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Department of Defense Research, Development, Test, and Evaluation (RDT&E): Appropriations Structure

Updated June 25, 2018

Congressional Research Service
https://crsreports.congress.gov
R44711

CRS REPORT
Prepared for Members and
Committees of Congress

Summary

The Department of Defense (DOD) conducts research, development, testing, and evaluation (RDT&E) in support of its mission requirements. The work funded by these appropriations plays a central role in the nation's security and an important role in U.S. global leadership in science and technology. DOD alone accounts for nearly 40% of all federal R&D appropriations ($49.2 billion of $125.3 billion, or 39.3%, in FY2017).

In its annual congressional budget requests, DOD presents its RDT&E requests by organization and by its own unique taxonomy aligned to the character of the work to be performed.

More than 95% of DOD RDT&E funding is provided under Title IV of the annual defense appropriations act. These funds are appropriated for RDT&E in the Army, Navy, Air Force, a Defense-wide RDT&E account, and the Director of Operational Test and Evaluation. RDT&E funding is also provided for the Defense Health Program in Title VI; the Chemical Agents and Munitions Destruction Program in Title VI; and previously the National Defense Sealift Fund in Title V, though the President's FY2019 budget does not request RDT&E funds for this purpose. In addition, some of the funds appropriated to the Joint Improvised-Threat Defeat Fund (JIDF, formerly the Joint Improvised Explosive Device Defeat Fund) have been used for RDT&E though the fund does not contain an RDT&E line item. In some years, RDT&E funds also have been requested and appropriated as part of DOD's separate funding to support Overseas Contingency Operations (OCO, formerly the Global War on Terror (GWOT)). These funds have typically been appropriated for specific activities identified in Title IV. Finally, some OCO funds have been appropriated for transfer funds (e.g., the Iraqi Freedom Fund (IFF), Iraqi Security Forces Fund, Afghanistan Security Forces Fund, and Pakistan Counterinsurgency Capability Fund) which can be used to support RDT&E activities, among other things, subject to certain limitations.

Parsing RDT&E funding by the character of the work, DOD has established seven categories identified by a budget activity code (numbers 6.1-6.7) and a description. Budget activity code 6.1 is for basic research; 6.2 is for applied research; 6.3 is for advanced technology development; 6.4 is for advanced component development and prototypes; 6.5 is for systems development and demonstration; 6.6 is for RDT&E management support; and 6.7 is for operational system development.

DOD uses crosswalks to report its RDT&E funding to the Office of Management and Budget and to the National Science Foundation. These crosswalks use different taxonomies than DOD's for accounting for R&D funding.

Contents

Organization and Program Structure 1
Character of Work Structure 3
Alignment with Other Federal R&D Taxonomies 5
DOD RDT&E Funding 7
Selected Issues 9
What Is the Appropriate Funding Level for DOD RDT&E? 9
Approach: DOD RDT&E as a Share of DOD Funding 9
Related Data and Discussion 9
What Is the Appropriate Funding Level for DOD Science and Technology? 11
Approach: DOD Science and Technology as a Share of Total DOD Funding 12
Related Data and Discussion 13
Approach: DOD Science and Technology as a Share of DOD RDT&E 15
Related Data 15
What Is the Appropriate Funding Level for DOD Basic Research? 15
Approach: DOD Basic Research as a Share of DOD S&T 16
Related Data 16
What Is the Appropriate Balance Between Investments in Incremental RDT&E and Investments Directed Toward Revolutionary Technological Advancements? 17
Approach: Revolutionary Research as a Share of DOD S&T 17
Related Data and Discussion 18
Approach: High Risk, High Payoff Research as a Share of RDT&E 19
Related Data and Discussion 19
Concluding Observations 20

Figures

Figure 1. DOD Share of Federal R&D 1
Figure 2. DOD RDT&E Crosswalks to OMB, NSF Taxonomies 6
Figure 3. Title IV RDT&E Funding by Character of Work, FY1996-FY2017 7
Figure 4. Title IV RDT&E Funding by Character of Work, FY1996-FY2017 7
Figure 5. FY2017 Title IV RDT&E by Character of Work 8
Figure 6. Title IV FY2017 RDT&E by Organization 8
Figure 7. DOD Title IV RDT&E 10
Figure 8. DOD Title IV RDT&E as a Share of DOD Total Funding 11
Figure 9. DOD Science and Technology (6.1-6.3) Funding 13
Figure 10. DOD Science and Technology Funding as a Share of DOD TOA 14
Figure 11. DOD Science and Technology Funding as a Share of Title IV RDT&E 15
Figure 12. DOD Basic Research Funding 16
Figure 13. DOD Basic Research as a Share of S&T 17
Figure 14. DARPA Funding 18
Figure 15. DARPA Funding as a Share of DOD S&T Funding 19
Figure 16. DARPA as a Share of DOD RDT&E 20

Tables

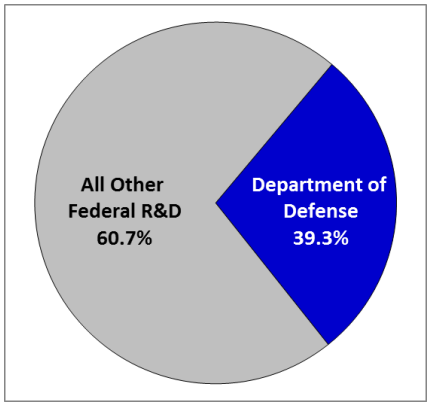
Table 1. DOD RDT&E Budget Activity Codes and Descriptions 3

Contacts

Author Information 20

The Department of Defense (DOD) receives nearly 40% of all federal research and development (R&D) appropriations, and more than 43% that of the next largest federal recipient, the Department of Health and Human Services.[1] The work funded by these appropriations plays a central role in the nation's security as well as an important role in U.S. global leadership in science and technology.

Figure 1. DOD Share of Federal R&D



Source: CRS analysis of FY2017 data from Analytical Perspectives, *Budget of the United States Government, Fiscal Year 2019*.

This report provides an introduction to the structure of DOD's research, development, test, and evaluation (RT&E) budget for staff attempting to understand DOD RDT&E appropriations. In its annual budget request to Congress, DOD presents its RDT&E by organization and program and by the character of the work to be performed. The RDT&E request is summarized in a supporting budget document titled "Research, Development, Test, & Evaluation Programs (R-1)," which is often referred to simply as the R-1.[2]

Organization and Program Structure

DOD RDT&E appropriations are provided annually through the defense appropriations act, one of the 12 regular appropriations acts that provide most of the discretionary funding for operation of the federal government.[3] Generally, DOD RDT&E funding is provided in four of the act's titles (see box). More than 95% of DOD's RDT&E funding is appropriated in Title IV (Research, Development, Test, and Evaluation), which includes RDT&E appropriations for the Army, Navy, Air

DOD RDT&E by Appropriations Title

Title IV: Research, Development, Test, & Evaluation
- Army
- Navy
- Air Force
- Defense-wide
- Operational Test and Evaluation

Title V: Revolving and Management Funds
- National Defense Sealift Fund

Title VI: Other Defense Programs
- Chemical Agents and Munitions Destruction
- Defense Health Program

Title IX: Overseas Contingency Operations
- Any of the above
- Joint Improvised-Threat Defeat Fund
- Transfer Funds

[1] Executive Office of the President, Office of Management and Budget, *Analytical Perspectives, Budget of the United States Government, Fiscal Year 2019*, February 12, 2018, pp. 238-239, https://www.whitehouse.gov/omb/budget/Analytical_Perspectives. Beginning with the President's FY2018 budget, the Office of Management and Budget adopted a new R&D taxonomy for collecting and reporting federal R&D funding that it asserts would better align its data with the survey data collected by the National Science Foundation, and to be consistent with international standards. Under this taxonomy, OMB no longer counts certain DOD funding (budget activity 6.7, Operational System Development, discussed below) as a part of total federal R&D. Under the previous taxonomy, DOD accounted for nearly half of total federal R&D. For more information on this change, see CRS Report R45150, *Federal Research and Development (R&D) Funding: FY2019*, coordinated by John F. Sargent Jr.

[2] R-1s are available on the Under Secretary of Defense (Comptroller) website at http://comptroller.defense.gov/Budget-Materials.

[3] Often two or more of these acts are included together in a consolidated or omnibus act. For further information, see CRS Report RL32473, *Omnibus Appropriations Acts: Overview of Recent Practices*, by James V. Saturno and Jessica Tollestrup.

Force, a Defense-wide RDT&E account, and the Director of Operational Test and Evaluation. Within each of these accounts are dozens of program elements (PEs) that specify funding for particular activities (e.g., night vision technology, aviation survivability, cyber operations technology development).

RDT&E funds are also appropriated for programs in other parts of the act. For example, RDT&E funds are appropriated as part of the Defense Health Program and the Chemical Agents and Munitions Destruction Program, and sometimes as part of the National Defense Sealift Fund.

The Defense Health Program (DHP) supports the delivery of health care to DOD personnel and their families. DHP funds (including any RDT&E funds) are appropriated in Title VI. The program's RDT&E funds support congressionally directed research on breast, prostate, and ovarian cancer; traumatic brain injuries; orthotics and prosthetics; and other medical conditions.

The Chemical Agents and Munitions Destruction Program supports activities to destroy the U.S. inventory of lethal chemical agents and munitions. Funds for this program are requested through the Defense-wide Procurement appropriations request. Congress appropriates funds for this program in Title VI (Other Department of Defense Programs).

The National Defense Sealift Fund supports the procurement, operation and maintenance, and research and development of the nation's naval reserve fleet and supports a U.S.-flagged merchant fleet that can serve in time of need. The RDT&E funding for this effort is requested in the Navy's Procurement request and appropriated in Title V (Revolving and Management Funds) of the appropriation act.

RDT&E funds also have been requested and appropriated as part of DOD's separate funding to support Overseas Contingency Operations (OCO, formerly the Global War on Terror (GWOT)). Typically, the RDT&E funds appropriated for OCO activities in Title IX support specified PEs in Title IV. However, they are requested and accounted for separately. The Bush Administration requested these funds in separate GWOT emergency supplemental requests. The Obama Administration included these funds as part of its regular budget request, not in emergency supplemental requests, although it sometimes asked for additional OCO funds in supplemental requests. The Trump Administration included these funds as part of its regular budget requests.

The Joint Improvised-Threat Defeat Fund (JITDF, formerly the Joint Improvised Explosive Device Defeat Fund) works to counter improvised threats (e.g., improvised explosive devices (IEDs)) through tactical responsiveness and anticipatory, rapid acquisition. Some of the funds appropriated to JIDF are used for RDT&E. Under the President's FY2019 request, "In accordance with congressional intent ... all appropriations requested for the [Joint Improvised-Threat Defeat Organization] will be transitioned to Defense-wide appropriation accounts," including the RDT&E account.

In addition, OCO-related requests and appropriations have included funds for a number of transfer accounts.[4] In the past, these have included the Iraqi Freedom Fund (IFF), the Iraqi Security Forces Fund, the Afghanistan Security Forces Fund, and the Pakistan Counterinsurgency Capability Fund. Congress typically makes a single appropriation to each of these funds and authorizes the Secretary of Defense to make transfers to other accounts, including RDT&E,

[4] To provide the Defense Department with greater flexibility in carrying out activities for which costs are likely to fluctuate after funds have been appropriated, Congress has set up transfer accounts into which funding is appropriated for subsequent transfer to regular appropriations accounts for execution.

subject to certain limitations. These transfers are eventually reflected in prior-year funding figures for DOD Title IV.[5]

Character of Work Structure

While DOD Title IV appropriations are made by organization (e.g., Research, Development, Test and Evaluation, Army), the DOD R-1 and congressional appropriations reports and explanatory statements also typically characterize this funding by the character of work to be performed. This characterization is provided in seven categories, each with a budget activity code (6.1 through 6.7) and a description (see **Table 1**).

Table 1. DOD RDT&E Budget Activity Codes and Descriptions

Code	Description
6.1	Basic Research
6.2	Applied Research
6.3	Advanced Technology Development
6.4	Advanced Component Development and Prototypes
6.5	System Development and Demonstration
6.6	RDT&E Management Support
6.7	Operational System Development

Source: Department of Defense, *Financial Management Regulation (DoD 7000.14-R),* Volume 2B, March 2016.

DOD's *Financial Management Regulation* (DoD 7000.14-R) provides a detailed description of the types of activities supported in each budget activity category:[6]

> [6.1] Basic Research. Basic research is systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind. It includes all scientific study and experimentation directed toward increasing fundamental knowledge and understanding in those fields of the physical, engineering, environmental, and life sciences related to long-term national security needs. It is farsighted high payoff research that provides the basis for technological progress. Basic research may lead to: (a) subsequent applied research and advanced technology developments in Defense-related technologies, and (b) new and improved military functional capabilities in areas such as communications, detection, tracking, surveillance, propulsion, mobility, guidance and control, navigation, energy conversion, materials and structures, and personnel support…
>
> [6.2] Applied Research. Applied research is systematic study to understand the means to meet a recognized and specific need. It is a systematic expansion and application of knowledge to develop useful materials, devices, and systems or methods. It may be oriented, ultimately, toward the design, development, and improvement of prototypes and new processes to meet general mission area requirements. Applied research may translate promising basic research into solutions for broadly defined military needs, short of system development. This type of effort may vary from systematic mission-directed research

[5] Generally, DOD's annual budget requests provide three years of figures for obligational authority: for the coming fiscal year (request), for the current fiscal year, and for the prior year. The data in this report is based on prior year data from each R-1 (e.g., the FY2017 data is drawn from the FY2019 R-1).

[6] Department of Defense, *Financial Management Regulation (DoD 7000.14-R),* November 2017, Volume 2B, Chapter 5, pp. 5-4–5-6, https://comptroller.defense.gov/Portals/45/documents/fmr/Volume_02b.pdf.

beyond that in [6.1] to sophisticated breadboard hardware, study, programming and planning efforts that establish the initial feasibility and practicality of proposed solutions to technological challenges. It includes studies, investigations, and non-system specific technology efforts. The dominant characteristic is that applied research is directed toward general military needs with a view toward developing and evaluating the feasibility and practicality of proposed solutions and determining their parameters. Applied Research precedes system specific technology investigations or development. …

[6.3] Advanced Technology Development (ATD). This budget activity includes development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. [6.3] includes concept and technology demonstrations of components and subsystems or system models. The models may be form, fit, and function prototypes or scaled models that serve the same demonstration purpose. The results of this type of effort are proof of technological feasibility and assessment of subsystem and component operability and producibility rather than the development of hardware for service use. Projects in this category have a direct relevance to identified military needs. Advanced Technology Development demonstrates the general military utility or cost reduction potential of technology when applied to different types of military equipment or techniques. Program elements in this category involve pre-Milestone B efforts, such as system concept demonstration, joint and Service-specific experiments or Technology Demonstrations and generally have Technology Readiness Levels of 4, 5, or 6. (For further discussion on Technology Readiness Levels, see the Assistant Secretary of Defense for Research and Engineering's Technology Readiness Assessment (TRA) Guidance.) Projects in this category do not necessarily lead to subsequent development or procurement phases, but should have the goal of moving out of Science and Technology (S&T) and into the acquisition process within the Future Years Defense Program (FYDP). Upon successful completion of projects that have military utility, the technology should be available for transition.

[6.4] Advanced Component Development and Prototypes (ACD&P). Efforts necessary to evaluate integrated technologies, representative modes, or prototype systems in a high fidelity and realistic operating environment are funded in this budget activity. The ACD&P phase includes system specific efforts that help expedite technology transition from the laboratory to operational use. Emphasis is on proving component and subsystem maturity prior to integration in major and complex systems and may involve risk reduction initiatives…

[6.5] System Development and Demonstration (SDD).

System Development and Demonstration (SDD) programs [conduct] engineering and manufacturing development tasks aimed at meeting validated requirements prior to full-rate production. This budget activity is characterized by major line item projects... Prototype performance is near or at planned operational system levels. Characteristics of this budget activity involve mature system development, integration, demonstration... conducting live fire test and evaluation, and initial operational test and evaluation of production representative articles....

[6.6] RDT&E Management Support. This budget activity includes management support for research, development, test, and evaluation efforts and funds to sustain and/or modernize the installations or operations required for general research, development, test, and evaluation. Test ranges, military construction, maintenance support of laboratories, operation and maintenance of test aircraft and ships, and studies and analyses in support of the RDT&E program are funded in this budget activity. Costs of laboratory personnel, either in-house or contractor operated, would be assigned to appropriate projects or as a line item in the Basic Research, Applied Research, or ATD program areas, as appropriate.

> Military construction costs directly related to major development programs are included in this budget activity.
>
> [6.7] Operational System Development. This budget activity includes development efforts to upgrade systems that have been fielded or have received approval for full rate production and anticipate production funding in the current or subsequent fiscal year…

Funding in budget activity codes 6.1-6.3 is referred to by DOD as the science and technology (S&T) budget. This portion of DOD RDT&E is often singled out for attention by analysts as it is seen as the pool of knowledge necessary for the development of future military systems. In contrast, 6.4, 6.5, and 6.7 funds are focused on the application of existing scientific and technical knowledge to meet current or near-term operational needs. The funds in 6.6 are for RDT&E management may support work in any of the other RDT&E budget accounts. Within the S&T program, basic research (6.1) receives special attention, particularly by the nation's universities. DOD is not a large supporter of basic research when compared to the National Institutes of Health or the National Science Foundation. However, nearly half of DOD's basic research budget is spent at universities. DOD funding represents a substantial source of federal funds for R&D at institutions of higher education in some fields, including 60.6% of aerospace, aeronautical, and astronautical engineering R&D; 53.9% of electrical, electronic, and communications engineering R&D; 52.5 of industrial and manufacturing engineering R&D; 42.9% of mechanical engineering R&D; and 41.9% of computer and information sciences R&D.[7]

For FY2017 and subsequent years, the Office of Management and Budget (OMB) replaced the R&D category "development" with a subset referred to as "experimental development" in an effort that OMB asserts would better align its data with the survey data collected by the National Science Foundation, and to be consistent with international standards. Using this standard omits DOD budget activities 6.6 and 6.7 funding from federal calculations of research and development funding.

Alignment with Other Federal R&D Taxonomies

The Office of Management and Budget characterizes federal R&D funding in four categories: basic research, applied research, development, and facilities and equipment. With respect to Title IV funding, in general, DOD 6.1 funding is reported under OMB's basic research classification and 6.2 funding is reported as applied research. Historically, 6.3-6.7 funding has been reported as development.[8] However, OMB no longer includes 6.7 funding in its R&D reporting.[9] Some DOD 6.1-6.5 funding may be reported under OMB's facilities and equipment classification.

The National Science Foundation (NSF) collects R&D appropriations and performance data from all federal R&D agencies through its annual *Survey of Federal Funds for Research and Development.* The survey requests most agencies to identify their R&D activities in three categories: basic research, applied research, and development. NSF uses a modified survey for collecting DOD R&D data in which the development category is divided into two subcategories: advanced technology development and major systems development. DOD uses the following crosswalk to respond to the NSF survey: 6.1 funding is reported under NSF's basic research

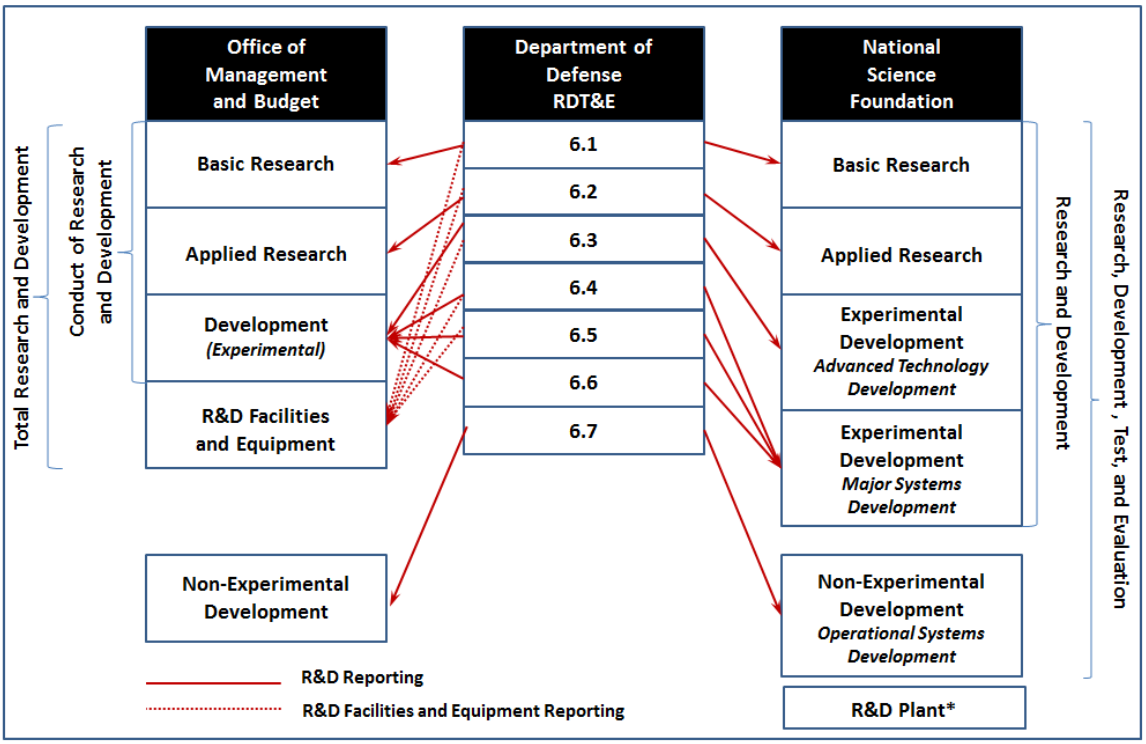
[7] National Science Foundation, *Higher Education Research and Development Survey, FY 2016,* data tables, Table 13, https://ncsesdata.nsf.gov/herd/2016/html/HERD2016_DST_13.html.

[8] According to OMB, "6.6, RDT&E Management Support, is administrative costs, would ideally be classified as the same Character Class or R&D activity as the program that is supported. However, very few 6.1 or 6.2 programs have large 6.6 costs associated with them, so in practice 6.6 is reported as Development." Email communication between OMB and CRS, December 1, 2016.

[9] Email communication and telephone conversation between CRS and OMB staff, December 1, 2016.

category, 6.2 funding is reported as applied research, 6.3 is reported as advanced technology development (experimental development), 6.4–6.6 funding is reported as major systems development (experimental development), and 6.7 is reported as operational systems development (non-experimental development).

Figure 2. DOD RDT&E Crosswalks to OMB, NSF Taxonomies



Source: CRS telephone and email communications with OMB and NSF, most recently June 25, 2018.

Notes: The National Science Foundation reports DOD Advanced Technology Development and DOD Major Systems Development as "Experimental Development," and reports Operational Systems Development as "Non-Experimental Development" under the R&D taxonomy adopted by the Office of Management and Budget and first used in the *Budget of the United States Government, Fiscal Year 2018*. OMB and NSF no longer report Non-Experimental Development as R&D; NSF reports Non-Experimental Development as part of RDT&E. OMB notes that DOD budget activity "6.6, RDT&E Management Support, [as] administrative costs, would ideally be classified as the same Character Class or R&D activity as the program that is supported. However, very few 6.1 or 6.2 programs have large 6.6 costs associated with them, so in practice 6.6 is reported as [Experimental] Development."

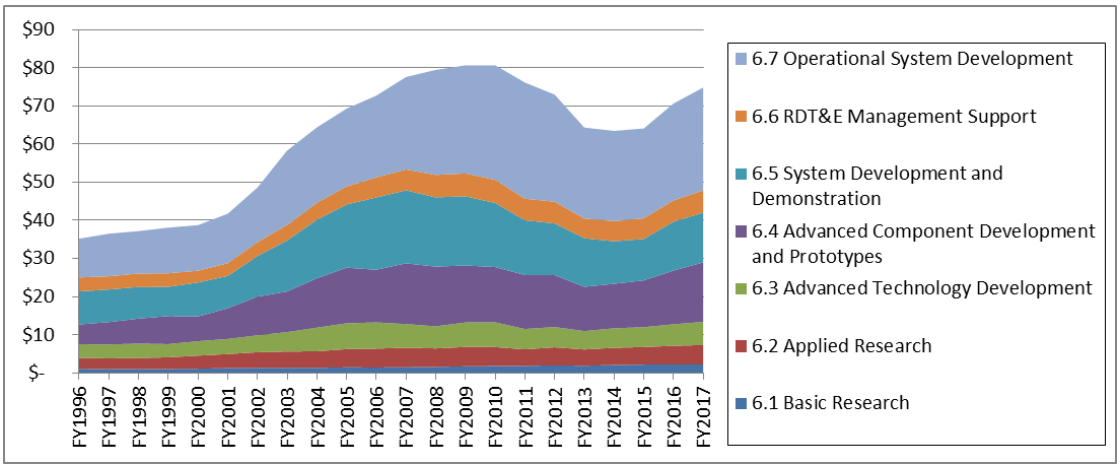
* The NSF category "R&D Plant" includes R&D facilities and equipment. It remains unclear which of the DOD budget activities (6.1-6.5) are included in NSF's R&D Plant and whether funding provided to DOD through the Military Construction, Veterans Affairs, and Related Agencies (MILCON) appropriations acts is included in the NSF's reporting of R&D Plant.

DOD RDT&E Funding

This section provides a number of figures that illustrate DOD RDT&E expenditure trends for the FY1996-FY2017 period. **Figure 3** illustrates DOD Title IV and OCO RDT&E expenditures in current dollars by character of work. DOD RDT&E funding provided in other appropriations titles are not included in the character of work (6.1-6.7) taxonomy; inclusion of these funds might affect the balance among the categories.

Figure 3. Title IV RDT&E Funding by Character of Work, FY1996-FY2017

obligational authority, in billions of current dollars

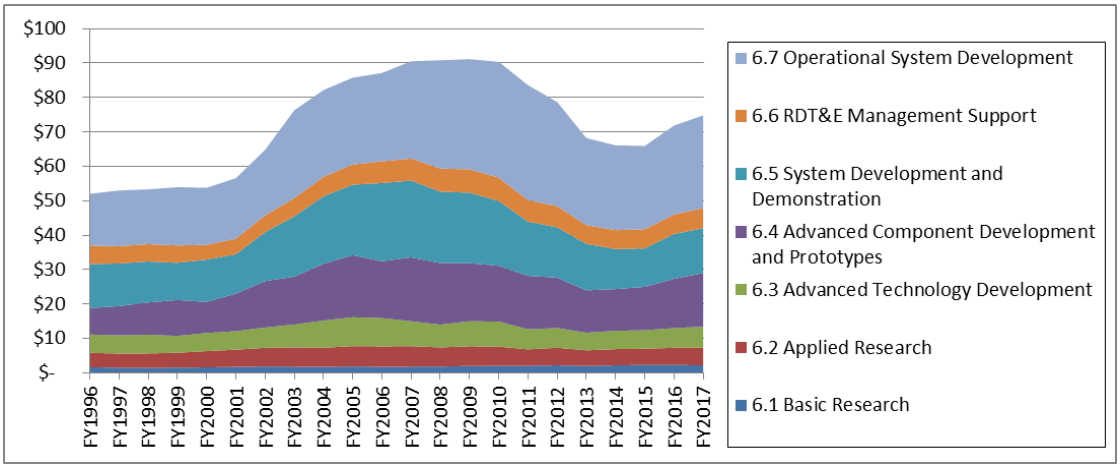


Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998- FY2019.

Figure 4 illustrates DOD RDT&E funding for FY1996-FY2017 in constant FY2017 dollars. Between FY2000 and FY2007, total DOD RDT&E funding rose by 73% in constant dollars, remained flat through FY2010, then fell by 27% between FY2010 and FY2015. Between FY2015 and FY2017, total DOD RDT&E funding rose by 13.5% in constant dollars.

Figure 4. Title IV RDT&E Funding by Character of Work, FY1996-FY2017

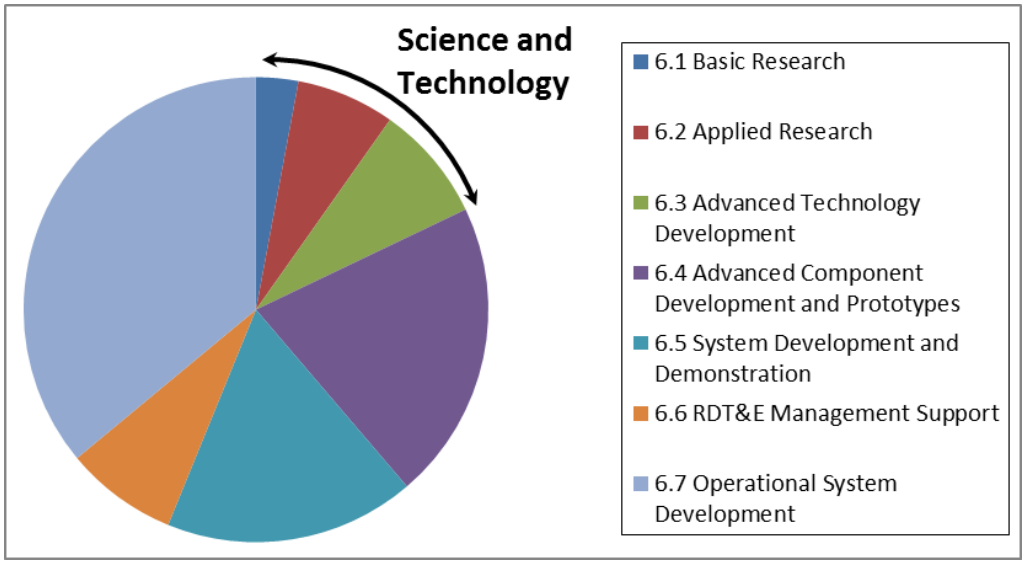
obligational authority, in billions of constant FY2017 dollars



Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998- FY2019.

Figure 5 illustrates the composition of RDT&E in FY2017 by character of work. Operational System Development was the largest component (36.7%). Science and technology (6.1–6.3) accounted for 18.8% of total RDT&E.

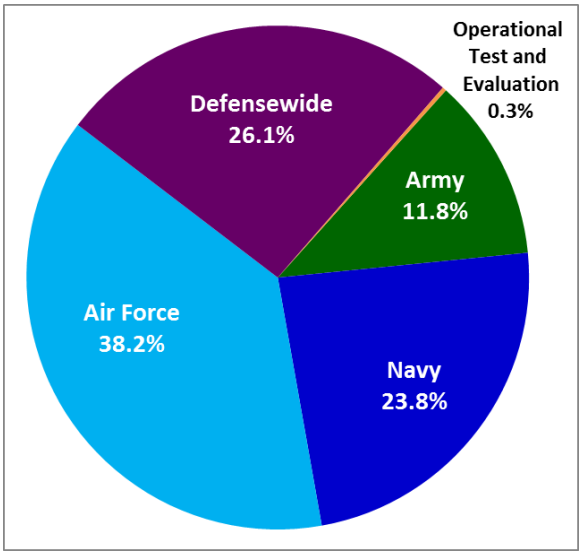
Figure 5. FY2017 Title IV RDT&E by Character of Work



Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY2019.

Figure 6 illustrates the composition of Title IV RDT&E funding by organization in FY2017. Title IV (base) and OCO appropriations provided $73.8 billion of $76.4 billion (96.6%) of total DOD RDT&E in FY2017.

Figure 6. Title IV FY2017 RDT&E by Organization



Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY2019. Includes Title IV (base) plus Overseas Contingency Operations (OCO) R&D appropriations.

Selected Issues

Through the authorization and appropriations processes, Congress grapples with a wide-variety of issues related to the magnitude, allocation, and strategic direction of defense RDT&E. These decisions play an important role in U.S. national security and economic strength. This section identifies several of these issues: the level of DOD RDT&E funding, the level of DOD S&T funding, the level of DOD basic research, and the balance between incremental-focused and revolutionary-focused DOD RDT&E.

While S&T and basic research are integral components of the DOD RDT&E whole, these elements are treated separately in this analysis. In practice, appropriations decisions are generally made about specific programs within the context of the available funding. The levels of RDT&E, S&T, and basic research funding are the result of many decisions made during DOD budget formulation and congressional appropriations, and in the end, are calculated on a post-facto basis. Nevertheless, an analysis of the kind that follows may be useful in assessing the "big picture" and in seeing funding trends in the context of an historical arc that may provide strategic insight and guidance.

What Is the Appropriate Funding Level for DOD RDT&E?

Each year Congress makes decisions about funding for DOD RDT&E. Authorization and appropriations levels, as well as programmatic priorities, are influenced by a wide range of factors, including current military engagements and international commitments, near-term national security threats, the perceived need for technology capabilities to address emerging and unanticipated threats, RDT&E funding and capabilities of adversaries and potential adversaries, RDT&E funding of allies, prior commitments to multi-year programs, competing demands for resources to support non-RDT&E DOD (e.g., personnel, acquisitions) and other federal non-DOD activities, the prior year's funding level, anticipated government revenues, and appropriations constraints (e.g., budget caps).

Approach: DOD RDT&E as a Share of DOD Funding

The question "What is the appropriate funding level for DOD RDT&E?" does not lend itself to a clear objective answer, in part because such an assessment necessarily depends on subjective assumptions about need and adequacy. Nevertheless, the question has been a focus of analysis and debate in Congress and DOD for some time. For example, in June 1998, the Defense Science Board (DSB) Task Force on the Defense Science and Technology Base for the 21st Century proposed the use of a standard industry benchmark—R&D as a share of sales—substituting total DOD funding for sales. The report stated:

> Using the pharmaceutical industry as a model, [the data show] about 14% of revenue devoted to research and development. With current DoD funding of about $250 billion, a total DoD research and development funding level of about $35 billion is indicated or close to the current DoD level.[10]

Related Data and Discussion

Figure 7 illustrates DOD Title IV RDT&E for the period FY1996-FY2017. Between FY1996 and FY2001, RDT&E grew slowly. Between FY2000 and FY2010, RDT&E grew more rapidly, more

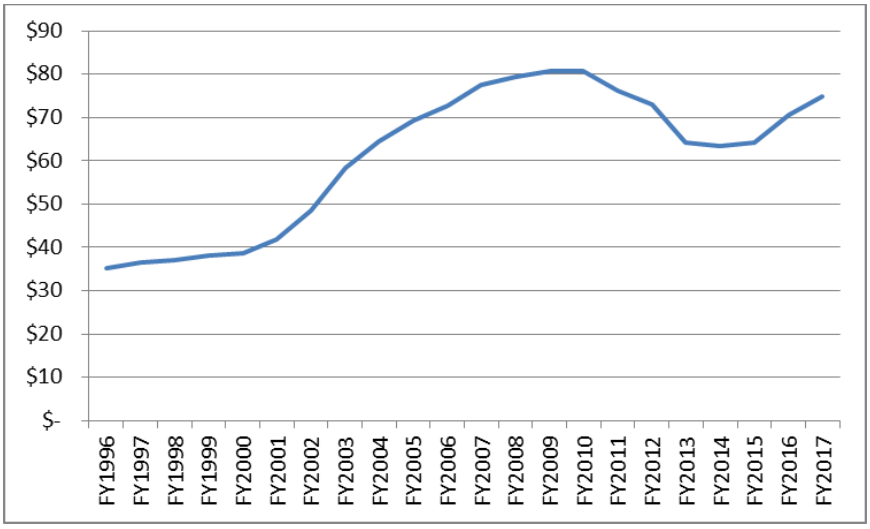
[10] Defense Science Board, *Report of the Defense Science Board Task Force on Defense Science and Technology Base for the 21st Century*, June 1998.

than doubling in current dollars from $38.8 billion to $80.7 billion. (In constant dollars, RDT&E grew by 68.1% from FY2000 to FY2010.) Between FY2010 and FY2015, RDT&E fell 20.5%to $64.1 billion, and then rose 16.7% to $74.8 billion in FY2017.

As a percentage of DOD's total obligational authority (TOA), RDT&E generally ranged between 13% and 14% between FY1996 and FY2006, but then slid to around 11% in FY2011 and remained there through FY2015. Between FY2015 and FY2017, RDT&E's percentage of TOA grew from 11.3% to 12.3%. (See **Figure 8**.)

Figure 7. DOD Title IV RDT&E

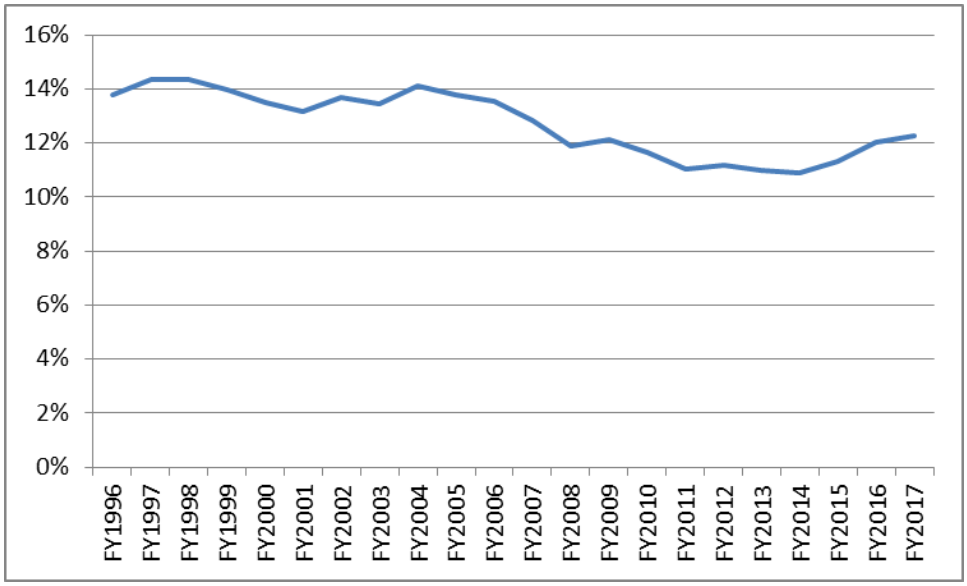
obligational authority, in billions of current dollars



Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998- FY2019.

Figure 8. DOD Title IV RDT&E as a Share of DOD Total Funding

Percentage of obligational authorities



Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998- FY2017; DOD, *National Defense Budget Estimates for FY2017 (Green Book)*, FY2017.

One challenge of using the metric of RDT&E as a share of DOD TOA is that during times of conflict, DOD TOA can increase substantially due to the cost of operations, replacing expended munitions, and increased force size. Thus even when RDT&E is increasing, it may decline as a share of DOD TOA. This is illustrated in **Figure 7** and **Figure 8** between FY2004 and FY2008, a period in which RDT&E grew by 23.4% and DOD TOA grew by 46.8% in support of U.S. post-9/11 military operations in the Middle East.

What Is the Appropriate Funding Level for DOD Science and Technology?

Congress and others have also expressed concerns about the adequacy of funding for the piece of DOD RDT&E known as defense science and technology (6.1-6.3). The scientific and technological insights that emerge from this funding, often referred to as the department's "seed corn," are seen by many as the pool of knowledge available to DOD and the industrial base for future defense technology development.[11] For this reason, defense S&T funding has sometimes been singled out for attention by Congress.

[11] Seed corn has historically referred to the high quality kernels of corn (and other crops) to be used as seeds for growing future corn crops. Thus, "seed corn" was essential to maintaining agricultural output. The term has subsequently been extended to refer to an asset or investment that is expected to provide future returns.

Approach: DOD Science and Technology as a Share of Total DOD Funding

As with overall RDT&E, the DSB's June 1998 report suggested two conceptual frameworks for S&T funding. The first approach, using industrial practice as a guide, proposed setting S&T funding at 3.4% of total DOD funding:

> The DoD S&T budget corresponds most closely to the research component of industrial R&D. Using 3.4% of revenue (typical of high-tech industries shown [elsewhere in the report]), the DoD S&T funding should be about $8.4 billion, which is a billion dollars greater than the FY98 S&T funding.[12]

To address this perceived shortcoming in funding, the FY1999 defense authorization bill (P.L. 105-261, Section 214) expressed the sense of Congress that DOD S&T funding should be increased by 2% or more above the inflation rate each year from FY2000 to FY2008. Subsequently, the FY2000 defense authorization bill (P.L. 106-65) expressed the sense of Congress that

> the Secretary of Defense has failed to comply with the funding objective for the Defense Science and Technology Program, especially the Air Force Science and Technology Program, as stated [P.L. 105-261], thus jeopardizing the stability of the defense technology base and increasing the risk of failure to maintain technological superiority in future weapon systems.[13]

The act further expressed the sense of Congress that the Secretary of Defense should increase DOD S&T, including the S&T programs within each military department, by 2% or more above the inflation rate each year from FY2001 to FY2009.

In 2009, the Senate-passed version of the National Defense Authorization Act (S. 1390) included a provision (Sec 217) that would have stated a sense of Congress that the Secretary of Defense should increase DOD S&T by a percent that is at least equal to inflation.

Congress embraced the DSB's three percent recommendation and underlying rationale in the conference report accompanying the National Defense Authorization Act for Fiscal Year 2003:

> The conferees commend the Department of Defense commitment to a goal of three percent of the budget request for the defense science and technology program and progress toward this goal. The conferees also note the finding in the Defense Science Board report that successful high technology industries invest about 3.5 percent of sales in research (equivalent to the DOD S&T program) and the recommendation that S&T funding should be increased to ensure the continued long-term technical superiority of U.S. military forces in the 21st Century. The conferees believe that the Department must continue to provide the necessary investments in research and technologies that ensure a strong, stable, and robust science and technology program for our Armed Forces.[14]

Other organizations have proposed using the same metric, but with a 3% as the level for S&T funding as a share of total DOD funding. A 2001 report based on the Quadrennial Defense Review (QDR), a legislatively mandated review by DOD of its strategies and priorities, called for "a significant increase in funding for S&T programs to a level of three percent of DOD spending

[12] Defense Science Board, *Report of the Defense Science Board Task Force on Defense Science and Technology Base for the 21st Century*, June 1998.

[13] P.L. 106-65.

[14] H.Rept. 107-772, p. 460, http://lis.gov/cgi-lis/t2gpo/https:/www.gpo.gov/fdsys/pkg/CRPT-107hrpt772/pdf/CRPT-107hrpt772.pdf.

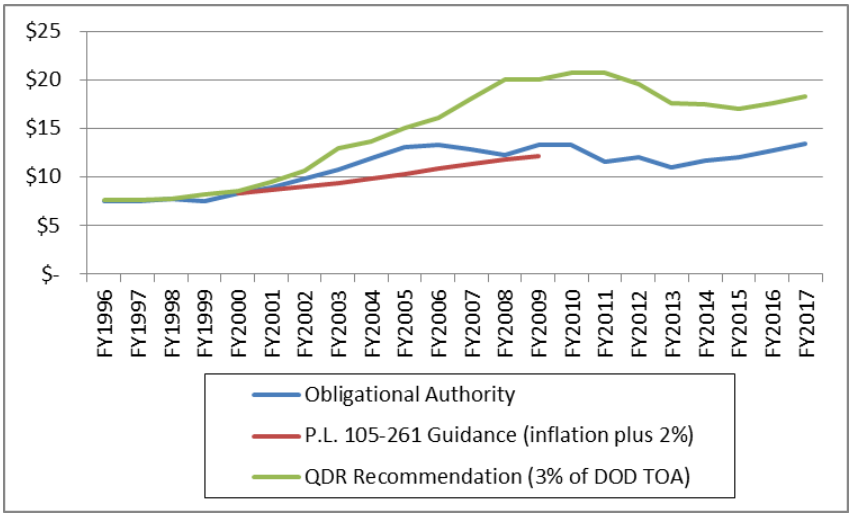
per year."[15] In 2004, the Council on Competitiveness, a leadership organization of corporate chief executive officers, university presidents, labor leaders, and national laboratory directors, reiterated the 3% recommendation of the QDR.[16]

Related Data and Discussion

Following a period of strong growth in the early 2000s, S&T funding peaked in current dollars at $13.3 billion in FY2006, then declined to $11.0 billion in FY2013 before rebounding to $13.4 billion in FY2017. (See **Figure 9**.) In constant dollars, S&T funding peaked in FY2005 before falling 27.8% through FY2013; between FY2013 and FY2017, S&T funding recovered somewhat, growing by 14.9%. Viewed as a share of DOD total obligational authority (TOA), S&T declined from about 3.0% in the late 1990s to about 1.7% in 2011, rebounding to about 2.2% in FY2017. (See **Figure 10**.) While the growth in the absolute amount of S&T funding that was sought in P.L. 105-261 (red line, **Figure 9**) was achieved, S&T funding would have been higher under the QDR recommendation (3% of DOD TOA, green line, **Figure 9**).

Figure 9. DOD Science and Technology (6.1-6.3) Funding

in millions of current dollars



Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998-FY2019.

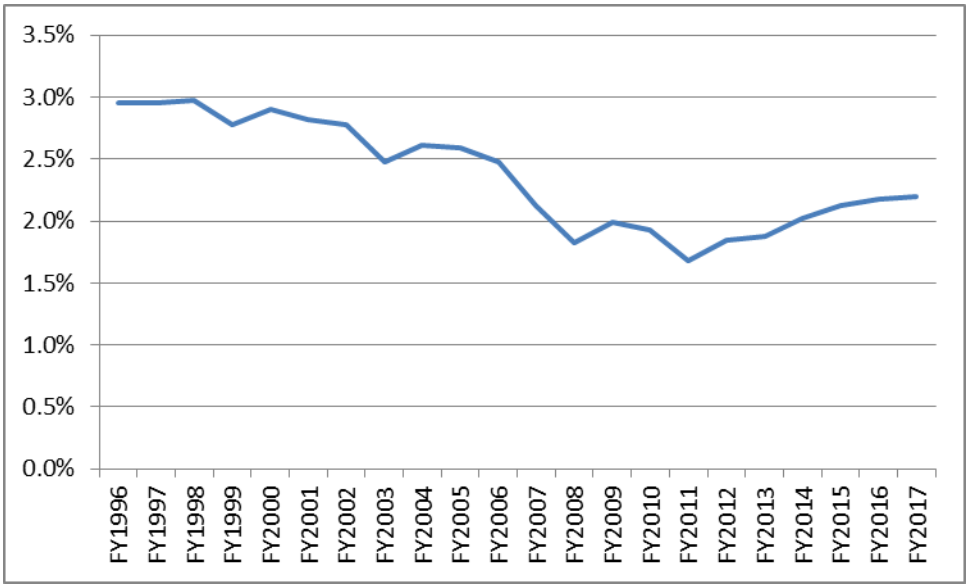
Note: For purposes of this chart, CRS used the GDP (Chained) Price Index from Table 10.1 of the Historical Tables in the *President's Budget for Fiscal Year 2019*, to determine an "inflation" level as this is the index used by the Office of Management and Budget to convert federal research and development outlays from current dollars to constant dollars. https://www.whitehouse.gov/sites/default/files/omb/budget/fy2017/assets/hist10z1.xls.

[15] Department of Defense, *Quadrennial Defense Review Report*, September 30, 2001, p. 41, archive.defense.gov/pubs/qdr2001.pdf.

[16] Council on Competitiveness, *Innovate America*, 2004, p. 58, http://www.compete.org/storage/images/uploads/File/PDF%20Files/NII_Innovate_America.pdf.

Figure 10. DOD Science and Technology Funding as a Share of DOD TOA

Percentage of obligational authorities



Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998-FY2019; DOD, *National Defense Budget Estimates for FY2017* (*Green Book*), FY2017.

Approach: DOD Science and Technology as a Share of DOD RDT&E

The DSB's second proposed framework, also based on industrial practice, was to use the metric of S&T as a share of DOD RDT&E:

> Another approach to this question is to note that the ratio of research funding to total R&D funding in high-technology industries, such as pharmaceuticals, is about 24%. When this percentage ratio is applied to the FY98 R&D funding of about $36 billion, the result is about $8.6 billion, well above the actual S&T funding.[17]

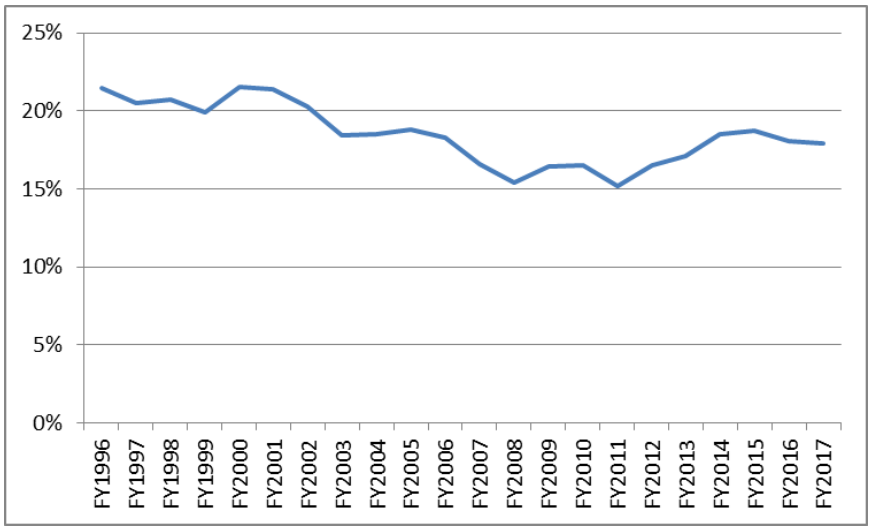
In 2015, a coalition of industry, research universities, and associations, the Coalition for National Security Research, asserted that DOD S&T funding should be 20% of DOD RDT&E.[18]

Related Data

Figure 11 illustrates S&T's share of DOD RDT&E for FY1996-FY2017. At the time of the DSB report, S&T's share of DOD RDT&E was approximately 20%. After rising to 21.5% in FY2000, the share fell to 15.2% in FY2011, recovering to 18.8% in FY2015. The share fell to 18.1% in FY2016 and to 17.9% in FY2017.

Figure 11. DOD Science and Technology Funding as a Share of Title IV RDT&E

Percentage of obligational authorities



Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998-FY2019.

What Is the Appropriate Funding Level for DOD Basic Research?

Within the S&T program, basic research (6.1) is singled out for additional attention, due in part to its perceived value in advancing breakthrough technologies and in part to the substantial role it

[17] Defense Science Board, *Report of the Defense Science Board Task Force on Defense Science and Technology Base for the 21st Century*, June 1998. CRS analysis of the FY1999 DOD R-1 shows $7.8 billion in defense S&T funding for FY1998. Some analysts may disagree with DSB's implicit assumption about the applicability of a ratio drawn from the R&D investment behavior of private firms competing in a commercial market to DOD S&T spending.

[18] Richard M. Jones, "Coalition Recommends Higher Level of Defense S&T Funding than Administration Request," *FYI: Science Policy News from AIP*, April 13, 2015, https://www.aip.org/fyi/2015/coalition-recommends-higher-level-defense-st-funding-administration-request.

plays in supporting university-based research in certain physical sciences and engineering disciplines. Basic research funding is seen by some to be particularly vulnerable to budget cuts or reallocation to other priorities because of the generally long time it takes for basic research investments to result in tangible products and other outcomes (i.e., reductions in funding can be made with minimal short term consequences) and to the uncertainty of the benefits that will be derived from the results of basic research.

Approach: DOD Basic Research as a Share of DOD S&T

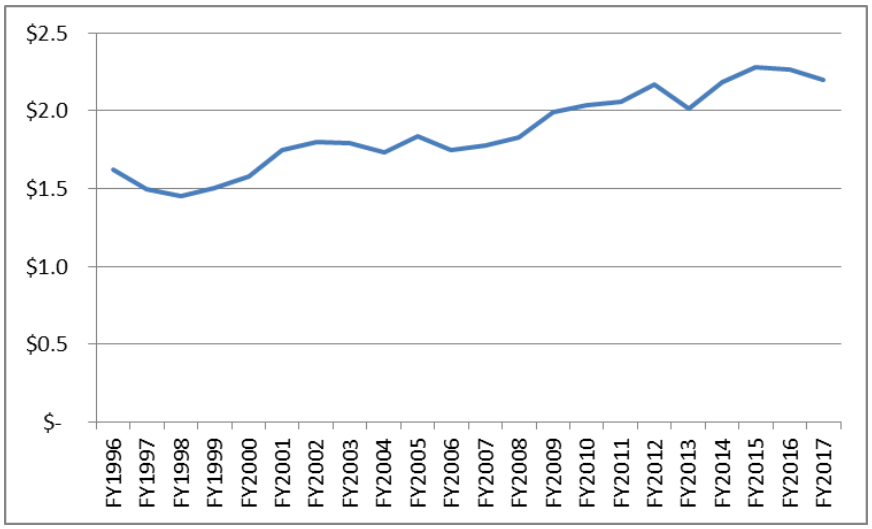
In 2004, the Council on Competitiveness asserted that DOD basic research should be at least 20% of DOD S&T.[19] In 2015, the Coalition for National Security Research also recommended 20% of DOD S&T.[20]

Related Data

DOD basic research funding grew steadily from FY1998 through FY2015, more than doubling in current dollars, then fell somewhat in FY2016 and FY2017. (See **Figure 12**.) As a share of S&T, basic research declined from 14.6% in FY1996 to 11.0% in FY2006, then began a steady rise to 18.4% in FY2015, its highest level in 20 years, then fell in FY2016 to 17.4% and in FY2017 to 16.4%. (See **Figure 13**.)

Figure 12. DOD Basic Research Funding

obligational authority, in billions of current dollars



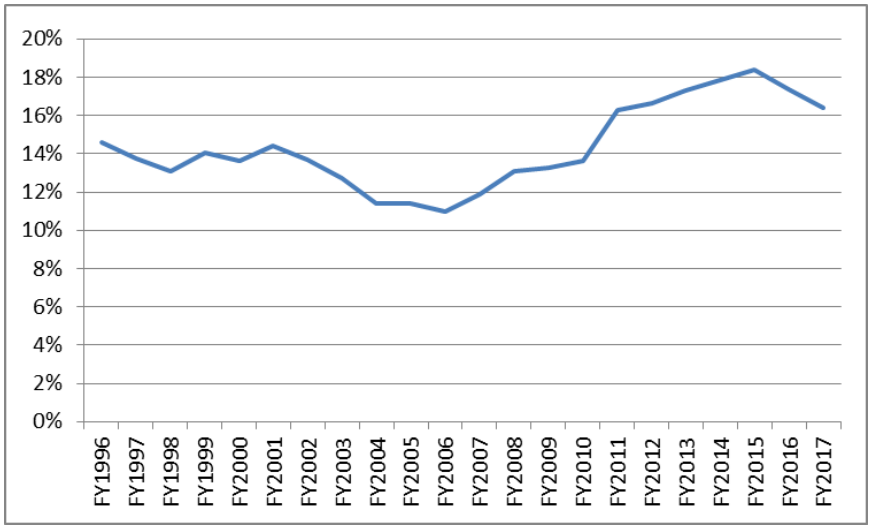
Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998-FY2019.

[19] Council on Competitiveness, *Innovate America*, 2004, p. 58.

[20] Richard M. Jones, "Coalition Recommends Higher Level of Defense S&T Funding than Administration Request," *FYI: Science Policy News from AIP*, April 13, 2015.

Figure 13. DOD Basic Research as a Share of S&T

Percentage of obligational authorities



Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998- FY2017.

What Is the Appropriate Balance Between Investments in Incremental RDT&E and Investments Directed Toward Revolutionary Technological Advancements?

Another key issue of concern to Congress is the balance in the RDT&E portfolio between funding focused on incremental or evolutionary improvements and funding focused on exploratory research that might lead to revolutionary technologies. The latter is frequently referred to as "high risk, high reward" research as it involves R&D activities that have low or unknown likelihood of success, but that, if successful, may yield revolutionary technological advances.[21]

Approach: Revolutionary Research as a Share of DOD S&T

The DSB's 1998 report noted industry's practice of

> allocating about 1/3 of the total available research funding to exploratory or potentially revolutionary projects. The other 2/3 of the effort is typically focused on identified product needs in the form of evolutionary improvements in current product lines.[22]

In accordance with this industrial practice, DSB recommended that DOD

> [ensure] that approximately 1/3 of the S&T program elements are devoted to revolutionary technology initiatives. DARPA should play a major role in executing these efforts along with the Services.[23]

[21] Historical examples of defense-led, science and technology-enabled, revolutionary advances include nuclear weapons, integrated circuits, jet aircraft, precision munitions enabled by the Global Positioning System (GPS), and the internet.

[22] Defense Science Board, *Report of the Defense Science Board Task Force on Defense Science and Technology Base for the 21st Century*, June 1998.

[23] Ibid, p. 45.

Applied to the FY2017 S&T budget, this formula would allocate approximately $4.5 billion to revolutionary technology initiatives.

In 2004, S.Rept. 108-46 accompanying the National Defense Authorization Act for Fiscal Year 2004 (S. 1050) expressed the committee's concerns that the DOD "investment in basic research has remained stagnant and is too focused on near-term demands."

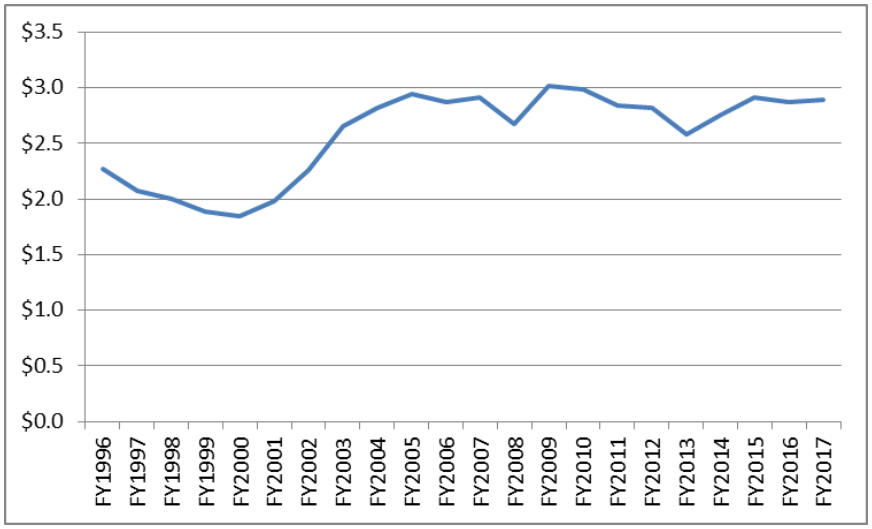
Related Data and Discussion

DOD does not report funding for revolutionary research. The Defense Advanced Projects Research Agency (DARPA) has been the lead DOD agency focused on revolutionary R&D since its establishment in 1958 following the Soviet launch of the first man-made satellite, Sputnik, in 1957. For this report, CRS examined DARPA funding as a surrogate measure of at least a portion of DOD's investments in revolutionary research.[24]

DARPA describes its mission as making "pivotal investments in breakthrough technologies for national security."[25] DARPA funding has remained generally steady since FY2003, ranging between $2.5 billion and $3.0 billion. (See **Figure 14**.) Similarly, DARPA's funding as a share of defense S&T has remained generally steady since FY1999, between 22% and 25%. In FY1996, DARPA funding accounted for about 30% of S&T funding, before sliding to 22% in FY2000 (See **Figure 15**.)

Figure 14. DARPA Funding

obligational authority, in billions of current dollars



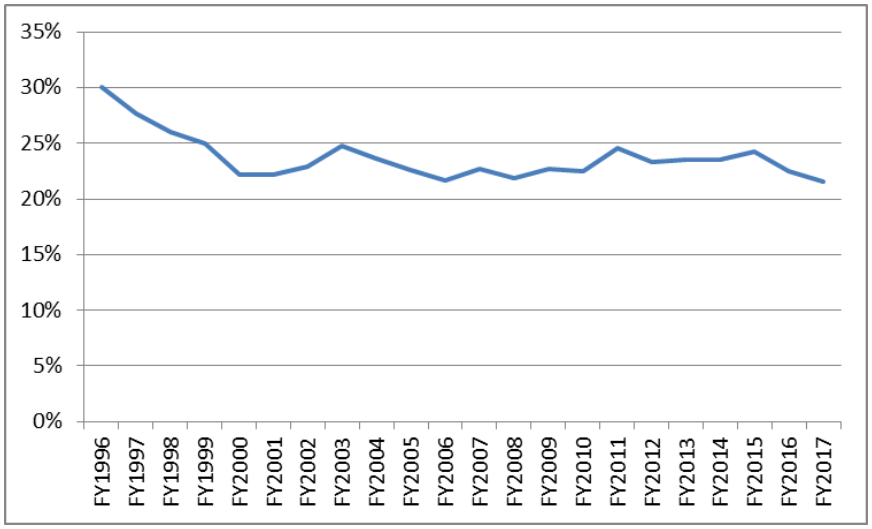
Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998-FY2019.

[24] Some analysts have expressed concern that DARPA funding has, at times, become too focused on near-term technology transition and less focused on pioneering research. See for example, John Paul Parker, "At the Age of 50, It's Time for DARPA to Rethink its Future," *National Defense: NDIA's Business and Technology Magazine,* September 2009, http://www.nationaldefensemagazine.org/archive/2009/September/Pages/AttheAgeof50,it%E2%80%99sTimeforDARPAtoRethinkitsFuture.aspx.

[25] Department of Defense, Defense Advanced Research Projects Agency website, accessed December 5, 2016, http://www.darpa.mil/about-us/mission.

Figure 15. DARPA Funding as a Share of DOD S&T Funding

Percentage of obligational authorities



Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998-FY2019.

Approach: High Risk, High Payoff Research as a Share of RDT&E

In its 2007 *Rising Above the Gathering Storm* report, the National Academies recommended that

> At least 8% of the budgets of federal research agencies should be set aside for discretionary funding managed by technical program managers in those agencies to catalyze high-risk, high-payoff research.[26]

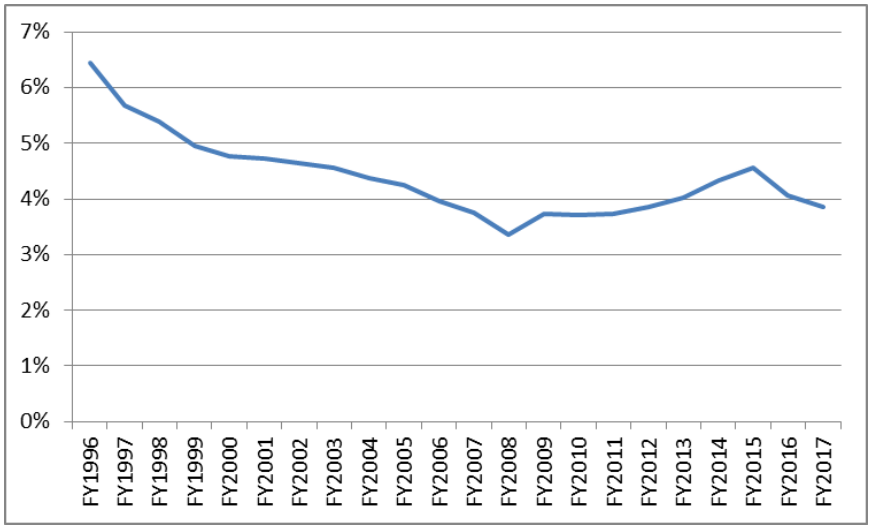
Related Data and Discussion

Using DARPA once more as a surrogate measure of a portion of DOD's high risk, high payoff research, **Figure 16** shows DARPA funding as a percent of DOD RDT&E. Between FY1996 and FY2008, DARPA's share of RDT&E fell by nearly half, from 6.4% in FY1996 to 3.4% in FY2008. DARPA's share subsequently rose to 4.5% in FY2015, and then fell again in FY2016 to 4.1% and in FY2017 to 3.9%. Based solely on DARPA funding, DOD funding for high risk, high payoff research is well below the 8% recommended by the National Academies. It is unclear how investments in high risk, high payoff research from other DOD accounts might affect this picture.

[26] National Academies, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, 2007, p. 149, https://download.nap.edu/cart/download.cgi?record_id=11463.

Figure 16. DARPA as a Share of DOD RDT&E

Percentage of obligational authorities



Source: CRS analysis of data from Department of Defense, *Research, Development, Test, and Evaluation Programs (R-1)* for FY1998- FY2019.

Concluding Observations

DOD RDT&E investments are highly complex and can be parsed in many ways. Some of these are highlighted in this report. Other ways of parsing RDT&E funding—such as allocation by performing organization (e.g., industry; universities; government-owned, government-operated facilities; federally-funded research and development centers (FFRDCs)), size of industrial performers, intramural and extramural performance—may also be important for the effective allocation of DOD RDT&E resources. Similarly, many DOD RDT&E stakeholders have asserted the importance of stability in funding streams. Among the many other factors that may affect the effectiveness of the performance of RDT&E are: organizational structures and relationships; management; workforce recruitment, training and retention; and policies related to cooperative research and technology transfer.

As Congress undertakes defense annual authorization and appropriations, it may wish to consider the issues raised in this report related to the magnitude and composition of funding for DOD RDT&E, as well as the other issues such as those identified above.

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