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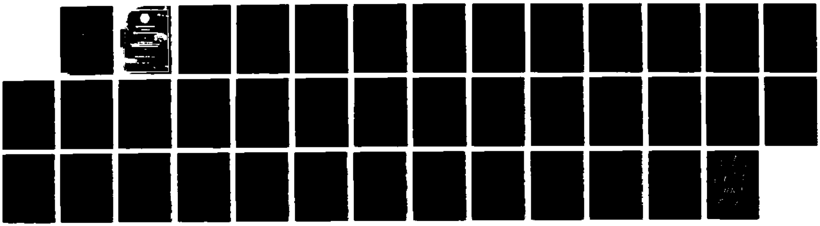

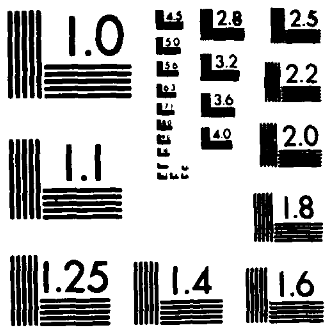

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DEPARTMENT OF DEFENSE

STATEMENT ON

[illegible] TECHNOLOGY PROGRAM

BY

DR. GEORGE P. MILLBURN

[illegible] DEPUTY UNDER SECRETARY OF DEFENSE

[illegible] AND ADVANCED TECHNOLOGY

TO

[illegible] CONGRESS, SECOND SESSION

MARCH 1988

THE DEPARTMENT OF DEFENSE

STATEMENT ON

THE SCIENCE AND TECHNOLOGY PROGRAM

BY

DR. GEORGE P. MILLBURN

THE ACTING DEPUTY UNDER SECRETARY OF DEFENSE

FOR RESEARCH AND ADVANCED TECHNOLOGY

TO

100TH CONGRESS, SECOND SESSION

MARCH 1988

The FY 1989 Department of Defense
Statement on
The Science and Technology Program

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Mr. Chairman and Members of the Committee:

INTRODUCTION

I am pleased to testify in support of the Department of Defense Science and Technology (S&T) program for FY 1989.

The military strength of the nation is often evaluated in the number of tanks, ships, aircraft and personnel that can be brought to bear on national security objectives. Certainly these are factors that must be present if our military goals are to be achieved. However, sheer dependence upon numbers is a difficult strategy for the US to pursue.

The build-up of Soviet nuclear and conventional forces places great pressure on the US and its Allies and threatens international security. This build-up is based in large measure on fielding military forces that vastly outnumber their opponents. The nature of our society and our economy precludes matching the Soviets tank-for-tank, aircraft-for-aircraft, satellite-for-satellite or man-for-man to provide a viable deterrent to their global ambitions.

In order to preserve our common defense and our future security, prudent improvements must be made to our forces as further threats to our national posture and readiness arise.

Central to those improvements is the ability to field superior equipment so that our commanders and their personnel can overcome the quantitative advantages of our adversary. However, in order to provide superior equipment, on a timely basis, mature technologies must be available for use in the development of materiel for our forces.

It is the task of the S&T program to provide technology options for future systems and thus for our future security. Technology leadership is the vehicle that will increase the deterrent value of our forces and also it is the tool by which the risk of adverse technological surprise is diminished. It is important that we, as a nation, explore technological horizons now so that we will be prepared for the realities of tomorrow.

US and Allied technological leadership is becoming more important because the Soviets are fielding equipment that is comparable to and, in some cases, more advanced than that of the West. Although we have technological leadership in most important military technologies, that lead is being challenged by the Soviets. It is the S&T program's objective to ensure that the US technological lead is maintained or widened so that an important strategic advantage is not lost.

In maintaining a position of technological leadership the US has a major advantage over the Soviet Union. DoD laboratories and the national (DOE) laboratories are important elements in accomplishing defense projects. In addition, we have large and creative university and industrial sectors that provide a strong base for the S&T program. The government laboratory-university-industry team is an innovative resource not available to the Soviets.

The S&T program encompasses the Research (6.1), Exploratory Development (6.2), and Advanced Technology Development (6.3A) RDT&E categories. The projects and programs range from fundamental investigations to discover new phenomena, to breadboard experiments and to large scale demonstrations. The output is mature technologies that will make up new systems with superior performance upon which to base future national strategies.

This administration has recognized that the S&T program is an investment in the future of the country and a necessary ingredient for a viable national strategy. There has been real growth in the program during our tenure and this request will continue to provide a strong foundation for future systems.

As we plan and execute the FY 1989 S&T program, we will not only give consideration to increased performance but also important factors such as affordability, supportability and readiness. This balanced program not only will strengthen our hand in deterring future aggression but also will, if deterrence fails, assure us of success on the battlefield.

The S&T program request for FY 1989 is $5,263 million which is approximately the same level as the FY 1988 program. This amount does not include Strategic Defense Initiative amounts that are in the Advanced Technology Development category but covered in separate testimony. Table I provides details on the request.

The S&T program is an essential element of the acquisition process and will continue to receive the support required in order to ensure that the technology needs of tomorrow will be a reality. The remainder of this testimony will highlight management and program activities of the S&T program.

TABLE I
SCIENCE AND TECHNOLOGY PROGRAM
(Dollars in Millions)

	FY 1988	FY 1989
Research		
Military Departments	709	729
Defense Agencies	192	187
Total Research	901	916
Exploratory Development		
Military Departments	1,514	1,577
Defense Agencies	878	784
Total Exploratory Development .	2,392	2,361
Advanced Technology Development		
Military Departments	1,342	1,362
Defense Agencies	561	624
Total Advanced Technology Development . .	1,903	1,986
TOTAL SCIENCE AND TECHNOLOGY	5,196	5,263
Strategic Defense Initiative	3,551	4,546

II. MANAGEMENT ACTIONS

The S&T program is often considered in terms of projects, efforts and tasks that lead to advances in military capabilities. However, the organizational frameworks, changing emphasis and procedural processes are important and provide the means for accomplishing goals and providing direction to the program. This section discusses recent activities that are central to the S&T program:

A. Balanced Technology Initiative

The Balanced Technology Initiative (BTI) was established as an important new element of the DoD Science and Technology Program in FY 1987 to provide additional support for the development of "promising new technologies that could substantially advance our conventional defense capabilities." A detailed and substantive BTI program plan was developed by the Office, Director Defense Research and Engineering and described in a comprehensive report to Congress. The program was structured to "make a difference" in the conduct of conventional defense missions.

The BTI program includes work in five categories. Work in the Smart Weapons Technology category is intended to promote the advancement of technologies critical to the development of next-generation, autonomous, fire-and-forget munitions having improved target acquisition, identification, and hit capabilities. Work in the RSTA/BMC3 Technology category, a category merging two widely used acronyms (RSTA- for Reconnaissance, Surveillance, and Target Acquisition; and BMC3 - for Battle Management, Communications, Command, and Control), develops enabling technologies for obtaining, processing, transmitting, and using information essential to the effective deployment and utilization of conventional defense resources. A major project involves underseas surveillance work by the Navy.

Projects included in the Armor/Anti-Armor Technology category are intended to be complementary and supplementary to ongoing work in the cooperative DARPA/Army/Marine Corps program. Activities include important work in the areas of advanced guns and projectiles, new weapons concepts, mine/countermine technology, and high performance materials and modeling. Work in the High Power Microwaves (HPM) category is intended to develop a comprehensive understanding of the effects of HPM on tactical weapons systems to help assure the survivability of US and Allied assets and to place vulnerable enemy systems at risk. The fifth program category, Special Technology Opportunities, includes work on enhanced blast munitions, superconducting ceramic materials, and advanced guidance for cruise missiles.

The great majority of BTI projects are being carried out by the Services and the Defense Advanced Research Projects Agency (DARPA). The BTI program will be managed as a special interest activity under the direction of the Director, Defense Research and Engineering. Funding for the program has been included in the revised FY 1989 budget request.

B. Semiconductor Foreign Dependence

The Defense Science Board (DSB) concluded that defense systems will become highly dependent upon foreign sources for semiconductors if immediate action is not taken to reverse this unfavorable trend. Further, they warned that US technology leadership in this area is rapidly eroding with serious implications for the nation's economy and the Defense Department. The DSB recommended that action be taken to retain a domestic strategic production base and to maintain a position of strength in the technologies of device and circuit design, fabrication, materials refinement and preparation, and production equipment.

The Department, Congress and industry, as a result of foreign dependency, have initiated the Semiconductor Manufacturing Technology program. This program will focus on developing world-class manufacturing technology in a cooperative, cost-shared effort with a consortium of semiconductor manufacturers known as SEMATECH. SEMATECH'S goal is to regain world semiconductor manfacturing leadership upon which we can draw to build technically superior weapons. We are currently in the process of making a grant to SEMATECH, in accordance with Congressional guidelines, to develop the manufacturing technologies necessary to national economic and security interests in this important area.

C. Superconductivity

Superconductivity has been discovered in certain oxides at temperatures in the vicinity of 90 degrees Kelvin (-297°F). This discovery has implications for magnetic and infrared sensors, computers, gyroscopes, particle accelerators, electromagnetic launchers/guns, rotating electrical machines, magnetic energy storage and other devices used in military systems. Detailed analyses and coordinated planning (both within DoD and with other federal agencies) has resulted in rapid definition of program direction for the individual Services and Defense Agencies.

While it is too early to precisely judge the ultimate impact of high-temperature superconductivity on military systems it is evident that the potential payoff is high. It is also evident that harnessing these complex and seemingly intransigent materials will require intense and sustained scientific and technical effort. While useful sensor applications might be expected within a few years, applications in electronics and electrical power systems may require one to two decades to develop. DoD is in a good position to exploit this technological opportunity because of the availability of a cadre of superconductivity experts seasoned by four decades of leadership in this area.

D. University Research

DoD derives dual dividends from university research. First, university researchers generate new knowledge in technical fields that underpin defense systems. Second, the Department relies upon university research programs to train future scientists and engineers. The new knowledge and new talent are key to our long-term military and economic competitiveness.

Universities performed approximately $725 million in Technology Base activities in FY 1987. This level of university activity was approximately eight percent greater in real terms than the prior year's activity, principally because of the University Research Initiative (URI). URI focuses on an interdisciplinary approach to research, complementing single-investigator university efforts in the Research program. The multidisciplinary approach can accelerate research progress in areas that are ripe for team efforts. It also can speed transition of research results to practical application in defense systems or in commerical spinoffs. In order to provide increased emphasis to URI, the program is managed by the Office of the Secretary of Defense in FY 1988 and this approach will be continued in FY 1989. Program execution will continue to be the responsibility of the research offices within the Services and DARPA.

E. Domestic Technology Transfer

National security depends upon both military strength and economic strength. While the principal objective of DoD's S&T program is to strengthen US military forces through superior technology, many scientific discoveries have potential for generating commercial products or processes that can enhance the competitiveness of US industry. If the nation is to derive the maximum return on DoD's investment in research and development, it is important to encourage domestic technology transfer. DoD laboratories have made technical advances that have had significant impact on the private sector. For example, defense R&D programs have resulted in recent commercial applications such as a new curing process for metal matrix composite materials, an electrostatic fabric device for filtering coal dust, and a real time weld inspection monitoring system.

The Federal Technology Transfer Act of 1986 increases the potential for greater contribution by DoD to both the public and private sectors. The Act authorizes DoD to enter into cooperative R&D agreements with state and local governments, universities and industry. This approach can provide dual dividends with the defense laboratories encouraging technology transfer to the private sector and at the same time benefitting from the infusion of university and industrial know-how.

Several of these agreements are currently being negotiated by our laboratories in order to take advantage of the statutory provisions. In addition, DoD is developing a database that will enable us to refer interested parties to technical experts in the laboratories in order to facilitate interaction with the private sector. This will serve as a catalyst to domestic commercialization activities.

F. Science and Technology Committee

A Science and Technology Committee has been established under the Defense Acquisition Board (DAB) to provide support to the DAB and the Defense Acquisition Executive. The Services, JCS, and principal OSD offices are members of the S&T Committee, so it provides the technology community a broad base from which to plan and implement S&T initiatives. In addition, the Deputy Under Secretary for Research and Advanced Technology, who is chairman of the S&T Committee, is also a member of parallel DAB committees (conventional, strategic etc.) concerned with the system acquisition process. There is now a strong and timely technology input to aquisition decision making.

G. Independent Research and Development

Independent Research and Development (IR&D) is the company-selected, company-sponsored technical effort necessary to remain competitive in a technological environment. The DoD recognizes IR&D charges to 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.

IR&D is a strongly leveraged program providing significant enhancement of the science and technology program. A recent independent study (conducted by the RAND Corporation) found that, in the long term, for each additional dollar DoD allows in the ceiling negotiated with a company, industry responds by spending two dollars to perform additional R&D in the cost centers which have ongoing business with DoD. In addition, RAND found that for the same dollar invested by DoD, industry increases by 75 cents the amount it spends on R&D in cost centers that have no business with DoD. Thus, DoD's IR&D support benefits not only DoD directly but also the nation as a whole.

We are working with industry to streamline the program. We have developed a review and oversight cycle which spans two years rather than the current annual requirement, without reducing significantly the visibility of the technical effort and its quality. This review will be accomplished by requiring annual updates on projects which have experienced major changes, while permitting more stable projects to run for two years. The benefit of this approach is that the administrative effort, and cost, to prepare expensive technical review documents are reduced. We expect the two year plan to be implemented in the near future.

H. Management of the Technology Base

The Defense Science Board (DSB) conducted a two-week summer study on Management of the Technology Base. The study focused on processes for utilizing available resources more effectively and efficiently, rather than addressing the adequacy of the present level of resources or the balance of support among key technical areas. Study Group recommendations stressed improvements in the basic research program, the laboratories and technology transition. For basic research the thrust was toward recognizing the importance of long-term research and establishing it as an integrated "corporate" program commensurate with budget and managerial authority already resident within OSD. Emphasis in the laboratory recommendations focused on upgrading personnel quality by improved personnel systems, and giving the laboratory director greater flexibility in contracting and financial matters. Additionally, recommendations were made on demonstration projects oriented toward attracting and retaining the highest quality staff, improving contracting effectiveness, improving personnel management, and, providing local laboratory management authority and accountability. To enhance technology transition, the Study Group recommended establishing a program of Advanced Technology Transition Demonstrations, and provided the management principles to structure such a program. There is general agreement with these recommendations, and actions are underway to implement them as soon as possible.

III. SELECTED FY 1989 TECHNICAL PROGRAMS

The S&T Program encompasses a broad base of activity and it is not possible to discuss all of the projects in this statement. However, a number of programs and activities will be highlighted:

A. Aircraft Technology

Airpower is a major factor in each of the Services' operational strategies. The Aircraft Technology program addresses improved operational performance, increased survivability and reduced costs for both design and operational considerations. In the performance area, significant advances in air combat maneuvering, hypersonics, and the man-machine interfaces are being made. Emphasis is on supermaneuverability, integrated flight/propulsion controls, vectored thrust, and advanced rotor designs for improved helicopter agility. Major flight demonstration programs include the Air Force F-15 Short Take-Off and Landing (STOL) program, the Navy F-14 Yaw Vane program and the DARPA/Navy X-31 Supermaneuverability effort. In the man-machine interface area, special attention is being given to cockpit automation and displays, building on the recent advancements in computer and graphics technology.

Hypersonic technology is centered around the National Aerospace Plane (NASP) program which is being conducted by the DoD (with Air Force lead) and NASA. If the technology proceeds as planned, the program will culminate in the flight demonstration of a hydrogen-fueled, experimental aircraft that can take-off from a conventional runway and fly at high mach numbers within the atmosphere and perhaps even into low earth orbit. The hypersonic-related technologies being addressed include air-breathing propulsion, computational fluid dynamics, and light-weight high-temperature materials and structures.

Reduced life cycle cost is being addressed on a broad front supporting the Reliability and Maintainability (R&M) 2000 doctrine. Significant reductions in vehicle maintenance are being anticipated via the application of advanced diagnostic technologies based on expert systems concepts. Of particular note, the expert system efforts have demonstrated the potential for significant reduction in supportability costs using embedded maintenance diagnostics.

B. Integrated Circuit Technology

The Very High Speed Integrated Circuits (VHSIC) program has successfully developed and demonstrated 1.25 micrometer minimum feature size integrated circuits (ICs) and will complete the development of 0.5 micrometer ICs by FY 1989. VHSIC 1.25 micrometer devices are available from multiple sources and the first operational VHSIC application was made in the F-111 aircraft radar digital signal transfer unit during FY 1987. Development of the pilot production lines for one-half micrometer VHSIC devices is on schedule and will demonstrate applications that should yield 50-100 fold increase in signal processing capability over present VHSIC devices.

The Microwave and Millimeter Wave Monolithic Integrated Circuits (MIMIC) program is oriented toward major improvements for analog functions of microwave and millimeter wave devices used in sensor electronic systems. A one-year study phase with 16 contractor teams began in January 1987, and the contract for the first of two three-year hardware/software development phases will begin in FY 1988. The MIMIC program will provide advance capabilities in analog circuitry, "the eyes and ears of electronic equipment," at affordable cost for use in aircraft, missiles, surveillance and other military systems.

C. Research

Technologies leading to enhanced military capabilities typically evolve from basic research discoveries. The DoD basic research (6.1) program is thus designed to ensure that the US stays at the forefront of militarily significant areas of science and technology. The translation of basic research discoveries into enhanced operational capabilities requires imaginative exploitation in the exploratory development process. Therefore, considerable attention is given to mechanisms for communicating basic research advances to the technology development community.

Basic research areas currently being investigated include mathematical sciences, computer sciences, physics, chemistry, material sciences, electronics, mechanics, propulsion, environmental sciences, space sciences and life sciences. Examples of current activities within these topics, and their military applications, follow:

Underwater Acoustics: The acquisition and tracking of enemy submarines is becoming increasingly difficult as acoustic signatures are reduced. Detection in the future will likely depend on transient, as opposed to steady state, phenomena. Ocean acoustics studies assess the propagation of transient noise in the ocean environment. Key factors include signal range, distortion, and the extent to which the ocean acoustic background (reverberation) masks transients of various frequencies. Ongoing investigation of these phenomena should provide the basis for improved submarine target acquisition and tracking systems optimized to transient acoustics.

Materials Processing: Future advances in materials will evolve in large part from an increased understanding of the relationship between properties and material processing variables. The result will be superior structural materials that will enhance the reliability, survivability and performance of military systems. Innovative approaches to the synthesis of new materials include advanced powder processing and laser methods to produce composite or dispersion-hardened metals and alloys with ultra-fine microstructures which show promise for enhancing such material properties as strength, ductility, and high temperature performance.

Optical Sensors: Detectors, detector systems, and pointing accuracy which simplify optical systems and compensate for distortions in optical imaging systems are important to future military systems. Research is being accomplished on high quantum efficiency photoemissive surfaces in the near-infrared and high gain detector wavelength regions. Studies of optical sensors and optical imaging systems involve the exploration of interferometric imaging systems which are fabrication error tolerant, and development of techniques to correct phase errors in images introduced by non-diffraction-limited optical systems. This work may lead to greatly improved boost phase missile detection and tracking, and to improved over-the-horizon decoy discrimination.

Combustion and Propulsion Sciences: Research toward understanding the fundamental processes of propulsion will lead to improved engines, missile propulsion systems and ordnance. Research on engine combustion is focused on intermittent, reacting flows encountered in diesel and small gas turbine combustors. There is strong emphasis on fuel injection processes, jet breakup, atomization and spray dynamics and consequent heterogeneous flame propagation. Gun propulsion system investigations include ignition and combustion sequences in liquid and solid propellants, multiphase flow processes in granular and stick explosives, and ignition processes of the modern low-vulnerability ammunition propellants. Comprehensive understanding of combustion is an important consideration in a military research program because of its applicability to a number of military uses.

D. Integrated High Performance Turbine Engine Technology (IHPTET)

IHPTET is a coordinated effort between Navy, Air Force, DARPA, NASA and industry to double propulsion capabilities by the turn of the century. Seven turbine engine manufacturers have developed complementary internal corporate plans to achieve IHPTET goals, and will fund a significant part of the program.

IHPTET goals will be achieved in three time-phased steps to insure that intermediate levels of technology are available to satisfy nearer term system needs. Significant initial progress has been made including over 100 hours testing of an experimental fighter engine which demonstrated satisfactory operation of an advanced augmentor (afterburner); experimental evaluation of a gas generator aimed at a 30 percent percent increase in thrust/weight ratio; cyclic testing of a continuous-fiber reinforced titanium spacer, which offers the potential for a 70 percent reduction in rotor system weight; operation of a carbon/carbon turbine nozzle for expendable engines for over three hours; and, demonstration of 30 percent reduction in losses in a compressor featuring three-dimensional, swept blades. These and planned actions are important to maintaining national preeminence in a technology essential not only for the nation's military well being but also for the health of the civil aviation sector.

E. Surveillance and Sensors

A key to the effective application of combat power and conventional deterrence is knowledge of the enemy's capability and status. Surveillance and sensors thrusts include automatic image processing, automatic target recognition, infrared focal plane staring and scanning arrays, array signal processing, and the fusion of sensor data. In addition, processing techniques to handle vast amounts of data in realtime to select targets from clutter and display essential information are under development. The significance of these developments cannot be overstated because they are at the heart of our strategy. Sensors are the foundation of equipment that allow our aircraft to find the enemy first, to navigate precisely at night and in bad weather, and to precisely guide weapons to the target. The aggregation of the information provided by sensors and surveillance systems permits us to see first, see clearly, and to make effective decisions to protect our forces.

F. Chemical Defense

The threat of chemical weapons against US and Allied forces motivates us toward developing a strong chemical defense posture. The chemical defense program is performed by the Services with the Army as the executive agent. The program also makes use of university and industrial capabilities to solve difficult problems in detection, personal protection, decontamination, and medical treatment problems.

Advances have been made that improve the survivability of our personnel on a contaminated battlefield as well as providing the basis for a deterrent posture. These advances include a new multipurpose protective mask, improved antidotes and pretreatment drugs, simplified collective protection equipment, and advances in detection technology. Other activities in the chemical defense program include support for arms control negotiations and evaluation of Allied equipment for possible use by US forces. A chemical/biological defense information analysis center has been established to support both industry and the Department's chemical defense needs. We will continue to emphasize chemical defense developments to ensure a credible deterrent posture and if deterrence fails, to ensure that US personnel will be able to survive and operate on a contaminated battlefield.

G. Materials and Structures

Defense S&T managers have long recognized the importance of materials R&D because advancements in materials are often a prerequisite to advancements in other technologies. An important element of the program is in the development of composite materials. This includes substantial work on high temperature composites which includes metal-matrix composites, ceramic matrix composites and carbon/carbon composites. In addition, several major demonstrations are being undertaken including the development of a composite turret and hull using the Bradley vehicle as a model, composite missile and spacecraft components and, fighter aircraft tail structures.

The advent of new reinforcement materials with a wide range of mechanical, thermal and electrical properties, combined with new matrix materials will enable us to direct our developments towards precise tailoring to satisfy stringent system requirements. Current efforts are directed toward evolving innovative materials and structures concepts using unique combinations of fibers in various arrays and architectures, mixed matrices, and thermally matched coatings for many temperature regimes. Important advances already have been made with the development of extremely stiff carbon fibers having thermal conductivity in excess of pure copper and also high electrical conductivity. Underlying these developments will be the continued emphasis on survivability of equipment to potential ballistic, directed energy and nuclear weapons.

H. Conventional Weapons Technology

Conventional munitions include small arms, guns, mines, countermines, missiles, bombs and torpedos. Conventional weapons R&D increases force survivability by providing weapon systems that are less detectable, and less vulnerable but with improved accuracy, range and lethality. Progress is being made toward reducing the hazards and signatures from rocket motors while not adversely affecting munition performance. Work on regenerative liquid propellants continues to show that a liquid propellant gun (LPG) is achievable. The LPG will have broad application in anti-armor, air defense and artillery roles. Of particular note, liquid propellants also offer substantial reduction in support and logistics requirements. In addition we are placing increased emphasis on landmine and countermine technology, which has been prompted to a large part by a Defense Science Board (DSB) study. Conventional weapons are an important part of the S&T program because their effectiveness is the measure of success for many military missions.

I. Training

Training in preparation for combat is an important peace-time activity in both our active and reserve forces. It is a major DoD expense. However, it is a necessary tool to ensure that weapon systems will be operated at the high levels of effectiveness of which they are capable. Training technology for improving combat readiness is being advanced by: (1) computerized training that provides individually tailored instruction, drill, and practice; (2) advanced simulator systems with fiber-optic or miniaturized cathode-ray tube displays, computer image generation, and networking to make realistic combat training possible; and (3) electronic internetting of training sites and computer wargames to permit widely separated groups to train collectively. Because training programs affect all military personnel, progress made in training technology is a cost effective approach to increase operational effectiveness.

I. Unified Life Cycle Engineering

It is important that DoD do more to leverage technology into quality products, particularly weapons systems that are reliable, maintainable, and available when needed. In pursuit of our goal of total quality management we are beginning to integrate product design, manufacture, maintenance and logistics support into one process, unified life cycle engineering. The benefits of technology will be incorporated not only into the product itself but also into the processes that support the product throughout its life.

Unified life cycle engineering is made possible by advanced technologies such as automation, robotics, manufacturing science, process control, expert systems, and computer integration. For example, the Army is developing robots for loading ammunition safely in hostile environments, the Navy is developing automation for the manufacture of small batches of spare parts, and the Air Force is developing expert systems to aid technicians in maintaining advanced weapons systems.

Development of logistics technology will have other payoffs as well. It bolsters industrial competitiveness and should attract some of the best students into manufacturing science and technology, thus benefitting national security both in the near and far term.

J. Biotechnology

Biotechnology is a pervasive and encompassing technology which has developed rapidly over the last ten years. The science of genetically controlling microorganisms to produce large amounts of useful materials has great potential to solve DoD logistics and operational problems. The majority of our present work is directed to medical research to improve vaccine development, and prophylaxis and therapy related to infectious diseases and chemical defense.

Long term non-medical research directed to applications in high-strength and light weight materials, high-strength adhesives, high-temperature lubricants, non-corrosive cleaners, decontaminants, and bio-electronic applications provide attractive alternatives to the solution of difficult DoD material problems. Already operational uses such as compliant coatings and polymers for undersea use and chaff for enhancement of signal responses are envisioned. This technology has potential for advancement over a range of supporting technologies.

K. Directed Energy

Research in directed energy weapons has highlighted the need for survivability of US systems against tactical threats from lasers and radio frequency effects. The protection of our advanced sensors and signal processing against emerging threats is essential for maintaining our technology edge. Survivability programs have developed hardening techniques against near term directed energy systems.

Advances in lasers include high power operation, automatic phase conjugation for beam quality correction, and the development of modular devices. The development of high power microwave and radio frequency devices has allowed large scale testing of systems to determine limits of operation in a severe electromagnetic environment.

L. Vehicular Electronics

The combat capabilities of the M-1 tank, F-16 fighter, and future weapon platforms are heavily dependent on integrated vehicular electronics and avionics systems. Programs in combined presentation of sensor data, threat information, vehicle performance and weapons status greatly increase the lethality and survivability of these systems. In addition, development of combat "heads up" visual displays and coordinated communications can be an important element toward achieving victory. Our goals are to increase the capabilities of combat crews to optimum levels despite bad weather, night or the complexities of battle. Also, redundant circuits, built-in-test and modular replacement are under development to minimize logistics support and lifecycle costs. The effectiveness of our forces, to a large measure, is highly dependent on the availability of platforms (tanks, ships, aircraft, etc.) to position and deliver weapons to hostile targets. Our programs in vehicular electronics play an important role in accomplishing this difficult task.

M. Computers and Software

Most modern military systems are dependent upon computers and software to accomplish their missions. Many military systems achieve their superiority as a result of having advanced computing elements embedded in them. Also, high performance computing is now a fundamental resource necessary for leadership and advancement in science and engineering. Research and development necessary for the creation of superior military systems is likewise dependent upon high performance computing capabilities.

Computer software provides the means by which computers execute complex computing tasks. The Consolidated DoD Software program seeks to improve reliability and cost effectiveness of the software for warfighting systems. The initiative has three components, the Ada standard programming language, the Software Technology for Adaptable, Reliable Systems (STARS) program, and the DoD Software Engineering Institute. The consolidation of these three programs into one element, as recommended by the Defense Science Board, is included in the FY 1989 request.

The Ada program was established to develop and introduce into military systems a standard computer programming language that not only satisfied difficult technical requirements but also permitted proper financial management of software procurement for embedded computers. The program is implementing comprehensive standardization, control and support to ensure its smooth, swift and widespread introduction into US and NATO defense systems.The STARS program seeks to achieve improvements in software quality/reliability and reduce software costs. Future weapons systems will rely on large quantities of software for their successful operation. STARS will demonstrate an order of magnitude productivity improvement by using software engineering principles made possible by Ada. Our goal is to bring a high degree of automation to the software development and maintenance process, and make possible widespread reuse of already coded and tested software. The combination of software automation and reuse should reduce labor costs, maximize the productivity of scarce software professionals, improve reliability and permit second sourcing of software procurement when appropiate.

The DoD Software Engineering Institute is working to accelerate the transition of software technology from the laboratory into DoD systems. It serves as the DoD center of excellence for software engineering and will help transition technology more quickly to DoD applications by evaluating new tools and techniques, upgrading them for large systems, and demonstrating their usability in military situations. It will also provide software engineering assistance to developers in the Services and Defense Agencies. The Institute will continue to play an important role in the development and use of DoD software.

IV. SUPPORTING TECHNOLOGIES

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

A. Scientific and Technical Information

Productivity of the S&T program depends to a great extent on the effectiveness of the DoD Scientific and Technical Information program. Summaries of R&D efforts underway are collected so that technical managers can take advantage of work being accomplished elsewhere. In addition, comprehensive reports of completed technical projects are collected and disseminated to researchers and developers. Information about IR&D efforts of defense contractors is provided to government planners thereby aiding their actions to assure that technical endeavors of government and industry are complementary. These supporting services are essential for efficient and effective R&D management.

Technical information activities are carried out primarily by the Defense Technical Information Center (DTIC), Information for Industry Offices (IFIOs) and specialized Information Analysis Centers.

DTIC is DoD's central activity for collecting, storing and disseminating information on planned, ongoing and completed R&D. It provides information services, including an extensive telecommunications network for defense organizations and contractors to review DTIC holdings and order information electronically.

The Information for Industry Offices permit industry access to information on DoD acquisition plans, R&D requirements, science and engineering objectives, and other planning documents relevant to the R&D plans and capabilities of their respective organizations. The IFIOs have been most useful to contractors in planning their IR&D programs. They also foster a competitive environment amongst our potential and on-board contractors, especially the small businesses that cannot afford to visit widely scattered purchasing activities.

Information Analysis Centers collect, review, analyze, and summarize information as well as provide advisory services in well-defined and specialized technical fields. Their work is distinguished from that of documentation centers and libraries by their concern with analysis of the technical information they collect rather than simply with its acquisition and dissemination. The Department of Defense also recognizes its responsibility to share the fruits of fundamental research with the general scientific community. In cooperation with professional societies and the academic community, policies and procedures have been developed for sharing technical informationin ways that satisfy both scientific and national security concerns. Many of these policies are incorporated in a recently-published regulation governing the presentation at technical meetings of DoD-sponsored research and development information.

The demand for information services continues to increase, and we are seeking to improve the quantity and quality of our products while keeping the cost of these services within affordable limits.

B. Environmental Sciences

DoD systems, whether they are battlefield sensors, tanks ships or aircraft, are affected by the environment. The magnitude of the impact can range from disaster, such as the disabling of a multi-million dollar spacecraft by solar particles, to mundane, such as impaired mobility over rain-soaked terrain.

The DoD Environmental Sciences program encompasses meteorology, oceanography, terrestrial and space science. This program develops methodologies and equipment to optimize the performance of existing and emerging DoD systems and to assure environmental effects are considered at critical points in the acquisition process. Recent emphasis on tropical storm forecasting, hazards to spacecraft, and high resolution gravity measurements have led to improved capabilities within DoD. An improved typhoon prediction model, tested in 1987, promises to reduce the 72 hour mean error in predicting a storm's position by 30 percent thereby reduce cost of unnecessary storm preparations and evacuations. In the space environment, improved models for electrostatic charging of large spacecraft have been developed, and a system to protect operational spacecraft from electro-static discharges will be flown and tested. Studies of solar proton events will soon be completed and the results transitioned to a satellite-based early warning system for solar flare hazards to manned missions or radiation sensitive systems.

The DoD Environmental Sciences program provides cradle-to-grave support for virtually all defense systems and tactical operations. The goal is to maintain and improve the high quality of our ongoing services and to improve environmental considerations early in the acquisition cycle of future weapon systems.

V. CONCLUSION

The 200th anniversary of the Constitution has highlighted the importance of this great document to the country. One of its key principle is "to provide for the common defense." The framers were keenly aware that a nation had to have a means of maintaining its sovereignty and of withstanding threats to its national values and interests. We, as S&T program managers, are also keenly aware that to preserve our future security, sound technology investments must be made now in order to provide for the future common defense. The DoD has maintained a strong S&T program and it is our goal to continue this program. Also, we have managed the investment wisely and will continue to provide effective stewardship of the resources applied to this essential and important element of the national defense posture.

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