boom for the National Aeronautics and Space Administration (NASA) Space Telescope program has been cooperatively developed and is baselined for the first flight on this program in 1985. This single 12-foot long boom also serves as a wave guide thus eliminating the need for separate booms originally planned, resulting in a 63 percent weight savings with a 50 percent increase in stiffness compared to aluminum. Additionally the NASA/DoE/DoD SP-100 nuclear space power development program will make significant use of the technology developed under our MMC program.

As an outgrowth of this broad technology development, a long range comprehensive program to develop MMCs for survivable large spacecraft structures has been started. This program will build upon the modest base established to develop the space telescope antenna support boom and a large spacecraft deployable antenna component program supported by DARPA. It will be guided toward generic component structural demonstrations and will necessarily include a large process development activity, design data collection, joining and inspection procedures, dynamic structural response investigations, and most importantly, analyses and tests of survivability capabilities. The major U.S. spacecraft manufacturers have enthusiastically responded by commiting considerable resources to a testing program to establish baseline/standard MMC components using government furnished MMCs.

E. Aircraft Propulsion Technology

Our technology base program in aircraft propulsion continues to be guided by two important facts: (1) rather modest increases in aircraft propulsion system performance have high payoffs in terms of the range/speed/payload/size/cost characteristics of air vehicles, and (2) the time required for aircraft propulsion system development is historically much longer than the time required for airframe development. Accordingly, our goals are to: improve performance; reduce development risk and costs; reduce maintenance costs; and reduce acquisition costs of aircraft propulsion systems.

In our Joint Technology Demonstrator Engine (JTDE) Program, we have recently demonstrated in a large fighter engine configuration the potential for a 15 percent increase in thrust/weight ratio, a 15 percent reduction in fuel consumption, and a 24 percent reduction in the number of parts compared to the current F100 engine. This variable bypass ratio configuration has completed over 120 hours of altitude and cyclic testing as a step toward improving our understanding of the engine environment and our ability to predict durability. We have also completed over 180 hours of cyclic testing on an improved core for this configuration which offers greater performance improvements. In the core of a competitive configuration, we have demonstrated the potential for a 20 to 25 percent increase in thrust/weight ratio, a 7 percent decrease in fuel consumption and a 60 percent reduction in the number of parts compared to the F100. This core has completed 80 hours of performance testing, and we have begun testing in the full engine configuration. In FY 1985 and FY 1986, we plan to demonstrate these improvements in full engine configurations and continue our assessments of durability to ensure technology readiness for transition to the Joint Advanced Fighter Engine (JAFE) for the next-generation tactical fighter aircraft, and other suitable applications.

The primary goal of our Modern Technology Demonstrator Engine (MTDE) Program is to demonstrate in a 6000-horsepower-class engine configuration a 20 to 30 percent reduction in specific fuel consumption compared to existing engines in this class (T55, T56, T64). We also expect to demonstrate the potential for significant reductions in acquisition and maintenance costs. One contractor has initiated gas-generator testing, and we anticipate that both contractors will complete the technical effort on schedule, in FY 1986. The potential applications for this class of engine include the joint vertical-lift (JVX) aircraft and the CH-47 or its replacement, and we plan to transition this technology demonstrator to full-scale engineering development of the Modern Technology Engine (MTE) in the latter part of this decade.

Recent assessments of the potential for technology advances in aircraft propulsion have indicated that significant improvements are foreseeable by the year 2000--for example, increases in thrust-to-weight ratio approaching 100 percent and reductions in specific fuel consumption of the order of 30 percent appear to be suitable goals in this time period. We have formulated an integrated technology plan based on reasonable technological alternatives to achieving these goals, and we shall continue to initiate and pursue the requisite ambitious Exploratory Development efforts.

E. Advanced Aircraft Technology

Approximately one-third of the Defense budget continues to be devoted to the acquisition, operation and support of aircraft and related equipment. Our aircraft technology program is oriented toward ensuring that this large investment in airpower will be as cost effective as possible by concentrating on technologies which will: reduce aircraft acquisition and support costs; develop new and more effective operational capabilities; and increase aircraft survivability. By the year 2000 incorporation of advanced aeronautical technologies is projected to provide an increased military capability equivalent to $20 billion annually that would be invested in additional units.

A key element in our ability to accomplish these improvements in military aircraft is our capability to transition technology into new aircraft or existing aircraft during modification cycles. In order to insure technology maturity, to foster user/technologist interaction, and to ultimately gain acceptance by the user, we have structured our program to focus on flight demonstration of emerging new concepts.

An outstanding example of the above technology transition mechanism is the Air Force Advanced Fighter Technology Integration (AFTI) Program which is directed toward providing significant improvements in combat aircraft capability through the integration of advanced flight control concepts with mission avionics systems. A major milestone occurred in this program in 1983, when a specially modified F-15B aircraft shot down a QF-102 drone in maneuvering flight at a closure speed of over 800 knots, a task heretofore considered impossible.

The focus of the AFTI program currently centers on an F-16 testbed aircraft that has been modified with the incorporation of a triplex digital flight control system and additional control surfaces which provide the capability to execute decoupled modes of motion (pure rotation or pure translation about any axis), and incorporate task tailored handling qualities. The Phase 1 flight tests of the AFTI/F-16 were completed early this year and included evaluations of: the triplex digital flight control system; task tailored decoupled control laws; controls and displays to reduce pilot workload, including a new wide field-of-view head up display (HUD); and voice command.

The second phase of the AFTI program will be devoted to exploring and demonstrating advanced concepts in automated maneuvering attack in both air-to-air engagements and in air-to-surface attack missions, to increase effectiveness and reduce aircraft vulnerability.

Our work in advanced rotorcraft is continuing to demonstrate a wide range of technology applicable to the Army's new light helicopter family (LHX). FY 1985 will see the culmination of our efforts to develop the Advanced Digital/Optical Flight Control System (ADOCS), with flight test of the concept in a modified UH-60 helicopter. The ADOCS is oriented toward increasing survivability through redundancy and exploiting the invulnerability of fiber optic data transmission to battlefield electromagnetic interference. Improved handling qualities and reduced pilot workload are seen as added benefits.

The Army is also pursuing the Advanced Composite Airframe Program (ACAP), which will demonstrate that composite materials technology can be applied to primary rotorcraft structures to achieve anticipated cost and weight savings of 22 and 24 percent, respectively. In addition ACAP will demonstrate reduced maintenance requirements, improved survivability, increased ballistic damage tolerance, reduced radar cross-section, improved crash worthiness and easier repair of battle damage. Bell Helicopter Textron and Sikorsky Aircraft are developing flight demonstrator concepts with flight testing anticipated to start in mid FY 1985.

G. Chemical Warfare Defense

The Department of Defense maintains a chemical warfare/defense technology program to improve both the defensive and retaliatory posture of U.S. forces. This is a key to overcoming the asymmetry in this area and developing an adequate deterrent posture. In addition, a small research program is in progress to develop new, innovative methods for disposal of obsolete or unusable munitions and agents.

The science and technology base in the chemical and medical defense areas has continued to expand with additional university and industry contracts. These are required to exploit new concepts and gain insight into basic mechanisms applicable to prophylaxis and therapy, decontamination, and detection and warning systems. New techniques involving biotechnology are being exploited in the detection field as well as the medical prophylaxis field.

Exploratory programs to apply the technology have been expanded to accelerate promising developments and to use available technology. Some of these developments include: investigations to incorporate antibodies to chemical agents and toxins in detectors; evaluation of man-portable mass spectrometers as detectors; an in-mask sampler and detector; and measurements of sub-doppler resolution vapor phase quantitative absorbence spectra of agents for detection systems. Development will continue on new decontamination concepts to rapidly decontaminate sorbed agents in fragile or sensitive materials or equipment. New protective materials development applicable to masks, gloves, and protective overgarments that provide agent resistance, durability, and enhanced operational capability without the attendant physical degradation to the wearer will continue. A number of promising antidote and prophylactic compounds as well as a casualty handling system will be pursued.

The technology applicable to new, more efficient munitions and chemical agents required to establish a credible deterrent will continue to be developed as well as a continuing evaluation of the threat and vulnerability of U.S. forces. This program will also consider toxin and other new threat agents to ensure that defensive equipment will protect against all threats.

Advanced development programs will concentrate on rapid detection systems, personal and collective protection and effective decontamination systems. These developments, when combined with improved training materials and techniques, will provide significant improvements in the survival of forces and sustaining operations in the contaminated battlefield.

H. Medical and Life Sciences

The medical and life sciences program is aimed at the following major goals: to improve the care of the combat casualty; to prevent militarily important disease and injury; to maintain and enhance personnel combat effectiveness and performance of individuals and man-machine systems; and to enhance human safety in military systems.

The Armed Services Biomedical Research Evaluation and Management Committee (ASBREM) has continued to function excellently in coordinating the DoD medical R&D programs and to be very useful in providing my office with support. The FY 1984 program reviews were conducted by the ASBREM which was an advantage in providing a comprehensive picture of the medical R&D programs. ASBREM completed a study of the opportunities for applying the lead agency concept in the area of combat casualty research which was requested by Congress. Based on that report and testimony received in hearings on the DoD medical programs, it was concluded by the House Appropriations Committee that these programs do not need to be consolidated at this time. ASBREM has been tasked by my office to provide us with a review of the applications of recombinant DNA and hybridoma technology to the infectious disease program with special attention to possibilities of expanding these applications in the future. An important advance in this area has been the doubling of projects which use these technologies in the past year. An example of this progress is the development and completion of testing of a completely genetically engineered vaccine to protect against dysentery.

Some examples of the productivity of the Medical and Life Sciences program in the past year and which also serve to emphasize the variety of research covered in this program are: the establishment of frozen blood facilities in Okinawa and on the USS Saipan to demonstrate the feasibility that frozen blood and blood components can be stockpiled for contingencies; the completion of the engineering design for an on-board oxygen generation system for aircraft; and the demonstration that L-tryptophan can induce sleep and allow for unimpaired performance if the sleep must be interrupted because of emergencies or mission requirements.

During the next year we will continue our efforts in the medical research program coordination assuring the relevance of these programs to the military and applying important advances in medical research to military problems.

I. Electronic Warfare

The Electronic Warfare (EW) Technology program is structured to provide a balance between near-term developments aimed at producing EW components for technology insertion into major systems, and longer term developments to meet the requirements of future warfare scenarios. The current program includes major thrusts in technologies to counter enemy communications, surveillance, tracking, and missile guidance systems operating in the radio frequency (RF), Infrared (IR), and electro-optical (EO) frequency spectrum.

Some of our accomplishments in the EW technology base which will provide product improvement in EW systems include:

- o Development and demonstration of a new infrared pyrophoric flare to protect our aircraft from enemy heat-seeking missiles.
- o Development of a millimeter wave (MMW) warning capability for integration on tactical aircraft and helicopter warning systems, e.g. AN/ALR-46, AN/ALR-67, AN/ALR-69 and the AN/ALR-74.
- o Demonstration of an advanced phased array transmitter to provide higher jamming power and increased frequency coverage for the EF-111 stand-off-jammer.
- o Development and demonstration of a new warning receiver for airborne detection of enemy laser radiation.

There are a number of relevant technological challenges with significant impact on EW in the 1990's and beyond. Current EW jammer capability is constrained in many cases by the limitations of power amplifiers. We are developing the capability for high power microwave amplifiers, more efficient tubes with greater bandwidth, broadband millimeter wave components, and broadband phased arrays employing traveling wave tubes and Gallium Arsenide amplifiers to generate higher effective radiated jamming powers. Corresponding developments are underway to generate higher power UHF and VHF sources to counter enemy communication centers. Major efforts continue in the development of solid-state lasers and detectors for countering enemy developments in the EO/IR spectrum.

Lessons learned during the Mideast conflict have resulted in an increased emphasis on distributed EW systems, particularly for tactical engagements. Experience clearly demonstrated the advantage of combining tactics with various EW techniques, e.g. drones, decoys, stand-off-jammers and defense suppression to achieve a decisive victory with minimum losses. In view of this, our EW technology program is being restructured to provide more emphasis on techniques supporting a mixed force concept. Major thrusts include:

- Expendable jammers to decoy enemy missile systems.
- Higher power stand-off-jammers using phased arrays to support tactical strikes into enemy territory.
- VHSIC and artificial intelligence processors to integrate RF, EO, and IR sensor data for more complete battlefield threat assessment in dense enemy signal environments.
- Drone-borne surveillance systems for real-time inspection of enemy positions and installations.
- Jamming concepts and techniques to support vehicles with reduced observables.

Finally, a major emphasis is being placed on both electronic counter-countermeasures and hardening techniques needed to protect our own radar and missile guidance systems from enemy countermeasures.

J. Search and Surveillance

The Search and Surveillance Program encompasses the functions of surveillance, reconnaissance, ranging, identification and classification. This field includes the mission areas of battlefield, undersea, and aerospace surveillance/search utilizing acoustics, EO and RF technology.

Our endeavors in these areas focus on the following systems:

- Night Vision: We are developing personal viewing devices and night sights for missile systems, combat vehicles, aircraft and fire control. Major goals include reduced cost of night vision goggles and forward-looking infrared (FLIR) systems incorporating focal plane arrays for increased detection range and reduced cost.

- Battlefield Surveillance: We are focusing on ground-to-ground systems for personnel and vehicle detection and ranging. Major goals are the development of low cost, common laser modules for rangefinders and target designators; laser wavelength diversification to reduce the countermeasure vulnerability and improve low system visibility performance; and, improvements in performance and foliage penetration capability of surveillance radars.

- Surface and Aerospace Surveillance: Our work is directed toward detection, location, identification and classification of targets located on the land or sea surface. Areas of emphasis include: advanced infrared search and track (IRST) system for passive detection of missiles and aircraft; long range classification of ships; long wavelength radar technology for all weather camouflage and foliage penetration; queing systems for reconnaissance to decrease operator detection time; and bi-static radar systems where the transmitter and receivers are separated to allow passive operation and anti-jam capability.

  A major thrust is the conformal array radar where solid state phased array transmit/receive modules are flush mounted on aerospace vehicles providing large volume search and surveillance capability without cumbersome rotating antennas.

- Undersea Surveillance: Our programs include the detection, localization and classification of undersea targets such as submarines and mines. The primary areas for increased emphasis focus on the technology to provide acoustic tracking and location of all military targets in an ocean basin.

K. Missile Propulsion Technology

Three significant efforts will dominate the missile propulsion technology base for the next three to five years. These efforts are concerned with space propulsion, ramjet propulsion and solid propellant burning rates.

During the past year the Air Force made a detailed evaluation of technology drivers for military operations in space. The analysis considered improving conventional launch vehicles, development of on-demand space missions, operation of a low earth orbit manned space base and space weapons, putting larger payloads in geosynchronous orbit (GEO), and needs outside of GEO. The major requirement was for new technology for orbital transfer vehicles, maneuvering in space, and placing more than 5000 pounds payload in GEO. In response to these requirements, we have initiated work on cheaper cryogenic engines, advanced structures, better thermal protection systems, and new propulsion concepts. Recognizing that future military operations in space will be dependent upon these advancements, about a third of the Air Force missile propulsion program is now devoted to space propulsion.

The USDRE has established a ramjet technology initiative which includes a coordinated effort among the Army, Navy, Air Force, DARPA, and NASA. Ramjets appear to be the key for the required increase in range to meet threats requiring engagement with the enemy at longer ranges for interdiction, outer air battle and wide area defense. Considerable research and development has been done on ramjets in the past, but they still have not been selected for fielded systems. Analyses of these programs indicate that the technology was not demonstrated adequately for users to have confidence in ramjets. We believe that ramjet technology demonstrations should be carried a step further than they have been in the past and that promising ramjet technology options should be evaluated. We are currently preparing an interagency ramjet technology plan to examine these options.

The third initiative in missile propulsion is the improvement of the burning rate of minimum signature solid propellants. When the ingredients that cause smoke from burning propellants are removed, the burning rate and energy content go down. A major effort is being made by the Army for ground applications and the Navy for airborne applications to raise the energy and the burning rate, with emphasis on the latter. The payoff will be tactical missiles that have higher performance with reduced detection from the smoke signature.

L. Training and Personnel System Technology

Over the past decade, there has been an increase in the technological sophistication of our hardware and software systems. During this same period, our country has experienced a serious decline in the basic math and science skills of our young people. The responsibility for bridging this gap between those basic skills required for operations and maintenance of our equipment and what the recruits bring with them into the Service is the responsibility of the Department of Defense. Because of this deficiency which may not fully prepare our young people to use the advanced technology available in the military and industry, we have begun a major effort to develop advanced training technologies that will adapt the course of study to meet the capabilities of the individual recruits. I am urging the Services to sponsor joint research and development projects in training and training technology. In addition, my office and the Assistant Secretary of Defense for Manpower, Installations and Logistics have established a joint Service center of excellence for training in Orlando, Florida, that features a computer-based instructional software library and a training data and analysis center. These actions should be effective in improving the capabilities of the men and women that will man our forces.

M. Munitions Technology

The effectiveness of conventional munitions continue to play an important role in the strength of our forces. Significant actions have been taken to improve our posture in this important technical area. Among them are:

o Explosively Formed Penetrators: This enhanced effort at the Army Armament R&D Center is focussed on shoot-to-kill munitions that have the potential to significantly increase the lethality of both direct fire and indirect fire ordinance.

o Directed Energy Warheads: This is a program to demonstrate a means to focus the fragment pattern of anti-aircraft warhead toward the target thereby significantly increasing the probability of kill.

o Munitions Effectiveness Methodology: This program asseses the lethality of candidate technologies by realistic target modelling as well as developing means of accurately reflecting the effects of subsidiary damage mechanisms on target models. Significant efforts are underway at the Service laboratories to advance the state-of-the-art in this area.

IV. Supporting Technologies

There are several behind the scene supporting areas related to the S&T Program that bear on the effectiveness of our forces and the R&D process itself.

A. Geophysics and Global Meteorological and Oceanographic Support

Our advances in the geophysical or environmental sciences are pointed toward optimizing the performance of the wide variety of weapon and sensor systems. Our major technology modernization programs for meteorological and oceanographic support are designed to provide significant enhancements in the operational effectiveness of our forces. The more sophisticated weapons and greater mobility of the modern combat forces are requiring significant advances in environmental support to ensure optimum performance. Many environmental situations can limit the use of certain weapons or tactics. The focus of our geophysical research and environmental support programs is to identify problems to assist in designing out limitations, and then provide the support to optimize employment tactics. In this way we can minimize problems such as unwanted spacecraft electrical charging; fog, snow, and dust limits on precision-guided munitions; natural underwater noise interference on anti-submarine warfare; and soft terrain effects on armor mobility.

The projects in environmental sciences continue to focus on tactical and space support problems. The Army has begun a major new effort to integrate the various elements of atmospheric sciences research and development into a coherent program to field the latest state-of-the-art hardware and software.

This is the Air Land Battlefield Environment program. New tactical decision aid software, tactical sensors and CRT displays provide the hub of the new Army environmental support technology. The Air Force Battlefield Weather Observing and Forecasting System is designed to solve the age old problem of acquiring prestrike low altitude weather observations over enemy territory and provide the newly developed tactical decision aid software for EO, IR, and millimeter wave precision-guided munitions employment. The Navy research and modeling projects are focusing on solving the difficult regional and small area forecasting problems which affect fleet task force operations. Another key area for environmental sciences is in the ionospheric and space sciences with emphasis on support for a number of vital surveillance and warning systems.

The major meteorological and oceanographic modernization programs are of vital importance to our forces. Our tactical forces operating in the field and aboard ships are using 1950 era meteorological equipment. DoD's technology transition program to provide off-the-shelf computer/display technology is the key to our ability to benefit from the advances in the research programs. The Navy's Tactical Environmental Support System will update the fleet by integrating oceanographic ASW and aviation shipboard support capabilities and provide the facilities for newly developed command and control support software. The Air Force Automated Weather Distribution System, a joint US-Canadian development with both fixed installation and tactical versions, will modernize the primary weather support operations but, more importantly, it will provide the capability for rapid support to weapons selection and employment decisions using the new tactical decision aids. The joint DoC/DoT/DoD Next Generation Weather Radar (NEXRAD) program has successfully moved into validation phase with its Doppler capability and offers DoD the greatest state-of-the-art advance in observing capabilities since the development of the weather satellite. Besides replacing the current failing equipment, the newly developed NEXRAD automatic algorithms for tornado warning, damaging wind tracking, and hail and wind shear detection will provide a new type of data to form the basis for continued improvements in DoD weather support for the next 10-15 years.

In summary, we are taking on the tough environmental support problems. Replacing our 1950 era environmental support equipment and building new support techniques for our combat forces will result in environmental sciences and support which will significantly enhance effectiveness.

B. The DoD Scientific and Technical Information Program

DoD-wide information support to technology base activities is provided by the DoD Scientific and Technical Information Program, primarily through the operations of the Defense Technical Information Center (DTIC), Information for Industry Offices (IFIOs) and twenty specialized Information Analysis Centers (IACs). DTIC maintains data bases on all planned and ongoing DoD research projects, on summaries of industrial IR&D efforts, and a bibliographic file for retrieving any of the million and a half technical reports in its collection. Use of these data bases and IFIOs helps to prevent duplication of projects, increases synergism in technical areas by identifying common interests among researchers, facilitates the sharing of planning information with industry to achieve better coordination and direction of national research efforts, and increases the productivity of bench-level scientists and engineers and technical managers by providing research materials and program information in easily-usable formats. The cost effectiveness and productivity enhancing potential of such support has been recognized by at least two task forces of the Grace Commission, whose estimates for cost savings in this area may well be underestimated.

The Information Analysis Centers serve as focal points for authoritative expertise in high-interest technical areas. They provide responses to direct technical inquiries, as well as technical handbooks and data books, state-of-the-art reviews, and technology assessments in their assigned areas of technology. IACs significantly reduce the time and effort of researchers in keeping current with fast-moving technologies and provide a source of evaluated information as opposed to uncorrelated data which may require extensive processing before it can be used. Some of the technical areas in which IACs have been established are nuclear information, tactical weapons guidance, metals and ceramics, metal-matrix composites, non-destructive testing, reliability, chemical propulsion, software, and therophysical and electronic properties.

V. CONCLUDING REMARKS

I have been able to cover only a sampling of all the technical programs within the DoD S&T program. S&T efforts in land mobility, ocean vehicles, tactical guidance and control, underseas warfare weaponry, guns and a host of other programs round out our goal to provide our future forces with the equipment and training they require for the nation's security. It is important that the DoD participate in and evolve these capabilities so that the U.S. can maintain a position of superiority in an arena that is so essential to our national well being.

In summary, our technological goals fit into DoD's objective for the long term modernization of our forces. Our programs are structured to provide us capable, affordable forces equipped to adapt to new and evolving threat environments and new theaters of operation. The long term future holds many international uncertainties for us and there is no clear way that we can forecast the events that will require the use of military strength either to deter conflict or, should deterrence fail, to deny adversarial forces their objectives. Although we can be certain that we will face uncertainty in the future, we can minimize the effects of the unknown to our forces and our nation if we are equipped with technological tools with which to conduct effective military operations. This is the purpose of our S&T Program. We solicit your continuing support in helping us to carry it out.

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