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Report of the

Defense Science Board Subcommittee

on

Department of Defense RESEARCH POLICY

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Part II. Further Analysis of Basic Research Policy

14 January 1965

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Exp. Date Jun 30, 1986

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS NONE
2a. SECURITY CLASSIFICATION AUTHORITY N/A 2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	3. DISTRIBUTION/AVAILABILITY OF REPORT Distribution Statement A. Approved for Public Release: Distribution is unlimited.
4. PERFORMING ORGANIZATION REPORT NUMBER(S) N/A	5. MONITORING ORGANIZATION REPORT NUMBER(S) N/A
6a. NAME OF PERFORMING ORGANIZATION Defense Science Board, Ofc of the Under Secy of Def (A) 6b. OFFICE SYMBOL (If applicable) DSB/OUSD(A)	7a. NAME OF MONITORING ORGANIZATION N/A
6c. ADDRESS (City, State, and ZIP Code) The Pentagon, Room 3D1020 Washington, D.C. 20301-3140	7b. ADDRESS (City, State, and ZIP Code) N/A
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Defense Science Board/OUSD(A) 8b. OFFICE SYMBOL (If applicable) DSB/OUSD(A)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER N/A
8c. ADDRESS (City, State, and ZIP Code) The Pentagon, Room 3D1020 Washington, D.C. 20301-3140	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. N/A PROJECT NO. N/A TASK NO. N/A WORK UNIT ACCESSION NO. N/A

11. TITLE (Include Security Classification)
Report of the Defense Science Board Subcommittee on Department of Defense Research Policy Part II. Further Analysis of Basic Research Policy, UNCLASSIFIED

12. PERSONAL AUTHOR(S)
N/A

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM N/A TO N/A	65/01/14	49

16. SUPPLEMENTARY NOTATION
N/A

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION
22a. NAME OF RESPONSIBLE INDIVIDUAL Diane L.H. Evans	22b. TELEPHONE (Include Area Code) (202) 695-4158/6463 22c. OFFICE SYMBOL DSB/OUSD(A)

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

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Report of the Defense Science Board Subcommittee

on

DEPARTMENT OF DEFENSE RESEARCH POLICY

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Part II. Further Analysis of Basic Research Policy

UNANNOUNCED

14 January 1965

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Washington, D.C. 20301

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OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

14 January 1965

TO: THE SECRETARY OF DEFENSE

THROUGH: THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

The Defense Science Board has completed its study on Department of Defense research policy and submits herewith Part II, Further Analysis of Basic Research Policy. Part I was submitted to you, through the Director of Defense Research and Engineering, as of 31 December 1963. This report has been a cooperative effort of the Defense Science Board and the President's Science Advisory Committee.

The reconstituted Subcommittee that carried through the analysis in Part II deserves to be commended for its additional careful review of this highly complex problem. As in Part I, a substantial portion of the data is published in this form for the first time. I commend the conclusions and recommendations to your thoughtful consideration.

In conclusion, I wish to express once again our appreciation of the cooperation and interest of Dr. Brown and the civil service staff in this study.

F. Seitz

Frederick Seitz
Chairman
Defense Science Board

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OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

14 January 1965

MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Report of Subcommittee on DoD Research Policy, Part II

The Subcommittee on Department of Defense Research Policy submits herewith its second report, Part II, Further Analysis of Basic Research Policy.

Part I, issued on 31 December 1963, was generally concerned with the historical aspects of DoD research policy, as well as some salient trends in that area, and included certain recommendations. In Part II, attention is focused on two sets of recent data on research expenditures, projected to 1970, that were separately compiled by the ODDR&E and the National Science Foundation.

The Subcommittee reaffirms and emphasizes the necessity that the Department of Defense play a central role in the nation's scientific progress. The Director of Defense Research and Engineering is to be commended for recognizing this obligation. The Subcommittee presents its findings, conclusions and recommendations (pages 11-13) as appropriate guidelines and goals considered essential to sustaining and strengthening the DoD's research program in a manner consistent with the increasingly complex technological requirements.

The Subcommittee:

C. C. Furnas
C. C. Furnas

ER Piore
Emanuel R. Piore

Harvey Brooks
Harvey Brooks

Allen E. Puckett
Allen E. Puckett

Gerald M. McDonnel

Frederick Seitz

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CONTENTS

1. INTRODUCTION

This is a continuation of the Defense Science Board's report on Department of Defense research policy; the first part, issued in December 1963, dealt with policy on support of basic research[1].

At a time when international relationships are changing, paralleled by corresponding alterations in our military posture and policy, there will inevitably be basic changes in the pattern of the Defense budget. They will affect funding levels, as well as content. Also, any changes in the balance of strategic, tactical and defense forces will influence the relative levels of procurement of new materiel for those forces, as compared with expenditures for operation and maintenance or for the development of new weapon systems.

A small but extremely important fraction of the Defense budget is for basic and early applied research. The factors that may determine readjustments in those categories are less obvious than those affecting the larger components mentioned before and are less subject—or amenable—to calculation. For this reason in particular, the categories of basic and early applied research warrant some special attention.

It seems clear that such a time of change is at hand. There is much evidence suggesting the possibility of a decline in the level of the total Defense budget over the next few years or, at least, a halt in the rapid rise that has characterized it in the recent past. We may expect the budget structure to alter materially in response to modified force requirements, e.g., a decreasing need for acquisitions in the strategic force structure and increasing attention to forces for limited war. Moreover, the development of major new weapon systems will be undertaken less frequently and only after more cautious and painful consideration.

The question must arise, therefore, "What policy will be used to guide the establishment of budgets for basic and applied research in the presence of those modified conditions that affect the budget as a whole?"

The smallness of the research budget category is an invitation to inattention, or to change by accident or default. Actually, the potential product of this effort, the military technology of the future, is so important that, in times of general decreases in the budget, we should consider the support of the research program even more carefully than might be necessary in other years.

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[1]Office of the Director of Defense Research and Engineering, Report of the Defense Science Board Subcommittee on Department of Defense Research Policy, "Part I. Policy on Support of Basic Research," 31 December 1963.

Essentially, this report is concerned with two major questions:

(1) Will the Department of Defense (DoD) program over the next few years provide adequate opportunity and encouragement for freewheeling research in those areas of science that may be expected to achieve an eventual importance in national defense?

(2) Will the national program of basic research and education give reasonable assurance that enough young scientists of the necessary quality to meet future Defense needs, who may engage in research related to problems of national security, will continue to be available? How, and to what extent, should the DoD participate in efforts to sustain an adequate resource of highly qualified scientific manpower?

This report focuses primarily on basic aspects of the natural sciences — chemical, physical, biological and mathematical. Since the social sciences are being considered by another subcommittee of the Defense Science Board (DSB), they are not included here. Also, the medical sciences, to the extent that they can be separated from the biological sciences, are not given major attention in this report. Although there are some unique problems of military medicine, they are mainly confined to applied rather than basic research. Insofar as basic aspects are concerned, the massive support given to the medical sciences, particularly by the National Institutes of Health, is judged to be adequate.

Within the area thus delineated, this report assesses the current plans, decisions and budgetary actions which loosely comprise the effective research policy of today. The Subcommittee's findings, conclusions and recommendations (sections 5 and 6) deal with factors that the Board considers are the minimum essential to accommodate substantive farsighted programs in consonance with the developing technology and changing requirements of the national defense.

It is recognized that, "In the U.S. there is no one substantive document which is the statement of the Nation's science policy."[2] In view of the extremely rapid changes in science and technology and the volatile international situation, it is probably fortunate that scientific organization and activity have not been obliged to follow any fixed, long-range plan. Any such planning structure would not have been flexible enough to meet the exigencies of many unique situations. As in the body of common law, the structuring of national research policy has been evolutionary and, to a large extent, based on overriding national considerations, primarily World War II and the present cold-war situation.

The lack of a firm statement of national policy does not mean, however, that the Subcommittee had no guidelines for its deliberations and recommendations. A number of the more definitive pronouncements of the legislative and executive branches of the U.S. Government, though not always consistent, were selected as representing certain aspects of the current de facto national policy on science. To furnish a rough frame of reference, some of those statements are presented in Appendix A to this report.

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[2]Organization for Economic Co-operation and Development, Country Reports on the Organization of Scientific Research: United States, O.E.C.D. Publication No. 16155, June 1963, p. 18.

A questionnaire concerning the most important factors of this study was sent to the members of the Defense Science Board. As the Board members are collectively representative of those holding high positions in research and development (R&D) in the academic, industrial and governmental sectors of the United States, their replies afford a substantive perspective of our nation's current scientific and technical composition. The questions and the consensus of opinions stated in reply are given in Appendix B.

Most important, since Part I was issued, a 5-year forecast of DoD expenditures for research, development, test and evaluation (RDT&E) has become available (see section 3 and Appendix C), and the National Science Foundation (NSF) has published an analytical study and projection of Federal R&D levels.[3] The availability of this new information gave the main impetus for conducting this further study.

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[3] National Science Foundation, Federal Agency Survey of R&D Levels Projected Through 1970; Updating of Obligational Data, July 1964, For Official Use Only.

2. TRENDS IN SUPPORT OF RDT&E

It is uniquely difficult and frustrating to try comparing data on the financial support of R&D activities from different sources throughout the country, because there are no universally accepted definitions of such terms as research, applied research, exploratory development, etc. Even when agencies accept common definitions, their interpretation of dollar expenditures in the various categories differs widely.

For purposes of analyzing trends in the DoD's support of RDT&E, therefore, primary emphasis is placed on data recently compiled by the Office of the Director of Defense Research and Engineering (ODDR&E). Beginning with FY 1962, those data have been organized in accordance with R&D program categories as defined by DoD Instruction 3200. 6, "Reporting of Research, Development and Engineering Program Information." (See Appendix D for these definitions.) Since this report deals primarily with research, it is appropriate at this point to give the following abridged definition of that category: Research includes all effort directed toward the increased knowledge of natural phenomena and environment and the solution of problems in the physical, behavioral and social sciences that have no clear, direct military application.

DoD funding data, starting with FY 1960 and projected (in some cases) through FY 1970, are tabulated in Appendix C. As far as this study is concerned, the significant facts and trends revealed by those tables are as follows:

(1) The proportion of all DoD dollars expended on RDT&E has increased from 5.7 percent for FY 1954 to about 14 percent in FY 1964 (Table C-1). This change, however, may be somewhat illusory. Because of a major change in accounting procedures in FY 1960 and the conversion of past data to the new system, the budget breakdown was necessarily somewhat less than exact. At that time all test and evaluation items, many of which are extremely costly (range support, for example), were consolidated with the R&D budget, thereby creating an all-inclusive budget for research, development, test and evaluation. Despite this shift, there has been an appreciable increase in the support of overall RDT&E activities relative to the total Defense budget.

(2) The proportion of total RDT&E dollars expended on research increases from 4.6 percent in FY 1962 to a projected 10.7 percent in FY 1970 (Table C-2). The category criteria of DoD Instruction 3200. 6 were used consistently from FY 1962 on. Hence, these data have true significance; they indicate an upward trend of support in the research portion of the total RDT&E effort.

(3) Projected expenditures for exploratory development show a small upward trend through FY 1970 (Table C-3).

(4) Anticipated expenditures for advanced development rise to a peak in FY 1967 and then recede nearly to the FY 1965 level by FY 1970 (Table C-4).

(5) Financial support of engineering development peaks in FY 1964 and steadily declines to FY 1970 when it is approximately 22 percent below the FY 1962 level (Table C-5).

(6) Expenditures for operational systems development have been decreasing steadily since FY 1962, and this trend will apparently continue through FY 1970, at which time funding will be two-thirds less than it was for FY 1962 (Table C-6).

(7) Management and support expenditures have risen consistently since FY 1962, and this trend will continue through FY 1970 for a 30-percent increase over FY 1962 (Table C-7).

(8) Total RDT&E support peaked in FY 1963 but has been declining since then. The projection shows that support for 1970 will be about 25 percent below the peak year of FY 1963 (Table C-9).

(9) The proportion of the gross national product (GNP) expended on military functions has remained approximately constant at 8 to 9 percent during the past 10 years (Table C-10).

(10) The annual rate of increase (compounded) of expenditures for research in the 5 years FY 1966-1970 is about 12 percent (Table C-2).

The significant qualitative observations on these trends appear to be as follows:

(1) The policy of "making what we now have work better" will be carried out for the next 2 or 3 years through the medium of engineering development, etc., and then will be somewhat deemphasized.

(2) In parallel with decreasing emphasis on further refinement of existing weapon systems, support of research and exploratory development is to be increased. This indicates that DoD policy-makers firmly realize the necessity for replenishing the reservoir of new knowledge and (hopefully) the need for educating a new generation of scientists and engineers who will be adequately prepared and may be available for defense work.

(3) Since there is at present a consistent trend toward cost inflation, in both money and technological resources, the impact of increased expenditures on research and early development will not be as great as the projected dollars might indicate. The trend of greater spending for research, however, is in the right direction for sustaining a superior defense posture.

(4) Since the national economy has adjusted to Defense expenditures of 8 to 9 percent of the GNP over the past decade, and since research represents only a fraction of those expenditures, very substantial increases in Defense research expenditures could be absorbed with no disruptive effect on the nation's economy. In the long run, as history has repeatedly shown, good basic research increases the GNP significantly and thus represents a sound national investment. Such increases could be initiated promptly and could be particularly augmented when and if the anticipated steady growth of the GNP materializes. Substantial increases in Defense research should be skillfully applied to avoid radically exceeding the capacity of the competent manpower available.

(5) It would appear that the DoD projections are based on the assumption that the world situation will remain relatively stable during the next decade. The Board has no firm information concerning any secondary or emergency plans for R&D that could be implemented quickly if some unforeseen crisis should arise. It is to be hoped that such plans have been prepared and that they are periodically realigned to the changing patterns and needs of the Department of Defense with regard to science and technology.

3. RESEARCH IN THE NATIONAL SCENE

The foregoing discourse on the optimistic trend of research under the DoD's aegis is somewhat negated by the National Science Foundation's recent survey[4] of R&D levels, projected through 1970. This apparent inconsistency is partly explained by two factors:

(1) Differences in definition and classification and

(2) The marked increase in support of research by other agencies, particularly the National Aeronautics and Space Administration (NASA) and the Department of Health, Education and Welfare.

In the extensive NSF study, the R&D obligations of 10 Federal agencies are projected through FY 1970, providing an opportunity for evaluating the DoD's role in the mainstream of national trends.

The following excerpts from the NSF report are relevant to this analysis:

> ...estimated Federal obligations for research are scheduled to reach $7.6 billion in fiscal year 1970, or approximately 90 percent more than actual obligations for research in 1963. Under the revised projections, research obligations in 1970 will represent 41 percent of total research and development obligations compared to 31-34 percent in 1963-65. /p. 6/

In the NSF report, "research" approximates the combined DoD definitions of "research" and "exploratory development." Hence, in comparing the two sets of data, care and discretion should be used to avoid reaching erroneous conclusions.

> DOD was the leading Federal research obligator in 1963-65, and is projected to continue to be in 1970. Its share of the Federal total, however, is scheduled to drop considerably, from about 41 percent in 1963 and 36-37 percent in 1964-65, to an estimated 27 percent in 1970. /p. 7/

> DOD was the major obligator of applied research funds in 1963-65 and as projected for 1970. Its share of the Federal total, however, dropped from 49-53 percent in 1963-65 to an anticipated 38 percent in 1970. /p. 8/

> Federal basic research obligations, according to the updated projections, will total $3.0 billion in 1970 compared with $1.3 billion in 1963; $1.6 billion in 1964; and $1.8 billion in 1965. By 1970, it is anticipated that 39 percent of total Federal research obligations will be for support of basic research. This compares with 33 percent of total research obligations in 1963 and about 36 percent in 1964 and 1965.

[4]Ibid.

> The updated basic research projection total for 1970 is about 2 percent less than the previous projection total for 1970. This decrease was occasioned largely by DOD's projected reduction of $105 million in basic research obligations for 1970. /p. 9/

The Subcommittee was distinctly disturbed that a reconsideration should have brought the DoD to forecast a major decrease in basic research funds 5 years from now.

> NASA was the number one obligator of basic research funds, both in 1963-65 and as projected in 1970. /p. 9/

The Board is skeptical of the significance of this statement. Probably the high figure quoted by NASA is due to the great cost of space vehicles and support equipment, which are necessary but do not, in themselves, contribute to the advance of scientific knowledge. It is likely, therefore, that the NASA data do not accurately reflect the situation; that is, the bulk of NASA funds is going into expensive, though necessary hardware, rather than into science. (The dilemma of "big science" is stated more specifically in section 4.1 of this report.)

> Federal intramural obligations for total research amounted to $.9 billion in 1963; $1.0 billion in 1964; an estimated $1.1 billion in 1965; and a projected $2.0 billion in 1970. /p. 16/

> Federal research obligations to educational institutions proper were $.8 billion in 1963; $1.0 billion in 1964; an estimated $1.1 billion in 1965; and a projected $2.0 billion in 1970. In 1963-65, research obligations for educational institutions proper represented from 67 to 70 percent of total research obligations to educational institutions, both proper and research centers. By 1970, it is projected that the proportion of the total going for educational institutions proper will rise to 81 percent. /p. 17/

In 1963, DoD expenditures for intramural research were $334.7 million; the projection for 1970 is $472.7 million—an increase of 41.5 percent over a period of 5 years (NSF Table 12, p. 56). In 1963, DoD research obligations to educational institutions were $185.7 million; the projection for FY 1970 is $217.6 million, an increase of only 17.1 percent over the 5-year period (NSF Table 15, p. 59).

The Board believes these data represent a most undesirable trend—the rapid expansion of DoD in-house research along with a nominal incline in Defense-sponsored research in academic institutions. This imbalance could have a cumulatively adverse effect on the nation's scientific welfare.

The NSF compilation (NSF Table 2, p. 46) shows the total Federal obligations for research expanding from $5.022 billion in FY 1965 to $7.595 billion in FY 1970, a 50-percent increase in 5 years. The corresponding figures for DoD research are $1.835 billion in FY 1965 and $2.026 billion in FY 1970, an increase of 10 percent over that period.

4. IMPORTANT QUALITATIVE TRENDS

The preceding exercise in numbers indicates a favorable trend of sustained interest and a modest increase in the DoD's support of research. With each passing year, however, the effectiveness of the DoD research dollar is reduced by certain qualitative factors. Essentially, these may be classified as follows:

(1) "Big science"
(2) Programmatic research
(3) Financial and technological inflation

4.1 Big Science

This refers to areas of investigation that call for very expensive—often very large—apparatus requiring costly maintenance or large operating teams (or both), which must be sustained whether or not there is any useful scientific output.

In certain fields the presence of "big science" is inevitable if any progress is to be made, but it should not be assumed that money spent on it is automatically producing worthwhile scientific results. Scientific input to those fields is not proportional to total dollars spent but to the number of dollars invested above some threshold that represents the cost of enabling work in a given field. Although the amount of money spent up to that threshold is prerequisite to meaningful research in the field, it does not, by itself, produce results that are significant to the research objective.

Two prime examples of big—hence, expensive—science are space research and oceanography. The trend is shown by an illustration from the latter field. The Office of Naval Research (ONR) recently issued a report[5] in which the operating costs of research vessels against Navy RDT&E appropriations are compiled.

Those operating costs of RDT&E in FY 1963 were $4.943 million. The projected costs for FY 1969 are $15,632 million, an increase of 320 percent in 6 years. In 1969, the bulk of the money, $11,472 million, is to come from the ONR budget. These are only logistic costs, which should not be construed literally as research funds. It is evident that, if that trend were to continue for a few more years, the ONR would, with anticipated ceilings, have zero dollars for scientific work.

4.2 Programmatic Research

This refers to the grouped scientific activities in prescribed areas of major interest. They may involve many investigators in numerous locations, and the individual segments may not be unduly expensive; but as the programs grow they tend to take first priority for available funds and so prevent the employment of other investigators in new fields.

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[5] Office of Naval Research, Operating Costs of Research Vessels, by Category, 22 June 1964, ONR Code 520.

4.3 Financial and Technological Inflation

Of greatest impact are the steadily increasing complexity and costs of research equipment. Although the Bureau of Labor Statistics' cost-of-living indexes imply that there has been only minor financial inflation over the past several years, it is undeniable that the annual cost per scientific investigator is rising fast, from 5 to 7 percent each year, in universities as well as other research establishments.

The major part of this cost increase is caused by the rapid rise of salaries of scientists and engineers, which is partially due to the very tight market—the excess of the demand for really good men over the supply. Another important factor is the age structure of this professional group. Since modern science and technology are essentially young men's games, the average age of investigators is definitely on the young side. Even in a noninflationary economy, therefore, their salary scales would inevitably become higher and higher as they gain experience and skill.

* * * * *

When funding levels are more or less constant, the overall effect of these three imponderables—big science, programmatic research, financial and technological inflation—is a steady lessening of opportunities for introducing new research personnel into the program and developing novel ideas. This would be especially harmful to freewheeling research and graduate programs in the universities. Unless well-considered adjustments are made, this potentially grave situation could seriously impede our defense within a few years.

5. FINDINGS AND CONCLUSIONS

(1) The ODDR&E is to be commended for effecting increases in programmed obligations for research until FY 1970, in view of the gradual decline in both RDT&E and total DoD obligations.

(2) Despite the projected increase, by 1970 DoD research will be lagging behind the mainstream of Federal research programs.

(3) The ODDR&E is also to be commended for instituting a system of monitoring the DoD research program. The entire program is divided into four general areas, each with 14 subdivisions, and records are kept of complete data on obligations and level of effort for each part. This system fills a long-standing need for readily available information to be used in effectively guiding and controlling the R&D program.

(4) The Board notes that the FY 1965-70 projections show substantial increases for research programs in the DoD's in-house laboratories. The increments of DoD support of research in academic institutions, however, are considerably lower.

In-house R&D programs have contributed significantly to our national defense posture, and this trend toward greater support of those activities conforms to the separate recommendations of the Bell Committee[6] and the Defense Science Board[7]. Both reports emphasized the critical need for strengthening in-house Defense laboratories, but "strengthening" does not necessarily call for increases in size or major increases in expenditures.

It is undeniable, though, that scientific progress is contingent upon the existence of a base of highly trained and qualified scientists, of which academic institutions are virtually the only source, "... as universities are the natural centers for jointly thriving basic research and graduate education."[8] It cannot be overemphasized that this indispensable role of academic institutions must be regarded literally, lest the future efficacy of national defense be jeopardized.

(5) By decreasing the support available for freewheeling research and graduate programs in the universities, "big science" and programmatic research have a deleterious effect on that sector of research activity. It seems inevitable that within a few years this situation, unless carefully controlled, will retard or obstruct the timely input of fundamental scientific information in many critically important areas.

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[6]Bureau of the Budget /David E. Bell, Director/, Report to the President on Government Contracting for Research and Development, April 1962.

[7]Defense Science Board, Report of the Defense Science Board on Government In-House Laboratories, 6 September 1962.

[8]President's Science Advisory Committee, Scientific Progress, the Universities, and the Federal Government, 15 November 1960.

6. RECOMMENDATIONS

In addition to the composite data on trends and programming previously noted, the following recommendations should be considered in the light of the legislative and executive branches' general pronouncements on science and public policy (Appendix A), particularly, the rationale presented by Dr. Harold Brown, Director of Defense Research and Engineering (DDR&E):

(1) The DoD should take steps to ensure that its current share of financial responsibility for specific fields of science in academic institutions is not unduly inhibited by considerations of immediate relatedness to mission.

(2) The Departments and agencies of the DoD should give even greater adaptability to their grant and contract mechanisms for extending the period of funding commitments—e. g., through step funding, guaranteed renewals at minimum levels, etc. —while minimizing the legal commitment against annual appropriations.

(3) In order to segregate and control the logistic costs of large-scale research, both in academic research and in DoD-supported research generally, a separate subcategory for logistic costs should be established immediately in the RDT&E budget. Further, each large-scale project and each tightly organized major program should be considered on its own merits, somewhat apart from the consideration of general costs covering numerous small projects by individual investigators.

(4) Funding of research should be increased in annual increments so that, by FY 1970, obligations will be $150 million larger than the presently projected figure of $585. 5 million.

(5) One-half of this funding increase (i. e., $75 million by FY 1970) should be designated the DDR&E's Discretionary Fund, as distinguished from the Emergency Fund. It should be directly controlled by the DDR&E and used to expedite action designed to keep the DoD research program properly oriented and balanced. According to the DDR&E's judgment, monies from this fund could be allocated to the individual Military Departments for research by appropriate organizations, either in-house or outside the DoD. Projects started in this manner, however, should be financed from beginning to end by the DDR&E's Discretionary Fund. The Departments should not be expected to assume the responsibility for funding such programs after the DDR&E has established them.

(6) The other half of the funding increase ($75 million by FY 1970) should be designated the DDR&E's Academic Fund, to be used solely for grants to colleges or universities. The grants should not be made on the basis of specific projects; it would be appropriate, however, to specify that they be used for advanced academic work in a given area—for instance, some field of the physical sciences.

(7) To make up-to-date information available for planning purposes, current efforts to obtain, correlate and keep current information in the three management

categories listed below, for both in-house and extramural activity, should be continued and strengthened:

(a) Expenditures for research (6.1) and for research phases of exploratory development (6.2), classified with regard to location and area of research;

(b) Capital expenditures for fixed facilities and equipment;

(c) Technical manpower, classified by rank and location.

This information would constitute an easily available source of specific data on the extent and nature of the involvement of Defense funds in university programs, in the Defense-contractor effort and in other technical activities of national importance. It would enable a continuing comparison of Defense R&D practice involving capital funds and operation and maintenance funds with corresponding practices of the better industrial organizations. Moreover, it would permit better management of scientific and technical personnel in the DoD by providing planning and other data of the extent and quality that the Military Departments now use in forecasting their future needs for military officers.

APPENDIX A

Pronouncements of the U.S. Government's Legislative and Executive Branches on Science and Public Policy

1. The following is an excerpt from Federal Research and Development Programs, Hearings before the Select Committee on Government Research of the House of Representatives, 88th Congress, first session, Part 1; held 18-22 November 1963; p. 175.

Dr. Brown....One may well ask why the Department of Defense should be in the area of research. I think it is a lot more clear why we are in the area of development, since all military systems are produced through development.

The Department of Defense of course was in research long before some of the other agencies which have been set up specially to carry out research existed at all. Shortly after the Second World War, it was the Department of Defense which was the principal supporter, governmental supporter, of research in this country, and...our percentage share of all the research support in the country has gone far down, and we now are I think perhaps not more than 15 percent of the total research support, although our amount has gone up as the total amount [of] research supported by the Federal Government has grown greatly in the past decade and a half.

We support research in universities, in industry, in other non-profit organizations, and in-house, that is in the Defense-owned laboratories, for the following reasons.

First of all, we are the largest user of development in the Federal Government, and in the end all development depends in one way or another on basic research. or on research, research that has been done in the distant past sometimes. We believe that it is an obligation of our agency to replenish that store from which development later follows.

Second, it is important for the Defense Department, which has such terribly difficult and complicated development problems to do, that it maintain contact with the best technical people outside of the Government, and a good many of the best technical people themselves work in research.

So by supporting some of their research efforts, which are supportable on their own merits, we gain a bonus, which is that we can interest them in some of our more applied problems, even though that is not what they devote their principal professional careers to.

Third, we can, by supporting basic research or applied research, get a good deal of special attention to our areas of special interest. If, for example, we are interested in chemical warfare agents, by supporting basic research we can often engender an interest in the more applied or developmental aspects of some of these problems.

With respect to research, I would offer an opinion that you have already heard from others. It is one which I happen to share. It is that although duplication can occur in research, it is not a severe problem, because it tends to be self-regulating.

2. The following are excerpts from Federal Research and Development Programs, First Progress Report of the Select Committee on Government Research of the House of Representatives, 88th Congress, 2d session; House Report No. 1143, dated 17 February 1964, pp. 2, 3, 6, 12, 13.

The research and development expenditures estimated in the new budget are nearly seven times greater than those for the conduct of our foreign policy, including foreign aid. They are about triple the amount estimated for all veterans' benefits and services, or for all the agricultural programs of the Federal Government. They are about 50 percent greater than the total of all Federal financial assistance to State and local governments.

But perhaps the most significant thing that can be said about these figures is that, isolated, they are misleading. At best, they may be educated estimates and generalizations. To make an accurate comparison between today's level of support and that of former years, for example, one must consider not only the changes in dollar values but also the changes in the Federal agencies' definitions. These definitions now include, as research and development, many items and projects which in former times may have been found and funded in other administrative categories. /p. 2/

* * *

The Federal Government's marriage to research and development has been marked by an amazingly long and luxurious honeymoon. This is due mainly to the exhilarating nuclear age atmosphere in which the union was finally fused and unsparingly nurtured.

Noting the recently slackening annual increase of Federal funds for research and development activities, some say the honeymoon is over.

Be that as it may, it is certain the marriage will endure. And while it is not so certain what precise course this permanent venture will take, what must be made certain is that some plans are now provided to help avoid the diversions and obstacles and problems of all sorts that inevitably lie in the road ahead. At the same time it is the task of this committee to insure that the incentives for engaging in research and development are strengthened and safeguarded rather than strangled by excessive controls and redtape. /p. 3/

* * *

A study of the Government's research and development effort requires a broad analysis of the major expenditures for physical plants and equipment. As much as 15 percent of the total Federal expenditure for research and development each year, in excess of $2 billion this year, is applied to the acquisition of land, equipment, and construction of new buildings to house laboratories, testing sites, and other scientific facilities. In the three major agencies—Department of Defense, National Aeronautics and Space Administration, and Atomic Energy Commission—as much as half or more of the research and development funds have, in some years, been allocated to acquisition, construction, equipment, and maintenance of plant facilities. /p. 6/

* * *

Without minimizing the importance of science for its own sake, the ultimate question which Government agencies must resolve before obligating funds for research and development is: What is the relationship of the program to the national interests and the responsibilities of the Government? Conversely, the question might be put: What areas of research and development is it not the proper function of the Government to support?

In an area where definitional problems run rampant, perhaps the most complex problem of all is to define national goals and policies. /pp.12, 13/

3. The following are excerpts from Scientific Progress, the Universities, and the Federal Government, Statement by the President's Science Advisory Committee, 15 November 1960, pp. v, 2, 3, 5, 7, 8, 10, 18.

I call particular attention to the conclusion of the Science Advisory Committee that the process of basic scientific research and the process of graduate education in universities must be viewed as an integrated task if the nation is to produce the research results and the new scientists that will maintain the leadership of American science. In this great endeavor, the partnership between the Federal Government and the nation's universities will assume growing importance in the future.

Dwight D. Eisenhower

/p. v/

* * *

Most of all we have learned to recognize that the defense and advancement of freedom require excellence in science and in technology.

American science in the next generation must, quite literally, double and redouble in size and strength. This means more scientists, better trained, with finer facilities.... It is the simple truth that if this country is to safeguard its freedom and harvest the great opportunities of the next generation of science, the level of its scientific investment must be multiplied and multiplied again.

Yet the right word is investment. What this country spends on excellence in the sciences is not money gone with the wind. It is money that brings us handsome returns, and of many kinds.... We are only just at the beginning of the use of scientific investment in this large sense, and the returns it can bring in are literally incalculable. Simply in terms of economic self-interest our proper course is to increase our investment in science just as fast as we can, to a limit not yet in sight. [p. 2]

* * *

Scientific progress does not occur in any neatly predictable way; nor can we be sure ahead of time which research project is likely to have particular consequences for our prosperity or security. Moreover scientific discovery is not easy, and many experiments fail. Nothing could be more unwise than an effort to assign priorities or judge results in basic research on any narrow basis of immediate gain. It is the advance of science as a whole on which we must rely, for material as well as other returns. [p. 3]

* * *

...the process of graduate education and the process of basic research belong together at every possible level.

...For as we are describing it, the process of graduate education depends on "research" just as much as upon "teaching"—indeed the two are essentially inseparable—and there is a radical error in trying to think of them as different or opposite forms of activity. From the point of view of the graduate student, the teaching and the research of his professor are, at the crucial point which defines the whole, united. What he learns is not opposite from research; it is research. [p. 5]

* * *

Basic research and graduate education, together, are the knotted core of American science, and they will grow stronger together or not at all. [p. 7]

* * *

In addition to the research interests of particular agencies, the government has two other more general responsibilities. One is its concern for the development of fields of basic and applied science which may be of general importance for the national security and the general welfare; the other is its concern for the strength of American science and higher education as a whole. /p. 8/

* * *

As our scientific efforts have expanded in many industries and government installations, the universities have naturally lost their near monopoly on scientific work. But it is essential that this process should not go too far. For the universities are the source of tomorrow's scientists, as they are the natural centers for jointly thriving basic research and graduate education.

... No matter how many diverse elements of our society may join in their support (and the more the better), basic research and graduate education are in the end, by their very nature, a problem for the nation as a whole, and so for the national government. There is not one physics for California and another for Texas. A first-rate program in Massachusetts or Connecticut must not be limited to New Englanders. Science flourishes by honorable rivalry, but not by any effort to consider only narrow or local interests. Both basic research and graduate education must be supported in terms of the welfare of society as a whole. It is in this large sense that the role of the Federal Government is inevitably central. /p. 10/

* * *

Ideally, perhaps the best way of financing graduate education would be to take the dollar sign off each of its separate component elements, entwined as they are, and give full support to the student from a general pool of money, while arranging his work in research, learning, and teaching so that in part it would meet the needs of others beside himself. As we work gradually toward such a result we can at least make sure that separate programs, each good in itself, are administered with full respect for the general purpose of graduate education. /p. 18/

4. The following are excerpts from <u>Strengthening American Science</u>, a Report of the President's Science Advisory Committee, dated 27 December 1958; pp 2, 3, 9, 11, 12, 20-22.

A Statement by the President

...In making public this report, I call particular attention to the conclusion of the Science Advisory Committee that the task of further strengthening United States science is so broad that Government, industry, universities, foundations, and individuals all have essential roles to play. The future growth and strength of American science will depend upon the efforts of all of these parts of our national community if we are to rise to the demands of our times.

Dwight D. Eisenhower

* * *

Considering the speed and recency with which the U.S. has been thrust into the new age of science, the Nation must be more determined than ever before to shape its policies and methods to achieve new levels of excellence. In the past, major advances in the Government's management of science have come about under the pressure of emergencies. Ways now must be found for recognizing the importance of stability and other long-term goals, while preserving the flexibility to respond to emergencies. /pp. 2-3/

* * *

As administrator of a vast and highly diversified research and development effort, the Government faces a task of almost incredible complexity. On the one hand, it seeks fundamental new knowledge about Nature—starting inside the atom and extending to the edge of the universe—and, on the other, it must seek solutions to a myriad of practical and urgent problems, ranging from the design of ICBM's and nuclear powerplants to the treatment of mental illness and cancer. What research will uncover, no one can foresee, nor can anyone foresee how a development project may benefit from an obscure finding in one corner of the great edifice of science. /p. 9/

* * *

It is also important to recognize that Government agencies and departments need considerable independence and latitude to carry out their assigned responsibilities. The Department of Defense, with its complex requirements for weapons and weapons systems, must be free to sponsor imaginative and creative research—both basic and applied—if its development programs are not to become sterile. Yet a way must be found to preserve this departmental freedom, while encouraging all agencies to meld their individual efforts under broad common policies that seem both reasonable and desirable. /pp. 11-12/

* * *

In the past dozen years, Government support has done much to increase the scientific and academic strength of American universities. Most of this valuable Government aid has taken the form of a small project grant or contract. Several Federal agencies have had success in developing their programs by means of "project systems" in a manner that leaves the work under the control and guidance of the scientist. While the project system should be continued and strengthened, we need additional methods in order to meet the full range of scientific opportunities ahead. These new areas of opportunity frequently cross the borderlines of two or more sciences (e.g., biophysics, radiation chemistry, geophysics) and call for interdepartmental and interdisciplinary laboratories to provide adequate research facilities. Research of this type cannot always be most effectively supported piecemeal by a multiplicity of small project grants or contracts. /p. 20/

* * *

Unfortunately, there is a tendency to believe that in providing a contract or grant for a single specific project the chance of finding a solution to a problem is being maximized and is also more economical. In reality, however, the overall research effort may be hurt. Program grants or institutional grants would permit more effective research in broad areas of science and provide greater freedom for the scientific community to give direction to the work undertaken. They might also prove to be an important administrative device for reducing the potential growth of Government administration if, otherwise, a greatly increased number of selecting and reviewing boards were necessary. /pp. 21-22/

5. The following is an excerpt from Government and Science, No. 4, "Geographic Distribution of Federal Research and Development Funds," Report of the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, 23 October 1964, 88th Congress, 2d Session, Serial J, pp. 53-54.

5\. That all reasonable emphasis be placed on the development of new centers of science and technology by those agencies which are primarily mission-oriented, e.g., Department of Defense and NASA. This appears desirable since there is no assurance that existing research and technological competence will be adequate for the requirements of the future. The alternative, then, lies between strengthening old facilities or establishing new ones. When an analysis of the situation reveals obsolescence of existing facilities in research-concentrated areas, priority should be given to support of new facilities in the less favored areas.

APPENDIX B

DSB Questionnaire and Resultant Consensus on DoD Basic Research Policy

1. Should the DoD support basic research not immediately identifiable with military objectives? And, if so, how much of it? About what percent of DoD funds for research, development, test and evaluation (RDT&E), currently expended at the rate of about $7 billion per year, should be used to support basic research? (The total DoD budget for this year is about $50 billion.)

CONSENSUS: The DoD, like any major consumer of basic-research results, must contribute to the support of basic research. It cannot safely disassociate itself from concern with the broad front of scientific exploration particularly. No one person or agency can be so wise as to determine what basic research will have a direct payback to defense applications. Historically, it has been demonstrated that ultimately the DoD uses in one form or another the results of basic research in most fields of science. It is essential that the DoD be sensitive to what is going on in all fields of science, and the best way to develop this awareness is for the DoD to support such research. Almost any research in the physical sciences could be broadly related to military objectives. Relevance to mission should not be the primary determinant for granting support to research programs. Scientific excellence is more relevant to the ultimate applicability of the results than apparent relevance will be at the time the research is initiated.

At a minimum, the DoD should at least continue its present level of support for basic research. These funds should be protected and should gradually grow, even though there may be decreases in the total DoD budget or the total RDT&E budget. Just to maintain the current level of effort will require increased monetary support.

2. If the DoD considers only its own mission in supporting research, will this leave serious gaps in the national research effort?

CONSENSUS: If the DoD reduces its support of research, it will, from the national point of view, introduce a highly undesirable perturbation in the national research effort. A number of major fields such as solid-state physics and chemistry would probably be curtailed by at least 25 percent, and virtually all DoD-supported work on nuclear physics would be eliminated. A casual perusal of the credit lines in most learned journals of the exact sciences will show that a large amount of the open literature is now being supported by the Armed Services—particularly doctoral theses. An underlying strength of our research and educational system is the diversity of users and suppliers and of mechanisms by which money gets from one to the other. We do not—and should not—have a monolithic system for making the decisions and dispersing the money.

3. One of the general purposes of the National Science Foundation (NSF) is as follows: At the request of the Secretary of Defense, to initiate and support specific scientific research activities in connection with matters relating to the

national defense by making contracts or other arrangements for the conduct of such scientific research. Should the DoD make maximum use of this mission of the NSF?

CONSENSUS: The monies that the DoD spends for basic research should be administered directly by the DoD for the purpose of making Defense aware of what is going on in science. If this is done by the NSF, the DoD will be one step removed from direct contact with the scientific community. The resulting impediment would obviously hamper direct and responsive interchange between the principals. The NSF is the child of military-supported research, with the Office of Naval Research as its most obvious parent. It was created in part to provide nonmilitary sponsorship of unclassified work. There is no evidence that either party has an outstanding edge over the other in the effective support of sponsored research. Unless there is a specific understanding with the Administration that it will support larger budget ceilings for NSF to compensate for tasks assigned by the Secretary of Defense, such projects would have to be supported by curtailing other DoD programs.

4. Are there meaningful criteria that we can use for evaluating the relevance and profitability of research and early development programs with respect to the DoD objective?

CONSENSUS: Certainly there are meaningful criteria for evaluating the relevance and profitability of research and early development programs—and every competent research establishment in the country tries to apply them. However, they are not unique, and any attempt to codify them would inevitably be self-defeating. Intrinsic worth is best established by the judgment of peers. Relevance to the goals of the organization is best determined by the management of the organization, and the Services and DoD have a hierarchy of review to perform this task No management in history has ever been (or should ever expect to be) 100-percent successful, but the overall record of government and industry in the U.S. is quite respectable. In the military context, the careful development of meaningful operational needs is the principal means of expressing the goals of the organization. Measurement of research achievements against these needs is a fairly straightforward process. The crux of the matter is to set the right tasks.

5 (a) Should the DoD grant qualified academic institutions general discretionary funds for research (i.e., make "institutional grants" analogous to the independent research program in industry)? And, if so, should the amount granted be based on the total amount of present DoD contracts and grants or on some other factor?

(b) Should the DoD increase its "program" support to universities at the expense of "project" support?

CONSENSUS: It is not the function of the DoD to give general funds for research to academic institutions. The research program should be so formulated that the academic institutions have the freedom to modify the research dictated by the character of the research and the results obtained. Departmental grants are favored in lieu of institutional grants. Institutional grants—wherein the distribution of the grant among departments of possibly very uneven quality and merit is left to the institutional administration—make as little sense as a collective grant to a group of universities. If it is the desire to build up a weak department, then the grant should be so designated; if the grant is to support the research program of an already strong department, again it should be so designated. But these two aims should not be allowed to become confused—and diffused—by the institutional administration.

The difference between program research and project research is a question of size. One gives a lump sum of money for a laboratory to operate in a certain scientific field without detailed identification of each research project; this is program research. If the sum is small, just able to cover one project, this is project research. The DoD ought to have the freedom to do both and must exercise judgment, depending upon the content of the field, the character of the people, and how it is most profitable from the point of view of the DoD to get meaningful information. It seems plausible that in many fields it would be useful for the DoD to increase its support of interdisciplinary programs at universities, even at the expense of some project support. It would be undesirable to take any action which would result in termination of existing projects in order to make funds available for new programmatic grants. However, we should examine thoroughly the concept of consolidating existing contracts and grants into program support wherever this can be negotiated to the satisfaction of the institutions involved.

6. In its support of research, should the DoD consider not only the merit of the investigator receiving the contract or grant and his available resources for the research but also location, size, standing or other characteristics relevant to our national research capability of the institution employing him?

CONSENSUS: Basing DoD research grants on anything other than merit certainly opens up a Pandora's box and is contrary to the present procurement policy. The DoD accounts for about half of the Federal budget, and this power of the purse can obviously be applied to make sweeping social and political changes in the structure of the country. But once the test of merit is circumvented, it is difficult to see what would be the necessary substitute gauge for scientific excellence. If there is to be a geographical distribution of our research funds, any imbalances caused by agencies such as the DoD should be corrected by other agencies such as the NSF. The DoD should not try to set national policy with regard to distribution of funds for research.

APPENDIX C

Department of Defense Funding Tables

C-1. DoD Appropriations, FY 1954 - 1965

Department of Defense RDT&E Program:

C-2. Research
C-3. Exploratory Development
C-4. Advanced Development
C-5. Engineering Development
C-6. Operational Systems Development
C-7. Management and Support
C-8. Emergency Fund
C-9. Summary

C-10. Total Federal Expenditures and Gross National Product Compared with DoD Military Expenditures

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Table C-1. DOD NEW OBLIGATIONAL AUTHORITY, FY 1954 - 1965
($ billions)

Appropriation	Fiscal Year 1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
Military Personnel	12.0	11.4	11.5	11.5	11.6	12.0	12.0	12.1	13.1	13.1	14.2	14.9
O&M	9.5	8.3	8.8	9.7	10.2	10.2	10.3	10.7	11.8	11.5	11.7	12.5
Procurement	10.6	7.4	9.8	11.3	11.0	14.3	11.7	11.7	15.7	16.7	15.6	13.4
RDT&E	2.2	1.7	1.8	2.2	2.3	3.8	5.6	6.0	6.4	7.1	7.1	6.5
Military Construction	0.3	0.9	2.0	1.9	2.1	1.4	1.4	1.1	1.0	1.2	0.9	0.9
Other	3.9	2.2	0.2	1.6	0.9	1.1	1.0	1.4	1.4	1.6	1.5	1.6
TOTAL	38.4	32.0	34.2	38.3	38.1	42.7	42.0	43.1	49.4	51.1	50.9	49.8
RDT&E $ / Total DoD $ = %	5.7	5.3	5.3	5.7	6.0	8.9	13.3	13.9	12.9	13.9	13.9	13.0

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[redacted]

Table C-2. DEPARTMENT OF DEFENSE RDT&E PROGRAM
Research

($ millions)

DoD Agency	Fiscal Year 1962	1963	1964	1965	1966	1967	1968	1969	1970
Army	73.0	72.9	74.3	82.2	91.8	104.2	116.7	130.7	146.9
Navy	119.0	126.3	117.9	124.5	137.6	154.1	172.6	193.3	216.5
Air Force	70.0	83.5	85.0	93.4	102.9	115.4	129.2	144.7	162.1
ARPA	32.8	30.7	33.9	44.7	47.0	53.0	55.0	59.0	60.0
Total	294.8	313.4	311.1	344.8	379.3	426.7	473.5	527.7	585.5
Research $ / Total RDT&E $ = %	4.6	4.4	4.4	5.3	5.6	6.4	7.5	9.0	10.7

[redacted]

Table C-3. DEPARTMENT OF DEFENSE RDT&E PROGRAM
Exploratory Development
($ millions)

DoD Agency	Fiscal Year 1962	1963	1964	1965	1966	1967	1968	1969	1970
Army	142.0	228.5	261.6	249.0	253.6	261.0	270.4	285.0	300.0
Navy	324.0	355.2	361.6	338.3	342.2	357.3	371.6	393.9	417.5
Air Force	299.0	292.2	302.4	318.4	315.9	331.4	344.2	365.9	388.0
ARPA	217.8	223.7	252.7	227.3	230.0	242.0	240.0	237.0	228.0
Total	982.8	1099.6	1178.3	1133.0	1141.7	1191.7	1226.2	1281.8	1333.5

Table C-4. DEPARTMENT OF DEFENSE RDT&E PROGRAM
Advanced Development
($ millions)

DoD Agency	Fiscal Year 1962	1963	1964	1965	1966	1967	1968	1969	1970
Army	164.9	239.9	145.0	111.1	125.6	129.2	159.3	133.4	143.3
Navy	53.0	89.5	143.1	150.7	222.9	282.6	335.2	291.1	210.7
Air Force	380.0	453.1	385.2	310.4	478.7	723.3	640.1	545.1	231.5
Total	597.9	782.5	673.3	572.2	827.2	1135.1	1134.6	969.6	585.5

Table C-5. DEPARTMENT OF DEFENSE RDT&E PROGRAM
Engineering Development
($ millions)

DoD Agency	Fiscal Year 1962	1963	1964	1965	1966	1967	1968	1969	1970
Army	517.2	464.0	638.5	613.2	678.8	720.9	486.2	422.3	356.8
Navy	67.0	113.1	151.3	137.0	167.4	181.1	189.1	165.6	120.3
Air Force	349.4	639.6	884.8	674.7	492.8	323.6	281.9	258.4	252.9
Total	933.6	1216.7	1674.6	1424.9	1339.0	1225.6	957.2	846.3	730.0

Table C-6. DEPARTMENT OF DEFENSE RDT&E PROGRAM
Operational Systems Development
($ millions)

	Fiscal Year								
DoD Agency	1962	1963	1964	1965	1966	1967	1968	1969	1970
Army	178.4	101.5	134.7	100.2	73.9	43.9	30.7	19.1	19.9
Navy	603.0	608.0	590.4	429.4	447.7	266.1	199.8	211.8	256.5
Air Force	1724.0	1782.7	1339.0	1171.7	1117.7	876.4	717.2	432.7	317.0
DCA	3.6	10.9	27.1	24.4	25.4	23.8	19.0	19.0	18.0
DASA	141.9	129.2	88.2	107.4	103.0	114.0	114.0	114.0	114.0
NSA	47.2	57.6	63.2	67.0	67.1	70.6	71.8	71.8	74.3
SADA	--	.6	6.9	8.1	8.1	8.9	9.3	9.7	10.0
DIA	--	--	--	2.3	2.0	2.0	2.0	2.0	2.0
JTF-2	--	--	--	4.1	6.3	5.0	5.0	5.0	5.0
CD	19.0	11.0	10.0	10.5	15.0	15.0	15.0	15.0	15.0
Total	2717.1	2701.5	2259.5	1925.1	1866.2	1425.7	1183.8	900.1	831.7

Table C-7. DEPARTMENT OF DEFENSE RDT&E PROGRAM
Management and Support
($ millions)

DoD Agency	Fiscal Year 1962	1963	1964	1965	1966	1967	1968	1969	1970
Army	137.1	163.4	180.7	221.6	240.6	256.0	253.1	256.4	274.0
Navy	154.4	188.2	200.9	185.8	154.8	170.3	180.3	183.2	188.3
Air Force	574.4	691.2	663.7	637.9	668.7	713.8	731.3	736.3	772.1
DDC	--	--	5.9	11.4	11.5	11.3	11.3	11.3	11.3
Total	865.9	1042.8	1051.2	1056.7	1075.6	1151.4	1176.0	1187.2	1245.7

[redacted]

Table C-8. DEPARTMENT OF DEFENSE RDT&E PROGRAM
Emergency Fund
($ millions)

	Fiscal Year								
	1962	1963	1964	1965	1966	1967	1968	1969	1970
Emergency Fund	--	--	--	118.3	150.0	150.0	150.0	150.0	150.0

Table C-9. DEPARTMENT OF DEFENSE RDT&E PROGRAM
Summary
($ millions)

	Fiscal Year								
DoD Agency	1962	1963	1964	1965	1966	1967	1968	1969	1970
Army	1205.0	1270.3	1435.0	1376.3	1464.3	1515.2	1316.4	1246.9	1240.9
Navy	1319.3	1480.3	1565.2	1365.7	1472.6	1411.5	1448.6	1438.9	1409.8
Air Force	3379.0	3942.3	3660.1	3205.9	3176.7	3078.9	2838.9	2478.1	2123.6
Def. Agencies	444.0	452.7	477.9	496.7	500.4	530.6	528.0	528.8	522.6
Emer. Fund	*	*	*	118.3	150.0	150.0	150.0	150.0	150.0
Total	6347.3	7145.6	7138.2	6562.9	6764.0	6686.2	6281.9	5842.7	5446.9

Note: *The Emergency Fund for these years has been allocated and distributed to the other entries in the column.

[redacted]

Table C-10. Total Federal Expenditures and Gross National Product, Compared with DoD Military Expenditures

Fiscal year	Gross national product (billions)	Total Federal Government		DoD Military Functions (excluding Military Assistance)		
		Expenditures (millions)	% GNP	Expenditures (millions)	% GNP	% Total Government
1939	$ 88.2	$ 8,841	10.0	$ 1,075	1.2	12.2
1940	95.7	9,055	9.5	1,492	1.6	16.5
1941	110.5	13,255	12.0	5,998	5.4	45.2
1942	140.5	34,037	24.2	23,570	16.8	69.2
1943	178.4	79,368	44.5	62,664	35.1	79.0
1944	202.8	94,986	46.8	75,797	37.4	79.8
1945	218.3	98,303	45.0	80,048	36.7	81.4
1946	202.8	60,326	29.7	42,044	20.7	69.7
1947	223.3	38,923	17.4	13,838	6.2	35.6
1948	246.6	32,955	13.4	10,937	4.4	33.2
1949	261.6	39,474	15.1	11,573	4.4	29.3
1950	263.8	39,544	15.0	11,891	4.5	30.1
1951	310.8	43,970	14.1	19,764	6.4	44.9
1952	338.8	65,303	19.3	38,897	11.5	59.6
1953	359.7	74,120	20.6	43,604	12.1	58.8
1954	362.0	67,537	18.7	40,326	11.1	59.7
1955	377.0	64,389	17.1	35,531	9.4	55.2
1956	408.5	66,224	16.2	35,792	8.8	54.0
1957	433.0	68,966	15.9	38,436	8.9	55.7
1958	440.2	71,369	16.2	39,070	8.9	54.7
1959	466.7	80,342	17.2	41,223	8.8	51.3
1960	494.8	76,539	15.5	41,215	8.3	53.8
1961	506.6	81,515	16.1	43,227	8.5	53.0
1962	539.4	87,787	16.3	46,815	8.7	53.3
1963	568.4	92,642	16.3	48,252	8.5	52.1
1964	604.0	98,405	16.3	50,900	8.4	51.7
1965	640.0	97,900	15.3	50,000	7.[illegible]	51.1

APPENDIX D

Inclosure 3 to DoD Instruction 3200.6, "Reporting of Research, Development and Engineering Program Information," 7 June 1962

PROGRAM VI. RESEARCH AND DEVELOPMENT

STRUCTURE

The RDT&E Program is structured in R&D categories as follows:

1. Research - Includes all effort directed toward increased knowledge of natural phenomena and environment and efforts directed toward the solution of problems in the physical, behavioral and social sciences that have no clear direct military application. It would, thus, by definition, include all basic research and, in addition, that applied research directed toward the expansion of knowledge in various scientific areas. It does not include efforts directed to prove the feasibility of solutions of problems of immediate military importance or time-oriented investigations and developments. The Research elements are further characterized by using level of effort as the principal program control.

2. Exploratory Development - Includes all effort directed toward the solution of specific military problems, short of major development projects. This type of effort may vary from fairly fundamental applied research to quite sophisticated bread-board hardware, study, programming and planning efforts. It would thus include studies, investigations and minor development effort. The dominant characteristic of this category of effort is that it be pointed toward specific military problem areas with a view toward developing and evaluating the feasibility and practicability of proposed solutions and determining their parameters. Program control of the Exploratory Development element will normally be exercised by general level of effort.

3. Advanced Developments - Include all projects which have moved into the development of hardware for experimental or operational test. It is characterized by line item projects and program control is exercised on a project basis. A further descriptive characteristic lies in the design of such items being directed toward hardware for test or experimentation as opposed to items designed and engineered for eventual Service use. Examples are VTOL Aircraft, ARTEMIS, Experimental Hydrofoil, X-15, and Aerospace Plane Components.

4. Engineering Developments - Include those development programs being engineered for Service use but which have not yet been approved for procurement or operation. For example: MAULER, TYPHON, B-70. This area is characterized by major line item projects and program control will be exercised by review of individual projects.

5. Management and Support - Includes research and development effort directed toward support of installations or operations required for general research and development use. Included would be test ranges, military construction, maintenance support of laboratories, operations and maintenance of test aircraft and ships. Costs of laboratory personnel, either in-house or contract-operated, would be assigned to appropriate projects or as a line item in the Research,

Exploratory Development, or Advanced Development Programs areas, as appropriate. Military Construction costs directly related to a major development program will be included in the appropriate element.

6. Operational System Developments - Include research and development effort directed toward development, engineering and test of systems, support programs, vehicles and weapons that have been approved for production and Service employment. This area is included for convenience in considering all RDT&E projects. All items in this area are major line item projects which appear as RDT&E Costs of Weapons Systems Elements in other Programs. Program control will thus be exercised by review of the individual research and development effort in each Weapon System Element.

Categories are further subdivided into elements and aggregations. The R&D program element is the smallest subdivision of the R&D Program considered in this system. Each element will consist of RDT&E projects in the same budget activity. It may consist of a number of projects in a related field as in the Research and Exploratory Development categories or it may be a single major project. In the Advanced Development and Engineering Development categories it may be desirable to group a number of related elements under a descriptive title. Such groupings are called aggregations; e.g., in the Army Engineering Developments, the elements dealing with communications are grouped into a Communications Aggregation.

ABBREVIATIONS

ARPA	Advanced Research Projects Agency
CD	Civil Defense
DASA	Defense Atomic Support Agency
DCA	Defense Communications Agency
DDC	Defense Documentation Center
DDR&E	Director of Defense Research and Engineering
DIA	Defense Intelligence Agency
DoD	Department of Defense
DSB	Defense Science Board
GNP	gross national product
JTF-2	Joint Task Force 2
NASA	National Aeronautics and Space Administration
NSA	National Security Agency
NSF	National Science Foundation
ODDR&E	Office of the DDR&E
O&M	operation and maintenance
ONR	Office of Naval Research
R&D	research and development
RDT&E	research, development, test and evaluation
SADA	studies and analysis Defense agencies