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**THE DEPARTMENT OF DEFENSE
STATEMENT ON
THE SCIENCE AND TECHNOLOGY
PROGRAM**

By
**COLONEL DONALD I. CARTER, USAF
ACTING DEPUTY UNDER SECRETARY OF DEFENSE
FOR RESEARCH AND ADVANCED TECHNOLOGY**

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**BEFORE THE SUBCOMMITTEE ON
RESEARCH AND DEVELOPMENT OF
THE COMMITTEE ON ARMED SERVICES OF
THE UNITED STATES HOUSE OF REPRESENTATIVES
99th CONGRESS, FIRST SESSION**

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The FY 1986 Department of Defense
Statement on
The Science and Technology Program

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Mr. Chairman and Members of the Committee:

I. INTRODUCTION

I am grateful for this opportunity to testify in support of the Department of Defense (DoD) Science and Technology (S&T) Program for FY 1986.

Today I will describe our objectives for the DoD S&T program, the role that it plays in the development and acquisition of materiel for the DoD, the relationship of S&T to the Soviet threat and the means by which the program is managed and executed in DoD. In addition, I will describe some of the specific programs that make up the DoD S&T program.

America's paramount national interests are peace, freedom and prosperity for ourselves and for others around the world. Supporting these interests is our desire for an international order that encourages self determination, democratic institutions, economic development and human rights.

In an increasingly complex world, the fulfillment of U.S. national interests requires military strength because the international order we envision cannot be guaranteed in the face of the numerically superior forces of our adversaries. Major developments in Soviet military capabilities pose new challenges to our defense policy:

- o The Soviet military buildup, both quantitative and qualitative, has produced a major shift in the nuclear and conventional balance.
- o The Soviet military posture has become increasingly more capable in its offensive orientation.

- o The Soviets have significantly extended the global reach of their military forces, enhancing their ability to project influence and power, especially in the third world.

Since 1981, substantial progress has been made toward ensuring that our military capabilities are strong enough to fulfill their critical purpose. Current programs are building more ready conventional forces, more modern nuclear forces, more modern command and control systems, well equipped tactical ground and air forces and greatly improved maritime forces. The technology that provided the options for this progress was developed over the past two decades by the DoD S&T program in partnership with the technology community of our private sector.

Technology, however, is a perishable commodity. Our task is to sustain progress in order that we will have the technical options available to provide future commanders and troops with the tools to accomplish difficult and uncertain tasks in many potential combat environments. However, the lead times from ideas to military hardware are long. Therefore, it is important that we conduct a strong and vigorous S&T program now as an investment in the future well being of the country's security.

The Soviets also recognize the importance of technologically superior weapons and have given their research, development, test and evaluation (RDT&E) program high funding priority. This heightens the challenge to the United States in that we depend heavily on qualitatively superior weapons to provide an edge over numerically superior adversaries.

In the technology race we do have an advantage not available to the Soviets. In addition to the efforts undertaken in the DoD S&T Program, the U.S. possesses a strong, viable and innovative private sector which is available to do sound research and development both on its own behalf and in support of the defense sector. The combined efforts of these participants has provided us the lead in most militarily significant technologies and it is important to continue a large and vigorous S&T program to preclude progressive erosion of our position.

As you can see from our program, we plan to continue reliance on the technology edge. It is the most viable of our options and we must increase our investment to maintain our technological lead. We plan to continue to make full use of the in-house laboratories and the industrial sector. In addition, we will continue to strengthen our relationship with the university community by allocating to them a significant portion of the basic research program, by continuing our program of upgrading university research instrumentation and by supporting efforts to increase scientific and engineering education in areas of interest to DoD.

The S&T program request for FY 1986 is \$5.3 billion which covers the combined Army, Navy, Air Force and Defense Agencies programs. Table I is a summary of FY 1985 amounts and our request for FY 1986. Table I includes Research (6.1), Exploratory Development (6.2) and Advanced Technology Development (6.3A).

The S&T Program encompasses the Strategic Defense Initiative (SDI) in the Advanced Technology Development category. This topic will be covered by

separate testimony. I have outlined the SDI amounts in Table I for informational purposes.

There is no doubt that the technological superiority upon which our national security depends is being challenged as never before. Our only hope of meeting this challenge is through the continued superior achievements in the DoD S&T program by academia, industrial and government organizations and with continued support from your Committee and the Congress.

TABLE I
SCIENCE AND TECHNOLOGY PROGRAM
(Dollars in Millions)

	<u>FY 1985</u>	<u>FY 1986</u>
Research		
Military Departments.....	778	870
Defense Agencies.....	83	101
Total Research.....	861	971
Exploratory Development		
Military Departments.....	1,515	1,685
Defense Agencies.....	746	870
Total Exploratory Development.....	2,261	2,555
Advance Technology Development		
Military Departments.....	1,163	1,546
Defense Agencies.....	214	202
Total Advanced Technology Development.....	1,377	1,748
TOTAL SCIENCE AND TECHNOLOGY.....	4,499	5,274
Strategic Defense Initiative.....	1,389	3,713

Note: Numbers may not add due to rounding

II. MANAGEMENT ACTIONS

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

A. DoD-University Relationships

The DoD-University Forum has made considerable progress during its first full year of operation as a Federal advisory committee. The DoD-University Forum is jointly sponsored by DoD and three higher education associations: the Association of American Universities, the National Association of State Universities and Land Grant Colleges and the American Council on Education. This year, the Forum has demonstrated its value by enabling the DoD and the universities to address together, in candid and constructive discussions, the range of mutual concerns and opportunities that will shape future research and education programs of importance to the national defense.

Among the issues dealt with by the Forum over the past year have been the development of DoD policies on the relation of export controls and university research; engineering and science education; and, foreign languages and area studies. In particular, the DoD-University Forum and the discussions which led to its establishment have helped to bring a new awareness to the defense community of the vital role which the nation's university research and education programs play in maintaining the country's economic and military strength.

As the first full year of the Forum closes, the principal concern being addressed is the part DoD should play in supporting science and engineering education to enhance the success of its national security mission . DoD's initiatives to increase Basic Research (6.1) funding to institutions and interactions which enhance quality education and training in defense-related research have received a strong and favorable response from the academic, industrial and public sectors.

B. University Research Instrumentation Program

Research success is tied closely to the implementation of the extraordinary advancements in laboratory instruments. However, the costs of new instruments (that enable major advancements) are often beyond the budget of research grants and contracts. The University Research Instrumentation Program (URIP) addresses this problem. URIP is a five-year, \$150 million DoD initiative to upgrade research instrumentation, funded at \$30 million per year through FY 1987. The program is directed at major items of equipment (\$50,000 to \$500,000) and approximately equals the funding level for equipment items which are routinely included in research contracts with universities. In our first three years, we awarded \$90 million in over 650 grants to 152 universities in 47 states. For FY 1984 and FY 1985 we have received 1870 proposals requesting \$370 million in grants. This has been a very successful program.

C. University Research Initiative

In FY 1986, the Department of Defense will initiate a new university research initiative. This program will address some of the concerns expressed

by Congress regarding DoD support for the infrastructure of science and technology in the United States. Twenty-five million dollars has been included in the Research (6.1) program, approximately \$6 million for each of the three Services and DARPA. In FY 1987, funds for the initiative will grow to a total of \$50 million. For the first two years of the program, each of the four components will give priority to graduate fellowships, research assistantships, exchange scientists and instrumentation programs. Emphasis in later years will shift toward university research projects in a number of new, potentially high payoff projects in emerging technologies such as materials and structures, biotechnology, computer sciences, mathematics and statistics, electronics, fluid mechanics, aeronautics, physical sciences and chemical sciences.

D. S&T Role in Export Control

Management of the DoD export control process was enhanced by the establishment of the International Technology Transfer Panel and two subpanels, Subpanel A on Export Control Policy and Subpanel B on Research and Development issues. Subpanel B formalized a much needed process to balance the requirement for export controls while still relying on an open scientific environment to provide the technology which will leverage our military, and indeed, national security. Among the accomplishments of the group was the development of implementing regulations for DoD's new authority (granted by the 98th Congress) to withhold certain export-controlled technical data. This directive, "Withholding of Unclassified Technical Data from Public Disclosure," establishes a system where technical data can be shared within the U.S. with a minimum of administration, without losing the protections of

our export laws. Another directive was revised to support this system by requiring that newly generated technical documents be plainly marked if they are subject to the withholding authority. In addition, throughout the year expert technical support has been provided to the Department of State in the identification of emerging technologies and in their COCOM review of specific items on the Commodities Control List.

E. Independent Research and Development (IR&D)

Independent Research and Development is the company-selected, company-sponsored technical effort necessary to remain competitive in a technological environment. The DoD recognizes IR&D charges in overhead as a necessary cost of doing business with its contractors. Through recognition of the independent nature of IR&D efforts, the DoD seeks to encourage innovative concepts that broaden and complement those being developed internal to the DoD, to stimulate competition, and to contribute to the economic stability of its contractors by allowing them to develop a broad base of technical products.

DoD contractors' IR&D technical programs, including results of their efforts, are reviewed annually for technical quality and relevance to DoD functions or operations. During the past year, the DoD has highlighted for its contractors two areas of special concern. These are increased industry/university interactions and increased attention to weapons systems supportability and maintainability.

The ultimate objective in stimulating greater interactions between companies and universities is to speed the transition of research discoveries from academic to industrial application. The industrial response to DoD encouragement was good in 1984. Companies reported establishment or expansion of their involvement with educational institutions in a variety of ways. We believe that the mutual benefits accruing to both the companies and the universities will promote continued expansion of these interactions.

Supportability and maintainability of our weapons systems are recognized as crucial. The DoD has endeavored to convey to its contractors the need for consideration of maintainability and supportability at the earliest possible phases in the developmental process. This special initiative was implemented in 1984, through contractor identification of such support efforts and specifically focused review by DoD logistics experts of IR&D projects for weapons systems support considerations.

F. Small Business Innovation Development Program (SBIR)

The President signed the Small Business Innovation Research Program (SBIR) into law in July 1982, and DoD, like other Federal Agencies with major R&D programs, established an SBIR program in FY 1983. In FY 1986, we estimate that DoD SBIR awards will be about \$160 million. We are providing central management of this program to ensure coordination of the annual solicitation brochure and evaluation procedure. In FY 1984, 368 proposals were accepted from more than 3000 proposals received and approximately 30,000 FY 1985

solicitations were distributed. This program is encouraging rapid implementation of high technology and provides incentives for the high technology businesses to involve university researchers.

Even though the SBIR program is relatively new, it is already a successful endeavor. As an example, a West coast small business has demonstrated a chemical vapor deposition process for high temperature oxidation protection for refractory metals. This advancement is expected to establish a new manufacturing capability for a wide variety of high technology components for energy conversion systems.

G. Consolidation of Computer Resources Management

During the past year we have taken several steps to consolidate and strengthen the management of defense computer resources. The Deputy Under Secretary of Defense for Research and Advanced Technology (DUSD(R&AT)) was designated as the Senior Official for Mission Critical Computer Resources with the authority to determine which systems are designated mission critical in accordance with the provisions of 10 U.S.C. 2315, the Warner Amendment. Also, the DUSD(R&AT) is the principal advisor to the Defense Systems Acquisition Review Council on mission critical computer resources and is assisted in policy matters by the newly established DoD-wide Computer Resources Council and Defense Computer Resources Board (DCRB). These management changes will improve the ability of the Department to manage this important resource efficiently and effectively.

III. SELECTED FY 1986 TECHNICAL PROGRAMS

The S&T program covers a wide range of projects and programs of interest to DoD. These projects and programs form the basic foundation for our future military forces. It is not practical to cover all endeavors in this statement; however, a number of the programs underway will be highlighted.

A. Software Initiatives

Advances in computer hardware technology and architectures by themselves only go half-way toward significant improvement in system performance. Without software to define the functions these computers are to perform, such computers are essentially "empty" or "hollow" electronic black boxes. Software is the human intelligence that is programmed into our systems. It allows advanced sensors to discriminate and track, navigation systems to follow prescribed routes, guidance systems to control trajectories, and communication systems to properly route thousands of messages. Software keeps track of the status of our forces, maintains intelligence information on enemy forces and aids our commanders in deciding on targeting actions. Virtually all modern defense systems are critically dependent on computers and their software - and will not work without them. Of 160 major programs discussed in the Secretary of Defense's Annual Report on the FY 1985 budget, 120 have a very large and critical software component.

Unfortunately our ability to rapidly create reliable software at affordable costs has not kept pace with the demand for software or with advances made in computer hardware. The need for software grows with each new system and with each system upgrading. These demands are outstripping our capability to be responsive to all our software requirements.

The Department of Defense has a major software initiative to provide these needed improvements. This initiative includes the Ada Program, the Software Technology for Adaptable, Reliable Systems (STARS) Program, and the Software Engineering Institute.

The Ada Program involves the development and implementation of a common high order software language for defense systems. The Ada language, now a standard of the American National Standards Institute, is required for all mission critical computer systems in DoD. It has received wide-scale international acceptance and will be a required NATO standard. It is one of the two programming languages authorized for defense systems in the United Kingdom. The International Standards Organization has accepted DoD's description and reference manual as a proposed standard, a significant step toward its approval as an international standard. Compiler developments have had dramatic success. There are validated compilers hosted on ten different computers and over thirty more are in development. Experiments in developing avionics software for digital flight control using Ada have demonstrated a fivefold improvement in programming productivity. These experiments were conducted by two different contractors with F-15 and F-20 aircraft. While much is still left to be done, we are now beginning to experience real payoffs.

The Software Technology for Adaptable Reliable Systems (STARS) Program complements and builds on the solid foundation of the Ada Program to address other aspects of software development. Its objective is to increase productivity by at least a factor of ten beyond that available through Ada, and at the same time greatly improve the reliability of our software products. STARS will make improvements to all aspects of software planning, development,

testing, acquisition and reuse that occur throughout the life cycle of software-based systems. STARS will develop automated aids for software requirements, specifications, and design. STARS will develop means to permit rapid prototyping of software.

In the near term, the STARS program has three primary thrusts: (1) the integration of a number of automated aids, or software tools, together with Ada compilers into cohesive systems to achieve a much higher degree of automation. In this way, the labor-intensiveness associated with software development will be reduced. These systems are called "software engineering environments" and are the key to the achievement of an "automated software factory" capability. (2) The development of means for reuse of previously developed defense software packages or components, including the development of libraries of reusable defense software. And finally, (3) the transition of software developments into practice. Toward this latter thrust, the Software Engineering Institute (SEI) was established.

The SEI was established in 1984 as a companion to STARS. Its primary mission is to accelerate the transition of new software technology from research, development and academic institutions to widespread use in the defense industry. Early studies have shown and the STARS program has confirmed that a significant amount of new software technology has been emerging over the past several years offering the opportunity to make significant improvements in the practice of software. Unfortunately, this technology has been very slow in making its way into practice in industry. Adopting a new technology can be

costly and the unfamiliar often seems risky in the context of a real system's budget and schedule. The SEI will evaluate and demonstrate the emerging software technologies and will provide assistance to system program offices in the use of such technology. A small amount of the SEI's resources will be devoted to research in software engineering environments and in software engineering training.

B. Very High Speed Integrated Circuits (VHSIC)

The VHSIC Program is the major effort in the DoD Science and Technology program to develop state-of-the-art integrated circuits (IC's) meeting the requirements of military weapon systems, and to make that technology accessible to our weapon system developers in a timely fashion. VHSIC continues to receive the highest priority among the DoD technology base programs and has begun producing the results for which the program was initiated.

The VHSIC Program will produce two generations of advanced silicon IC's or chips, with the goals of increasing the U.S. lead time in IC technology deployed in weapon systems and minimizing the time delay before technology deployment. The first generation chips have internal feature sizes of 1.25 micrometer and clock rates of 25 MHz or greater. The second generation chips will have internal feature sizes of 0.5 micrometer and clock rates of 100 MHz or greater. The first generation devices will recover one-half the lag time behind equivalent commercial technology introduction that has developed over the past two decades, and the second generation deployment will intercept the commercial pace.

The first phase of the program has been substantially completed. Each of the six VHSIC contractors has fabricated fully functional first generation IC's of at least one chip type, three contractors have completed their full Phase 1 chip sets. All together they have produced over 2,000 fully functional VHSIC chips. In addition, application system brassboards have been successfully demonstrated, computer-aided design tools have been developed and beneficially employed, a VHSIC hardware description language has been defined, advances have been made in silicon starting materials and lithography equipment, and several issues involving packaging, testing and qualifying VHSIC chips have been resolved. Thirty-eight programs to insert VHSIC technology into actual weapon systems have been initiated, which coupled with fabrication yield enhancement programs and manufacturing technology initiatives, will get the Phase 1 advanced IC technology into weapon systems almost three years ahead of the original schedule.

Contracts were awarded to three companies in late 1984 to initiate development of the critical second (0.5 micrometer) generation of VHSIC. Submicrometer IC's will be necessary for providing the compact high-speed signal processing and data processing capabilities that will be required of military systems in the late 1990's and beyond. We will continue to provide the VHSIC Program strong management emphasis to achieve the expected increase in war-fighting capability that will result.

C. Research

The DoD Research (6.1) Program supports long-range research to provide technological progress on an evolutionary basis. However, some projects have potential for revolutionary improvements in our future military capabilities. Enhancement of our research base guards against technological surprise by our adversaries. Typical examples of areas we plan to emphasize this year include:

- o Oceanography: Prediction of oceanic conditions is critical to the optimal deployment of strategic and tactical naval forces. Our research efforts in oceanography are expanding and focusing on the coupling of remotely sensed ocean data with super computer technology to provide improved predictive capability for dynamic ocean processes which directly impact military operations. With a better understanding of ocean fronts, eddies, sea state, rainfall and near-surface winds we can optimize deployment of forces both offensively and defensively. These same ocean parameters have broader scientific interest and impact in the improvement of global weather forecasts, assessment of climate change and for many areas of resource recovery including fisheries. We are continuing to develop the Navy Remote Ocean Sensing System (NROSS), the Nation's first operational oceanographic satellite, which will provide data of vital interest to military operations, the ocean research community and the civil sector. Our oceanographic research efforts continue to be closely coordinated with the programs of other agencies both to optimize resource expenditure and to insure the long term health of U.S. scientific leadership in this important area of environmental science and technology.
- o Aircraft Maneuverability: This initiative will provide the scientific and conceptual foundations for enhancing technologies which will exploit controlled, unsteady flow separation for high maneuverability flight in the post-stall environment. The scientific goals are to provide fundamental understanding of the dynamics and controllability of unsteady flow separation, to develop generic actuator and unsteady flow control concepts, and to provide new theoretical and computational methods for accurate and reliable prediction of highly-coupled and strongly-nonlinear fluid-structure interactions.

Advanced aerodynamic concepts based on lift enhancement by controlled, unsteady, separated flows, together with new knowledge of strongly-coupled fluid-structure interactions and advances in distributed parameter control theory will enable the development of new technologies for highly maneuverable flight vehicles.

- o Monolithic Microwave and Millimeter Wave Integrated Circuits. This initiative seeks to identify improvements in materials, device designs and automated processing techniques supporting the development of monolithic microwave and millimeter wave integrated circuits. Monolithic refers here to the fabrication on a single semiconductor chip containing all needed active and passive components such as transistors, capacitors, inductors, and interconnections. Basic research is needed on substrates, active layers, device modeling, millimeter wave device designs, and monolithic integration. Among the significant advantages of the monolithic approach are: cost reduction, reliability improvement, size and weight reduction, performance improvement, and new and improved functions.

Systems that would benefit significantly from this technology are future airborne surveillance radars, space based radars, tactical radars, terminal missile guidance systems, broadband surveillance receivers and secure communications.

- o Computer Science. The speed of electronic computers has increased a million-fold primarily because of the progression from vacuum tubes to transistors to integrated circuits. However, speed increase due to this type technology has limitations. The DoD is now focusing long range computer science basic research on parallel computer architecture and on parallel algorithms. This relatively new research has produced significant ideas and progress for speeding up the solution of specific problems such as matrix multiplication which plays a key role in scientific computation. Research in this area will lead the way toward the development of more flexible parallel processors for critical applications in robotics, scientific computation, artificial intelligence, and intelligence.
- o Biotechnology. Biotechnology provides an opportunity to create new protective and treatment measures for naturally occurring infectious diseases, biological warfare agents and chemical warfare attacks. Product development potential includes vaccines, diagnostic agents, and rapid detection and identification systems. One possible use for biotechnology enzymes is the neutralization of nerve agents while other products could be developed for degradation and decontamination of biological and chemical agents. In addition, application to materials, adhesives, lubricants, enzyme cleaners, compliant coatings, etc. could have both logistical and operational implications in military scenarios.

D. Materials and Structures

An important achievement emerging from materials technology is the direct transition of the erosion resistant carbon/carbon (C/C) composite nose tip technology to the TRIDENT D-5 re-entry vehicle. This achievement resulted from a Navy/Air Force thrust to develop C/C composites needed to improve the all-weather capability of re-entry vehicles. The C/C composite program is being expanded to the development of materials for extremely high temperature gas turbine applications. A tri-Service/Defense Advanced Research Projects Agency program has been launched to move the development of these materials into testing because of the high payoff potential in fuel consumption and weight reduction.

Components developed in the metal-matrix composites (MMC) program are moving from development to the structural test and demonstration/validation phase. The MMC helicopter transmission case developed by the Army will soon be rig tested. The missile fins and wings developed by the Navy will be flight tested and an Air Force MMC missile motor case will be hot fired during this coming year. Other MMC components, such as long life submarine battery grids, tracked vehicle components, and kinetic energy penetrator sabots have transitioned rapidly into system development.

Progress is being made in the MMC spacecraft structural survivability program initiated last year. Large quantities of carefully controlled, very high modulus, graphite fiber reinforced aluminum and magnesium matrix uniaxial sheets and plates are being fully characterized before being subjected to underground nuclear and laser testing at in-house and contractor facilities.

In addition, tubes and other structural elements are being fabricated and tested by major spacecraft manufacturers. A computerized data bank, which will be accessible to all qualified requestors, is being established to assist in the management of this program.

E. Aircraft Propulsion Technology

The S&T program in aircraft propulsion continues to be guided by two important factors: (1) modest increases in aircraft propulsion system performance which 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 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 engines.

In our Joint Technology Demonstrator Engine (JTDE) program, we continue to make progress toward our immediate goals, in large fighter engines, of demonstrating the potential for a 15 to 25 percent increase in thrust/weight ratio, a 7 to 15 percent reduction in fuel consumption, and a 24 to 60 percent reduction in the number of parts compared to the current F100 engine. Over 370 hours of performance and life assessment testing have been completed on one experimental engine configuration, and approximately 100 hours of similar testing have been completed on a competitive configuration. The data obtained thus far has verified the performance levels, and that the desired life appears to be achievable. In FY 1986, we plan to continue our demonstration of performance improvements and our assessments of durability to ensure

complete technology readiness for transition to the Joint Advanced Fighter Engine (JAFE) for the next-generation tactical aircraft, and other suitable applications. For the longer term, we have also initiated efforts aimed at demonstrating significant performance improvements beyond JAFE, e.g., a 50 percent increase in thrust/weight ratio, and we are pursuing an exploratory development program aimed at more than a 100 percent increase in thrust/weight ratio by the turn of the century.

The Modern Technology Demonstrator Engine (MTDE) Program, initiated in FY 1983, is also progressing well. One contractor has completed approximately 80 hours of testing of a full engine configuration, and the results obtained were in basic agreement with pre-test predictions. The other contractor has initiated gas-generator high-pressure spool testing, in addition to conducting extensive component testing. We anticipate that both contractors will complete the technical effort on schedule, in FY 1986, and that the goal of demonstrating a 20 to 30 percent reduction in fuel consumption compared to existing engines in this class, such as the T55, T56 and the T64, will be achieved. These engines are candidates in the joint vertical-lift aircraft (formerly the J VX, now the V-22) engine competition, and a decision is expected in the summer of 1985.

F. Advanced Aircraft Technology

The importance of aviation to the Defense mission is reflected in the allocation of approximately one-third of the Defense budget for the development, procurement and operation of aircraft and related equipment. Therefore,

we strive to take advantage of the leverage afforded by research, exploratory development and advanced development programs in the aeronautical area. The major driver is the need to counter known and anticipated threats to U.S. operational systems. As in other areas, a major consideration is pursuing needed aircraft improvements that are both affordable and cost-effective.

The Air Force F-16 Advanced Fighter Technology Integration (AFTI) program completed a demonstration of a triplex digital flight control system and auxiliary control surfaces. The program's second phase, now under way, is an investigation of the feasibility of an Advanced Maneuvering Attack System (AMAS). The fully integrated AMAS provides for highly accurate, maneuvering attack against ground targets at very low altitude, as well as improved capabilities in air-to-air combat. This phase of the investigation will be completed in 1986, and the technology will be available for possible use in the Air Force Advanced Tactical Fighter in the 1990's time frame.

In October 1984 the Air Force awarded a contract to modify an F-15 aircraft into an experimental configuration to investigate short takeoff and landing (STOL) and maneuvering capabilities. Advanced technologies to be incorporated include a two-dimensional thrust vectoring and reversing exhaust nozzle, an integrated flight and propulsion control system, advanced cockpit displays for STOL operation, and rough/soft field landing gear. Program objectives are to demonstrate technologies which can increase combat maneuverability and effectiveness and which permit very short and rough field operations which would be required, for example, on bomb-damaged or unprepared runways.

The Navy is continuing its research on high angle-of-attack flight behavior of fighter aircraft in a five year joint program with NASA. The program includes computational aerodynamics assessments, wind-tunnel model tests, and full scale flight research with an F-18 developmental aircraft. Results of this program will be used to enhance the F-18's maneuverability and expand its safe-flight envelope and will also provide generic design information for future high performance aircraft.

Technology programs applicable to the Army's new Light Helicopter family (LHX) are continuing. An important element of this work is the Advanced Digital/Optical Flight Control System (ADOFCS), to be validated with a flight demonstration program using a UH-60 helicopter. An essential factor in this is increased system reliability through redundancy and the invulnerability of fiber optic data transmission to battlefield electromagnetic interference. Other factors include improved vehicle handling qualities and reduced pilot workload.

The Army's Advanced Composite Airframe Program (ACAP) last year passed a milestone with the flight of the Sikorsky Aircraft ACAP flight demonstrator. The Bell Helicopter Textron ACAP flight demonstrator is scheduled for a first flight in mid-1985. A primary objective in each program is to verify that all-composite construction would increase helicopter mission effectiveness and survivability through reduced radar cross-section and greater ballistic damage tolerance. Other expected benefits are easier repair of battle damage,

improved crash survivability for the crew, and reduced maintenance requirements. Anticipated cost and weight savings for these structures remain 22 and 24 percent, respectively, relative to conventional metallic designs.

G. Undersea Warfare

Changes in the submarine threat have created a need for improved torpedo warheads, as well as better propulsion, lower drag, and quieter operation. Some of what has been learned in land warfare in defeating armored targets can be transferred to the underwater environment. However, the special conditions dictated by the anti-submarine warfare environment create new problems which must be addressed and require exploration of new technologies. Undersea warfare technology is supported by only one Service and is an area needing attention and support. The FY 1986 programs give this area increased attention.

H. Missile Propulsion

A major part of our strategic and tactical defense depends upon the reliable and safe operation of rocket motors. For the most part, missile performance improvements in range and average velocity have been evolutionary rather than revolutionary. For example, the Air Force demonstrated the feasibility of composite material motor case construction for air-launched missiles which reduced missile weight and increased range and speed. Navy exploratory development efforts established the techniques for producing extruded, more energetic propellants for unguided rockets which simultaneously improved performance and simplified manufacturing procedures.

Ramjet and multiple pulse rocket motors are two efforts that offer the potential for revolutionary improvements in missile range and velocity. Ramjets can potentially double both range and average velocity of tactical missiles without an increase in missile weight or volume. This is possible because the ramjet uses atmospheric oxygen as an oxidizer rather than carrying its own oxidizer as in conventional rockets. An Air Force ramjet engine was recently selected for the Navy's Supersonic Low Altitude Target (SLAT) program. Ramjet engines and pulse rocket motors are under consideration for application to the Air Force's SRAM II program.

Technology base efforts for space applications are strongly influenced by DoD use of the space shuttle. Emphasis is on "work horse" type rocket motors that can be deployed from the shuttle, "parked" in orbit for long periods of time and used to boost payloads from low orbit to higher orbits. Exploratory and advanced developments are concentrating on improved performance liquid fueled rockets with new fuel tank packaging concepts. More "exotic" propulsion concepts are also being considered with the goal of providing motors that remain in space indefinitely and can be used repeatedly to transport payloads from low to high orbits. One such concept uses concentrated solar radiation to provide the heat energy for the rocket propellant.

In summary, rocket propulsion capability continues to be a valuable national asset and technology efforts to maintain our lead in this area are being continued.

I. Chemical Warfare Defense

A principal factor in developing an adequate deterrent posture for U.S. forces is the maintenance of an S&T program in both the chemical defensive and retaliatory areas. In addition, development and procurement of the products of the technology program are required to overcome deficiencies in this area. A small research program is maintained to develop new and innovative techniques for disposal of obsolete and unusable munitions and agents and a small effort has been initiated to develop treaty verification techniques and procedures.

The S&T Program in the chemical and medical defense area continues to expand in the university and industrial contract areas. These efforts are needed to exploit new concepts, take advantage of all expertise, and better understand the basic mechanisms and actions involved in medical prophylaxis and therapy, decontamination, and detection principles. One new technology involved, biotechnology, is already promising significant advances in detection devices and in new vaccines and prophylaxis.

Exploratory development programs have expanded to accelerate promising technology and to apply new concepts. Some of these efforts are: evaluation of decontamination and protective formulations for use on intact or injured skin; development of a low-temperature regenerative air purification device and a pressure swing regenerative filter for air purification systems; development of a freon based and multipurpose decontamination systems; assessment of distribution of contamination in complex terrain; exploitation

of sea water for Navy use in decontaminant formulations; and, development of future overgarments and new concepts for hand and foot protection.

Development will continue in many areas such as evaluation of a man-portable mass spectrometer detector system; a vital signs monitor for casualties; filter efficiency studies and regenerative filter prototypes; and new decontamination concepts to effectively and rapidly decontaminate sensitive materials and equipment. Assessments will be made under operational conditions of the individual and combined effects of nerve agent and pretreatment compounds. Development of an effective chemical casualty care system will be continued. A chemical warfare, chemical/biological defense information center will be established.

New, more efficient and safe chemical munitions will continue in development to ensure that technology is available to establish a credible deterrent. A part of this effort is a continuing evaluation of the threat and vulnerability of U.S. forces including consideration of new threat agents to insure that the defensive equipment in development will protect against all possible threats.

J. Training and Personnel Systems Technology (TPST)

While the science and technology programs are oriented toward the development of future capabilities, they are also rooted firmly in the training and personnel issues being faced by the Services today. Personnel and related costs are the DoD's largest single expense of the Defense budget.

In future major military confrontation, our adversaries will undoubtedly be able to supply far greater numbers of people than the U.S. can. Our approach must be to improve the productivity and effectiveness of our military personnel by multiplying our capability with innovativeness of selection, training and use of manpower while continuing to improve the design of equipment for operation and maintenance.

It is well known that computer-assisted instruction, which is an individualized method of instruction, in many instances teaches military personnel as effectively as conventional, classroom instruction while saving about 30 percent of the time required to complete technical courses. This coming year, the DoD will be embarking on demonstration programs to evaluate, in the field, "personal" electronic training and job aids which are small enough to be hand carried. We believe that the further development and proper implementation of such portable instructional aids will continue to provide major enhancements in maintenance capabilities, both in training and operational situations. Such a device is but one example of how our technological accomplishments in semiconductor logic, memories, displays, voice synthesis and consumer electronics can be focused to improve the capabilities of our military personnel.

Portable maintenance aids will help with a great number of tasks. However, there is a continuing need for improved hands-on maintenance training. Just as flight simulators have been shown to provide effective pilot training, maintenance simulators are projected to do the same. In addition, maintenance trainers which are simulations of the actual equipment

are more easily modified as engineering changes occur. These trainers can be used with complete safety; they can train for every conceivable maintenance action required; and they cost up to two-thirds less than the actual equipment. This year we will see an increased emphasis on such simulators which, when combined with the portable aids and our new programs emphasizing design criteria for maintainability, will reduce the cost, errors and time required for maintenance.

To monitor these and other projects, an R&D management system is being established at the Defense Technical Information Center which will be on-line to appropriate laboratories with specially tailored summaries and available technology to industry. This type of system should significantly reduce the paperwork burden.

K. Medical and Life Sciences

The medical and life sciences program is aimed at improving the care of the combat casualty, preventing militarily important disease and injury, maintaining and enhancing personnel combat effectiveness; and enhancing human safety in military systems.

The program continues to be ably coordinated through the Armed Services Biomedical Research Evaluation and Management Committee (ASBREM). ASBREM conducted the FY 85 program reviews and assisted OSD in studies and topical reviews. One of these studies concerned the integration of new biotechnology techniques (recombinant DNA, hybridomas, monoclonal antibodies) in the

infectious disease program. This study showed that these technologies are being extensively used in all of the infectious disease areas where they are applicable. One of the accomplishments was the cloning and sequencing of the protein which stimulates the immune response of one of the causative organisms of malaria, a major step forward in the development of a vaccine.

Our emphasis on non-medical biotechnology has continued with a review of the entire DoD program. The DoD interest and investment in the application of this technology in areas of ship hull anti-fouling, ultrasensitive sensors, novel adhesives and material production continues to increase. During FY 1985 we will establish a DoD coordinating committee to provide oversight of this research to ensure that DoD stays current with the advances in this rapidly growing field.

The Medical and Life Sciences program affects most aspects of military operations. Laser eye protection prototypes were acquired for further testing. A prototype system for the generation of medically pure water for production of intravenous fluids using shipboard potable water was tested. This accomplishment will decrease the logistics problems of providing these fluids in the combat zone. An improved actuator was developed to increase anti-G suit valve inflation rates to provide pilot protection in high-performance aircraft, and finally a new method of calculating decompression schedules was developed to increase the safety and efficiency of those schedules for diving.

L. Precision Guided Munitions (PGM)

S&T efforts on precision guided munitions include seeker, mid-course guidance, and aerodynamic flight control aspects of sensor-fuzed munitions, terminally guided submunitions, guided projectiles and guided missiles. The range of threats dictates a spectrum of capabilities that future air and surface launched PGMs must meet. These demands must be satisfied at lower cost, greater reliability, and with less operator complexity.

Progress has been made during the past year to provide technology to meet these needs. The low cost anti-radiation missile seeker for future HARM application has progressed well and will transition into systems development in FY 1986. High value ship and shore installation target recognition was demonstrated with microwave and infrared seekers. Fiber optics guided missiles have demonstrated that a missile can be vertically launched from a concealed vehicle and guided to hit a combat vehicle five kilometers away. Tests in severe snow demonstrated a high probability of a millimeter wave/infrared sensor fuzed munition detecting multiple targets in various arrangements.

A number of other technological advances offer promise for future PGMs. The synergistic effect of combining microelectronics, algorithms, sensors, optical capabilities, signal processing, and target signature characteristics offer high potential for improving fire and forget weapon capabilities. An initiative in microwave and millimeter wave components is being formulated that has the potential for reducing component sizes by ten to one hundred

times and costs by a half or more. Attention is also being given to unnecessary duplication. In summary, emphasis is being placed upon supporting weapons needs and transitioning PGM science and technology into systems applications.

M. Search and Surveillance

Electronic systems research and development activity includes the mission areas of battlefield, undersea, and aerospace surveillance and search utilizing acoustics, radio frequency, microwave and electro-optics technology. The major functions of target detection, location and identification are investigated in this program.

o Surveillance and Target Detection:

- o Advanced, long range, airborne and spaceborne radar and infrared search and surveillance techniques to locate and classify targets in the air and on the surface are being developed. These radar systems will use combinations of monostatic and bistatic, active, microwave technology to maintain continuous surveillance of potential adversaries under all weather conditions. Bistatic radars have the transmitter and receivers separated to allow passive operation and counter countermeasures capability.
- o A major thrust continues in conformal array radars where flush mounted, solid state, phased array modules are integrated with aerospace vehicles to provide large volume search and surveillance capability without cumbersome rotating antennas.
- o The Air Force Avionics Laboratory and NASA completed an experiment demonstrating the potential for using space borne radar as a "sanctuary" illuminator in the bistatic radar mode for supporting passive all-weather operations.

o Battlefield Surveillance:

- o Low cost, common laser modules for range finders and target designators are being developed to complement our common module thermal imaging systems. These systems along with the soldier's night vision goggles provide the Army with an excellent night vision fighting capability.
- o Significant advances in uncooled imaging technology have resulted in a development program for a new thermal sight for the M16A2 rifle. This sight will weigh less than four (4) lbs and will provide efficient night combat capabilities at M16A2 ranges.

- o Radar and laser techniques are being developed to reduce counter-measures vulnerability, and improve foliage penetration and target tracking. Also, automatic target recognition and tracking techniques are being developed to aid the battlefield commander in the effective use of his firepower.
- o Undersea Surveillance:
 - o The use of magnetic and fiber optic sensors in fixed installations and towed arrays to detect, localize, and classify undersea targets such as submarines and mines is being investigated.
 - o Increased emphasis is being placed on active acoustic techniques to locate quiet targets. Long range detection will be accomplished by the integration of airborne, shipborne and fixed sensors utilizing sophisticated computer systems.
 - o Significant progress has been made in the past year and is continuing in expanding our understanding of acoustic and non-acoustic signatures of advanced submarines in various ocean backgrounds.
 - o New concepts are being demonstrated in hydrophones, source transducers for active sonars, sonar calibration methods and parametric receivers for detection and tracking over a broad range of frequencies.

IV. SUPPORTING TECHNOLOGIES

In addition to the management and technology areas discussed in the previous sectors, there are supporting areas that influence the management of our research and development and also the effectiveness of our forces. Several of these subjects are discussed.

A. Geophysical Sciences and Global Environmental Support

The principal goal of research efforts in the geophysical sciences and related environmental support is to optimize the performance of existing and emerging weapons systems, sensors and platforms. As these vital elements of our national defense become increasingly sophisticated, they also become more sensitive to the surrounding environments in which they operate. In fact, many environmental situations can limit or actually nullify certain systems. Hence, it is critically important to identify and quantify adverse conditions, and focus our research and support efforts to avoid or mitigate them.

Research projects in the geophysical sciences continue to emphasize tactical support problems. For example, the Army has a major program to integrate the various elements of atmospheric sciences research and development into a coherent program to field modern and up-to-date hardware and software. A related effort is the Air Force Battlefield Weather Observing and Forecasting System. This system is designed to solve the continuing and perplexing problem of acquiring prestrike low altitude weather observations over enemy territory. This information will then provide newly developed tactical decision aid software for electro-optical, infrared and millimeter

wave munitions employment. Similar Navy research and modeling projects are focusing on solving the difficult regional and small area forecasting problems which affect naval battlegroup operations. Development of tactical decision aids utilizing locally obtained measurements are also an important part of the Navy program. A system called the Tactical Environmental Support System will ultimately emerge from these projects.

Major meteorological and oceanographic modernization programs are also of vital importance to our forces. Our tactical forces operating in the field and aboard ships are in many cases using equipment that was developed in the 1950s. As indicated above, the Navy's Tactical Environmental Support System will update the fleet by integrating new anti-submarine warfare and aviation shipboard support capabilities as well as providing 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. The joint DoC/DoT/DoD Next Generation Weather Radar (NEXRAD) program has successfully moved into validation phase with its Doppler capability and offers the greatest advance in observation capabilities since the development of the weather satellite. Besides replacing the current failing equipment, 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 combining a forward looking R&D program with a vigorous attack on tough environmental support problems. Replacing our outdated equipment while at the same time pursuing new methods of improving support techniques for our combat forces will result in significantly enhanced effectiveness, and can act as an effective force multiplier.

B. The DoD Scientific and Technical Information Program

DoD-wide information support to technical 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-two specialized Information Analysis Centers (IACs). DTIC maintains data bases on DoD research projects, on summaries of industrial IR&D efforts, and on 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 sharing information with industry and increases the productivity of bench-level scientists and engineers.

Increasing emphasis is being placed on developing new products and services to increase the availability of information to DoD researchers and enhance their ability to manipulate and evaluate information to meet their individual needs. One example is the intelligent gateway system being developed jointly with NASA and the Department of Energy. It provides access

to many different government and commercial data bases using a single query language, and provides powerful post-processing capabilities for data obtained from those data bases.

The Information Analysis Centers (IAC) 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, and software. Two new centers were established in FY 1984 on aircraft systems survivability/vulnerability and manufacturing technology. In FY 1985 an IAC will be established on chemical warfare/chemical-biological defense.

V. CONCLUDING REMARKS

This Administration in 1981 began building up the military strength that is necessary for this country to achieve its national goals and position of leadership. Much ground has been covered in this process but we are still several years from completion. As indicated earlier, this buildup is possible because of the S&T work accomplished over the past two decades. It is in our paramount interest to continue an aggressive S&T program now so that our country in the future will have the technology tools with which to maintain a strong national security posture.

In summary, our technology goals fit into DoD objectives for the modernization of our forces and the ability to adapt to changing threats and conditions throughout the world. If we can provide in the future a range of effective technical options to overcome unforeseen national security problems our efforts today will indeed be worthwhile. This is the purpose of the S&T program. We solicit your continuing support in helping us to carry it out.