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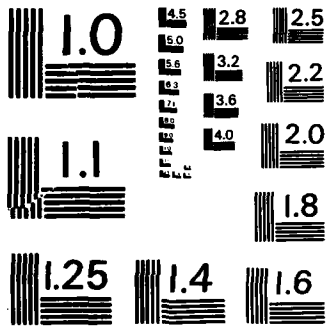

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THE DEPARTMENT OF DEFENSE STATEMENT ON SCIENCE IN THE MISSION AGENCIES AND FEDERAL LABORATORIES

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

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BEFORE THE TASK FORCE ON
SCIENCE POLICY OF
THE COMMITTEE ON SCIENCE AND TECHNOLOGY OF
THE UNITED STATES HOUSE OF REPRESENTATIVES
99th CONGRESS, FIRST SESSION

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2 OCTOBER 1985

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Mr. Chairman and Members of the Task Force:

1. INTRODUCTION

I am grateful for the opportunity to testify before this Task Force which has been specially established to hold hearings on "Science in the Mission Agencies and Federal Laboratories."

Today I will describe our objectives for the DoD Science and Technology (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.

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:

- The Soviet military buildup, both quantitative and qualitative, has produced a major shift in the nuclear and conventional balance.

- The Soviet military posture has become increasingly more capable in its offensive orientation.

- 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 so 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 have provided us the lead in most militarily significant technologies but it is important to continue a large and vigorous DoD S&T program to preclude progressive erosion of our position.

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 signiticant 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.

2. THE DOD SCIENCE AND TECHNOLOGY PROGRAM

A. Funding

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). I have outlined the SDI amounts in Table I tor information 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 academic, industrial and governmental organizations.

TABLE I
SCIENCE AND TECHNOLOGY PROGRAM
(Dollars in Millions)

	FY 1985	FY 1986
Research	861	971
Exploratory Development	2,261	2,555
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

When Congress established the Office of Naval Research in 1945, DoD became the first government organization to formally support basic research. Our commitment to research continued with the establishment of the Army Research Office, the Air Force Office of Scientific Research, and the Defense Advanced Research Projects Agency.

Today we are but one of several major sponsoring agencies for basic research in the physical sciences and engineering along with NSF, DoE, and NASA. The major sponsor of scientific research is the Department of Health and Human Services which emphasizes the areas of medical and biological research. Figure 1 depicts the current distribution.

There was a steady erosion in DoD sponsored research in the decade 1965 to 1975; both in absolute terms and as a percentage of the total Federal government support for basic research. Figure 2 shows that, in constant dollars, DoD support for research in FY 75 was only one half of what it had been in the mid-sixties. Similarly, Figure 3 shows that as a percentage of the Federal government's support for research, the DoD share fell from over 25 pecent in the early-sixties to only 11 percent in 1975, and has remained at that reduced level.

B. Personnel

There are approximately 2.9 million scientists and engineers (S&E's) at work in the nation. We employ 105,000 (3.6%) of them in our civilian and military workforce of 3.1 million people. Of these S&E's approximately 78,000 are civilians -- 72 percent of whom are engineers -- 27,000 are military officers.

DoD also employs almost 740,000 technicians, 22,000 of whom are civilians. About 715,000 technically qualified individuals are in the military enlisted force; they account for 40 percent of total enlisted personnel.

Beyond the 105,000 civilian and military S&E personnel directly employed by the Department, another 13 percent of the nation's total S&E workforce is directly linked to Defense budgets and programs. We, therefore, have an important, although by no

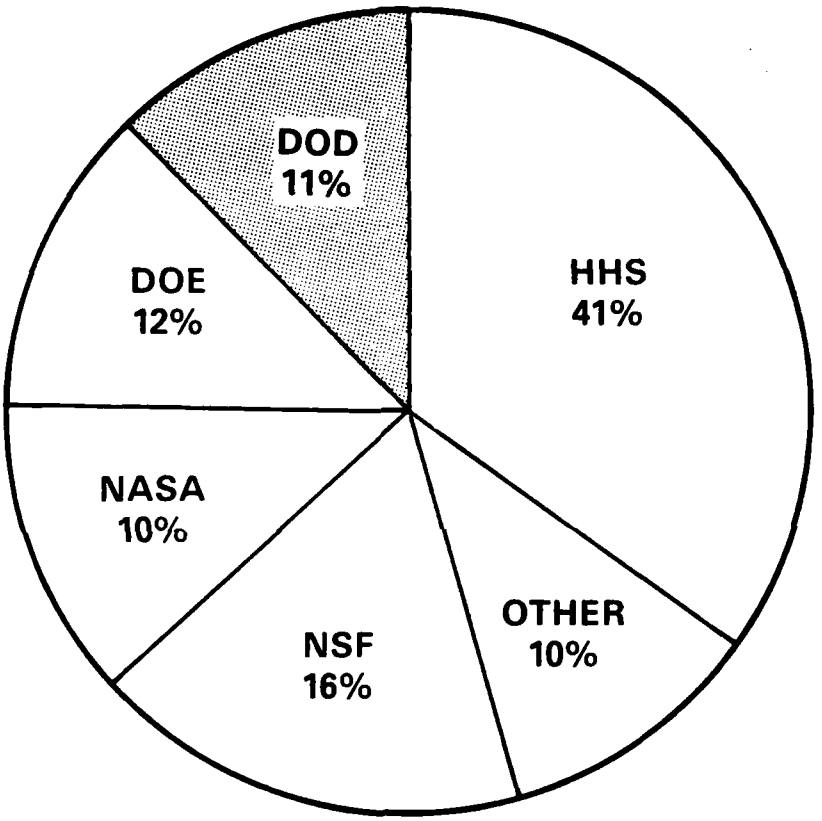


FIGURE 1 - DISTRIBUTION OF BASIC RESEARCH FUNDS
BY AGENCY (1985 ESTIMATE)

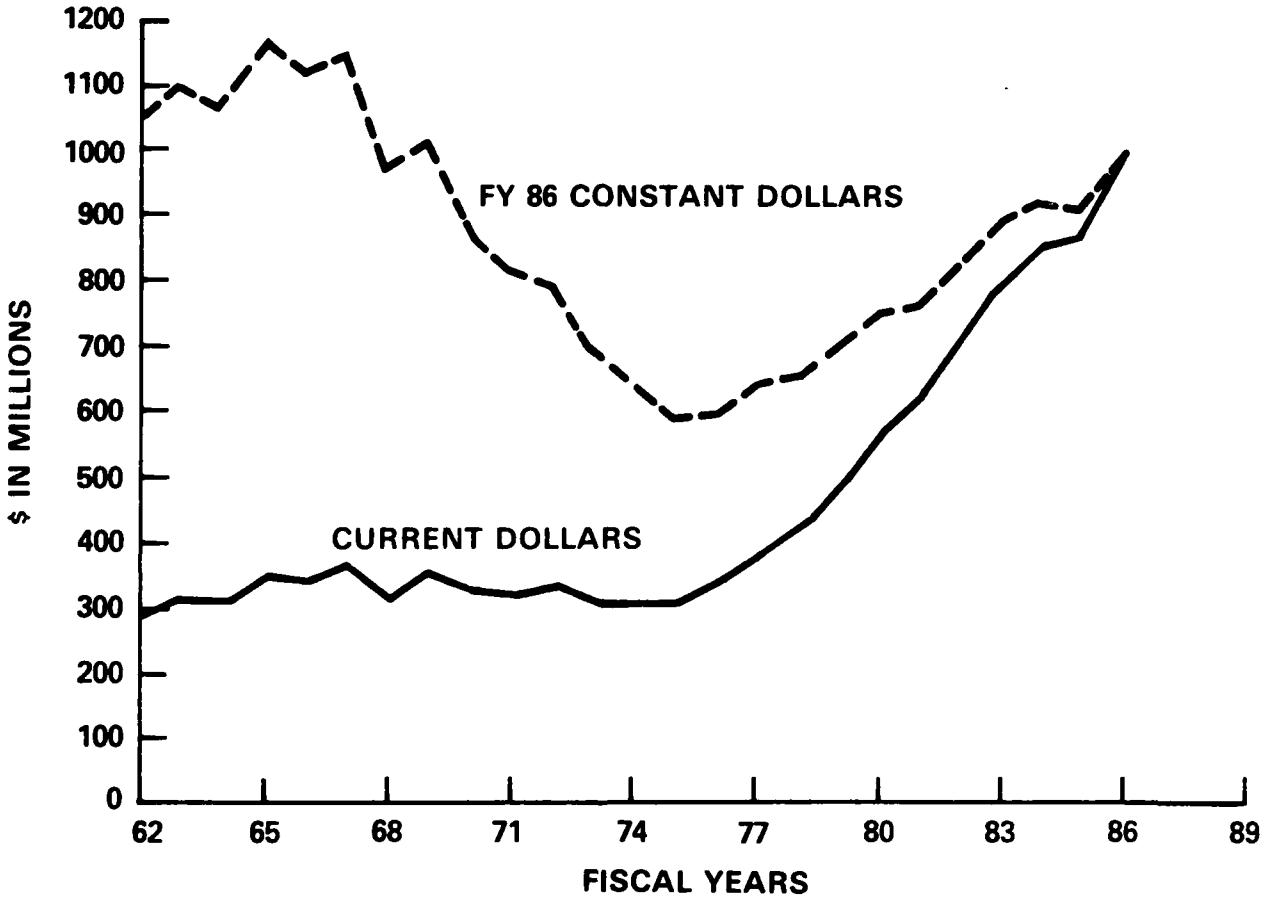


FIGURE 2 - DoD SCIENCE AND TECHNOLOGY TREND CURRENT AND CONSTANT DOLLARS RESEARCH (6.1)

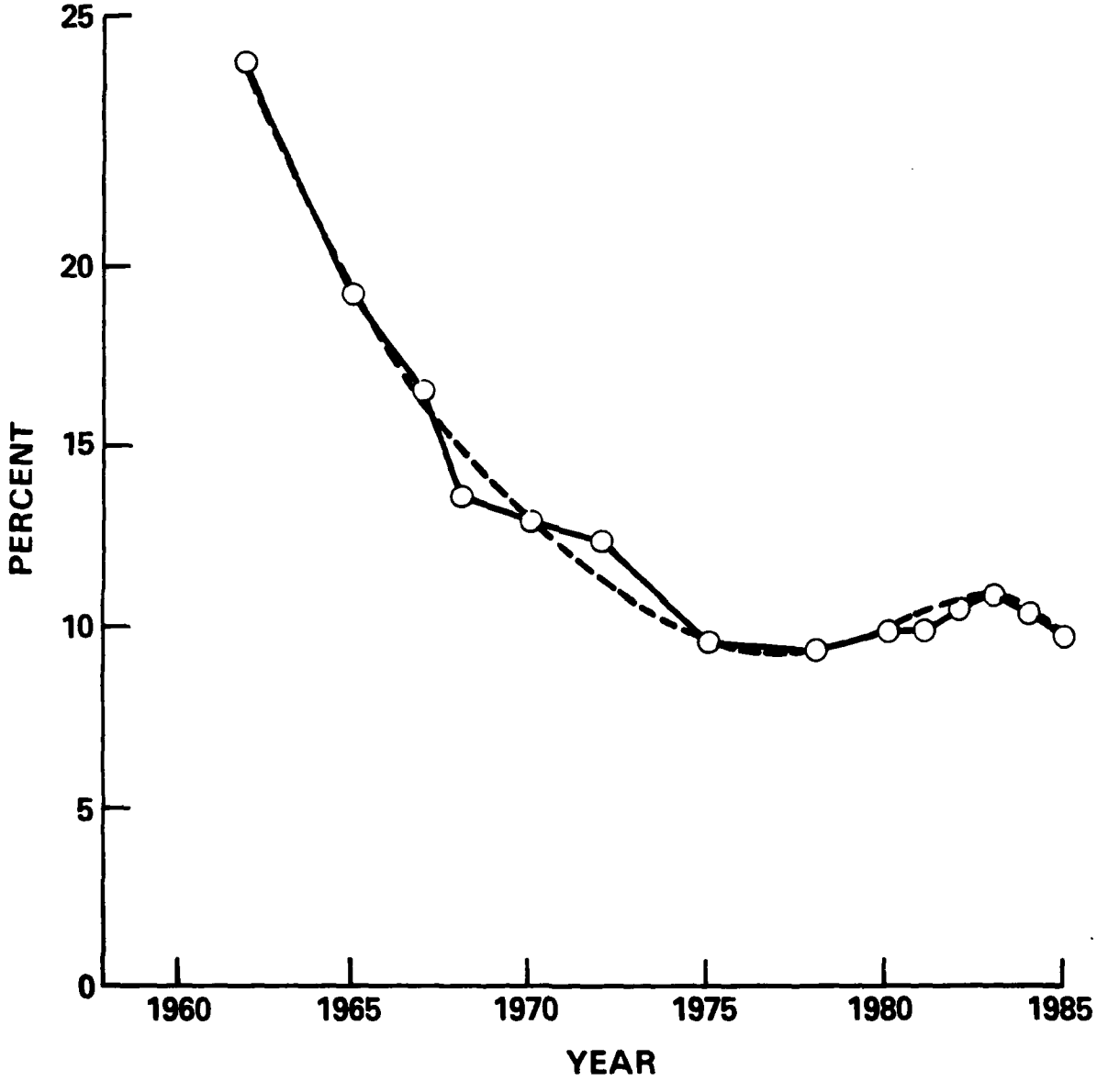


FIGURE 3 - PERCENTAGE OF TOTAL FEDERAL GOVERNMENT SUPPORT FOR RESEARCH PROVIDED BY DoD (6.1)

means dominant, stake in the quality and supply of the national pool of scientists and engineers. Other institutions and sectors of our economy cumulatively have an equal, if not greater, impact and leverage in working these problems.

C. Technical Areas

The DoD Science and Technology program covers a wide range of projects and programs. These projects and programs span the spectrum of military activities and form the basic foundation for our future military forces. Table II gives examples of the technology areas represented in the program.

TABLE II
SCIENCE AND TECHNOLOGY PROGRAM
TECHNOLOGY AREAS

- Space Technology
- Computer Sciences
- Electronics
- Surveillance
- Command and Control
- Communications
- Propulsion
- Aerodynamics
- Night Vision
- Chemical and Biological Defense
- Materials and Structures
- Medical and Life Sciences
- Others

The military Service research offices (ARO, AFOSR and ONR) play a major role in the interface between the operational-capability-driven military needs and the discipline-oriented university research community. Research required to support the DoD mission is concentrated in the twelve classical disciplines shown in Table III.

TABLE III
RESEARCH DISCIPLINES

Physics, Radiation Sciences, Astronomy, Astrophysics	Aeronautical Sciences
	Oceanography
Electronics	
	Terrestrial Science
Chemistry	
	Atmospheric Sciences
Mathematics and Computer Sciences	Biological and Medical Sciences
Mechanics and Energy Conversion	
Materials	Behavioral Sciences

D. Accomplishments

During World War II, our program supported the development of such crucial technologies as atomic energy and radar which have had a major impact on the very nature of warfare. Research during the 1950's and 1960's led to the maser and laser, superconducting devices, integrated circuits, intercontinental missiles, computerized weaponry, vastly improved communication systems, and advances in medical science. Research in the 1970's and early 1980's has made major contributions to aircraft and missile

technology, command and control systems, strategic and tactical surveillance, and has provided the foundation for the Strategic Defense Initiative.

The development of the TRIDENT submarine's advanced echo sounder provides a good illustration of the effectiveness of our S&T program in integrating the effort of universities, in-house laboratories, and industry. A research program initiated in 1963 at Brown University developed the concept of parametric sonar based on non-linear acoustics. Programs at Brown University and the Applied Research Laboratory at the University of Texas turned the concept into hardware. Together with in-house laboratory personnel, Raytheon developed the operational system for the TRIDENT.

The S&T program is woven into the fabric of national life in a pervasive though not always obvious way. The very-high-speed integrated circuit (VHSIC) program now in progress will have a major effect on the electronics industry; VHSIC will eventually enter our lives in ways that will make the wonders of children's talking toys and personal computers seem elementary by comparison. Similarly, work on parallel arrays may profoundly affect the next generation of large computers.

E. Performers

Our S&T program is executed by teams of scientists and engineers working within the DoD, industries, and universities. The funds allocated to the three major performers are shown in Figure 4 for both the research and the total S&T program.

Universities are the major performer of research, conducting about one-half of the effort. This is not surprising since universities are the nation's primary resource for research.

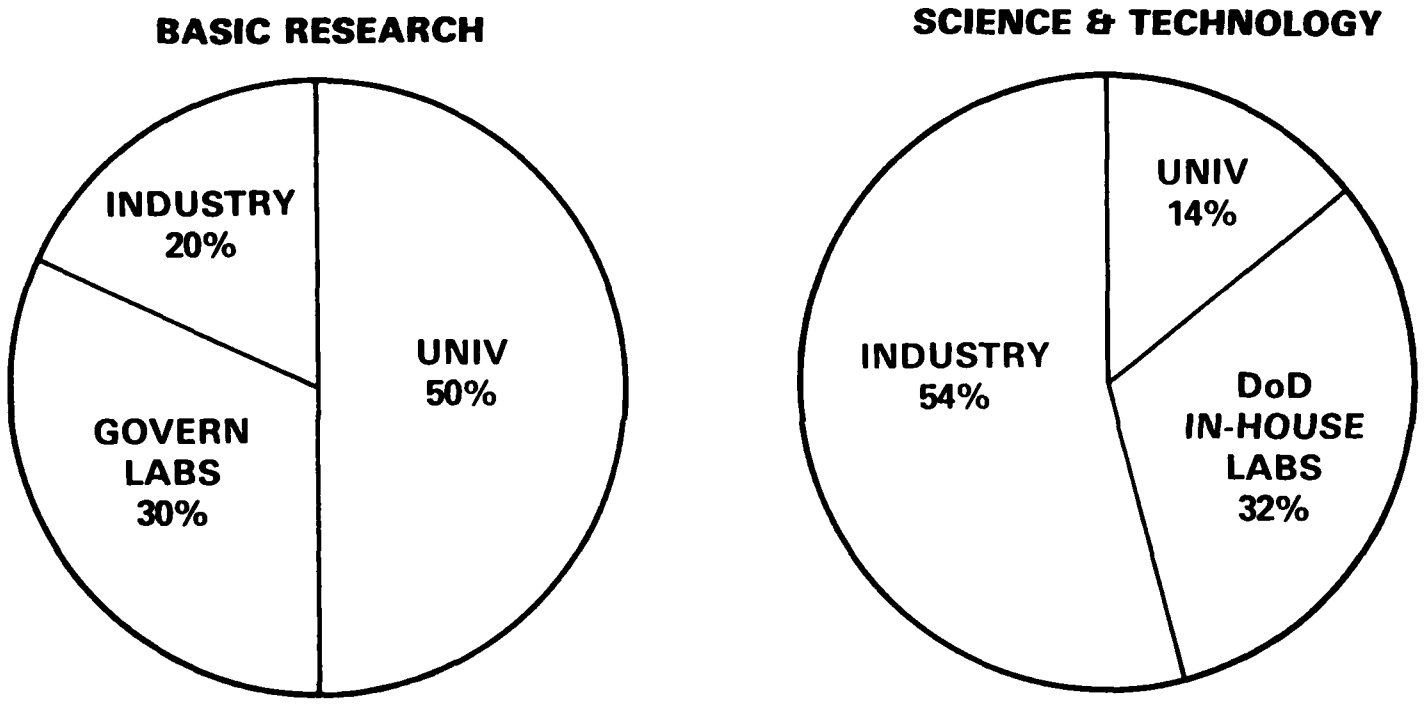


FIGURE 4 - PERFORMERS OF DoD SCIENCE AND TECHNOLOGY

They are involved in a much smaller amount of applied research and development. Their involvement in DoD programs is critical to the achievement of our technology objectives. Close ties with the university community also act to strengthen the in-house and industrial components of the program. A further benefit is that gained through the education of future scientists and engineers in disciplines essential to DoD.

We look to our in-house laboratories to be the key integrators of the S&T program and to take a lead role in research and exploratory development. They help lead the search for new knowledge and concepts. The in-house laboratories provide analytical advice and technical services in planning DoD's R&D program. These laboratories must maintin high scientific and technical competence so that outside technical advice can be evaluated and put into proper perspective in the decision making process. They provide the strong base of technical knowledge necessary for effective assistance in acquiring new systems; that is, to help make DoD a "smart buyer." One of the laboratories' more basic responsibilities is the maintenance of a highly competent technical staff to keep DoD and the Services informed of the latest scientific and technical opportunities pertinent to defense needs.

Industrial participation in the program gives us access to the highly skilled workforce and extensive facilities of our nations' industries. Involvement of industry in the Exploratory Development and Advanced Technology Demonstration programs also facilitate the transition of the technology to systems development and production.

F. Program Management

(1) Management

The Deputy Under Secretary for Research and Advanced Technology is responsible for the DoD Science and Technology Program. My responsibilities are to provide the policy and guidance to be followed by the Services in their execution of the program and to maintain oversight to insure the productivity, strength, and vitality of the program. In executing these responsibilities my office serves as a principal scientific advisor to the Under Secretary of Defense for Research and Engineering, and as the DoD point of contact for the scientific community. Through our role as DoD's S&T focal point, we can coordinate the program across the Services, resolve technical differences arising in the separate Service programs, and enhance the return on the S&T investments in defense.

(2) Program Formulation

With overall guidance from the Office of the Secretary of Defense, the S&T program is formulated by the three Services and DARPA. The process of defining what work needs to be done involves a consideration and evaluation of the operational needs and the technological opportunities for meeting those needs. The needs are derived through a comparison of the future, projected threat with planned U.S. capability and doctrine. Programs are developed to address these needs based on the exploitation of technology opportunities. Addressing long-term, more general requirements and providing the basis for future technology advancement requires the development of new research efforts. Examples of current research efforts include:

signature suppression, less vulnerable communications, space propulsion, improved visibility in degraded environments, elimination of corrosion, advanced energy beaming weapons, artificial intelligence, robotics, and microelectronics. Many more programs are proposed than can be accommodated within the Services' budget. The S&T programs must compete within the Service with the other requirements for systems development, equipment acquisition, operations and maintenance, facilities, etc.

The necessity of supporting a strong S&T program, while addressing other priorities was underscored by the Secretary of Defense in 1984.

> "As we allocate resources to the short term goals, however, we must not sacrifice our national security... We must provide now for the technology that will permit us to acquire, operate and support weapon systems that will be entering our inventory 15-20 years from now. To do otherwise would jeopardize our security in the future since we are relying on the leverage provided by deployed systems which utilize superior technology."

(3) Communication of Requirements

We widely publicize our program requirements. Formal solicitations are included in the Commerce Business Daily. Service research offices issue Broad Agency Announcements. Laboratories and commands provide information briefings to industry. The research community is reached through presentations at professional societies and other national and regional forums.

(4) Program Review

We use a three-tier review process to guide the prioritization of the S&T program, ensure scientific and technical adequacy within the program, and ensure cross-Service coordination.

The S&T investment strategy of each Service is reviewed annually. I chair this review which covers: investment rationale, program technology thrusts, resource allocation (people and funds), and accomplishments. This review provides a top-down examination of S&T programs at the laboratory level.

Science and Technology reviews are structured to provide a middle management review of the Services' S&T programs in specific areas such as Materials and Structures, Environmental Sciences, Computer Software and Systems, etc. These reviews are conducted by my office Directors. At such a review, mid-level managers from each of the Services present the S&T program content in the area with an emphasis on direction at the project level. Major attention is given to quality, program milestones, potential payoffs and technology transition.

In-depth Topical Reviews of the Service's programs in focused areas are conducted as required. These reviews cover the DoD-wide effort in focused areas such as gun and missile propulsion, jet engines, electron devices, chemical defense, etc. The reviews are conducted by staff specialists in my office and feature presentations by laboratory scientists and engineers on the technical programs in the particular area. These reviews provide an in-depth technical assessment of the area and are a valuable coordination tool.

(5) Coordination

Coordination is a significant element of planning and executing a research and development program. We are concerned that we do this well to ensure the maximum exchange of technical information, to preclude unwarranted duplication of effort and to facilitate management and investment decisions. To this end we maintain an extensive documentation center that provides information on planned, on-going and completed programs for DoD units, defense contractors, and other interested government agencies. This is supplemented by other activities.

The nation's defense is based on an alliance concept and it is important that appropriate exchanges be conducted among our Allies. A major portion of Allied coordination is accomplished via bi-lateral and multi-lateral agreements tailored to the needs of participating countries. In the science and technology program area, particularly effective coordination is carried out in The Technical Cooperation Program, the NATO Defense Research Group and the NATO Advisory Group on Aeronautical Research and Development. In our view, the international coordination in areas of defense technical interest are extensive and well done.

In the domestic arena we are engaged in a series of formal and informal activities to achieve coordination goals. Internal to DoD we continuously review the various aspects of the program to optimize our return on investment and to determine programs suitable for joint execution. In the interagency arena formal arrangements exist with other government agencies such as NASA and DoE in areas of mutual interest. Also, there are frequent contacts with the National Science Foundation, the National Academies of Science and Engineering and the university community. And finally, as in the case of all organizations doing

R&D, we are engaged in active sponsorship of and participation in symposia, conferences and meetings in the research and development field.

G. Technology Transfer

The transfer of the results of the S&T program proceeds through many routes, depending upon the nature of the program. For basic and applied research, the dominant means is through publications in professional jounals and reports. These are also made available through the established information sources such as the Defense Technical Information Center and the National Technical Information Service.

A more effective route to infuse the latest technology into DoD operations is through close collaboration between extramural and in-house laboratory researchers and with systems development. Such collaboration provides the immediate benefit to DoD of results and breakthroughs achieved on sponsored programs. In recognition of the importance of this mechanism we are taking steps to strengthen the laboratory-university relationships; partly through the University Research Initiative which will be discussed later.

3. CHALLENGES AND RESPONSES

As we look to the future, we see some areas which will demand our attention to insure technological advancement. Foremost of these are the needs for science and engineering education and laboratory (both university and in-house) modernization.

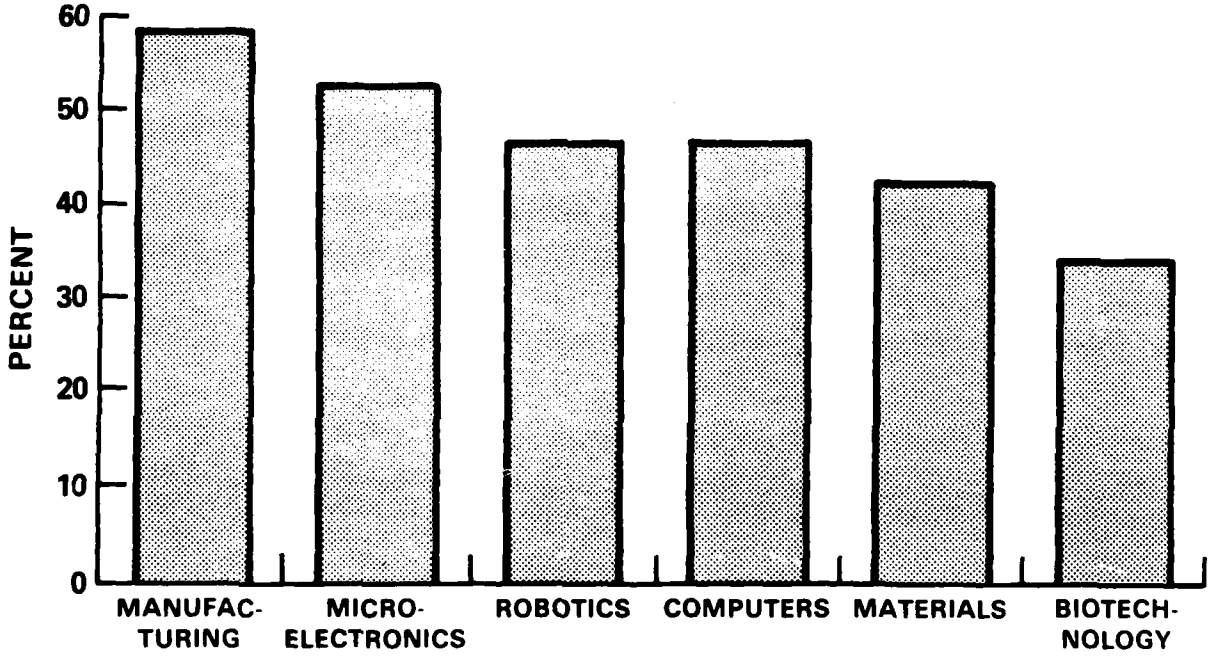
A. Education

The U.S. defense industry is a major employer of the scientists and engineers trained by U.S. universities and colleges. One out of six (17%) scientists and engineers is either directly employed by DoD or works for a defense industry. A recent National Science Foundation (NSF) study projects rapid growth and shortages exceeding 10 percent of the workforce (by 1987) in disciplines particularly important to DoD: aeronautical engineers, computer specialists, and electrical/electronic engineers.

The prospects for attracting greater numbers of outstanding students into careers in science and engineering in DoD are clouded by a number of important factors including:

- Graduate schools, particularly in engineering and related disciplines are having difficulty recruiting and retaining U.S. citizens. The distribution of foreign students in emerging engineering areas is illustrated in Figure 5. Reasons for the decline in the graduate education of U.S. citizens include the lure of industry with existing pay differentials, the increasing cost of graduate school, and the decline in federal financial assistance.

- The number of Ph.D.'s in engineering awarded to U.S. citizens by U.S. universities declined steadily throughout the 1970's and early 1980's, with a net decline of 42 percent between 1968 and 1982. Nearly half of all engineering Ph.D.'s now are awarded to foreign nationals. Foreign engineering Ph.D.'s, even if they remain in the U.S., generally cannot obtain U.S. security clearances and are thus not available for direct DoD employment.



SOURCES. NATIONAL SCIENCE FOUNDATION AND AMERICAN COUNCIL ON EDUCATION

FIGURE 5 - FOREIGN DOCTORAL STUDENTS IN EMERGING ENGINEERING AREAS: 1984

The ability of the United States to maintain superiority in broad areas of science and technology will largely depend on how well universities and colleges are able to recruit and train new scientific and engineering talent. It is especially important that the DoD take an active role in S&E education to insure the future availability of trained personnel.

The direct funding of university research meets our requirements for new technology and contributes to the S&T education program. A 1980 Navy study suggests that, on average, a million dollars of 6.1 university research funding provides financial support for approximately 10-15 graduate students. On that basis, our research program provided financial assistance for well over 4000 graduate students in 1984. In addition, the combination of research contracts and instrumentation programs provides a university research environment that is essential to retain university faculty and to attract graduate students.

During the past decade, DoD has initiated numerous "people-oriented" programs designed to increase the supply of qualified technical personnel, both uniformed and civilian, and to attract exceptional candidates into careers in areas of particular importance to DoD. The complete set of programs is extremely diverse, ranging from secondary school level through undergraduate and graduate school. Some are also designed for postgraduates and university faculty. These formal programs are supplemental to DoD's research programs.

B. University Research Instrumentation

There has been a growing realization among the scientific and university communities, and in state and Federal government agencies and the Congress, that the condition of research instrumentation in U.S. universities declined significantly during the 1970's.

In 1983 the DoD initiated a new program to provide funding dedicated to the purchase of some of the more expensive S&T equipment items required to modernize university laboratories. The University Research Instrumentation Program is a five-year, $150 million program to provide items of equipment in the $50,000 to $500,000 price range which can be used in research of primary concern to the Services. The program is funded at $30 million per year through FY 87, and approximately equals the annual 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. Awards for the next increment of $60 million for FY 86 and FY 87 will be announced next spring as the result of the evaluation of proposals due in by November 1985.

C. DoD-University Research Initiative

In FY 1986, we will initiate a new DoD-University Research Initiative. This program will address some of the widespread concerns about the infrastructure of science and technology in the United States and its relation to a stronger national defense and national economy. Twenty-five million dollars has been included in the Research program, approximately $6 million for each of the three Services and DARPA. We plan to grow this program in the near term. This new start will consist of two major thrusts.

The first thrust includes fellowship, assistantship, exchange scientist and instrumentation programs. The first three, "people" programs, will involve our in-house laboratories and scientific research offices with the objective of enhancing the nation's science and engineering capability and, at the same time, strengthening the interaction between in-house laboratory and university researchers. Additional funding for instrumentation has been included in this initiative.

The second thrust of this new initiative will be the initiation of multidisciplinary science and engineering research programs in a number of high risk, potentially high payoff areas such as materials and structures, fluid mechanics, aeronautics, biotechnology, communication networks, computer science, microelectronics, and optical materials. The intent is to support programs which concentrate talent to achieve the "critical mass" required to accelerate research achievements. These multidisciplinary programs will be managed through a Tri-Service and DARPA committee which will provide close coordination with DoD and a single point of focus for the universities.

We have high hopes for this new start.

4. CONCLUSION

The DoD is supporting a vigorous Science and Technology program which is designed to assure the continued technological superiority of our defense systems. The program is planned to meet our critical needs and exploit technological opportunities. From basic research through development, our program successfully integrates the efforts of the university, industrial and in-house laboratory performers. Through attentive management and careful coordination we are maximizing the return on our S&T investment.

We see areas which require our concern and attention to maintain the momentum of our S&T program. We are addressing the critical areas of science and engineering education and laboratory modernization.

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