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THE DEPARTMENT OF DEFENSE REPORT ON

THE UNIVERSITY ROLE IN DEFENSE RESEARCH AND DEVELOPMENT

FOR THE COMMITTEES ON APPROPRIATIONS UNITED STATES CONGRESS

APRIL 1987

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The Department of Defense
Report on
The University Role in Defense Research and Development

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I. INTRODUCTION

This document is in response to a request of the Committee of Conference for the Fiscal Year 1987 Defense Appropriations Act (Public Law 99-500). In House of Representatives Report 99-1005, p. 544, they state:

> The managers wish to stress the importance to our long-term national security of the Department's university technology base programs. The new University Research Initiative and the closely related defense research sciences programs of the services offer substantial potential to assist in meeting our future security needs. Greater investments will be required to sustain and develop both the new University Initiative and the research programs of the services. The Committee therefore requests the Department to develop a plan for the next five years that will provide for the sustained real growth of both the University Research Initiative and the university research programs of the services, and to present the plan to the Committees by March 15, 1987.

This request raises the important issue of future support for two Department of Defense (DoD) basic research programs, Defense

Research Sciences and the University Research Initiative. These two programs and a third, In-House Laboratory Independent Research, comprise DoD's basic research program. The issue of basic research at universities is best addressed within this broader context of the total basic research program, a program performed by universities, industry, and DoD laboratories.

The basic research program is one element of DoD's Research, Development, Test, and Evaluation (RDT&E) program (budget categories 6.1-6.5). Basic research (6.1) and exploratory development (6.2), DoD's analogue to applied research, form the technology base, the foundation of RDT&E.

Universities perform a greater share within the basic research and exploratory development categories but they also receive funding from 6.3-6.5 programs. For example, universities participate in the Strategic Defense Initiative (SDI) within the 6.3A budget category, especially through the SDI Innovative Science and Technology program. Universities also contribute through 6.3A programs in the Services, programs that are essential for the successful and timely transition of technology into military systems.

This report addresses DoD support for basic research at academic institutions in the context of the total basic research program and of overall RDT&E funding at universities. Section II presents historical trends for RDT&E, technology base, and basic

research funding at universities. This provides background perspective for Section III, which discusses future plans.

The report may be summarized as follows:

- DoD sustained real growth in funding for university RDT&E, technology base, and basic research during the last decade.

- In 1986, DoD provided about 11% of total university R&D funding from all sources, federal and non-federal, and 8% of total university research funding. By comparison, DoD draws upon the talent of 14% of the U.S. scientists and engineers that universities train.

- University participation within technology base and basic research programs increased during the last decade, allowing real growth for university funding even in years without real growth for the total programs. This resulted from a deliberate DoD policy to increase university participation in these programs.

- Future increases in university funding preferably will be accompanied by corresponding growth in the total programs, so that complementary efforts by industry and DoD laboratories will be sustained. This balance among

performers enhances the potential for cooperative research activities among academe, industry, and DoD laboratories. The balance also is important to assure that basic research results are fully utilized by technology transition to defense systems.

- There are abundant scientific and technical opportunities to be exploited within defense research if sustained real growth occurs, as shown by Service and DARPA plans in Section III.

- Moreover, an abundance of unfunded proposals attests to further university capacity for performing high-quality defense research.

- Projected funding trends for the total programs are the best indicators of future trends in RDT&E, technology base, and basic research support for academic institutions.

- The President's FY 88-89 budget requests 12% net real growth for RDT&E between FY 87 and FY 89, 5% for technology base, and 3% for basic research.

II. HISTORICAL TRENDS

Research and development at American academic institutions have played critical roles in sustaining the nation's lead in science and technology. Fundamental research at universities has been responsible for much of our scientific knowledge. Development and technological innovation of this knowledge have enhanced our military and economic competitiveness. *University R&D in this country has paid additional dividends because it is integrated fully with graduate education and is essential to training scientists and engineers.*

DoD has a history of support for research and development at universities. Congress emphasized the importance of this commitment by formally establishing the Office of Naval Research in 1946. This was followed by the establishment of the Army Research Office in 1951, the Air Force Office of Scientific Research in 1952, and the Defense Advanced Research Projects Agency in 1958.

DoD and other federal agencies use merit review procedures in selecting university research programs to be supported. DoD must consider the scientific and technical merits of the proposed research and the potential significance to the Department's national defense mission. This merit review process ensures that

DoD attracts the best and brightest talent to work on defense research. It also has led to the worldwide preeminence of America's research universities.

Present and future prospects for DoD support for university R&D, discussed in the following chapter, are best understood in the context of historical trends. This chapter addresses past trends in funding for DoD's RDT&E, technology base, and basic research programs. For each of these, the discussion looks at total program funding, at support for university efforts, and at DoD's role relative to other funding sources.

A. Research, Development, Test and Evaluation

Overall RDT&E funding sustained real growth between FY 80 and FY 86, reversing a 17-year trend of slow decline, as shown in Table 1 and Figure 1. Between FY 63 and FY 80, RDT&E funding decreased by about 29% in real terms. Gross National Product (GNP) increased by 69% during this period and RDT&E funding fell by more than a factor of two relative to it, from 1.2% of GNP in FY 63 to 0.5% in FY 80. Real growth in funding since FY 80 resulted in a partial recovery of RDT&E to 0.8% of GNP by FY 86.

University RDT&E funding generally has followed that for the program as a whole. As shown in Table 1 and Figure 1, support for university R&D peaked in the mid-1960's and declined through the late 1970's, as did overall RDT&E funding. University funding

TABLE 1. DoD RDT&E OBLIGATIONS: TOTAL AND TO ACADEMIC INSTITUTIONS

Fiscal Year	Current Dollars (Billions)		Constant Dollars (FY 87 Billions)		Percent of RDT&E to Acad Inst
	Tot	to Acad Inst *	Tot	to Acad Inst	
1955	2.621	**	12.142	**	
1956	3.539	**	15.029	**	
1957	4.381	**	17.524	**	
1958	4.159	**	16.311	**	
1959	5.144	**	19.639	**	
1960	5.476	.154	20.636	.580	2.8%
1961	6.366	.191	23.593	.708	3.0%
1962	6.269	.208	23.279	.772	3.3%
1963	7.028	.237	25.848	.872	3.4%
1964	7.053	.292	25.666	1.063	4.1%
1965	6.433	.291	22.866	1.034	4.5%
1966	6.885	.295	23.635	1.013	4.3%
1967	7.225	.280	23.949	.928	3.9%
1968	7.263	.244	23.305	.783	3.4%
1969	7.730	.263	23.874	.812	3.4%
1970	7.399	.216	21.710	.634	2.9%
1971	7.123	.211	19.895	.589	3.0%
1972	7.584	.217	20.160	.577	2.9%
1973	8.020	.204	20.157	.513	2.5%
1974	8.200	.197	18.768	.451	2.4%
1975	8.632	.203	17.888	.421	2.4%
1976	9.520	.240	18.362	.463	2.5%
1977	10.585	.273	18.791	.485	2.6%
1978	11.503	.383	18.889	.629	3.3%
1979	12.362	.438	18.506	.656	3.5%
1980	13.492	.495	18.301	.671	3.7%
1981	16.630	.573	20.757	.715	3.4%
1982	20.070	.664	23.674	.783	3.3%
1983	22.829	.724	25.966	.823	3.2%
1984	26.862	.830	29.474	.911	3.1%
1985	30.571	.940	32.489	.999	3.1%
1986	33.676	1.074	34.803	1.110	3.2%

* Source: "Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955-1987," National Science Foundation, Division of Science Resources Studies (Aug., 1986).

** Reliable data for these years not available.

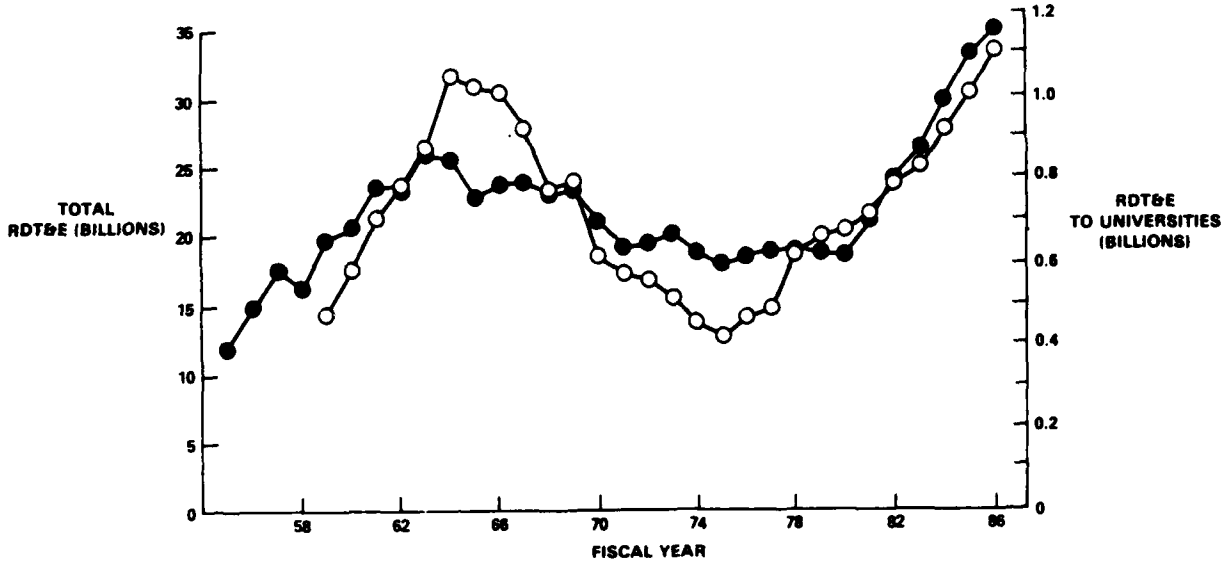

Figure 1. Historical trend in total RDT&E funding (dark points, left-hand vertical scale) for FY 55-86 and in RDT&E funding at universities (open points, right-hand vertical scale) for FY 59-86. Both shown in constant FY 87 dollars.

since FY 80 also reflects the real growth in the total program, increasing by an average of 8.8% per year in real terms.

It should be noted that these data include some funding for laboratories administered by universities. For example, the increase in university funding shown in Table 1 and Figure 1 between FY 77 and FY 78 is partially due to a redesignation of the Applied Physics Laboratory at Johns Hopkins University, which previously had been designated as a Federal Contract Research Center administered by the university.

In addition to direct funding for university R&D, DoD in the 1980's has provided incentives in the Independent Research and Development program for defense contractors to support R&D at universities. It is difficult to quantify the additional support for university R&D due to these incentives because the support includes exchanges of scientists and engineers and in-kind contributions such as research equipment, in addition to financial support. Nonetheless, the IR&D incentives are considered effective in increasing support for university R&D.

B. Technology Base

Total funding for technology base, comprising DoD's basic research (6.1) and exploratory development (6.2) programs, peaked in the mid-1960's in real terms. As indicated in Table 2 and

TABLE 2. DoD TECHNOLOGY BASE (6.1 + 6.2) OBLIGATIONS: TOTAL AND TO ACADEMIC INSTITUTIONS

Fiscal Year	Current Dollars (Billions)		Constant Dollars (FY 87 Billions)		Percent of Tech Base to Acad Inst
	Tot	to Acad Inst *	Tot	to Acad Inst	
1962	1.363	**	5.060	**	
1963	1.504	**	5.530	**	
1964	1.533	**	5.579	**	
1965	1.550	**	5.510	**	
1966	1.538	**	5.280	**	
1967	1.486	**	4.927	**	
1968	1.324	**	4.249	**	
1969	1.338	**	4.133	**	
1970	1.326	.173	3.892	.506	13.0%
1971	1.295	.184	3.618	.514	14.2%
1972	1.440	.177	3.828	.470	12.3%
1973	1.419	.161	3.567	.404	11.3%
1974	1.412	.167	3.232	.382	11.8%
1975	1.411	.165	2.924	.342	11.7%
1976	1.509	.192	2.910	.369	12.7%
1977	1.678	.221	2.979	.392	13.2%
1978	1.802	.243	2.959	.399	13.5%
1979	2.011	.271	3.010	.406	13.5%
1980	2.266	.313	3.074	.424	13.8%
1981	2.604	.363	3.250	.453	13.9%
1982	2.930	.413	3.456	.487	14.1%
1983	3.242	.472	3.688	.537	14.6%
1984	3.061	.539	3.359	.591	17.6%
1985	3.120	.587	3.313	.624	18.8%
1986	3.233	.712	3.341	.735	22.0%

* Source: "Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955-1987," National Science Foundation, Division of Science Resources Studies (Aug., 1986).

** Reliable data for these years not available.

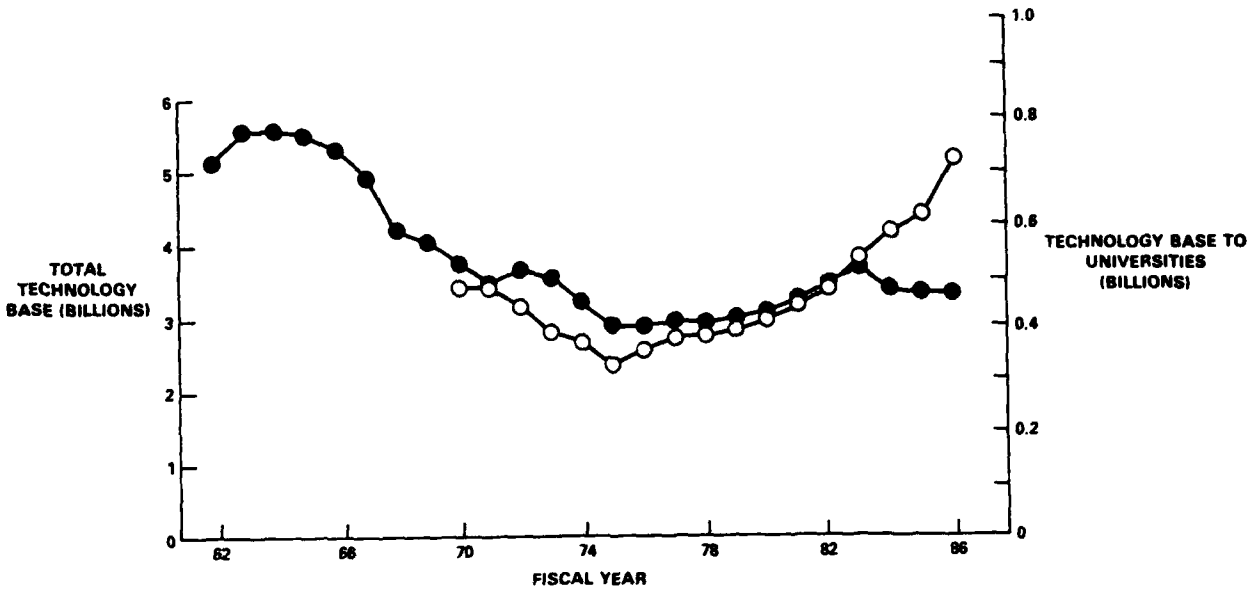

Figure 2. Historical trend in total Technology Base (6.1 + 6.2) funding (dark points, left-hand vertical scale) for FY 62-86 and in Technology Base funding at universities (open points, right-hand vertical scale) for FY 70-86. Both shown in constant FY 87 dollars.

Figure 2, real funding has been relatively constant in recent years at about 60% of the mid-1960's level. As with RDT&E, technology base funding declined relative to GNP, from 0.26% in FY 63 to 0.085% in FY 80. This ratio was about 0.077% in FY 86.

Within the nearly constant level for total technology base funding, the Department doubled support in real terms for technology base activities at academic institutions during the last decade. Real growth in funding to academic institutions averaged 7.2% per year between FY 76 and FY 86, as shown in Table 2 and Figure 2. University funding increased without a corresponding increase in total funding because the portion of technology base funding awarded to universities increased from 12.7% in 1976 to 22.0% in 1986.

There is a general correlation between the trend in total technology base funding shown in Figure 2 for years prior to 1984 and the trend in funding for universities. Therefore, although reliable data on technology base funding to universities are not available for fiscal years before 1970, one may infer from the trend of total technology base funding that universities probably received greater funding in the mid-1960's than in 1970, perhaps as much in real terms as they received in 1986.

C. Basic Research

Funding for basic research also peaked in the mid-1960's, as shown in Table 3 and Figure 3. It decreased with overall RDT&E funding through the mid-1970's, to about half of its mid-1960's level. Real growth in the last decade led to funding in FY 86 at about 80% of the mid-1960's figure. Relative to GNP, basic research funding decreased from 0.053% in FY 63 to 0.019% at the low point in FY 76. This ratio increased to 0.023% in FY 86.

Basic research funding at universities more than doubled in real terms between 1976 and 1986, for an average real growth of 9.8% per year. This increase was greater than that for the program as a whole because the university portion increased from 34.2% to 54.5% of total 6.1 funding over the last decade.

As with technology base funding, one may use the correlation between the total 6.1 funding trend and the university 6.1 funding trend to infer university 6.1 support for fiscal years before 1970. It seems likely that university 6.1 support in the mid-1960's was comparable in real terms to that received in 1986.

TABLE 3. DoD BASIC RESEARCH (6.1) OBLIGATIONS: TOTAL AND TO ACADEMIC INSTITUTIONS

Fiscal Year	Current Dollars (Billions)		Constant Dollars (FY 87 Billions)		Percent of 6.1 to Acad Inst
	Tot	to Acad Inst *	Tot	to Acad Inst	
1962	.292	**	1.083	**	
1963	.313	**	1.150	**	
1964	.310	**	1.129	**	
1965	.347	**	1.234	**	
1966	.341	**	1.171	**	
1967	.362	**	1.201	**	
1968	.318	**	1.021	**	
1969	.353	**	1.091	**	
1970	.323	.127	.948	.373	39.3%
1971	.318	.130	.889	.363	40.8%
1972	.328	.130	.872	.346	39.7%
1973	.304	.115	.764	.288	37.7%
1974	.303	.106	.693	.243	35.1%
1975	.305	.106	.633	.219	34.6%
1976	.328	.112	.632	.216	34.2%
1977	.373	.142	.662	.252	38.0%
1978	.413	.168	.678	.276	40.7%
1979	.475	.179	.711	.268	37.7%
1980	.553	.208	.750	.283	37.7%
1981	.615	.244	.767	.305	39.8%
1982	.697	.305	.822	.360	43.8%
1983	.786	.360	.894	.410	45.8%
1984	.842	.405	.924	.445	48.1%
1985	.852	.409	.902	.434	48.0%
1986	.954	.520	.986	.537	54.5%

* Source: "Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955-1987," National Science Foundation, Division of Science Resources Studies (Aug., 1986).

** Reliable data for these years not available.

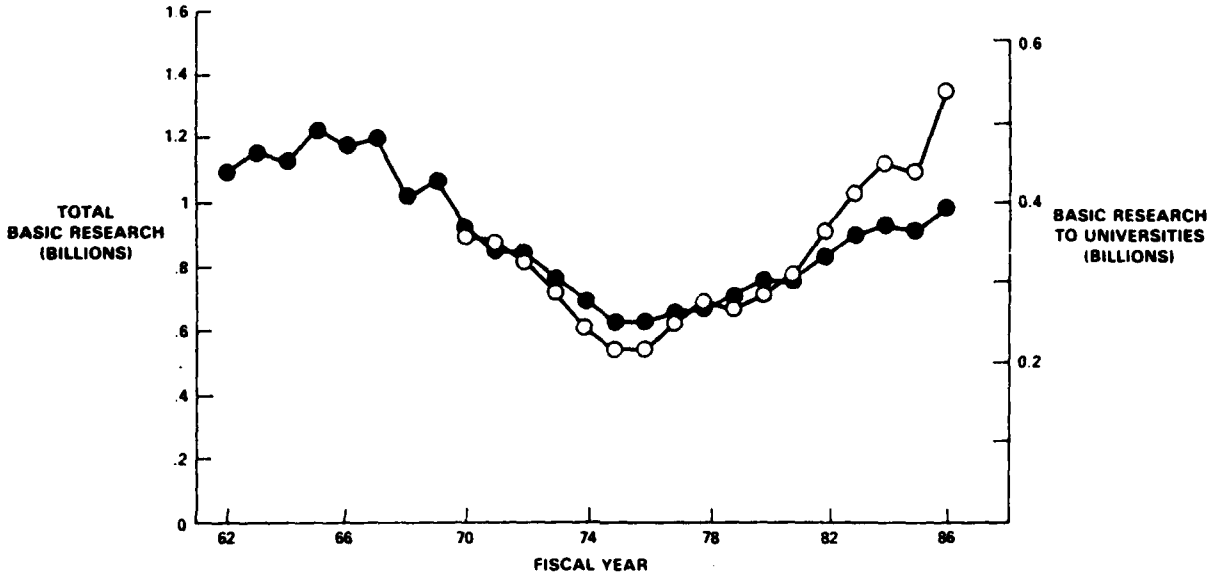

Figure 3. Historical trend in total basic research (6.1) funding (dark points, left-hand vertical scale) for FY 62-86 and in basic research funding at universities (open points, right-hand vertical scale). Both shown in constant FY 87 dollars.

D. DoD Commitment Relative to Other Funding Sources

The Department of Defense is a significant source of university R&D funds. As shown in Table 4, DoD provided about 16% of total federal support for university R&D in FY 86.

TABLE 4. DoD OBLIGATIONS RELATIVE TO TOTAL FEDERAL OBLIGATIONS FOR ACADEMIC INSTITUTIONS

Fiscal Year	R&D	Basic and Applied Research *	Basic Research
1970	14.6%	13.5%	15.7%
1971	12.8%	12.9%	14.8%
1972	11.4%	10.8%	12.7%
1973	10.6%	9.5%	10.9%
1974	8.9%	8.5%	9.3%
1975	8.4%	7.9%	8.4%
1976	9.4%	8.5%	8.3%
1977	9.4%	8.6%	9.1%
1978	11.3%	8.3%	9.5%
1979	11.3%	8.1%	8.6%
1980	11.6%	8.5%	9.0%
1981	12.8%	9.3%	9.8%
1982	14.4%	10.2%	11.2%
1983	14.6%	10.6%	11.6%
1984	14.9%	10.7%	11.5%
1985	14.9%	10.3%	10.2%
1986	16.4%	12.0%	12.3%

Source: "Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955-1987," National Science Foundation, Division of Science Resources Studies (Aug., 1986).

* As in National Science Foundation reports, DoD Exploratory Development (6.2) is regarded as applied research and the sum of basic and applied research is the DoD Technology Base (6.1 + 6.2).

DoD no longer dominates federal R&D funding at universities, as it did in the years immediately following World War II. The recent increase in the DoD commitment to universities, discussed in subsection II.A., is reflected in a modest upward trend since FY 79 in the DoD share of federal support for university R&D. However, this share is well below the level prior to 1960, when DoD provided more than one-third of federal support for university R&D.

Within the development portion of R&D funding, one important source of university support is provided by advanced technology development (6.3A) programs. This includes university participation within the Strategic Defense Initiative and its Innovative Science and Technology program. Universities also contribute through 6.3A programs in the Services, programs that are essential for the successful and timely transition of technology into military systems.

In basic and applied research, the DoD fraction of federal support for universities was estimated to be about 12% for 1986, as shown in Table 4. DoD is the third largest federal source of funding for university research, with the Department of Health and Human Services and the National Science Foundation ranked first and second at 53% and 17% of federal support, respectively.

Federal funding accounts for about two-thirds of R&D funding at universities.[1] Therefore, one may infer that DoD provides about 11% of the total federal and non-federal investment in R&D at academic institutions. Similarly, DoD provides about 8% of the total investment in basic and applied research from all sources, including the private sector.

It is interesting to compare DoD's share of the total investment in university R&D with the defense sector's share of the scientific and engineering work force. A 1984 Survey of employed scientists and engineers revealed that DoD wholly or partially supported about 14% of the nation's scientists and engineers, about 7% of the nation's scientists and 19% of the engineers.[2]

III. PRESENT AND FUTURE PROSPECTS

It is important for DoD to build upon the university base that the Department fostered during the previous decade because universities will continue to be important to the success of RDT&E efforts. Their special qualities as R&D performers and their

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[1] Science Indicators: The 1985 Report, National Science Foundation (1985). Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Stock Number 038-000-00563-4).

[2] "U.S. Scientists and Engineers: 1984," detailed statistical tables available from the National Science Foundation, Division of Science Resources Studies.

unique role as educators for future scientists and engineers virtually ensure their continued prominence within defense R&D programs.

A. Total Funding for RDT&E, Technology Base, and Basic Research

Current estimates are shown in Table 5 for FY 86-87 obligations for RDT&E, technology base, and basic research. Also shown are the President's requests for FY 88-89. Subject to Congressional appropriations, total RDT&E would have a net real growth of 12% over the two-year period between FY 87 and FY 89, as required to meet program objectives.

TABLE 5. CURRENT ESTIMATES OF OBLIGATIONS FOR FY 86-87 REQUESTS FOR FY 88-89 (MILLIONS)

Current Dollars

	FY 86	FY 87	FY 88	FY 89
Bsc Rsrch	954	892	918	986
Tech Base	3,232	3,233	3,421	3,643
RDT&E	33,676	36,946	43,719	44,203

Constant FY 87 Dollars

	FY 86	FY 87	FY 88	FY 89
Bsc Rsrch	986	892	884	920
Tech Base	3,339	3,233	3,296	3,398
RDT&E	34,789	36,946	42,118	41,234

Within the growth for total RDT&E, technology base would grow 2-3% per year in real terms between FY 88 and FY 89. Basic research decreases by 0.5% in FY 88 and increases by 3% over the two-year period. The budget requests would sustain technology base and 6.1 activities at about the real level maintained since FY 84. These trends for FY 86-89 are shown in Figures 4 and 5, in relation to the trends for the previous decade.

The requests result from an allocation of available resources to RDT&E programs needed for the U.S. to respond to external threats. These needs include technology base programs with long-term payoffs into the next century, 6.3B through 6.5 programs with nearer-term dividends in force modernization, and 6.3A programs to serve as the technology bridge between the research phase and weapons development.

There must be a balance between the funding for these RDT&E categories to ensure that new technologies are effectively and efficiently transitioned into products that are useful for military systems. Significant changes in the ratios from those included in the President's budget request would not be prudent R&D management.

Budget requests have not been prepared for fiscal years beyond 1989. Those future requests will depend upon the assessment of RDT&E needs relative to available resources at the time the budgets are prepared. They also will depend upon appropriations for fiscal years 1988-89, as yet unknown.

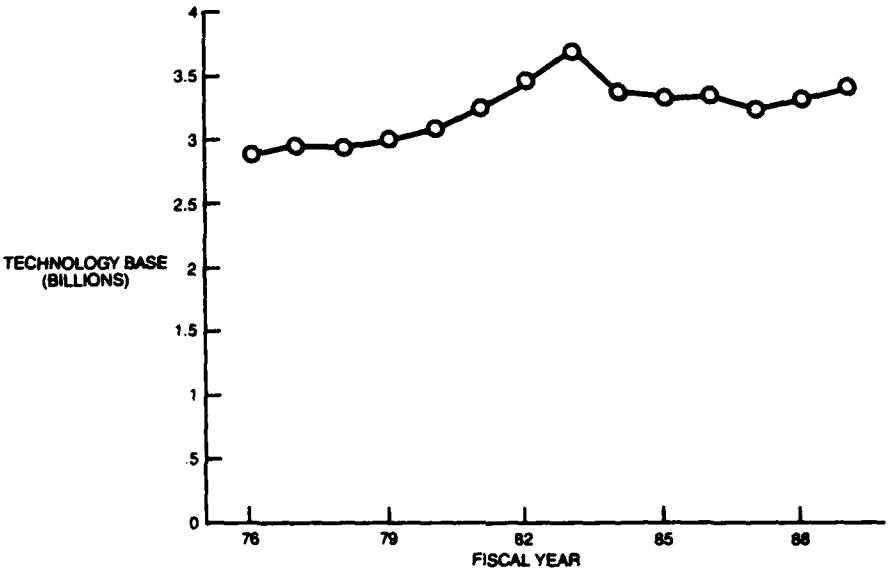

Figure 4. Projections for Technology Base (6.1 + 6.2) funding in constant FY 87 dollars. Current estimates for FY 86-87 and budget requests for FY 88-89 shown relative to the trend for the previous decade, FY 76-86.

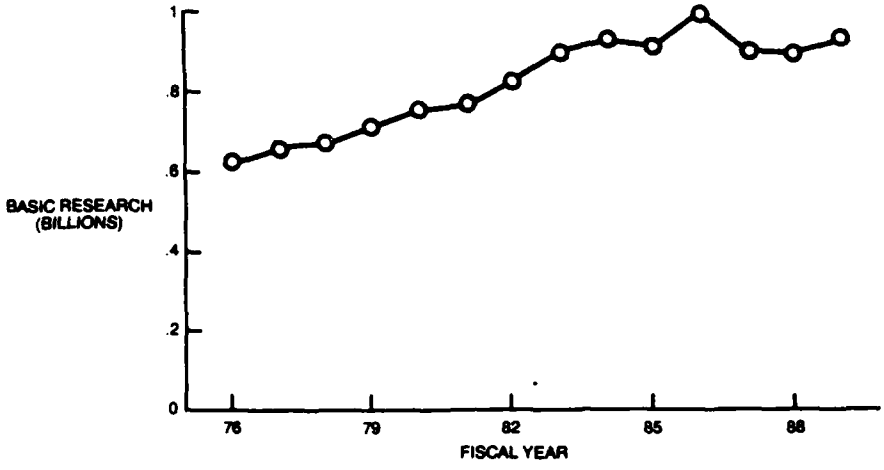

Figure 5. Projections for basic research (6.1) funding in constant FY 87 dollars. Current estimates for FY 86-87 and budget requests for FY 88-89 shown relative to the trend for the previous decade, FY 76-86.

B. University R&D Funding

University funding generally rises with total program funding, as shown in Section II. Projected trends for RDT&E, technology base, and basic research funding are indicators, therefore, of future trends in support for academic institutions.

University funding also depends upon the balance among RDT&E performers. For example, increased university participation in technology base and basic research efforts led to a real growth for university funding in excess of that for the total program between FY 76-86, as shown in the previous section. This allowed university technology base funding to increase during FY 84-86, a period of negative real growth for the total technology base program.

Future increases for university funding preferably would result from growth in overall programs rather than shifts in the balance among performers. The RDT&E program greatly benefits from having diverse performers involved in 6.1 and 6.2 programs. Universities' unique capabilities complement those of industry, in-house DoD laboratories, and federal contract research centers. Interactions and cross-fertilization among these performers are valuable to the defense mission.

It is not very helpful to speculate about exact levels of future university funding. It is constructive, however, to focus on the basic research program, where universities play the greatest role, and to address two issues: (1) are there areas of scientific and technical opportunity that could be explored if real growth in basic research funding allowed; and (2) is there capacity in the university research base to address these defense research topics.

C. Areas of Future Defense Research Opportunity

The Services and the Defense Advanced Research Projects Agency (DARPA) have identified scientific and technical areas with significant potential for defense applications and with good potential for accelerated progress with increased investment in the next five years. These areas of future opportunity, as perceived presently, include:

- Materials Science. A new and exciting area of opportunity arises with the future possibility of "nanoengineering," using biotechnology or other approaches to assemble materials at the atomic and molecular level. In principle, composites could be fabricated with no macroscopic defects, perhaps increasing material strength ten-fold and strength-to-weight ratios one hundred-fold relative to today's conventional structural materials. Polymers might be built with greater resistance to corrosion or with other novel electronic, optical, or physical properties. One might use the same techniques to assemble microelectronics components with enhanced performance (e.g., smaller size for higher speed), greater reliability, or lower cost.

- Sensors. Future sensors may go beyond vision, exhibiting tactile response, for example. Studies of transduction in vestibular hair cells, designed to elucidate the cellular basis for motion sickness and spatial disorientation, may have an additional payoff in an entirely new class of robotic sensors based on the same biological principles.

- Data and Signal Processing. Supercomputers process large quantities of data in real time, promising improved battle management, coordination of multiple-sensor systems for improved target acquisition and tracking, and real-time analysis or control of complex systems and processes. Basic research is required in fast and efficient processing algorithms and in architectures for ultrafast parallel and concurrent processing. In addition to research in mathematics and computer science, a better understanding of neural architectures and processing in the human brain may enable us to design massively parallel networks that emulate it.

- Ocean Science and Engineering. A coordinated program of field observation with theoretical, numerical, and laboratory modeling is needed to improve forecasting of ocean surface conditions for the fleet. Near-term gains in understanding could increase benefits from five remote-sensing missions to be launched in the early 1990's. These are designed to revolutionize our understanding of ocean dynamics and ocean-atmosphere interactions, with significant implications for surface, submarine and amphibious operations and surveillance. In other areas, improved knowledge of undersea acoustic propagation, of arctic oceanography, and of bioluminescence are important to submarine detection and tracking.

Other areas of presently perceived opportunity include: manufacturing science, including sensors and interactive digital control, bioreactors, and new processes for manufacture of integrated circuits; nonlinear optics; optical computing; energetic materials, including high energy density propellants; and research into human cognitive skills, to improve the use of manpower. Many of the scientific and technical areas discussed above have good dual-potential for enhancing both military and economic competitiveness. University research would play an important role in all of these areas.

In addition to the opportunities discussed above, the Defense Science Board has identified another need in a just-released study of the U.S. semiconductor industry as it relates to national defense. Due to the critical defense dependence upon semiconductor devices and the current competitive problems facing the U.S. semiconductor industry, the DSB recommended that DoD establish eight centers of excellence for semiconductor science and engineering. These centers would develop innovative approaches to device design and manufacturing that lower costs and improve performance and quality. Those located on university campuses would also train students needed to build for the future of the industry.

Of course, research is an exciting endeavor partly because it is so unpredictable. Therefore, new areas of scientific and technical opportunity surely will arise in addition to those perceived at the present time.

D. Potential for Expanding Defense Research at Universities

In the various programs and scientific areas, the Services and DARPA fund between 1/3 and 1/10 of the proposals submitted by university researchers. Scientific officers estimate that roughly twice this fraction are worth funding, in the sense that the proposals are scientifically meritorious and address problems of critical importance to national defense.

One recent program, the University Research Instrumentation Program (URIP) funded in FY 83-87, and one current program, the University Research Initiative (URI), are good examples. During the five years of the URIP, about 5,900 proposals were received and 1,065 awards were made. In the FY 86 competition for URI, 965 proposals were received. About 165 were judged to be in the category of greatest scientific merit and importance to national defense. Of these, 86 were selected for awards, given available funds. These examples indicate that available resources, rather than universities' abilities to perform high-quality research, currently determine the level of effort for defense research.

E. A University Community View

DoD greatly values the opinions of the academic community on issues that are of mutual interest to the Department and to universities. On the issue of DoD support for university research, the Department requested the views of the Working Group on Engineering and Science Education of the DoD-University Forum. The Forum and its Working Groups are federally chartered advisory committees to the Department that previously have served the Department on issues including export control, research publication policies, and defense needs for foreign language and area studies.

The Working Group on Engineering and Science Education discussed university funding in open session on January 21, 1987. Following this meeting, the university members of the working group submitted a report to the Department that affirmed DoD's need to invest in long-term research and noted the additional capacity available within the university community to contribute to those research efforts.

The university representatives further recommended that DoD:

(1) build upon recent gains in DoD funding for university research by sustaining real growth for technology base, including basic research (6.1) and exploratory development (6.2);

(2) sustain real growth for the University Research Initiative by increasing funding to $200 million per year;

(3) sustain real growth for the total 6.1 program, to include single-investigator university research efforts supported by Defense Research Sciences as well as URI, so as to attain a doubling of 6.1 Research funding by 1992;

(4) seek the necessary statutory authority and establish policies and programs to address the need for modernization of university research facilities, at a recommended level of $100 million per year for 10 years; and

(5) consider alternative strategies for management of technology base programs so as to establish advocacy and leadership on behalf of technology base programs, including university programs, at the highest levels of the Services and the Department.

The Department appreciates this university perspective and will give these recommendations serious consideration. On the last recommendation, in particular, the Department is already planning a Defense Science Board study on technology base management during the summer of 1987.

IV. SUMMARY

Universities are central to the research base that enhances our military and economic competitiveness. They contribute to this national effort both as research performers and as educators of future scientists and engineers.

The Department of Defense affirmed the importance of academic research and development by sustaining real growth in funding during the last decade. Between 1976 and 1986, funding for technology base and basic research efforts at academic institutions doubled in real terms and university participation increased relative to the total program.

Projected trends for RDT&E, advanced technology development, technology base, and basic research funding are the best indicators of future trends in support for academic institutions. The President's request for FY 88-89 includes 12% net real growth over the two-year period for the overall RDT&E program, 68% for SDI and 30% for other advanced technology development within the Services and Defense Agencies, 5% for the technology base, and 3% for basic research. This request represents an allocation of available resources among near-term force modernization needs, longer-term research needs, and technology transition requirements.

There are abundant scientific and technical opportunities for defense research at universities. Moreover, there is ample evidence that universities are capable of performing much more high-quality defense research than is currently funded.

However, the Department is committed to a balance between basic research, exploratory development, advanced technology development, and more advanced development categories. This is necessary to ensure that basic research results are exploited for military applications in a timely manner through technology demonstration and transition.