A History of the Department of Defense Federally Funded Research and Development Centers

June 1995

OTA-BP-ISS-157

GPO stock #052-003-01420-3



Recommended Citation: U.S. Congress, Office of Technology Assessment, *A History of the Department of Defense Federally Funded Research and Development Centers*, OTA-BP-ISS-157 (Washington, DC: U.S. Government Printing Office, June 1995).

Foreword

The 104th Congress, like its recent predecessors, is grappling with the role of modeling and simulation in defense planning, acquisition, and training, a role that current and contemplated technological developments will intensify. The Department of Defense (DoD) Federally Funded Research and Development Centers (FFRDCs), some closely tied to defense modeling and simulation, are also a topic of recurrent congressional concern owing to their unique institutional status. The 104th's emphasis on private sector solutions suggests that this Congress in particular will seek to address the FFRDCs. This Office of Technology Assessment Background Paper has been prepared to help Congress do so.

The DoD FFRDCs trace their lineage to ad hoc, not-for-profit, university-based organizations created during World War II to address specific technological problems. Some performed studies and analyses on topics such as anti-submarine warfare, but the majority were laboratories engaged in the development of radar, the proximity fuze, and other war-winning weapons including nuclear weapons. These centers proved useful in bridging the organizational, compensation-related, and cultural gaps between science and the military, and more were created during the Cold War. The laboratories continued to predominate in some respects, but centers devoted to study and analysis grew and entered the public consciousness as "think tanks," and other centers embarked upon a new role—system integration. In all three capacities, the Federal Contract Research Corporations (FCRCs), as they were then known, provided services that the federal government could neither create in-house or buy in the open market, either because of severe concerns regarding conflict of interest, the safekeeping of competitition-sensitive information, and other hazards of the open marketplace, or simply because the open market did not offer what was needed.

In the present day, the for-profit world offers a fuller range of intellectual services than it did at the onset of the Cold War, and the centers' federal government sponsors are precluded from assigning to an FFRDC work that could be done as effectively outside. Annual ceilings limit the total amount of Defense department work done in the centers. For these and other reasons there remain only ten DoD FFRDCs, out of over 70 that have existed at one time or another. Yet the FFRDCs, by virtue of their long-term partnership with the federal government and their arm's length relationship to their sponsors and to

other businesses alike, continue to play a unique role in today's rapidly changing national security community. This role includes, but is by no means limited to, the centers' decades long series of contributions to combat modeling and simulation.

This Background Paper is the second of several publications in the OTA's assessment of defense modeling and simulation, requested during the 103rd Congress by Representatives Ronald V. Dellums (Chairman) and Floyd Spence (Ranking Minority Member) of the House Committee on Armed Services, Senators Sam Nunn (Chairman) and Strom Thurmond (Ranking Minority Member) of the Senate Committee on Armed Services, and Senators Jeff Bingaman (Chairman) and Bob Smith (Ranking Minority Member) of its Subcommittee on Defense Technology, Acquisition, and Industrial Base. Much seminal work in defense modeling and simulation has been, and is being, conducted at FFRDCs.

In undertaking this assessment, OTA sought and received the assistance of a broad range of individuals and organizations. We gratefully acknowledge their contributions of time and intellectual effort. OTA also appreciates the cooperation and assistance of the Department of Defense. As with all OTA publications, the content of this background paper is the sole responsibility of the Office of Technology Assessment and does not necessarily represent the views of our advisors or reviewers.



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Summary

Between the onset of World War II and 1991, more than 70 centers were created that came to be known collectively as Department of Defense (DoD) Federally Funded Research and Development Centers (FFRDCs). The maximum in existence at any one time was 43, in 1972. An ongoing sequence of DoD reviews has affirmed a continuing need for some FFRDCs. Other FFRDCs have been either discontinued because they were no longer required or, far more commonly, decertified as FFRDCs and allowed to continue, whether on a not-for-profit basis or not, without the FFRDC mantle. Currently, there are 10 DoD FFRDCs. These can be categorized as study and analysis centers, systems engineering and integration centers, and laboratories. DoD study and analysis FFRDCs have had a special role in combat modeling and simulation. Their history over the past 50 years is the focus of this background paper, which forms part of the Office of Technology Assessment (OTA) study of defense modeling and simulation. To provide perspective, some information on other DoD FFRDCs is included.

FFRDCs, formerly called Federal Contract Research Centers (FCRCs), grew out of the semi-academic laboratories and research groups created by the federal government for defense research during World War II. In some cases the lineage traces all the way back to the war. The Massachusetts Institute of Technology's (MIT's) wartime Radiation Laboratory led to the peacetime Lincoln Laboratory, at first a federal research center, then an FCRC, and finally an FFRDC. The Navy's wartime Operations Research Group eventually turned into the Center for Naval Anal-

yses. In still other cases, the lineage is collateral: the RAND Corporation and the Institute for Defense Analyses, to many the archetypal FFRDCs, are study and analysis centers created after the war.

Federally funded research centers grew out of the need to obtain objective assessments of military problems or programs of increasing technical complexity. To carry out this function, integral to the mission of the federal government, FFRDCs received long-term access to a broad range of information from both the federal government and industry. To keep their assessments free from the institutional pressures of either sector, FFRDCs were established as private not-for-profit organizations, independently operated either by universities or by not-for-profit corporations established for this purpose. To maintain their special working relationship with the federal government and industry, FFRDCs agreed to terms and conditions more restrictive those accepted by other organizations doing business with the federal government. The substance of these agreements was that FFRDCs not make profit, not compete for federal work, not work for commercial clients, not manufacture products, and not carry out functions performed by DoD. They follow their sponsoring agreements' mission statements, and their sponsors do not assign work that could be carried out as effectively by for-profit companies except on a very limited basis to maintain expertise and continuity within the FFRDCs. More detailed aspects of these agreements arise from federal laws and procurement regulations.

The dynamic between the independent federal research centers and their sponsoring agencies has included conflicts. However, the centers have striven to maintain free research, independent from conflicts of interest including their sponsor's interests, while sponsors have wanted immediately useful outputs from their research centers. In a larger context, costs and competition have at times become issues. The pay differential between federal research center workers and their federal government counterparts, an intentional feature at the outset, led to situations in which people found themselves working side by side on a project at very different salary levels and to a wider belief that federal centers were an expensive way for the federal government to accomplish its work even though they were not-for-profit. On the centers' side was the argument that at least in some cases the federal government ought to have a way of obtaining something other than the lowest bidder's least-cost work. This discussion opens the vexing issue of how to assess the quality of federal government work.

When the disciplines developed in these research centers became established parts of academic curricula, for-profit companies were able to offer the federal government services similar to those of the FFRDCs. The for-profit world of consultants, often associated with the Washington Beltway in the vernacular through such terms as "highway helpers," has flourished in the postwar era. Some see the DoD FFRDCs, especially those devoted to study and analysis, as dinosaurs that have had their day and now should make way for the new breed, the for-profits. Those who see a continuing role for the FFRDCs look on them as having developed a new role. While no longer monopolists of the methods they pioneered, they are now patient intellectual capital, more able than the for-profit companies to maintain expertise in specific areas regardless of the vicissitudes of year-to-year contracting, and able to develop new tools and skills in a way that would prove difficult absent a long-term partnership between the federal government and the research entity. FFRDCs also afford the federal government a means of integrating proprietary information provided by multiple for-profit companies.

Federal study and analysis centers (then known as Federal Contract Research Centers) came into the public eye in the 1950s when their long-range and strategic-planning studies sometimes took issue with established military policy. However, staff involved in such work never exceeded 1 percent of the FCRC population. The point at issuethe relationship between military and civilian experts in the formulation of defense policyhas undergone constant reassessment to this day. This reassessment has extended well beyond the

TABLE S-1: Profile of Current DoD FFRDCs

	CNA	IDA	PAF	Arroyo	NDRI	LMI	LL	SEI	Aerospace	MITRE	C³I
Founded[a]	1942	1956	1946	1984	1984	1961	1951	1984	1960	1958	
Sponsor	Navy	DoD	USAF	Army	DoD	OSD	USAF	ARPA	USAF	DoD	
Type	S&A	S&A[b]	S&A	S&A	S&A	S&A	Lab	Lab	SE	SE	
Owner	CNA	IDA	<------—	RAND	--------->	LMI	MIT	CMU	Aerospace	MITRE	
Staff[f,c]	500	800	<---------	1,100	—------>	300	2,300	300	3,600	3,700	
Location[c]	VA	VA[b]	<----------	CA, DC	---------->	VA	MA	PA	CA	MA, VA	
FY 1994 total[d]	$50M	$108M	<------—	$108M	--------->	$36M	$328M	$33M	$379M	$590M	
FY 1994 DoD	$50M	$108M	$24M	$20M	$24M	$30M	$275M	$30M	$363M	$450M	

KEY: Aerospace = Aerospace Corp., ARPA= Advance Research Projects Agency; Arroyo = Arroyo Center; CA = California, CMU = Carnegie-Mellon University; CNA = Center for Naval Analyses, DC = Washington, DC; IDA = Institute for Defense Analyses, Lab = laboratory; LL = Lincoln Laboratory; LMI = Logistics Management Institute; MA= Massachusetts; MIT= Massachusetts Institute of Technology; MITRE C³I Corp.; NDRI = National Defense Research Institute; OSD = Office of the Secretary of Defense; PA-Pennsylvania; PAF = Project Air Force, RAND = RAND Corp.; S&A = study and analysis center; SE = systems engineering; SE I = Software Engineering; USAF = U.S. Air Force; VA = Virginia.

[a]Because of CNA's unbroken link to its wartime predecessor, the Operations Research Off Ice, its wartime starting date is shown: a hiatus separates Lincoln Laboratory from its wartime predecessor, the Radiation Laboratory. NDRI was formed out of an existing division at RAND Corp., whose work effectively dates back to the 1960s, if not earlier.
[b]Most of IDA is a study and analysis FFRDC, but part of the center functions as a laboratory and is not in Virginia.
[c]Lincoln Laboratory has, for some purposes, been considered government-owned because it occupies government-owned land
[f]Staff levels are rounded to the nearest 100. SEI, the only DoD FFRDC with a congressionally set celling on staff, is limited to 250 full-time-equivalent members of its technical staff.

NOTE: Project Air Force, the Arroyo Center, and the National Defense Research Institute are part of RAND Corporation.

FFRDCs, which now constitute a very small part of the industry that carries out studies and analyses for the DoD.

The close relationship between FFRDCs and the federal government requires FFRDCs to have access to classified information. Though Cold War compartmentalization did in some cases deny this information to FFRDC study efforts that could have benefitted from it, FFRDCs performed an important function in limiting the need to distribute classified information widely to industry, as they could provide specifications for system development or study scope without revealing the sensitive information that drove the specifications. In some cases, an FFRDCs' access to classified information has led to reconsideration of its relationship with a university sponsor. Because of universities' perception that the presence of classified information runs counter to a desired atmosphere of open inquiry, there has been a trend towards FFRDCs as independent not-for-profit corporations rather than university-sponsored cen ters.

Though the federal research centers were established by various federal government agencies including DoD, they evolved in an environment lacking in unified federal government regulations and policies. On the one hand, they enjoyed no protection for their special function. On the other, they were regulated by individual sponsoring agencies acting without a comprehensive policy framework specific to the research centers. Like all federal contractors, these centers were subject to the policies, explicit or implicit, of the acquisition regulations. Issues such as whether the assets of a research center belonged to the federal government or the center, the disposal of those assets in the event of the closure of the center, and who decided whether the results of studies should be accessible outside the sponsoring agency, were typically resolved on a case-by-case basis. For some of these issues, larger public values might outweigh the interests of the sponsoring agencies. The Office of Federal Procurement Policy published a government-wide FFRDC policy in 1984,

subsequently codified in the Federal Acquisition Regulations, in sponsoring agreements between the federal government and individual FFRDCs and in FFRDC contracts with the federal government. In the 1990s, the DoD supplemented these regulations with a Management Plan for FFRDCs.

Today the FFRDCs inhabit a world much different from that of their predecessors in the late 1940s and 1950s. The FFRDCs history and current status are summarized in table S-1. Epochal change brings into question the continued need for institutions created during World **War** II and the Cold War and whether their continued presence amid private sector competition is in the national interest. By law, FFRDCs are to be used only to meet special research or development needs that cannot be met as effectively by existing federal government or contractor resources. Some of the frequent questions raised are answered inbox S-1. Re-examination of the centers' origins and history provides an opportunity to revisit the value of these research centers as a national resource. Discussion of specific policy options lies beyond the scope of this OTA background paper.

BOX S-1: Answers to Frequently Asked Questions About DoD FFRDCs

Q: What does "FFRDC" stand for? Is that the same thing as "FCRC"?

A: "Federally Funded Research and Development Center." "FCRC" stood for "Federally Chartered Research Center," a term that grew into use without statutory definition and was supplanted by ""FFRDC" after that term became formally defined.

Q: *How many DoD FFRDCs are there?*

A: Ten. They are the Center for Naval Analyses, the Institute for Defense Analyses, The Aerospace Corporation, MITRE C^3I, Lincoln Laboratory, the Software Engineering Institute, the Logistics Management Institute, Project Air Force, the Arroyo Center, and the National Defense Research Institute. The last three are all parts of RAND Corporation. Generally speaking, the centers can be divided into those concentrating on study and analysis, those concentrating on engineering and technology, and laboratories, as shown in table S-1.

Q: What about the Applied Physics Laboratory Los Alamos, the Concepts Analysis Agency the Naval Research Laboratory and all these other places of which 1 have heard?

A: APL, like the Systems Development Corporation and many others, is a former DoD federal research center. Many former FFRDCs have continued to exist and to do business with the federal government, either on a for-profit or not-for-profit basis, without being FFRDCs Los Alamos National Laboratory, like others, is a Department of Energy (DOE) FFRDC and not a DoD FFRDC. CAA and NRL, like many other centers and laboratories, are in federal government research operations.

Q: Are FFRDCs the same thing as GOCOs---government-owned, contractor-operated entities?

A: No. Of the current DoD FFRDCs only Lincoln Laboratory occupies a significant amount of federal government-owned or -leased space, and even it is not always counted as a GOCO. Some DOE FFRDCs are GOCOs

BOX S-1: Answers to Frequently Asked Questions About DoD FFRDCs (Cont'd.)

Q: What makes FFRDCs unique?

A: Because FFRDCs are not allowed to compete for federal government work, and are restricted in many other ways, federal government sponsors establish long-term partnership relationships with their FFRDCs enabling the FFRDCs to provide continuity of effort and to be trusted with close access to federal government officials and highly sensitive data. Consequently the FFRDCs are able to address long-term problems of considerable complexity and to analyze technical questions with a high degree of objectivity borne of having renounced any possibility of selling products to the federal government or forming partnerships with those who do, while remaining outside of the federal government itself.

Q: Why not just bring the FFRDC work in-house and let federal government employees do it?

A: At their inception, one of the reasons—in addition to organizational independence—for creating the federal research centers was that the terms of federal government employment could not attract the needed scientific talent. In the present day, any move to bring FFRDCs in-house would run counter to decades of effort by Administrations and Congresses of both majority parties with widely disparate outlooks, to let as much work as possible be done in the private sector. The FFRDCs honest-broker status depends at least as much on their insulation from their customers as it does on their insulation from the rest of the private sector. A federal government employee or military person could find it difficult to pass judgment on equipment or procedures designed at the behest of his or her own boss or commanding officer. This insulation, in some cases intentionally reinforced by physical distance, also protects the FFRDCs from being drawn into the heated exercise of day-to-day federal government.

Q: Do FFRDCs get budget line-items?

A: Some do; some don't. Line-item funding is less than a tenth of total DoD FFRDC funding. The bulk of DoD FFRDC funding comes out of the appropriations for the DoD programs on which the FFRDCs work.

Q: How is it decided how much FFRDC work is needed?

A: Beyond the small fraction of their revenue that is a line item, Congress sets a ceiling on the total amount of DoD-appropriated money that can be spent at the FFRDCs The Office of the Director of Defense Research and Engineering (DDR&E) decides how this ceiling is partitioned among the centers, and the centers' sponsors assign the work. Nonsponsors within DoD who would like to have work done at an FFRDC must find the money within their own budgets and then persuade the FFRDC's sponsor to assign the work.

Q: Do FFRDCs compete with private industry?

A: Although not-for-profit, FFRDCs are themselves a part of the private sector. Many people think that DoD FFRDCs compete with for-profit industry in the sense that work that otherwise might be competed winds up being done by FFRDCs Strictly speaking, that should not happen because the centers' charters forbid them from being assigned work that could be done as effectively outside. People being only human, budgets being tight, time being short, and contracting regulations being onerous, it is certainly possible that from time to time FFRDCs receive work because it is cheaper, easier, or quicker to give it to them rather than to compete a contract among all comers. Perhaps for this reason, some people have the mistaken impression that FFRDCs actually bid against other companies on competitive DoD contracts as well as contracts let by other parts of the private sector. These people may also have confused FFRDC bidding on DoD contracts, which would violate the centers' charters and the law, with

(continued)

BOX S-1: Answers to Frequently Asked Questions About DoD FFRDCs (Cont'd.)

something else. For example, some FFRDCs can and have bid on state and local government work or work for foreign countries. The DoD FFRDCs or their "parent organizations" (universities or, increasingly, not-for-profit corporate entities designed for the purpose of possessing FFRDCs all do some work that is outside their FFRDC's mission, but which draws on the expertise created in performing that mission. Such work is also subject to restrictions analogous to those imposed on FFRDC work.

Q: If FFRDCs are not-for-profit, how are they able to charge a fee?

A:Some of the federal research centers have charged the federal government fees, above and beyond the cost of doing the work contracted, to provide capital funds for the organization and funds for other activities: the Defense Acquisition Regulations explicitly provide for such fees, and recent legislation limits the uses to which they can be put. Some centers charge fees to cover ordinary and necessary costs of doing business that are not otherwise reimbursable, but that the federal government explicitly recognizes must be incurred. They also make possible a small but important amount of independent research.

Q: If these FFRDCs were invented in the Cold War and some of them even started under other names during World War II, do we still need them? Why hasn't anyone addressed this?

A: This question has actually come up repeatedly. The need for each individual FFRDC is formally re-evaluated every five years. Over the years more than 60 DoD FFRDCs have in one way or another ceased to be FFRDCs (though most have lived on in other forms), suggesting that the Department of Defense is in fact capable of weeding out unnecessary FFRDCs while continuing to make use of others, and of the FFRDC role in general. Congress has addressed the question of continued need for FFRDCs several times. [1]

SOURCE: Office of Technology Assessment, 1995

[1] Producing or causing to be produced such efforts as the Office of the Director of Defense Research and Engineering's, Report of the *Defense Science Board Task Force* on *Federal Contract Research Center Utilization* (Washington, DC. February 1976) and their subsequent *Management of the Federal Contract Research Centers* (Washington, DC: Department of Defense, June 1976); the Executive Office of the President, Office of Management and Budget, *OFPP Policy Letter 84-1 to the Heads of Executive Departments and Establishments, Subject: Federally Funded Research and Development Centers* (Washington, DC: letter April 4, 1984, printed in the *Federal Register volume 49,* no. 71, April 1, 1984); *Competition: Issues in Establishing and Using Federally Funded Research and Development Centers* (U.S. General Accounting Office, Washington, DC: 1988), and several other investigations including at least three (by the General Accounting Office, the DoD Inspector General, and the Defense Science Board) current with this Office of Technology Assessment effort.

A History of the Department of Defense Federally Funded Research and Development Centers

This background paper is a brief history of the Department of Defense (DoD) Federally Funded Research and Development Centers (FFRDCs), with a focus on those that are study and analysis centers. As part of the Office of Technology Assessment's (OTA) combat modeling and simulation assessment, this background paper primarily addresses those study and analysis centers that are involved in supporting or creating DoD models and simulations. DoD laboratories and system engineering FFRDCs such as MITRE Corporation and The Aerospace Corporation are discussed only briefly to provide context. The Department of Energy (DOE) laboratories are not discussed to any extent, even though they are partially funded by DoD and some do considerable model and simulation work. This paper covers the period from World War II and the development of operations research, the discipline that helped lead to the creation of study and analysis centers, until the issuance of the revised Federal Acquisition Regulations (FAR) in 1990 that addressed FFRDCs. Budget data and the status of DoD FFRDCs presented in this report are reported through FY 1994.

The federal research centers that came to be known as FFRDCs are a varied group of facilities with differing individual characteristics founded at different times. They have no prescriptive definition, although a descriptive definition was attempted in 1967. The basis for their creation during World War II and the Cold War is described in this paper, with a history of their evolution and growth. The federal research centers grew along with the development of the disciplines of operations research, systems analysis, system engineering, and broader multi-disciplinary studies and analyses. The role of these centers and their relationship with the federal government has evolved over the decades since their

inception. Lists of these centers appear in the appendices. The 10 current DoD FFRDCs are profiled in the last section.

The development of the federal research centers began during World War II. More scientists were used in this war effort than in preceding wars. In the West, scientists developed the atomic bomb, the proximity fuse, better radar and sonar, and fundamentally kept the Western allies in a state of overall technological superiority, even when compared to the very impressive German scientific and engineering establishment.

But in the U.S. at the war's end, most scientists were interested in returning to their research in the traditional university environments. The rapid epochal changes in technology, the advent of new disciplines like operations research, and the developing threat from the Soviet Union created a desire on the part of the military and the Atomic Energy Commission (AEC) to retain a number of these scientists for national needs.

Federal research centers were a logical development. Reasons for their creation include:

1. to attract the best scientific minds;
2. to provide an atmosphere conducive to freedom in research, usually a university-type atmosphere;
3. to provide independent and unbiased analysis;
4. to provide continuity;
5. to isolate the centers from the concerns of a profit motive;
6. to allow the centers to assemble stable, interdisciplinary teams of people; and
7. to develop the appropriate sciences and techniques (49,50,59).

There have been approximately 150 of these organizations certified, chartered, or funded by agencies in the federal government since World War II (83). (A list of all known DoD-sponsored FFRDCs is provided in appendix C.) Of these, more than 70 are DoD-sponsored FFRDCs. Originally, they were simply termed "research centers" (52) These were research organizations the federal government took an active role in helping to establish. They were often given seed money and were guaranteed a certain level of work. The structure and nature of each of the centers was unique, as was its contracting relationship with the federal government.

The nature and purpose of FFRDCs have evolved over the years. The reasons for their establishment in the late 1940s are not the reasons for their continuance to the present. Their origins are in World War II and in the highly charged Cold War atmosphere after the War. These institutions have evolved, some have dissolved, and the surviving successful FFRDCs are those that have:

- a function that cannot be carried out as effectively by a federal government agency or a for-profit company;
- a special relationship with the sponsoring federal government agency, based upon:
  a) independence of the FFRDC, but commitment by the FFRDC to the objectives (not always the policies) of the sponsor;
  b) responsiveness of the FFRDC, but not the daily response of an extended staff;
  c) a pattern of cooperation that establishes a long-term partnership relationship, as opposed to the "arm's length" relationship required in for-profit contracts; and
  d) significant investment over time by the federal government in the FFRDCs capabilities.
- a set of restrictions that makes this relationship safe: not-for-profit, not a producer of products, and not in competition with for-profit industry; and
- a body of scientific or technical expertise that cannot be recruited, sustained, and managed within the civil service.

Over time, this became the pattern, with all FFRDCs defined and characterized by the existence of their sponsoring agreements.

Some see the FFRDCs' emergent ability to provide a "quick response capability" for the federal government as the great advantage of FFRDCs (86). In contrast, the RAND Corporation was deliberately located in California so that it would not be interrupted with daily requests from the federal government. The 1990 Federal Acquisition Regu-

lations (FAR) may have been the first official codification of this added quick-response mission for FFRDCs. FAR Clause 35.017 states, "This relationship should be of a type to encourage the FFRDC to maintain currency in its field(s) of expertise, maintain its objectivity and independence, preserve its familiarity with the needs of its sponsor(s), and provide a quick response capability." (17) The federal research centers' ability to provide quick response to their sponsoring agencies acquired added importance as a shortcut to a contracting process seen by many to have become more complex, slower, and less flexible since the passage of the Competition in Contracting Act (CICA) in 1983.

Through their acceptance of constraints not commonly applied to other organizations, FFRDCs are subject to special federal government procurement and contracting regulations. This feature can make them very attractive to the DoD officer or civilian manager who needs work done quickly. Like other companies operating under a long-term, broadly-scoped contract, FFRDCs can provide responses to requests in weeks or months. They are not intended to replace in-house action officers or respond to daily requests, but they do not take months to change the direction of their research, or to shift to an urgent line of work. Inherent in the competitive contracting process with for-profit industry is a delay of several months before contract award. In dealing with for-profit companies, DoD uses in some cases the "Basic Ordering Agreement" mechanism to establish multi-year contractual relationships. Once a BOA is in place, individual tasks can be (and are) assigned rapidly, with little further paperwork. This omnibus contract approach was ratified and affirmed by Section 2304a ("Tasks and delivery order contracts") of the Federal Acquisition Streamlining Act of 1994. But for-profit companies must compete for, and recompete for, their BOAs.

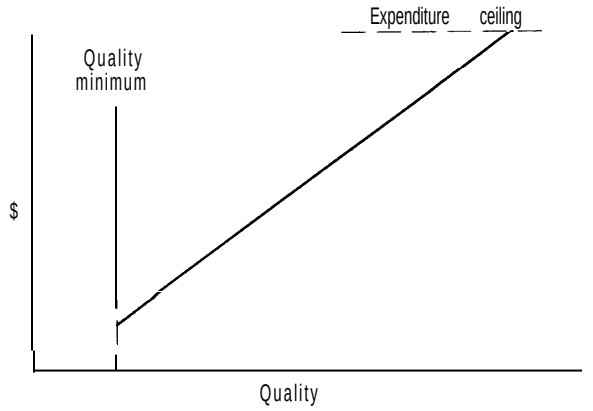
The Competition in Contracting Act permits the federal government to use sole-source procedures to establish or sustain an FFRDC. DoD is now forbidden by law from establishing any new FFRDCs, but the FAR spells out the procedures for doing so, and other agencies may create new FFRDCs. The most recent FFRDC to be established was the Tax Modernization Institute, sponsored by the Internal Revenue Service in FY 1993. The most recent FFRDC established by DoD was the Institute for Advanced Technology, sponsored by the Army in FY 1991, but "decertified" as an FFRDC in November 1993 (52).

Some of the recently established FFRDCs, like the Software Engineering Institute (established February 1984) and the Internal Revenue Service-sponsored Tax Modernization Institute, were established by a competitive solicitation. Under CICA, the federal government could have made either a sole-source award, after providing sufficient justification. The renewal of contracts to FFRDCs is almost always done in sole-source awards, but must be justified in accordance with the CICA procedures.

The goal of the FFRDC system has been to obtain top quality without incurring needless expense. This goal differs from that of most federal government procurement, which is to incur the lowest expense consistent with satisfactory quality. Neither approach is perfect, though each reflects precedents in the world of business: major corporations may buy many goods and wage-grade services on a least-cost basis, but they usually pay whatever is necessary for top-quality professional services such as legal representation or architecture.

There being no such thing as a "lowest acceptable price" or a "highest acceptable quality," very low price and very high quality are only of concern insofar as they are warning signs of unacceptably low quality and unbearably high price, respectively. Absent any known way for the federal government to choose "best buys" in the midrange of the price-quality tradeoff while maintaining adequate safeguards against waste, fraud, and abuse, the federal government normally follows its well-known policy of buying from the lowest bidder. The federal government tempers this policy by specifying a base level of quality that it deems acceptable, so as to avoid obliging itself to buy

FIGURE 1-1: Procurement Boundaries



SOURCE: Off Ice of Technology Assessment, 1995.

shoddy goods just because the price is 1ow.[1] When, as in the case of the FFRDCs the federal government permits itself to chose the highest quality instead of the lowest price, it must likewise temper this policy by placing a ceiling on expenditure. This ceiling plays the same role at its end of the price-quality trade-off that the lowest-acceptable-quality barrier plays at the opposite end.

In the case of buying the products of FFRDCs the ceiling is on the annual total expenditure, not on the cost of each buy as illustrated in figure 1-1.

Congress annually sets a ceiling on total expenditure of DoD-appropriated funds at FFRDCs (See also appendix D.) This ceiling does not apply to non-DoD work by the FFRDCs Being below the current demand, the ceiling limits the availability of the FFRDCs to do work and the flexibility of the federal government program managers to award them work. The ceilings, through limiting expenditure, indirectly limit staff levels and therefore the size of the FFRDC system as a whole. One DoD FFRDC, the Software Engineering Institute, is also subject to a congressionally imposed ceiling on staff, specifically.

This history follows the development of federal research centers through four stages of their development. The initial stage was the wartime laboratories and operation research efforts. This phase culminated after the war with the establishment of a study and analysis center for each branch of the service. The second phase was a period of growth from the conflict in Korea until the early 1960s, corresponding to the darkest days of the Cold War and the heightened threat to U.S. interests from the Soviet Union and the People's Republic of China. At the end of this period, the phrase "federal contract research center" was invented to provide a label for these 66 centers (43 sponsored by DoD). The third period covers a time of intense change in the social and political culture of the country, when the FCRCs came under scrutiny and criticism, expanded seriously into nondefense work, and ended with many of them falling into disfavor. This period of turmoil ended in the mid- 1970s, with approximately 40 FFRDCs surviving, but fewer than 10 sponsored by DoD. The final stage carries the FFRDCs to the present, with limited changes in their number and types, steady use, declining employment of late, and growing missions. They have become integrated with the communities they serve, with their role and missions more clearly defined.

FFRDC Nomenclature

The federal research centers have their roots in operations research done for the military by civilian scientists during World War II. At first they were simply called research centers. From 1961 to 1967 (and sometimes after 1967) the research centers established before 1961 and additional centers were called Federal Contract Research Centers FCRCs Then in 1967 they were called Federally Funded Research and Development Centers FFRDCs All these terms were labels for diverse entities that were neither federal government agencies nor for-profit companies, but somewhere in between. FFRDCs range from RAND's Project

[1]As notoriously occurred during the Civil War, when equipment supplied by lowest bidders simply disentegrated in the field.

Air Force, the prototype analytical "think tank"; through MITRE, a large systems engineering and technical integration organization similar to many for-profit companies; to the large nuclear laboratories, where the facilities are owned by the federal government.

What differentiated these centers from other federal government centers or for-profit defense research companies was a combination of nonfederal government personnel and federal government sponsorship. The federal government encouraged the establishment of these centers and intended to fund them over a period of time and to take an interest in supporting their survival for national needs. Facilities could be owned either by the contractor or the federal government. Work could be varied. But the original conception that germinated these centers was the federal government's World War II need to harness independent scientific inquiry to solve federal government (specifically military) problems. By 1960, a second theme had emerged: the need for private support whose objectivity was strengthened by separation from industry, and by other restrictions.

The defining trait of an FFRDC is a sponsoring agreement with the federal government, clearly identifying the entity as an FFRDC and placing limitations on competition with non-FFRDCs. The federal government's commitment to the existence of an FFRDC implies that there will be a long-term stable financial relationship. Ultimately, FFRDCs become FFRDCs because the federal government says they are. Clause 35.017-8 of the Federal Acquisition Regulations states that the National Science Foundation (NSF) will maintain a master federal government list of FFRDCs (17). This list was formally established in 1967 (73) and is the final record of which organizations are FFRDCs (10). The agencies themselves determine which contracts and sponsoring agreements will be written as FFRDCs and report the information annually to the National Science Foundation (11).

Each DoD FFRDC is governed by six documents:

- the OFPP Policy Letter 84-1,
- the Federal Acquisition Regulations,
- the FFRDC Defense Management Plan, issued by the Director of Defense Research and Engineering (DDR&E) August 1992, and revised 13 September 1994,
- the individual sponsoring agreement for each FFRDC,
- the individual charter for each FFRDC, and
- the individual contract(s) with each FFRDC.

In addition, DoD FFRDCs are subject to:

- Internal Revenue Service regulation as tax-exempt organizations,
- state not-for-profit corporation law,
- Departmental regulations, and
- specific provisions in annual DoD Authorization and Appropriation Acts.

In its report, *Federal Funds for Science*, Vol. I, produced in 1952, the National Science Foundation clearly identified "research centers" as separate entities different from federal government entities, laboratories, universities, for-profit corporations, and other not-for-profit corporations. The report enumerated 23 in 1950 to 1951 and 24 in 1951 to 1952. The 12 mentioned in the text of that report were all later considered FCRCs and FFRDCs, including RAND. In the sixth annual report, a "List of Research Centers" for the fiscal years 1956 through 1958 appeared as an appendix. There were 46 centers listed, including one that had been deactivated since FY 1956. The list also appeared in the subsequent report, and then was not shown in the next two reports. Almost the same list reappeared in the FY 1960-1962 report in the same format and was titled "Federal Contract Research Centers."

The Federal Council for Science and Technology named the FCRCs Federally Funded Research and Development Centers in 1967, but the acronym FCRC remained in general usage for a number of years (56). The difference between the last list of "Federal Research Centers" and the first list of "Federal Contract Research Centers" was that five were removed from the FY 1957-1959 list, including three that were later returned to the list, while 19 new ones were added. Substantially the same list, relabeled "Master List of Federally

Funded Research and Development Centers," appears in the FY 1967-1969 report. "FFRDC" was simply a convenient label to apply to that heterogeneous collection of research centers that were clearly not federal government laboratories nor traditional free-market for-profit contractors. For the purposes of this background paper, the term "FFRDC" will only be used when referring to an organization that was officially considered an FFRDC after 1967. Otherwise organizations will be referred to as "federal research centers." Since contractor-operated laboratories and "think tanks" existed before the term "FFRDC" came into use, the definition the federal government created in 1967 was more descriptive than prescriptive. It described the majority but not all of them and applied to organizations that were not considered FFRDCs.

At present 39 FFRDCs exist, according to the master federal government listing of the National Science Foundation for FY 1995. Of these, 10 are DoD-sponsored FFRDCs (53). A list of all current FFRDCs is provided in appendix A.

Categories

The federal research centers comprise three types of entities with different functions:

- laboratories,
- study and analysis centers, and
- system engineering and technical direction centers.

The first centers founded were scientific research laboratories working in the traditional sciences on technical issues. Some of these laboratories were large federal government-owned, contractor-operated facilities like Los Alamos National Scientific Laboratory and Oak Ridge National Laboratory. They included facilities funded by the Atomic Energy Commission (later the Department of Energy) as well as a number of pure science efforts. The laboratories provided considerable technical support and engineering services in addition to their research orientation.

The next centers founded were DoD study and analysis centers, which pioneered a new discipline called operations research to produce study and analysis of problems not traditionally addressed by scientists. Over time, the range of their work increased, and operations research became just one of many study and analysis tools they used. These centers became what people commonly refer to as "think tanks" such as RAND.

The system engineering and technical direction centers were later creations developed for systems integration. These centers did not grow directly out of organizations that functioned in World War II; the first emerged in 1958 from the need to integrate the complex technologies that were being used in modern defense systems. Representative of these centers are The Aerospace Corporation and the MITRE C^3I center. The system engineering and technical direction centers were to provide technical support in defining, developing, procuring, deploying, and operating complex systems. In effect, they provided the technical depth, systems engineering approach, and corporate memory that the federal government needed to effectively deal with the industrial companies that actually developed and produced the systems.

The ownership of these varied centers is discussed in box 1-1.

THE DEVELOPMENT OF THE RESEARCH CENTERS

At the start of World War II, virtually all of the scientific talent of the country resided in universities and private industry. The United States military did not have a large, research-oriented scientific establishment, but had a growing need for scientific knowledge. In the total-war environment of World War II, Allied nations harnessed the resources of their entire population and economy, including technical and scientific knowledge. Through arrangements with academia, the U.S. military established centers of excellence that developed radar, artillery fuses, atomic weapons, and a new and esoteric discipline of applied math-

BOX 1-1: Federal Government Research Facilities: Discussion of Ownership

Research facilities available to the federal government can be categorized in terms of their ownership and operation. Facilities can be owned or operated by the federal government or the contractor as government-owned, government-operated (GOGO); government-owned, contractor-operated (GOCO); or contractor-owned, contractor-operated (COCO) facilities. A 1969 survey of 723 research and development installations showed that among the FFRDCs the facilities could be owned by the contractor or the federal government and the major items of equipment could be owned by the contractor or the federal government or leased.[1] FFRDCs cannot be GOGOs, some are GOCOs (especially those working for the Department of Energy), and some are entirely owned by the contractor organization. A 1982 search by the Executive Office Information Center found no statutory definitions of *"GOCO"* or *"FFRDC."* However, in the statutory definition of what constituted a federal agency, *"GOCO"* was specifically excluded.[2]

A 1982 letter from the Executive Office of the President, Office of Science and Technology Policy, referred to a 1978 congressional inventory of research, development, test and evaluation (RDT&E) facilities and compared them to the NSF list of FFRDCs The 1978 congressional inventory classified 779 federal government research facilities as follows:

Government-owned, government-operated	608
Government-owned, contractor-operated	54
Contractor-owned, contractor-operated	18
Government-leased, government-operated	99

The letter compared the 35 FFRDCs on the NSF list, stating that 30 FFRDCs were also listed as GOCOs, with 26 GOCOs listed that were not considered FFRDCs (The mathematical discrepancy of 56 in the comparison versus 54 GOCOs as the total number on the inventory list was not explained, but IS possibly related to some FFRDCs being defined as more than one facility). Only five FFRDCs were not GOCOs:[3] the Institute of Defense Analyses, the Center for Naval Analyses, The Aerospace Corporation, the C[3]I Division at MITRE Corporation and Project Air Force at the RAND Corporation.[4] None of these five are laboratories in the traditional sense and all are considered either study and analysis centers or systems integration organizations.

None of the 10 current DoD FFRDCs are considered GOCOs, although there are FFRDC GOCOs outside of the DoD. Nine of the 10 DoD FFRDCs operate principally in contractor-owned facilities. Lincoln Laboratory has been considered a GOCO and operates in government-owned and leased facilities.

SOURCE Office of Technology Assessment, 1995

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[1] National Science Foundation, *Directory of Federal R&D Installations, for the Year Ending June 30, 7969* (Washington, DC National Science Foundation, 1970).

[2] Joe Clark, "Memorandum for the File, Subject: GOCO and FFRDC Facilities" a letter from the Executive Office Of the President, Office of Science and Technology Policy, Washington, DC Jan. 22, 1982).

[3] Joe Clark, "Memorandum for the File, Subject: GOCO and FFRDC Facilities" a letter from the Executive Office Of the President, Office of Science and Technology Policy, Washington, DC Jan. 22, 1982).

4 Identified in a "Diary Note, " Subject: Federally Funded Research and Development Centers FFRDCs and government-owned contractor-operated facilities, Jan 12, 1982, signed by Norman W. Friedman of NSF and attached to the letter of Jan 22, 1982 by Joe Clark.

ematics, operations research. The desire by the defense establishment to maintain and expand operations research was one of the underlying reasons for the establishment of the first three study and analysis centers, RAND, the Operations Research Office (ORO), and the Operations Evaluation Group (OEG).

The organization that indirectly fostered operations research in the United States was the National Defense Research Committee (NDRC) established in June 1940. The NDRC, through the efforts of its chairman, Vannevar Bush, coordinated all scientific research among the different services during World War II. Several of its members traveled to England where they met with the new British operational research groups to discover how scientists were contributing to operations. This information was used to apply operations research to the problems of combating U-boats (78).

The U.S. military laboratories at this time were structured toward hardware development and testing. Pure science and new technologies were still the province of universities and some private companies. To integrate the efforts of scientists and the military in World War II, a civilian organization called the Office of Scientific Research and Development (OSRD) was set up with Bush, a respected scientist and engineer, as the head of the organization. The organization reported directly to the President of the United States, received its funds directly from congressional appropriations committees, and was relatively unrestricted in the manner in which it spent its budget. OSRD supported individual scientists and major research efforts through awarding them contracts (68). It established the pattern of contracting with civilian scientists to provide support to the military on technical and scientific questions and contracting out for scientific studies instead of developing in-house capabilities.

Establishment of Operations Research Centers at the End of World War II

At the end of World War II, operations research had proved to be of value to the British Royal Air Force and Navy and to a lesser extent the British Army. It had also definitely proved useful to the U.S. Navy and Army Air Forces. Operations research establishments were in place in all three services in England. The U.S. military services, through the OSRD, contracted extensively with outside institutions and individuals to obtain operations research during the war (68). At the end of World War II, OSRD was closed down, as Bush, himself, had recommended. While it had accomplished its mission, he felt it was losing its flexibility with considerable time being spent on contractual concerns and procedures. Bush wanted to establish a new comprehensive civilian organization, the National Research Foundation, with scientific support for the military carried out by one division of this organization (77).

Navy

At the end of World War II, the Naval Operations Research Group (ORG), originally ASWORG, had a staff of approximately 80 scientists and an annual budget of $800,000. The Navy, under the strong encouragement of Fleet Admiral Ernest Joseph King, Chief of Naval Operations and Commander in Chief of the United States Fleet, did not want the organization dissolved. The Navy moved quickly to ensure its uninterrupted continuance and approached MIT to sponsor it. MIT was reluctant to sponsor this collection of unseen individuals located 500 miles away from campus, but did so nonetheless on November 1, 1945. The group's name was changed to the Operations Evaluation Group (OEG) to assuage the sensitivities of the Navy's Office of Naval Research, which had direct responsibility for the Navy's "research." OEG maintained its structure of a central office in the Pentagon and field teams among the major commands, but the entire staff was reduced to about 25 scientists and a budget of $300,000. The contract was for three years. The Office of Naval Research, independent of OEG, commenced funding private contractors to conduct a wide array of small research projects to explore human behavior and many other promising areas.

OEG, in its first year of operation, tried to spend its time writing up what it had done during the war. It wrote and issued studies (some 55 is-

sued in 1946) and prepared basic methodology texts on operation research. But instead of being left alone to write about past glories, the office found itself with more new assignments and tasking than it could handle and began a slow and steady expansion. By the start of the Korean conflict, OEG had a staff of approximately 60 people, including almost 40 scientists, with an annual budget averaging over $500,000. As a result of budgetary restrictions, almost all of its field programs were placed in abeyance (78).

Air Force

Near the end of World War II, General H. H. "Hap" Arnold, commanding general of the Army Air Forces, along with other senior officials and consultants in the War Department, was convinced of the need to keep intact part of the scientific corps that had been mobilized during World War II. On December 1, 1945, a new headquarters was created for the Air Force, led by the Deputy Chief of Air Staff for Research and Development. Its first head was Major General Curtis LeMay. The Air Force was particularly concerned about the areas where military policy, planning, and technology interacted. It created an entirely new organization, based upon the concept of independent scientific analysis. In a conference on October 1, 1945, the Air Force fully faced the constraints on the service it wanted:

- The project needed to be attached to an existing firm to get off to a good start.
- The founders did not believe that a university would want a highly classified project.
- A high-talent scientific group could not be assembled within federal government because of the salary and personnel practices of the civil service.
- It would be difficult to recruit scientists in a project directly administered by the military.

The Air Force wanted to locate the project away from Washington, DC so as to insulate the staff from routine requests that would interfere with research. A letter contract for $10 million was issued to the Douglas Aircraft Company on March 2, 1946 to conduct "a program of study and research on the broad subject of intercontinental warfare, other than surface, with the object of recommending to the Army Air Forces preferred techniques and instrumentalities for this purpose." Project RAND, as it was called (an acronym for research and development), was created to address issues of interest to the Air Force. The first product was a report issued May 2, 1946 called, "Preliminary Design of an Experimental World-Circling Spaceship" (61, p. 77; 68). This report was prepared with a team of 50 analysts (18, p. 23).

RAND also subcontracted some of its work out to other Air Force manufacturers like Boeing and Northrop. In May 1947, Project RAND moved from the Douglas Aircraft Company to its own offices in Santa Monica. (See explanation box 1-2.) By early 1948, RAND had grown to some 200 staff, including mathematicians, engineers, aerodynamicists, physicists, chemists, economists, and psychologists (61, p. 4).

RAND in 1948 also conducted expanded research on the air-defense problem, but the Air Force decided that the kind of research that RAND was willing and able to perform would not meet program requirements and schedules for the type of research required. The Air Force, Army, and Navy requested that MIT establish a laboratory for air defense. The old wartime Radiation Laboratory had been closed, but ongoing work at MIT and the Air Force Cambridge Research Laboratory formed the nucleus for creating Lincoln Laboratory (75). Lincoln Laboratory work was often of an experimental nature, while RAND continued background and analytic work in this area (68, pp. 89,90).

Army

The Army, excluding the Army Air Forces, had no specific research programs to protect at the end of World War II. They simply sent the scientists they had employed back into civilian life and maintained no research not related to hardware development.

However, an April 30, 1946 memorandum by General Dwight D. Eisenhower, then Army Chief

BOX 1-2: Avoiding Conflict of Interest

In the case of RAND, the federal government originally contracted the work to a private firm, Douglas Aircraft Corporation. This arrangement was greatly facilitated by the close personal relationship between General H. H. "Hap" Arnold, Commanding Officer of the Army Air Corps, and the president of Douglas. One of General Arnold's sons was married to Donald Douglas's daughter, The federal government expected all firms to participate and develop an interest in the work of Project RAND at Douglas. Not surprisingly, Douglas Aircraft's competitors viewed Project RAND with some suspicion. During its first two years of operation, people within the industry became concerned that this research organization being part of one of the major manufacturers might create a conflict of interest. Furthermore, Douglas Aircraft Corporation itself was interested in releasing Project RAND from its control, as they felt the federal government, in its attempt to appear to be completely even-handed, had not awarded Douglas contracts that might have been awarded otherwise.

It was therefore agreed that a new not-for-profit corporation should be established, separate from any manufacturer. The Ford Foundation provided the initial funding, and the RAND Corporation was officially established as an independent not-for-profit corporation, chartered in California with its own board of directors in November 1948. Its articles of incorporation were dated May 14, 1948, but the contract between the Air Force and RAND was not established until November 4, 1948. Up until then, of course, the work was still being done by the Douglas personnel, who then transferred to the RAND Corporation. Project RAND remained the major contract of the new corporation for some time. At the time that RAND was created as an independent corporation in 1948, it had approximately 300 employees. [1]

There was a strong feeling by 1948, both within private industry and in the Department of Defense, that study and analysis agencies should not be tied to a major private corporation.[2]

SOURCE: Off Ice of Technology Assessment, 1995

[1] Gregg Herken, Counsels *of War (New* York, NY. Oxford University Press, 1987), p. 74.
[2] Bruce L R, Smith, The ***RAND Corporation, Case*** *Study of a Nonprofit Advisory Corporation* (Cambridge, MA Harvard University Press, 1966)

of Staff, discussed the establishment of a civilian research organization outside the Army. Eisenhower recommended that the Army contract extensively for scientific and industrial services. The effort was further developed by soldiers such as Lieutenant General A. C. McAuliffe, who headed the Army's research and development program after the war. In June 1948 the General Research Office was created, an organization similar to RAND. It commenced operations in September and was renamed the Operations Research Organization (ORO) in December (77).

ORO was established under contract with Johns Hopkins University, but its offices----originally at Ft. McNair in Washington, DC, and then in Chevy Chase, Maryland-had no connection to Johns Hopkins University. The Army provided ORO with a senior military advisor, usually a colonel, who had a small staff. This office was setup in July 1948 and continued until June 1, 1972. In June 1952, when ORO moved to Chevy Chase, Maryland, its staff totaled 220 (66).

The decision to establish ORO as part of a university was certainly shaped by the ideas of Bush. Johns Hopkins University was chosen because it was conveniently located, enjoyed an excellent reputation, and had several years of experience running the Applied Physics Laboratory for the Navy (77). By tying the research organization to a university, the Army intended to:

- provide an atmosphere that would attract the best minds to ORO,
- create an atmosphere of intellectual independence, and
- create a university atmosphere conducive to good scientific research.

In contrast to the approach of the Air Force, which resolved some internal conflicts in setting up an organizational structure for RAND that provided for independent analysis, the Army did not develop a larger vision for their research organization. Many researchers at ORO, in their original conception of their mission, saw themselves as scientists who were to explore all aspects of warfare and its long-range implications, while the Army appeared to be primarily interested in seeking ways to apply operations research to questions concerning logistics and supply. Also, the Army did not seem to be interested in applying operations research to the use of weaponry in combat.[2] In fact, in the early 1960s, the background studies that led the Army to develop and deploy the Hawk air-defense missiles came from an Air Force study done by RAND. This study was then handed over to the Army by the Air Force (68, p. 109). This difference in viewpoint was the start of the troubled relationship between the Army and ORO that would persist throughout ORO's history (87,66,77).

Establishment of Laboratories at the End of World War II

The first contractor-operated federal research laboratories established came primarily out of the need to develop the atomic bomb during World War II. OSRD also established other laboratories for purposes other than atomic bomb research. MIT became involved in the war effort in 1940 when the NDRC established the Radiation Laboratory, the forerunner of Lincoln Laboratory, to further improve radar. The Johns Hopkins University Applied Physics Laboratory was established in 1942 to conduct research related to anti-aircraft firing. It did fundamental research and development and provided technical oversight for the design, production, and use of the proximity fuse and anti-air guided missiles. The Ordnance Research Laboratory was established in 1945, under the management of Pennsylvania State University.

In the development of the atomic bomb, the federal government had a strong desire to obtain access to the best research minds from the universities and, therefore, established the nuclear research laboratories at or in conjunction with universities. These projects were handled by a contracting organization called the Manhattan Engineering District, and the entire atomic bomb research program was referred as the Manhattan Project.

Established under the Manhattan Project were the Argonne National Laboratory, the Oak Ridge National Laboratory, and the Los Alamos National Scientific Laboratory, the Lawrence Radiation Laboratory, and Sandia National Laboratory. The Argonne National Laboratory evolved from the University of Chicago's Metallurgical Laboratory. It was under the auspices of the Metallurgical Laboratory that the first nuclear chain reaction occurred in 1942 under a stadium in the city of Chicago as part of the Manhattan Project. The Oak Ridge National Laboratory was also established under the University of Chicago, with its control reverting to an association of universities after World War II. The Los Alamos National Laboratory, located in New Mexico, was and still is operated by the University of California. It began operation in 1943 developing nuclear explosives for military purposes (49) and was the site of the first nuclear explosion. Even though it is reported as a university-operated laboratory, its has no association with the daily campus life and research activities of the university and is effectively a

[2] This conclusion was reached by comparing the discussions on the work OEG and RAND did to the actual list of reports prepared by ORO and SORO. Interestingly enough, a review of the reports issued by the British operational research establishments shows a considerable amount of analysis of weapons effectiveness, both from an engineering viewpoint and an applications viewpoint.

large independent not-for-profit corporation. The Lawrence Radiation Laboratory was administered by the University of California and housed the cyclotron invented by Dr. Ernest O. Lawrence (49). This laboratory was the father of two current FFRDCs, the Lawrence Livermore (27, p. 59)[3] and Lawrence Berkeley National Laboratories. In 1945, a subsidiary of Western Electric Company, Sandia Corporation, established a separate organization at the Los Alamos Laboratory. Sandia Corporation was a not-for-profit company established as a service to the federal government (49).

After World War II, some of these highly classified university laboratories were transferred to research facilities that were separate from their universities. In the case of Oak Ridge, management was transferred to Monsanto Chemical Company in 1945: later the Union Carbide and Carbon Company was awarded the contract to operate the facility and did so for many years until replaced by the present incumbent, Martin Marietta (49). Also, Oak Ridge Associated Universities were formed in 1946 to provide a vehicle for academic institutions to participate in federal atomic energy research in association with Oak Ridge National Laboratories. Most of these universities were from the southeastern United States, certainly nearer to Oak Ridge, Tennessee, than was the University of Chicago (51). Another consortium, the Associated Universities Incorporated, managed the Brookhaven National Laboratory, starting in 1947.

Formalization of FFRDCs

The earliest located official definition of an FFRDC is in a memorandum from the chairman to the members of the Federal Council for Science and Technology, dated November 1, 1967. This definition was updated, revised, and issued by the Office of Management and Budget on April 4, 1984, and registered in the Federal Register on April 11, 1984 (73). The definition in the 1984 memorandum is as follows:

(1) FFRDCs do not have a prescribed organizational structure. They can range from the traditional contractor-owned/contractor-operated or Government-owned/contractor-operated (GOCO) organizational structures to various degrees of contractor/Government control and ownership. In general, however, all of the following criteria should be met before an activity is identified as an FFRDC:

   (a) Performs, analyzes, integrates, supports (non-financial) and/or manages basic research, applied research, and/or development. (Activities primarily engaged in routine quality control and testing, routine service activities, production, mapping and surveys, and information dissemination, even though otherwise meeting the requirements of paragraph 5.c., are specifically excluded from FFRDC designation).

   (b) Performance of the functions in 5.c.(1)(a) is either upon the direct request of the Government or under a broad charter from the Government, but in either case the results are directly monitored by the Government. However, the monitoring shall not be such as to create a personal services relationship, or to cause disruptions that are detrimental to the productivity and/or quality of the FFRDCs' work.

   (c) The majority of the activity's financial support (70% or more) is received from the Government with a single agency usually predominating in that financial support.

   (d) In general, most or all of the facilities are owned by the Government or

[3] Edward Teller lobbied for the establishment of a second nuclear weapons facility (the Lawrence Livermore Laboratory) because of his continuing feuds with Robert Oppenheimer. This would be a case of a research center being established because of personal and professional animosity.

funded, under contract, by the Government.

(e) The activity is operated, managed and/or administered by either a university or consortium of universities, other not-for-profit organization or industrial firm as an autonomous organization, or as an identifiable separate operating unit of a parent organization.

(f) A long term relationship evidenced by specific agreement exists or is expected to exist between the operator, manager, or administrator of the activity and its primary sponsor.

(2) In addition to the above criteria, the relationship between the activity and the Government should exhibit the following characteristics in order to qualify for FFRDC identification:

(a) The activity (organization and/or facilities) is brought into existence at the initiative of a Government agency or bureau to meet some special research or development need which, at the time, cannot be met as effectively by existing in-house or contractor resources.

(b) Work from other than a sponsoring agency is undertaken only to the extent permitted by the sponsoring agency and in accordance with the procedures of the sponsoring agency.

(c) The activity, whether the operator of its own or a Government-owned facility, has access, beyond that which is common to the normal contractual relationship, to Government and/or supplier data, employees, and facilities needed to discharge its responsibilities efficiently and effectively, whether the data is sensitive or proprietary or not.

(d) The primary sponsor undertakes the responsibility to assure a reasonable continuity in the level of support to the activity consistent with the agency's need for the activity and the terms of the sponsoring agreement.

(e) The activity is required to conduct its business in a responsible manner befitting its special relationship with the Government, to operate in the public interest free from organizational conflict of interest, and to disclose its affairs (as an FFRDC) to the primary sponsor. (73)

This definition was modified slightly and condensed so as to be included in the Federal Acquisition Regulations, clause 35.017, which also defines "FFRDC." It is a derivation of the above definition and reads in part:

(2) An FFRDC meets some special long-term research or development need which cannot be met as effectively by existing in-house or contractor resources. FFRDC's enable agencies to use private sector resources to accomplish tasks that are integral to the mission and operation of the sponsoring agency. An FFRDC, in order to discharge its responsibilities to the sponsoring agency, has access, beyond that which is common to the normal contractual relationship, to Government and supplier data, including sensitive and proprietary data, and to employees and facilities. The FFRDC is required to conduct its business in a manner befitting its special relationship with the Government, to operate in the public interest with objectivity and independence, to be free from organizational conflicts of interest, and to have full disclosure of its affairs to the sponsoring agency. It is not the Government's intent that an FFRDC use its privileged information or access to facilities to compete with the private sector. However, an FFRDC may perform work for other than the sponsoring agency under the Economy Act, or other applicable legislation, when the work is not otherwise available from the private sector.

(3) FFRDCs are operated, managed, and/or administered by either a university or consortium of universities, other not-for-profit or nonprofit organization, or an industrial firm,

as an autonomous organization or as an identifiable separate operating unit of a parent organization.

(4) Long-term relationships between the Government and FFRDCs are encouraged in order to provide the continuity that will attract high-quality personnel to the FFRDC. This relationship should be of a type to encourage the FFRDC to maintain currency in its field(s) of expertise, maintain its objectivity and independence, preserve its familiarity with the needs of its sponsor(s), and provide a quick response capability (17).

Conclusion

The post-war period started with a large number of federal research laboratories continuing after World War II. These were mostly engineering and scientific centers, many associated with the development of nuclear weapons, except one was a study and analysis center. By 1950, there were 23 federal research centers, three were study and analysis centers: ORO, RAND, and OEG. RAND and OEG (renamed Project Air Force and the Center for Naval Analyses, respectively) survive to this day.

THE GROWTH OF RESEARCH CENTERS FROM THE KOREAN CONFLICT TO THE EARLY 1960s

With the conflict in Korea and the Cold War environment of the 1950s and early 1960s, federal research continued growing steadily. Defense budgets after the Korean conflict were reduced but stable, with spending on strategic weapons, mostly through the Air Force, growing considerably. The think tanks were supported by a positive view of what they could accomplish.

Prior to World War II, total federal spending on research and development was estimated to be $100 million a year. By 1950, this figure had grown to $1.1 billion and continued to grow throughout the 1950s and into the 1960s until in 1963 the budget was placed at $12.4 billion. This growth was attributed at the time to:

> ...the importance of scientific and technical work to the achievement of major public purposes. Since World War II the national defense effort has rested more and more on the search for new technology. Our military posture has come to depend less on production capacity in being and more on the race for shorter lead times in the development and deployment of new weapons systems and of countermeasures against similar systems in the hands of potential enemies (9, p. 1).

Army

At the start of the conflict in Korea in 1950, the Army's ORO had been in existence for two years and was able to conduct operations research in its traditional field environment, much as had the British groups during World War II (77). The war provided ORO with the laboratory for their work, and they quickly organized and sent field teams to Korea.

Ellis Johnson, the head of ORO, thought the conflict in Korea offered an excellent laboratory for operations research. ORO personnel, though many of them had never seen service, visited the theater. Johnson personally led a team of four into the battle area and within a few months the ORO contingent grew to eight teams of 40 analysts. Over 100 ORO staff, subcontractors, and consultants worked in Japan and Korea during and immediately after the war. One hundred and thirteen of ORO's staff members and consultants received the Korean Service Medal of the United Nations Command for work in the combat zone. The ORO analysts were also able to establish close working relationships with the operational researchers from Great Britain and Canada. All this provided ORO with an understanding of military affairs, experience with applying methodologies to operations, and the opportunity to test and develop new methodologies. The field representatives in Korea did extensive evaluations of close air support, utilization of indigenous manpower, effectiveness of leaflets, and a range of other items.

They had a number of notable successes, including convincing the Air Force that it should use

B-29s for tactical bombing at night (87).[4] The ORO researchers also conducted a systematic data collection on the causes of enemy tank losses by trying to conduct a ground check on every tank destroyed. This resulted in a number of post-war studies on tank losses and the causes. S. L. A. Marshall, well-known author of *Men Against Fire*, worked as a consultant for ORO and created a primer of Chinese tactics during the war. The primer was immediately distributed down to the platoon level in the Eighth Army. A number of ORO researchers, in the desire to collect field data, came under hostile fire. In one case an ORO researcher was shot down behind enemy lines and had to be rescued (66,77,87).

One of the elements encountered in the conflict in Korea was the use of psychological warfare by both sides. The psychological interest motivated the Army to establish the Human Resources Research Office (HumRRO) in 1951 with a contract administered by George Washington University. It was formed specifically to conduct research on human factors, or the study of how people behave as part of a system including tactical matters, training techniques, and man-machine interfaces. Its staff consisted of a large number of social scientists and psychologists. While some human factors research was conducted by ORO, the majority passed to HumRRO and later the Special Operations Research Office (SORO), another federal research center founded by the Army to study social science issues and counterinsurgency warfare (66).

ORO aided in the establishment in 1953 of the Combat Operations Research Group (CORG) at headquarters, Continental Army Command, Ft. Monroe, Virginia. This organization was extensively supported by a private corporation, Technical Operation Inc., starting in 1955. In the early 1960s this group was reorganized and tied to the Combat Developments Command in Ft. Belvoir, Virginia (66). The Combat Developments Command served as a major seed organization for the U.S. Army Concepts Analysis Agency (CAA). The Army formed CAA on January 15, 1973 to bring its research analysis in house, absorbing the functions of the existing Strategy and Tactics Analysis Group (STAG), the descendent of Combat Developments Command (79, pp. ii,3; 80, p. i-1; 86). The Stanford Research Institute (SRI) was established in 1956 to provide support for the Combat Development Experimentation Center (CDEC) at Ft. Ord, California (77). This not-for-profit organization was never considered a federal research center.

In 1957, the Special Operations Research Office was formed as a contract agency under The American University in Washington, D.C. It was intended to specialize in what is now referred to as low-intensity conflict or guerrilla warfare (81).

At the turn of the decade, the Army's senior analysis center, ORO, was dissolved and a new organization was established in June 1961. This change was done so as to be able to fire the ORO director, Dr. Johnson. ORO's administrative organization, Johns Hopkins University, was not willing to remove Johnson under pressure from the Army. It was mutually agreed then that Johns Hopkins and the Army would terminate the contract, and the Army established a new organization called the Research Analysis Corporation (RAC) (77,68). On September 1, 1961, there was a new contract between the Army and RAC, with ORO's research program, personnel, physical assets, leases and contracts for supplies and services transferred to RAC. All ORO personnel maintained their salaries and conditions of employment. There were some resignations, but the organization was unimpaired in its ability to continue performing (77,68, pp.271-273,25). A senior ORO staff member quipped that RAC stood for "Relax and Cooperate" (68, p. 272).

In May of 1963, the five agencies—of which only three were classified as federal research centers: CORG (supported by Technical Operations Inc.), CDEC (supported by SRI), RAC, SORO

[4] This is unusual in that an Army research center is providing recommendations on tactical air support to the Air Force (via the Army).

and HumRRO—had over 400 technical personnel and conducted most of the Army-wide studies in operations research and study and analysis (66, p. 6). The Army also had a developing in-house capability and was contracting to the developing private industry contractors. In FY 1962, 20 different study contractors and 50 research studies of an operations research nature were sponsored by 11 Army agencies to support their in-house operations. Their in-house operations consisted of at least 20 groups scattered among nine commands. They employed approximately 200 civilian and military personnel and ranged in size from 2 to 40 professionals. Like the study contractors, the in-house groups worked mostly in specific study areas with the mission of the command to which they reported (66).

Navy

The Navy became heavily involved in providing air support, interdiction, and shore bombardment in the conflict in Korea. The Navy's Operations Evaluation Group (OEG) primarily focused on determining ways to make air and shore bombardment and interdiction missions more effective. The number of scientists grew from just below 40 to just below 60 by the war's end. One died in combat.

After the end of the conflict in Korea and a period of consolidation, OEG resumed slow expansion. As a result of the rapidly changing technologies and the Cold War, OEG's staff rose to a peak of about 70 scientists in 1959 and 140 total staff in 1961, when it was absorbed by the Center for Naval Analyses (78).

Much like RAND, OEG also began to serve as a central point for the creation and spinning off of other federal research centers. The Navy's first attempt at long-range planning was the founding of the Operations Research Group (ORG) in June 1953, which was primarily oriented toward long-term military planning issues related to technological developments. It was staffed with OEG scientists with field experience on a rotational basis and its director was also the director of OEG. The Office of Naval Research (ONR), the federal government agency that originally objected to OEG calling itself ORG after World War II, wanted an organization for its own operations research group tasked to look at ONR problems only, which it then called ORG. In particular ONR wanted the organization to review long-term problems and solutions. The ORG was sponsored by MIT and located in the same offices as its customer, ONR. Its small staff never exceeded eight scientists, and it became an appendage of OEG, its achievements not considered noteworthy by many. The organization was dissolved on April 20, 1957, with a small group continuing until December 31, when its contract expired.

There had been considerable talk of creating a "Navy RAND" in the early and mid-1950s. On January 1, 1956, again as a spin-off from OEG, the Naval Warfare Analysis Group (NAVWAG) was established under contract with MIT. For its first four years, NAVWAG had the same director as OEG, who was also the director of ORG. Some personnel from OEG were used to seed the organization. It was a very small organization located in the Pentagon, starting with a staff of two. It grew to a staff of 14, with 10 scientists, before being absorbed in 1962 by the Center for Naval Analyses. In 1960 and 1961 it had a budget of approximately $230,000 (78).

Finally, OEG created a third spin-off group, the Technical Advisory Group (TAG), later named the Applied Science Division (ASD). It was established in November 1959, again under contract with MIT. It was oriented toward basic research and, over three years, grew to a staff of approximately 60 people with 30 scientists and a budget of $800,000 a year.

It was intended that OEG, NAVWAG, and ASD would exchange personnel as required for their missions. In 1959, the Navy established a long-range studies project headed by the Institute of Naval Studies (INS) in Cambridge, Massachusetts. For its support, it contracted with the Institute for Defense Analyses (IDA) (78). At the close of 1961, the Navy decided that ASD, being located near the Navy's Institute of Naval Studies

(INS), should support INS and severed the ASD connection with OEG.

Finally, in 1961, in response to a formal recommendation from IDA, DoD began looking at combining all these small OEG-influenced research centers into one organization. The Smithsonian Institution was selected as the contracting agency, but that approach ended when the Chief Justice of the United States, who was on the Smithsonian Board, objected strongly. Finally, a contract arrangement was established with the Franklin Institute, a not-for-profit scientific and educational institute that had been involved in sponsoring scientific research for over a century. The Franklin Institute assumed control of the newly established Center for Naval Analyses (CNA) on July 1, 1962. It combined all the functions and personnel of OEG, NAVWAG, INS, and ASD, taking over the contracts from MIT and IDA.

With the new center, the Marine Corps received its own operations research section in December 1961. Up until that time, the Corps had only one analyst at OEG (13, p. 16). The director of the division was located in the Marine headquarters and only reported administratively to CNA. In 1966, the INS along with the ASD was relocated from Cambridge, Massachusetts, to Washington, D.C. to be physically combined with the rest of CNA.

With the advent of a systems analysis division and a cost analysis group, the CNA was a full-service support facility that integrated all of the Navy's civilian operations research staff under one roof. In 1962 the staff of the OEG was 56 scientists (18 in the field) and 42 support personnel with a fiscal year budget of $1,625,000. NAVWAG had 10 scientists and 3 support personnel with a fiscal year budget of $221,500. ASD had 12 scientists and 6 support personnel with a budget of $800,000, and INS had 43 scientists (42 in Cambridge, 1 in Newport) and 14 support personnel with a budget of $1,500,000. This effectively created a research organization of 186 people with 121 scientists and a FY 1962 budget over $4 million.

Air Force

The conflict in Korea was not a major area of work for the newly established RAND. RAND was more focused on strategic issues of the future and did not become as involved in the conflict in Korea as the Army and Navy operations research organizations did, partly because the Air Force, unlike the Navy, had a well developed doctrine on interdiction and strategic bombing from World War II. Also, RAND itself was less interested in providing immediate operations research support and more interested in studying long-term problems. RAND's own histories make no mention of the conflict in Korea (59,60).

While RAND continued to expand during this period, it also fostered several spin-off organizations. In 1950 RAND began a study by a team of psychologists on how groups operating complex machines work under stress, which led to an air defense training system in 1953 that was put into operation throughout the Air Defense Command. A whole division, which grew to twice the size of the rest of RAND, supported this new, large semi-automatic air defense control system. The Systems Development Division provided routine technical services, computer programs, and training for this system (59, p. 17).

Because it differed in its basic purpose from RAND, the Systems Development Division became, on December 1, 1957, the Systems Development Corporation (SDC), an independent not-for-profit entity. The original proposal created a for-profit organization, but was rejected by the Air Force due to concerns about conflicts of interest (68, pp. 114-119). Lincoln Laboratory had been established in 1951 to develop an air defense system that became the Semi-Automatic Ground Environment (SAGE) system. RAND's support of the training aspect of this effort (arguably an early instance of distributed interactive combat simulation if not of virtual realitysee OTA background papers *Virtual Reality* and *Distributed Interactive Combat Simulation*) was continued by SDC. SAGE pioneered the use of a digital computer as

a real-time control system as well as to simulate combat: in training, radar operators and weapon controllers reacted to simulated targets presented to them as real targets (84, p. 10). After becoming independent of RAND, SDC continued to grow to many times the size and budget of its parent organization. At one point, SDC employed about 90 percent of the nation's computer programmers (18, p. 131). SDC survives to the present day.

RAND also helped create Analytic Services, Inc. (ANSER) in 1958 for reasons similar to those for which RAND separated from the Douglas Aircraft Corporation. Back in 1951, the Air Force had established the Assistant for Evaluation (later changed to the Director of Development Planning). The office was primarily responsible for estimating the technical feasibility of new weapons and planning the Air Force's research and development objectives. The office suffered from understaffing from its inception and was unable to obtain the right type of personnel through the civil service system or the military. RAND initially provided a number of technical people on loan. The office contracted work out to companies such as the Cornell Aeronautical Laboratory and Corvey Engineering and not-for-profit firms including the Stanford Research Institute.

Eventually the Air Force decided it needed a central study group, and Corvey Engineering was issued the contract. Meanwhile, Corvey Engineering was purchased by Melpar Inc., a manufacturing firm that developed and sold test equipment to the Department of Defense. Melpar was a subsidiary of the Westinghouse Air Brake Company. In September 1957, Melpar Inc., received a contract to create a Scientific Analysis Office using the Corvey Engineering personnel. Even though Melpar tried to physically and organizationally separate the people, this arrangement was ill-received by others in private industry and by the Air Force's own Air Research and Development Command because of the potential conflicts of interest. It was a situation analogous to the relationship between RAND and Douglas. The Air Force then requested RAND take over the office. RAND felt that this was a staff research function that did not fit RAND's mission and informally recommended that the Air Force use its own in-house technical capability, the Operations Analysis Office, an operations research group of approximately 200 people. Apparently concerns over performance, responsiveness, and objectivity predisposed the Air Force against another department in its own organization. So, RAND instead agreed to help establish ANSER, using the core of the personnel from the short-lived Melpar Scientific Analysis Office. ANSER was founded in July 1958 as a not-for-profit research corporation also incorporated in California.

On July 12, 1961, ANSER became independent of RAND except for two RAND members on the ANSER board of trustees. ANSER was considerably smaller than RAND, with 40 professionals. It was located in Virginia, within convenient distance of the office it was supporting. It conducted cost-effectiveness studies and technical evaluations of weapon systems and subsystems and provided technical advice to the Directorate of Development Planning.

In addition, a number of RAND personnel left to establish other organizations. Notable among these are the for-profit firm Planning Research Corporation (PRC), General Electric's TEMPO Division, and the not-for-profit Hudson Institute (68), founded by Herman Kahn in 1961 as a breakaway organization from RAND. In interviews Herman Kahn expressed concern that RAND was losing its vitality and becoming a captive of its client (27, pp. 89,189). He claimed RAND had become the "loyal opposition" while he was the "disloyal opposition" (68, p. 306). The Hudson Institute was a federal research center for a time during the 1960s, but was no longer listed as one by June 1, 1968 (52). (In 1983, after a competition among several institutions, the Department of the Navy would select the Hudson Institute as the contracting company for the Center for Naval Analyses, taking over from the University of Rochester (12).)

Two not-for-profit federal research centers, The Aerospace Corporation and MITRE Corporation, were established by the Air Force to provide systems integration and managerial assistance to particular Air Force commands to serve as a bridge

between the Air Force and industry. The Air Force lacked the in-house technical resources to design or specify systems in enough detail to conduct meaningful competitions for procurement and monitor the efforts of the chosen contractors.

On February 10, 1954, the Air Force Strategic Missiles Evaluation Committee (SMEC) reported that an intercontinental missile could be developed by 1960. (A study released by RAND two days earlier had stated a similar conclusion.) The Air Force decided that the systems engineering and technical oversight of the development of such a complex, high-risk system should be provided by an independent organization rather than an industrial manufacturer participating in the project. As such, the Ramo Wooldridge Corporation was contracted in 1954 as the systems engineering contractor. The division doing this work grew to become, in December 1957, the Space Technologies Laboratory (STL) of Ramo Wooldridge (1, pp. 12,13). The Air Force gave STL access to both federal government plans and contractor-proprietary data. The first Atlas launch was in June 1957, with successful launches of the Atlas and Thor missiles occurring before the end of the year (1, p. 15), well ahead of the SMEC forecast.

Ramo Wooldridge was financially backed by Thompson Products, a supplier for the automotive and aircraft industry. In 1958 Thompson Products and Ramo Wooldridge merged to become TRW Inc., with the STL as an independent but wholly owned subsidiary, creating a potential seeming conflict of interest analogous to that created by Douglas Aircraft's original ownership of RAND. There was a hardware exclusion clause in the Ramo Wooldridge contract, but no such clause existed for Thompson Products (1, p. 15). The Senate Armed Services Committee and a subcommittee of the House Committee on Government Operations investigated potential conflicts of interest between 1957 and 1959, with the House subcommittee recommending in a September 1959 report (1, p. 16) that STL be converted into a not-for-profit institution like RAND. When the Air Force, at Congress's request, set out to create a federal research center, it discovered that TRW did not want to relinquish STL. The Air Force requested that an organizing committee of private citizens establish a new not-for-profit corporation with a board of trustees. That not-for-profit became The Aerospace Corporation.

The Aerospace Corporation was established on June 3, 1960, as a not-for-profit organization under the laws of California. It was to be responsible for advanced planning, initial system design, technical evaluation of proposals, and technical oversight of hardware development and operation. On June 9, The Aerospace Corporation received a $1 million contract, effective July 1. On June 10, the Air Force gave Aerospace an advance of $5 million. This relieved the organization of having to obtain capital funds from other sources such the Rockefeller Foundation or the Ford Foundation. Aerospace consisted of a board of directors, a contract, and a major responsibility to integrate space and missile programs. It did not have a staff or facilities. At the end of the first month, it had 15 staff; a week later, 126 staff; and, at the end of six months, more than 1,700 (1, pp. 19,21). Most of this staff was recruited from private industry. The president from 1960 to 1977, Dr. Ivan A. Getting, had previously been director of the Fire Control and Army Ground Forces Division at MIT's Radiation Laboratory. Several other prominent Aerospace figures came from this World War II-era organization (1, p. 7). Other vice presidents and department heads came from the Naval Research Laboratory, RAND, Raytheon, and STL. Seventy-five percent of its staff came from STL.

To provide continuity until the work could be taken over, Aerospace gave STL a subcontract. Aerospace awarded subcontracts to other industrial firms for specific research tasks. To faciliate operations, the Air Force inserted clauses in Aerospace's contracts with the manufacturers that gave Aerospace right of access to the contractor's facilities, personnel, and information. Its original facilities were purchased from STL, eventually expanding to offices in Florida and California. By the end of 1962, The Aerospace Corporation employed 4,275 people, 1,463 of whom were engineers and scientists. Most of the technical staff

came from industry, only a few from universities and the federal government (2, p. 1).

The other systems integration research center was MITRE Corporation, formed in 1958 out of the Computer Systems Division of the MIT's Lincoln Laboratory. It was established to assume the responsibility for the operational implementation phase of the SAGE (Semi-Automatic Ground Environment) system. The SAGE system was part of the continental air defense system in the late 1950s and 1960s. The purpose of the system was integration of ground elements—radar, communications, computers and control centers—with a new generation of interception weapons. The Air Force did not have the needed systems-integration expertise in-house and did not wish, for reasons of potential conflicts of interest, to give the work to a for-profit contractor. MIT viewed the implementation work as extraneous to the desired scientific mission of Lincoln, and therefore the Air Force was obliged to create a new FCRC, MITRE. MITRE's first contract was with the Air Defense System Integration Division. MITRE eventually became involved with most of the major strategic air programs of the 1960s, 1970s, and 1980s, including North American Air Defense Command (NORAD) headquarters, Ballistic Missile Early Warning System (BMEWS), Airborne Warning and Control System (AWACS), and the Strategic Defense Initiative (SDI).

In 1959, MITRE got a second contract, to perform work on air traffic control systems for the Federal Aviation Administration (FAA). Air traffic control and continental air defense share many technologies in common, and in a Cold War environment the two functions overlapped. In 1966 MITRE began work with National Aeronautics and Space Administration (NASA) on its mission control centers (44).

Office of the Secretary of Defense

The Office of the Secretary of Defense (OSD) began creating federal research centers starting in 1956 in an effort to support its Weapons Systems Evaluation Group (WSEG), a defense agency established Fall 1947 as an adjunct of the Joint Chiefs of Staff to assess objectively the claims for competing weapons systems by the different services. There was considerable concern in the early and mid-1950s that this organization was not performing effectively, so the Institute for Defense Analyses (IDA) was created to act as a technical backstop to WSEG and to facilitate the recruitment of high-caliber scientific manpower. WSEG was to provide tasks for the Weapon Systems Evaluation Division (WSED) of IDA, arrange for access to information, provide military personnel to assist, and provide a board to review completed work and arrange for distribution and publication. There was considerable cross-over in assignments. For example, the same person served as the Director of WSED and the Director of Research for WSEG. This arrangement led to some confusion over who was ultimately responsible for the finished work, IDA or the federal government, and reflected wider uncertainty over whether contractors could have detachment and objectivity. It also resulted in an investigation by Congressman Chester Earl Holifield (D-CA) (68). As a result, late in 1962 members of DoD and IDA restructured the WSEG/WSED working relationship so that there were no more dual federal government and company positions and the WSEG review board was not actively involved in daily IDA work. These changes were strongly opposed by many professional military. They felt that the changes effectively eliminated military control over WSEG's studies, operations, and reports. They were concerned that the group's work would be less responsive to actual needs and security requirements. Another serious concern was that the changes would degrade the influence of the professional officer in the defense decision-making process. This controversy was part of the developing struggle over whether the civilian expert or professional military would be making the decisions on systems and weapons that were to be used by the military. The objections resulted in a revised decision that partially reasserted WSEG's control of WSED, but as part of the changes, the

WSED (IDA) was physically located outside of the Pentagon (68).

IDA's mandate soon expanded. In 1958, at the request of the Secretary of Defense, IDA established an Advanced Research Projects Division to support the newly created Advanced Research Projects Agency (ARPA, later Defense Advanced Research Projects Agency, now again simply ARPA) in DoD. In 1960, the Division was reconstituted as the Research and Engineering Support Division to undertake technical studies for all the offices of the Director of Defense Research and Engineering, including ARPA. At about the same time, IDA founded its Princeton-based Communications Research Division, whose mission was to carry out a long-range program of studies in communications, particularly research in mathematics, to support the work of the National Security Agency.

In 1961, the Logistics Management Institute (LMI) was created to serve as a research aid to the Assistant Secretary of Defense for Installations and Logistics (68). It was listed by the National Science Foundation that year as an FCRC and then disappeared from the listings until 1984, when it officially resurfaced as an FFRDC (52).

Conclusion

Twenty-three federal research centers existed in 1950, three of them study and analysis centers. The number of centers grew, especially in DoD. In 1962, when the name "FCRC" was established, there were 66 of these centers, with an all-time record 43 DoD centers. The research centers had differentiated into three basic types: 1) laboratories, 2) study and analysis centers, and 3) engineering and technical direction centers. Only six of the 43 DoD FCRCs have survived as FFRDCs until the present day (along with LMI, which became an FFRDC in 1984). The study and analysis centers went beyond operations research into a wide range of areas and began to take on non-DoD work. They had a clear impact on what was being discussed and how it was discussed within DoD.

Much of this growth was a response to the pressures of the Cold War environment. In some cases (e.g., that of Aerospace), expediency in establishing a functional operation outweighed other considerations. Also, the Soviet launch of the first satellite, Sputnik, in 1957 propelled the United States to commit considerable additional effort to R&D, from which the centers directly benefited.

CONFLICT AND TRANSITION FOR THE RESEARCH CENTERS IN THE 1960S TO MID-1970s

Social Changes

Many societal forces, including changes in society's faith in the power of science and attitude toward the military, affected the federal research centers in the 1960s. During World War II and the conflict in Korea, these factors generally favored the mission of the think tanks. In the 1960s, however, they changed.

This shift can be seen in the media of the 1960s. In the early 1950s, RAND had established an office of communications and public relations and had even gone as far as to buy general corporate advertising in 1957 through 1961 in various scientific and trade journals (61,68).[5] In the minds of many, "RAND" had become synonymous with "think tanks," even though there were a number of these in existence in the 1960s (61).[6] RAND was

[5] The purpose of this advertisement campaign was to increase the visibility of RAND. It originated in concern that RAND was losing out to private industry when recruiting new staff. Instead of providing recruiting ads that directly competed with commercial company's recruitment efforts (and could have raised complaints), the RAND ad campaign provided statements from RAND's division chiefs that illuminated the work and philosophies of RAND personnel.

[6] Providing some indication of the changes in the visibility of RAND over time, there is a "selected bibliography" of articles written on RAND in the back (pp. 104-106) of *The RAND Corporation, 40th Year.* It records eight articles written on the corporation in the 1950s. It records 71 articles written from 1960 through 1970, and only 14 since 1970. While this is certainly not a definitive list, research indicates a considerable expansion in the awareness and interest in think tanks during the 60s and early 70s, and then less of an interest as they become passé.

the object of a protest-style folk song by song writer Malvina Reynolds in 1961 (68). The stereotype of a strategic advisor for nuclear strategy was caricatured by Stanley Kubrick's Dr. Strangelove from the movie of the same name. He was supposedly a strategist from the "Bland Corporation" (27).

In the late 1950s and early 1960s, the Department of Defense began to refocus on conventional warfare. As the budget began to expand in the 1960s, there came an emphasis on making the equipment more cost effective. This position was clearly stated by Secretary of Defense McNamara at his swearing in on January 21, 1961 and led to cost analysis of systems becoming part of the work of all the think tanks. The Operations Evaluation Group (OEG) had already added economists to its staff in the 1950s (68). ORO began its cost-analysis efforts in the late 1950s (77). RAND played a role, with a whole department dedicated to developing a new budgeting system for the Department of Defense. All the services began using the RAND-developed Program Planning and Budgeting System (PPBS) (68), which was extended to all of the federal government by directive from President Lyndon B. Johnson in August 1965 (18, p. 64).

The conflict in Vietnam and the opposition thereto had a profound impact on the thinking of military people, politicians, and the populace in general that influences policy and decisions yet today. Opposition to U.S. involvement in Vietnam led to a critical and often hostile view of the military by many civilians and redefined the relationship between the military and the civilian worlds.

As opposition to U.S. involvement in Vietnam and anything military heightened on college campuses throughout the United States, many FFRDCs found their connections to an educational institution a liability (and vice versa). There were even concerns about being able to protect the research on campus.[7] The relationship with SORO, and its successor CRESS, at the American University declined in the late 1960s, with animosity coming from the school's professors and protests by the students (25). In the fall of 1967, the Students for a Democratic Society (SDS) organized protests to sever Princeton's ties with IDA. Similar protests were conducted by students at the University of Michigan and were an issue during the 8-day student revolt at Columbia University (18, pp. 146,147). On August 24, 1970, the Army Mathematics Center at the University of Wisconsin was bombed with 1,700 lb of nitrogen fertilizer soaked in fuel oil. The blast killed one researcher, injured three others, and destroyed a building wing, seriously disrupting the center's research program. The letter to the media by the bombers accused the center of being "a vital cog in the machinery of U.S. imperialism." The Army Mathematics Center was probably one of the least important DoD centers. It primarily conducted basic mathematics research, stimulated scientific contacts between military mathematicians and their civilian counterparts, and provided a training service in applied mathematics. After the bombing it was removed from the list of FFRDCs but continued to operate with support from the Army (18, p. 151). There were a number of demonstrations against CNA at the University of Rochester campus (13, p. 20), a factor in the migration away from University administration. As of June 1968, 10 of 16 DoD FFRDCs were administered by universities (52, p. 97). As of FY 1995, only 2 out of 10 DoD FFRDCs are administered by universities, both laboratories (53).

Criticisms of Federal Research Centers

Criticism of federal research centers also came from private industry, which objected to competing with organizations funded and established by their own federal government. The *Congressional Record* of June 2, 1960 on "Competitive Private

[7] One independent government research consultant studying causes of political violence had his graduate student assistants help him make copies of all the files from the study, which were being stored in the library at San Diego University, for fear of violence to that building. Interview with Professor Ivo Feierhabend, San Diego University, March 1983.

Enterprises in Space," for example, provided criticism of federal research centers as nationalized industry competing directly with private enterprise on a subsidized, nontax basis. It is not entirely possible to refute this criticism. Federal research centers were clearly established for the purpose of doing research and analysis for the federal government in an environment where there was a stable research facility, no market pressure, no conflict-of-interest questions, and the capability to produce the kind of the independent analysis unlikely to come from either a federal government agency or a for-profit private company.

Having a research and advisory center as part of a manufacturer and commercial competitor for hardware had led to conflict-of-interest problems, causing RAND to separate from Douglas, Aerospace to be created to replace TRW, and also providing the impetus behind the creation of ANSER Inc. independent from Melpar. In the early 1960s, IDA also opened itself up for this type of criticism when it had employees "on loan" from industry working on its staff (68).

There is also criticism, not well documented, that many federal research centers are simply not fully productive and are not always cost effective. The organizations themselves, on the other hand, are required to document their accomplishments, which include cost saving and improvements in effectiveness. In addition, the federal government regularly evaluates and documents the effectiveness and cost management of the centers. The fees that these organizations receive have come under attack at various times as being inconsistent with a not-for-profit organization, despite explicit provision for such fees in the Defense Acquisition Regulations (16). Some of the federal research centers charged the federal government fees, above and beyond the cost of doing the work contracted, to provide capital funds for the organization and funds for other activities.

Congressional Criticism

By the early 1960s, Congress was clearly wary of, if not actually opposed to, federal government support of not-for-profit corporations. A paper prepared in 1958 for a subcommittee of the U.S. House of Representatives Committee on Government Operations suggested that the issuance of contracts for research needed to be examined. It stated, "While the evidence is not entirely clear, it does seem to be true that contracting methods and specifications appropriate to the administration of traditional functions of the federal government have been carried over by brute force and sheer awkwardness into the area of scientific research contracting, in which they protect adequately the interests neither of the federal government nor the contractor." (9, p. 81).

A federal government committee appointed by President John F. Kennedy in 1961, under the Director of the Bureau of the Budget, David Bell, examined the usefulness of contracting for work, reviewed the contracting procedures, and sought to determine what limitations within the federal government result in the use of contractors. The committee looked into aspects of federal government contracting for scientific evaluations and advice, research engineering services, and technical and administrative management services. The committee's report (often referred to as "The Bell Report") was made public on April 30, 1962 and was the first comprehensive consideration of the issues related to contracting for services and expertise. Only in passing did it specifically address federal research centers (9,68).[8]

One of the primary recommendations of the report was that the federal government needed to raise federal salaries to be able to "obtain and hold first-class scientists, engineers, and administrators" (9). No recommendations were made related to any specific federal research center or to re-

[8] The director of the Bureau of the Budget, and the leader of the effort was David E. Bell, so this report is usually called the Bell Report, even though those words appear nowhere on the report.

search centers in general. Concerning the issue of compensation, the report stated: "We have carefully considered the question whether standards should be applied to salaries and related benefits paid by research and development contractors doing work for the federal government. We believe it is desirable to do so in those cases in which the system of letting contracts does not result in cost control through competition."

The Bell Report acknowledged the criticism that the new not-for-profit contractors doing systems engineering and technical direction work were intruding in areas traditionally done by private business. (The American Federation of Government Employees had submitted a statement in August 1961 to the 87th Congress, House Committee on Armed Services, expressing concern over the adverse effects of contracting federal government work to private business (9, p. 78).) The report concluded that, "The present intermingling of the public and private sectors is in the national interest because it affords the largest opportunity for initiative and the competition of ideas from all elements of the technical community. Consequently, it is our judgment that the present complex partnership between Government and private institutions should continue."

The report validated the original rationale for creating federal research centers as independent sources of analysis with the caveat of strong leadership. It noted that:

> Not-for-profit organizations (other than universities and contractor-operated Government facilities), if strongly led, can provide a degree of independence, both from Government and from the commercial market, which may make them particularly useful as a source of objective analytical advice and technical services....Contractor-operated Government facilities appear to be effective, in some instances, in securing competent scientific and technical personnel to perform research and development work where very complex and costly facilities are required and the Government desires to maintain control of these facilities (9).

The high salaries of employees of federal research centers have come under congressional scrutiny more than once. IDA and RAND, in particular, had a reputation for paying the highest salaries of the think tanks and contrasted sharply with their civil service counterparts. For example, in 1957 and 1958, IDA provided a major share of ARPA's initial working staff, for ARPA at that time had only a skeleton civil service staff. Thus IDA personnel and ARPA personnel were working at identical jobs with IDA personnel getting paid more (68). Aerospace and MITRE, using engineering and technical personnel with a high commercial marketability, were paying higher salaries than the think tanks (68, pp. 287,288).

Criticism of federal research centers in Congress in the late 1950s was primarily focused on problems related to one program or one corporation. A general analysis of the use of federal research centers does not appear to have been conducted prior to the Bell Report.

One corporation singled out was The Aerospace Corporation, established to help integrate the Air Force's Ballistic Missile and Space Program in the late 1950s, the most expensive defense program undertaken up to that time. For this and other reasons, it was the one federal research center that came under repeated congressional scrutiny in the late 1950s and early 1960s. The issue of salaries raised in the U.S. House of Representatives in the early 1960s was almost entirely focused on Aerospace Corporation.

In May 1961, the House Committee on Government Operations held a hearing on the formation of The Aerospace Corporation. This hearing addressed such items as salary scales, conflicts of interest, facilities, fees, and patent rights. It also discussed the concerns of private industry over systems engineering agents as "meddlers in the weapon-building process and as piratic employers of scarce or highly prized scientific personnel" and the concerns of federal government critics who thought these agencies were taking on tasks that should be performed by the federal government (9, p. 80).

The House Committee on Appropriations held hearings on Department of Defense Appropriations for 1962. On the establishment of Aero-

space Corporation, one witness stated, "My comment is, with the present rules and regulations, you could not set up an organization like the Aerospace Corp. within the Government in the time available to set it up. We needed it right away. It would be infeasible to have done it within the Government." (9, p. 77)

The House Committee on Appropriations in June 23, 1961 reported that:

> ....to a considerable extent the use of contracts with not-for-profit organizations is merely a subterfuge to avoid the restrictions of civil service salary scales.
>
> It is noted that the buildup of these organizations has not been accompanied by corresponding reductions in the number of military and civilian personnel on the Government rolls... Military and civilian personnel on the payroll should be competent to do the jobs assigned to them or they should be removed from the payroll. (9, p. 78).

The committee found Aerospace's salaries excessive, its overhead too high, and its planned staff too large (9, p. 78). Aerospace salaries also came up at a House of Representatives' Committee on Post Office and Civil Service Manpower Utilization in the Federal Government in 1961 (9, p. 82). The Defense Appropriations Subcommittee of the House Appropriations Committee stated, "The Committee feels that the salaries paid by the Aerospace Corporation are excessive, that its overhead costs are too high, and that it plans to employ too large a staff." The Committee reduced the funding for Aerospace, and placed a ceiling on the Aerospace program element that could only be raised with the consent of the Committee (1, p. 198).

Whether or not this is a valid basis for criticism, the federal research centers *were* designed to attract the best and the brightest people available using salary above the wage scale the federal government offers as an incentive. Furthermore, the space program was expanding rapidly and reduction in personnel could not be expected.

On the other hand, the House of Representatives Committee on Science and Astronautics commissioned a staff study on Aerospace and related organizations in 1963 to review whether or not they merited their special relationship with industry and the federal government. The study found that Aerospace provided the following functions:

- technical direction and management of engineering systems (especially missile and space systems),
- technical troubleshooting,
- judgment of technical aspects of industrial proposals,
- origination and development of scientific and technical ideas and plans,
- laboratory research, and
- confidential technical advice (2, p. 2).

In 1964 Congress, concerned about the growth of the research centers, placed a ceiling on the total funds for FCRCs. This ceiling was enforced starting in 1967 (85, p. 313,314), though Aerospace had had a ceiling since 1961, as described above.

An intense examination of Aerospace was conducted in 1964 and 1965 by the Special Investigations Subcommittee of the House Armed Services Committee, chaired by Congressman Porter Hardy (D-VA). The Committee reviewed cost items, acquisition of property, construction of buildings, the fee, the cost of moves, salaries, compensation, sick leave policy, and other matters. No evaluation of the technical performance of Aerospace was attempted. The Air Force strongly supported Aerospace during this investigation. Hearings resulted in a law requiring congressional authorization before Aerospace could purchase builidings or real estate, regardless of which Aerospace funds were used (85, p. 198). Because Aerospace already had built a number of facilities, the need for more did not arise until the 1970s, when approval of a new building took two years to obtain (85, pp. 203,204).

A ceiling placed on MITRE in 1964 applied only to Air Force work. Another ceiling, placed in 1968, applied to all DoD work. In that year MITRE's board of directors amended its certificate of incorporation to allow MITRE to do work

outside the federal government. DoD policy encouraged diversification outside DoD (43, pp. 126,252).

The Military Services

During the late 1960s and early 1970s the Army and Air Force both became increasingly dissatisfied with their FFRDCs. The Army decreased its support to SORO (renamed the Center for Research in Social Systems (CRESS)), HumRRO, and RAC. Further budget cuts resulted in CRESS seriously decreasing its staff. HumRRO became a private company. RAC was sold to General Research Corporation, a private company, after the Army informed RAC that it would no longer be supported as an FFRDC. The Army formed the U.S. Army Concepts Analysis Agency (CAA) (77,86,32)[9] in the early 1970s to replace RAC with its own in-house research organization (77), implying that the independence of the advisory organization was no longer an issue. The Army offered to bring part of the RAC staff in-house, but RAC decided to pursue selling itself to an outside company (20, p. 11). By September 1972, the Army sponsored no FFRDCs (52) but did continue to contract with some Air Force-sponsored FFRDCs.

The Air Force, for its part, decided that RAND was not responsive to its needs. (OTA notes that this complaint is stated openly in the RAND official 25-year history.) (68,59,60) As early as 1952, an Air Force study voiced complaints about RAND isolating itself from real weapons development by avoiding involvement in evaluations and by its refusal to participate in analysis that could lead to the granting of a contract to an industrial firm. Doing so would have directly involved RAND in evaluating other firms weapon system's proposal and compromised its independent "unbiased" position that was its reason for separating from Douglas Aircraft four years earlier (68). However, this role is regularly filled by Aerospace and MITRE.

RAND's failure to support the Air Force's position on the B-70 bomber was particularly annoying to some members of the Air Force. The effect was that RAND's budget in 1961 was initially cut in half, to $7 million. While this money was restored in the DoD budget before it went to Congress, the cut heralded a long, difficult period for the company's relationship with the Air Force. RAND's relationship with the Strategic Air Command, in particular, was troubled during the late 1950s and early 1960s (68).

Also, the Air Force felt that its unique lawyer-client relationship with RAND had been compromised by the extensive work RAND was doing for the OSD and other organizations. RAND shrank from a peak of 1,100 employees in 1963, with perhaps 900 involved in Air Force work (59), to approximately 1,000 employed, but only approximately 400 involved in Air Force projects in 1973 (60).

In the end, the Army shut down CRESS, RAC, and HumRRO, and the Air Force's participation in RAND was cut in half by the early 1970s. This entire shift in relationship with the Army and the Air Force occurred over seven years (roughly 1965 to 1972).

Though the Navy did not have such dramatic shifts in relationships with its research centers, there were, nonetheless, changes. With the increased U.S. involvement in Vietnam, in 1964 CNA's OEG resumed its interdiction studies. As the U.S. Navy's largest combat role in the Vietnam war was interdiction and air strikes, the operational analysis focused on these efforts as well as on the Navy's "brown water" riverine force interdicting supplies in the Mekong Delta. A separate division was established for Southeast Asia studies,

[9] Charles A. H. Thomson, in his 1975 history of RAC, mentions that the U.S. Army was setting up an organization that would take over some of the functions of RAC. That this organization was the U.S. Army Concepts Analysis Agency was confirmed in interviews in February 1994 with Howard Whitley, the Special Assistant for Model Validation at CAA and with Colonel William A. Lawrence (ret.), who was assigned to CAA when it was established in January 1973.

and a field representative program was set up. The office's work on assembling statistics of air and other operations was published widely and distributed monthly. Although the ability to measure the effectiveness of the air operations suffered from the same difficulties as it had during the conflict in Korea, there being no reliable method of determining the effectiveness of an interdiction campaign, the considerable collection of data served as material for analysis for some years thereafter.

CNA focused its attention on analyzing the rising naval threat from the Soviet Union, the first challenge to the U.S. Navy's supremacy since World War II. CNA worked with the Navy on its exercises to determine what lessons could be learned from these simulated combats. The OEG itself declined from its Vietnam peak of approximately 80 scientists (now called analysts) to a low of about 55 in 1977 and climbed to approximately 65 (about the same number as were employed in World War II) during the early 1980s. More significantly, after 1970 the fraction of analysts on field assignments increased rapidly to over half of the organization. It had never been much more than 30 percent before (78).

In 1967 the Navy was still having difficulty in its relationship with the Franklin Institute. The Navy complained about both lack of timeliness, quality, and realism in the CNA studies and management changes executed by the Franklin Institute. Another search went out for a new not-for-profit contract agent. RAND and the Stanford Research Institute (SRI) were seriously considered, but the Navy decided that a university would serve best. The University of Rochester was selected, even though it laid down a series of conditions, such as set-asides of 23 percent of CNA's budget for CNA-initiated research and 5 percent of the budget for University of Rochester research on matters of possible use to the Navy. The contract went into effect on August 1, 1967. It included wider distribution of CNA studies and a higher visibility in naval councils for the CNA director. Finally, it better integrated visiting officers into the work of CNA, including arranging for 3-year assignments (78).

In 1969, Secretary of Defense Melvin Laird encouraged Aerospace, and the DoD FCRCs generally, to increase work in nondefense programs, even though DoD was not intending to reduce its funding. Partially in response to requests from Congress that the technologies and knowledge developed in the defense industry be transferred to help address domestic problems, he wanted the civilian economy to benefit from some of the technology developed for military and space uses (2).

Conclusion

The period spanning the 1960s to mid-1970s started with 43 DoD FCRCs (the most DoD FFRDCs ever) in 1961. During this period of marked changes in public attitude towards the military, the DoD underwent the McNamara revolution and "civilianization," with an expansion of the FCRCs' unique disciplines beyond the centers both within DoD and private industry. This period also saw the expansion of the study and analysis centers into civilian work and the creation of a large number of FFRDCs for non-DoD work. By 1969 the number of FFRDCs had reached its maximum of 74, but only 16 were certified by the DoD. The official status of many of these FFRDCs changed (although most remained in operation), so that by 1975 there were only 39 FFRDCs left, with only 9 DoD FFRDCs: the RAND Corporation, IDA, CNA, Lincoln Laboratory, MITRE Corporation, The Aerospace Corporation, APL, ARL, and ANSER.

THE EMERGENCE OF UNIFIED POLICY REGARDING DoD FFRDCS

The period from the mid-1970s to the present saw changes in the military that influenced the missions of the FFRDCs. In 1972 the nature of the development of nuclear weapon systems was redefined with the signing of the ABM treaty and the SALT interim agreement on defensive arms with the Soviet Union. The U.S. military's active role in the Vietnam war effectively ended in 1973 and

decisively ended in 1975. With the end of conscription in 1973, the U.S. military became an all-volunteer force for the first time in over 30 years. During this time, the defense budget declined.

As a result of continued concern over the size and number of FFRDCs, the Director of Defense Research and Engineering (DDR&E) requested a yearlong series of studies by which to produce and evaluate a unified policy concerning the FFRDCs (then still called FCRCs by the DoD). A report from a special Defense Science Board Task Force on Federal Contract Research Center Utilization was presented to the Director of DDR&E, Malcolm Currie, in February 1976. The report, a whole-hearted endorsement of the FCRCs, stated that system of congressionally set ceilings was outdated and inefficient, that no further controls were needed, that the FCRC salaries were not excessive, and that the quality of the FCRC work was good. The report noted that some of the earlier salary discrepancies had been lessened by the growth of federal salaries during the 1950s (55, p. 13). The report closed with a series of recommendations, the first of which stated:

The Federal Contract Research Centers supporting Defense Department agencies are so valuable a resource, because of their perspective, the quality of their work, and the responsiveness they can exhibit because of their special relationship to their sponsorship, that they should be retained and protected in essentially their present roles. *This recommendation is meant to be read as a strong endorsement of the current Defense policy in use of the FCRCs* (55, p. 30).

While Dr. Currie was preparing his management plan for Congress, three out of the four Committees with FCRC budget and ceiling oversight took negative budgetary action, even though the Defense budget as a whole was being increased, and despite Dr. Currie's promise in February to provide Congress with a comprehensive plan before the end of the session. Dr. Currie forwarded his management plan for FCRCs to Congress on June 15, 1976 (19, pp. 1,2).

The actions outlined in the report included reduction of the number of centers from nine to six, by decertifying the remaining part of the Applied Physics Laboratory, the Applied Research Laboratory, and ANSER. The report recommended the continued certification of the remaining laboratory, Lincoln, on the grounds that "MIT views its DoD work as a matter of public responsibility and service and feels that the visibility of their 'line item,' PE 65705F, to the Services and Congress is desireable and good." The report called for MITRE's DoD C^3 work to be made a separate FFRDC in Bedford, Massachusetts, and that the rest of MITRE's work to be migrated to its McLean, Virginia, operation. MITRE Bedford and Aerospace would then be limited to doing only DoD work. Responsibility for IDA would be transferred from WSEG to DDR&E, and a separate Project Air Force would be created at RAND in a split similar to that mandated for MITRE (55, p. 35). The recommendations of this plan were accepted by Congress and largely, but not totally, implemented—MITRE's work for the Defense Communications Agency stayed in McLean.

MITRE and RAND had the most extensive non-DoD programs, their Air Force work being less than half of their total effort. Forty-six percent of RAND's 1975 professional labor-hours and 37 percent of MITRE's were devoted to nondefense work (55, p. 35). MITRE's work had extended overseas in 1973, in a contract with the United Kingdom (55, p. 147), although MITRE was not the first federal research center to undertake work for a foreign customer. The report also pointed out that the failure of the funding ceilings to keep pace with inflation had forced the research centers into a situation in which they were obliged to reduce staff or seek other sources of work. Those that had diversified had fared well but endured criticism from those who felt that they were "poaching" beyond the FFRDC preserve. Other serious problems had been caused by abrupt reductions in funding, especially late in the fiscal year, resulting in layoffs, degradation of morale, and impairment of the FFRDCs' ability to find and retain quality staff (56, p. 4).

The number of DoD FFRDCs reached its nadir of six in 1978 when the Navy decertified the sec-

ond of the two Applied Physics Laboratories (APL) near the end of 1977 (the first was already decertified in 1975) and the Applied Research Laboratory (ARL), and the Air Force decertified ANSER on October 1, 1976. In the case of the laboratories, they were simply declared no longer to be FFRDCs. The federal government continued contracting with them, but without the special FFRDC status. In addition, the MITRE and RAND corporations set up their FFRDC portions separate from the rest of the company. MITRE formed its C^3I Division and RAND renamed Project RAND Project Air Force. Both C^3I and Project Air Force became FFRDCs. Aerospace was asked no longer to diversify outside of defense work and to divest itself of its existing non-DoD work. MITRE in Bedford was similarly restricted, but the MITRE office in Washington was not.

This changing environment was described by the DDR&E in its report of June 1976 (56). It summarized the status of the nine existing FFRDCs (called FCRCs throughout the report). Their budget was $297 million, ranging from a high of $82 million for Aerospace to a low of $2 million for ANSER, and their total employment was 4,500. In its review of the study and analysis centers, it noted that their annual workload was around $40 million, 15 percent of all DoD expenditures on studies and analyses. A Defense Science Board task force had recently strongly endorsed the DoD FFRDCs. The DDR&E concluded that, while the industrial base capable of performing some of the tasks done by FFRDCs had grown markedly since their founding, the need for FFRDCs still existed and that FFRDCs provided "high quality, essential services" (56).

THE TRANSITION TO THE PRESENT

The number of FFRDCs remained stable from 1978 until 1984, when four new FFRDCs were established. Of these, three were essentially reorganizations of existing efforts and one was an entirely new entity (the Software Engineering Institute). The other three FFRDCs were LMI, NDRI (RAND) and the Arroyo Center (RAND). LMI had been in existence since 1961, and had been listed once by the National Science Foundation as an FCRC. The NDRI and Arroyo Center both evolved directly out of existing programs at RAND (61, p. 44).

The other significant event that occurred at that time was the 1983 passage of the Competition in Contracting Act (CICA). This act had provisions that clearly identified the FFRDCS and set procedures for issuance of contracts to them without competitive procurement. While these limitations did little to change the DoD business of FFRDCs, CICA did clarify their procedures. CICA made it more difficult, in some respects, to issue small study contracts in a timely manner to private firms, making the use of FFRDCs more attractive to the federal government managers. On the other hand, CICA also made non-DoD work by FFRDCs much harder to arrange.

In 1984 the Office of Federal Procurement Policy (OFPP) Policy Letter 84-1 was issued, codifying rules for establishing FFRDCs. The Federal Acquisition Regulations were modified in 1990 so as to bring them into conformity with OFPP 84-1.

As explained in the Introduction, the FFRDC system represents a departure from the federal government's usual pattern of buying from the lowest bidder, and requires a ceiling on expenditure for reasons analogous to those that necessitate tempering the lowest-bidder rule with a caveat regarding what constitutes acceptable quality. In the last 10 years, four different ceiling systems have been used to limit expenditure of DoD-appropriated funds at FFRDCs, indirectly limiting staff levels and therefore the size of the FFRDC system as a whole:

- Prior to FY 1991, the individual centers' DoD sponsors set ceilings on their individual centers' DoD use;
- Congress imposed center-by-center ceilings in FY 1991 and FY 1992;

- DR&E set individual ceilings on the DoD use of DoD FFRDCs in FY 1993; and
- Congress now places a financial ceiling on the DoD use of DoD FFRDCs and DDR&E apportions this ceiling among the centers; the FY 1994 and FY 1995 ceilings were set in this way and are shown in appendix D (31).

At present, the ceiling is below the current demand and limits the availability of the FFRDCs to do work and the flexibility of federal government program managers to award them work.

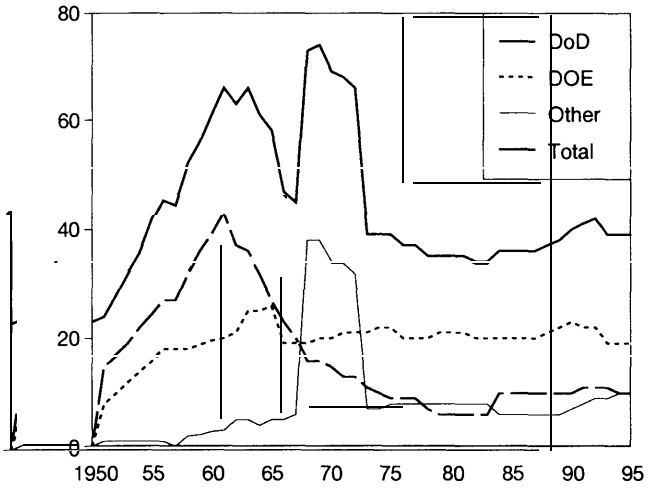
The 10 FFRDCs that existed or were created in 1984 are the same 10 that exist today. There was only one DoD FFRDC created after 1984, the Institute for Advanced Technology, sponsored by the Army and contracted through the University of Texas. It was created in FY 1991 and decertified after FY 1992. An abortive attempt was made to create a DoD FFRDC in connection with the Strategic Defense Initiative.

The work and missions of the study and analysis centers are different in emphasis from what they were when the centers were originally established. Descriptions of their missions today provide a different emphasis to the reasons FFRDCs exist. They are said to provide:

- continuity,
- ability to work with sensitive and classified data,
- responsiveness, and
- objectivity.

These reasons differ from the reasons for the centers' creation: the exploratory research mission has lost center stage, though it continues and arguably brings benefits disproportionate to its size. Instead of being free-wheeling think tanks operating in a university-like environment, the study and analysis federal research centers now strive to be reservoirs of knowledge, objectivity, and experience, on tap to support the military's ongoing mission. In some respects, this transition occurred because the federal research centers have completed the original mission assigned to them. Their success in developing new methodologies is demonstrated by the existence of a private industry capable of taking on at least part of their function.

FIGURE 1-2: A Count of Federal Research Centers[a]



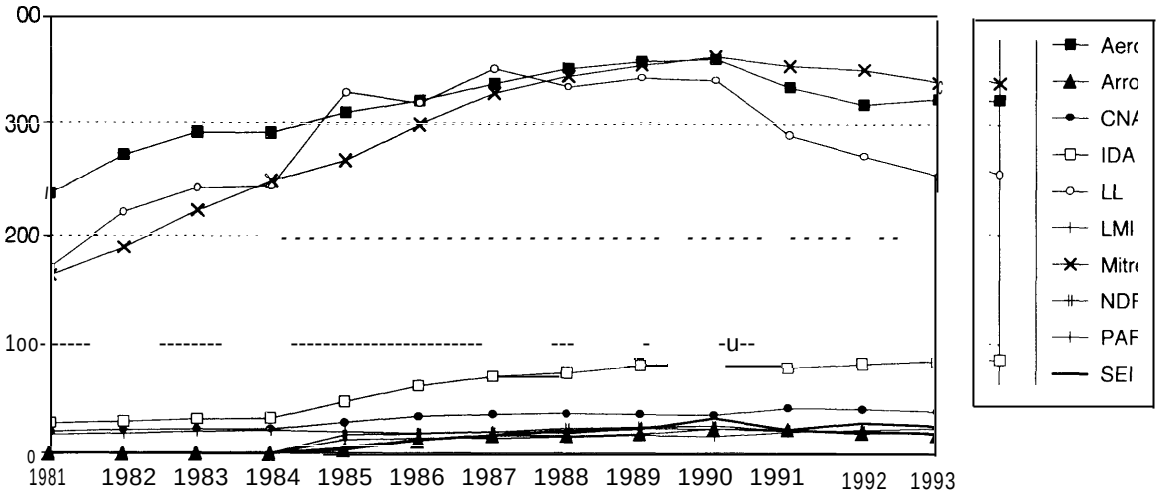
a The actual numbers used are provided in appendix B

SOURCES: National Science Foundation, *Federal Funds for Science, Federal Funds for Research, Development, and Other Scientific Activities,* and *Federal Funds for Research and Development,* vols. I through XLII (Washington, DC: 1952-1994).

As their missions were accomplished, the FFRDCs declined from the 43 DoD FCRCs reported in 1961 to the 6 that existed from 1978 to 1983. The annual NSF reports list federal research centers from 1950 to the present. Figure 1-2 shows the total number of centers reported for each fiscal year with separate counts for DoD, Department of Energy, and other centers. The data used for this graph are provided in appendix B.

The record of R&D obligations for FFRDCs is also provided by the NSF reports. However total expenditures or total receipts can exceed R&D obligations by 20 percent or more and only R&D obligations are reported by NSF. Figure 1-3 shows obligated DoD funding for each center. As can be seen from this graph, Aerospace, MITRE, and Lincoln Laboratory operate at an entirely different level of effort from that of the study and analysis centers. Figure 1-4 summarizes the disparity. The

FIGURE 1-3: Total DoD Funds for Each DoD FFRDC ($millions in 1987 $)



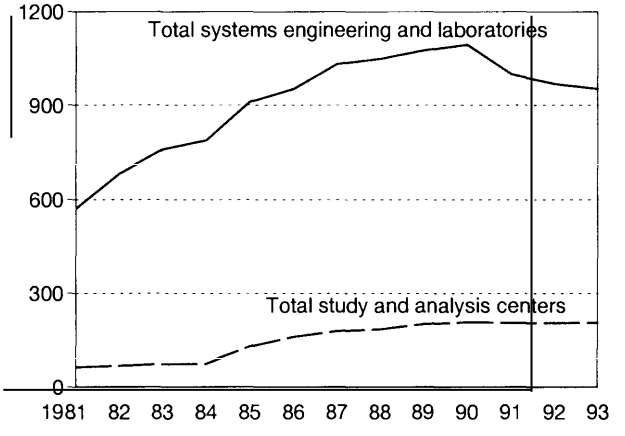
KEY: Aerospace =Aerospace Center; Arroyo = Arroyo Center; CNA = Center for Naval Analyses; IDA = Institute for DefenseAnalyses, LL = Lincoln Laboratory; LMI = Logistics Management Institute; Mitre = Mitre Corporation; NDRI = National Defense Research institute, PAF = Project Air Force; SEI = Software Engineering Institute.

SOURCES. National Science Foundation, *Federal Funds for Science, Federal Funds for Research, Development, and Other Scientific Activities,* and *Federal Funds for Research and Development,* vols. I through XLII (Washington, DC. 1952 through 1994).

higher line on this graph is the sum of the funding of the two system engineering centers and the two laboratories. The bottom line on this graph is the sum of the funding of the six study and analysis centers.

The centers continued existence, over 50 years after their creation, is attributable to their filling a useful niche that may not be filled as well by the federal government or private industry. What independent research the FFRDCs still do is now one of many aspects of their services, as opposed to their reason for existence (the notable exception being Lincoln, a laboratory). The surviving study and analysis FFRDCs have evolved from the conflict between the centers' desire for independent, basic research and their clients' desire for concrete useful results.

FIGURE 1-4: Total DoD Funds for Think Tanks versus Systems Engineering Centers and Laboratories ($ millions in 1987 $)



SOURCES: National Science Foundation, *Federal Funds for Science, Federal Funds for Research, Development, and Other Scientific Activities,* and *Federal Funds for Research and Development,* vols. I through XLII (Washington, DC. 1952 through 1994)

PROFILES OF THE EXISTING DOD FFRDCs

The FFRDCs can be differentiated from private industry and federal government laboratories by

BOX 1-3: Disposition of Assets

FFRDCs differ in how their assets are to be disposed of if the FFRDC closes. For example, RAND's corporate charter specifically provides that upon the dissolution of the corporation, all assets will be distributed at the direction of the Ford Foundation for scientific, educational, and charitable purposes. If the Ford Foundation has ceased to exist, then the Superior Court of California will dispose of RAND's assets. Neither of these agencies have any official relationship with the Department of Defense. Up until 1962, the System Development Corporation assets devolved back to RAND. I

By contrast, in the later Aerospace Corporation charter, the Air Force specifically insisted that after settlements of all debts and obligations Aerospace's assets would devolve upon the federal government and would be disposed of by the Air Force in the event of the company's dissolution. MITRE's original charter provided for the reversion of the assets as directed by the President of the United States.

The 1962 Bell Report briefly addressed the issue of ownership of facilities and other property of federal research centers with the statement that, "We should think it equitable, where the Government has provided facilities, funds to obtain facilities, substantial working capital, or other resources to a contractor, it should, upon dissolution of the organization, be entitled to a first claim upon such resources. "[2]

The OFPP Policy Letter 84-1, states that any new FFRDCs must have its assets devolve back to the federal government in the event of dissolution. These assets can include facilities, cash reserves, and intellectual property. Ownership of the assets of the corporations that evolved from existing FFRDCs (i.e., RAND, MITRE, and CNA) is not addressed by the Policy Letter.

SOURCE: Office of Technology Assessment, 1995.

[1] Bruce L. R. Smith, The *RAND Corporation, Case Study of a Nonprofit Advisory Corporation* (Cambridge, MA: Harvard University Press, 1966).

[2] Bureau of the Budget, *Report to the President on Government Contracting for Research and Development* (Washington, DC U.S. Government Printing Office, 1962).

their combination of civilian personnel and federal government sponsorship. The specifics of their organizational structure, their relationship with their host, and ownership of their assets varies considerably. (See box 1-3.)

A number of independent not-for-profit corporations are not federal research centers. These include such organizations as Stanford Research Institute (SRI), Systems Development Corporation (SDC), the Hudson Institute (for parts of its history), Battelle Laboratories, and Technical Operations Inc. Also, several not-for-profit and for-profit organizations were created when federal research centers were closed out by the federal government. These included HumRRO; General Research Corporation, the successor to RAC; and Abbott and Associates, established by a division manager of CRESS (25,26,66,68,77).

Most FFRDCs are *industrially funded,* meaning that within the financial ceilings imposed on their DoD work, the FFRDCs actual work is funded by the individual agencies within DoD that wish to use their services. This funding is passed through to the FFRDC via one contract (typically) that the sponsoring agency holds with the FFRDC.

There are some notable exceptions to the pattern. IDA, for example, holds three separate contracts. RAND holds a contract for each of its four FFRDCs (including one non-DoD FFRDC, the Critical Technologies Institute). MITRE C^3I has two major DoD contracts, one with the Air Force and one with the Army. Furthermore, Project Air

Force is funded as a line item in the congressionally appropriated budget for DoD. The Arroyo Center at RAND is also partially funded through a line item in the DoD budget. Line item funding is an attempt to separate the funding decisions from the immediate departments for which the FFRDC is doing studies, but the recommendation and demand for the level of work to be requested for the DoD budget still comes from the sponsoring agency.

Attached at the end of each of the following descriptions of the 10 FFRDCs is a chart showing the funding for that FFRDC from 1981 through 1994 in millions of 1987 dollars. Where data were available, each bar on the graph shows DoD and non-DoD funding. These figures were obtained from each FFRDC. The only other public source, NSF, only reports R&D money for the FFRDCs. While R&D money usually includes the majority of the money spent for FFRDCs in a year, it can differ from the real financial picture. For several years the Arroyo Center's primary source of funding was Operations and Maintenance money, and therefore no funding was reported by NSF, nor was Arroyo listed in their reports as an FFRDC.

The funding figures in this report are not all comparable. In some cases (such as that of IDA) they represent all the annual income for that FFRDC, whether from DoD or other agencies. This figure can also include interest from any financial reserve the company maintains. In some cases (such as that of CNA) it includes only DoD funding. Obtaining funding figures is complicated by centers, e.g., CNA and LMI, that no longer issue complete financial reports in their annual reports.

Study and Analysis Centers

Center for Naval Analyses

Having evolved directly from ASWORG, the Center for Naval Analyses (CNA) has been in existence since 1942, making it the oldest DoD federal research center.

In May 1983, the Navy informed the University of Rochester that is was opening the contract it held with them to competition. As a result, the not-for-profit Hudson Institute (once a federal research center) took over management of the CNA on October 1, 1983 (78). In 1990, it was decided that CNA could function as an independent entity, and on October 1, 1990, CNA begin to contract directly with the Navy. In 1993, CNA restructured as the CNA Corporation with two divisions: CNA as the FFRDC sponsored by the Department of the Navy, and a new operating unit, the Institute for Public Research (IPR). CNA also does work outside of DoD (13, pp. 36,41), its primary non-DoD customer being FAA. CNA's non-DoD work makes up less than 10 percent of its effort (15,30).[10] IPR provides analytical and support services to non-Navy clients (but can include DoD clients.) This work is handled outside of the FFRDC umbrella.

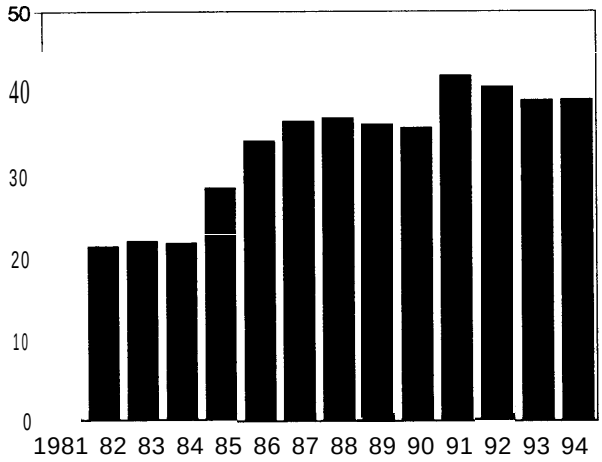
Figure 1-5 shows DoD funding for CNA and the FFRDC division of CNA after incorporation in current and constant dollars.

Institute for Defense Analyses

The Institute for Defense Analyses was originally owned by a loose holding company. Five, and later eight, universities contributed to form this company incorporated in Delaware as a not-for-profit organization. IDA's early mission broadened until the IDA group that supported its founding sponsor, WSEG, was only one of five IDA working divisions. Over the years, IDA has modified its structure in response to sponsor needs and requests in addition to the Systems Evaluation Division and the Science and Technology Division (successors to the divisions originally created to support WSEG and ARPA, respectively), IDA has established divisions to provide cost analyses, assessment of computing and information systems

[10] This figures does not include IPR revenue.

FIGURE 1-5: Center for Naval Analyses Annual Funding ($ millions in 1987 $)



SOURCE: Center for Naval Analyses, 1995.

and technology, and strategy and force assessments, as well as operation evaluations. It now has nine divisions: six supporting OSD as a whole (including ARPA), and three supporting the NSA. IDA became the principal advisory agency servicing the OSD as a whole.

In December 1992, IDA had a staff of 832, including 425 research staff members. Of these research staff members, 62 percent held doctorates and another 29 percent had master's degrees. The composition of the research staff was 27 percent mathematics, statistics, and operations research; 24 percent engineering; 21 percent physical sciences; 13 percent computer sciences; 11 percent economics and social and political science; and 4 percent other. Apart from the work conducted for the NSA, the Institute's research program is focused in eight areas: systems evaluations; test and evaluation; technology assessment; information systems and technologies; force and strategy assessment; advanced simulation, resource and support analyses; and economic and environmental studies.

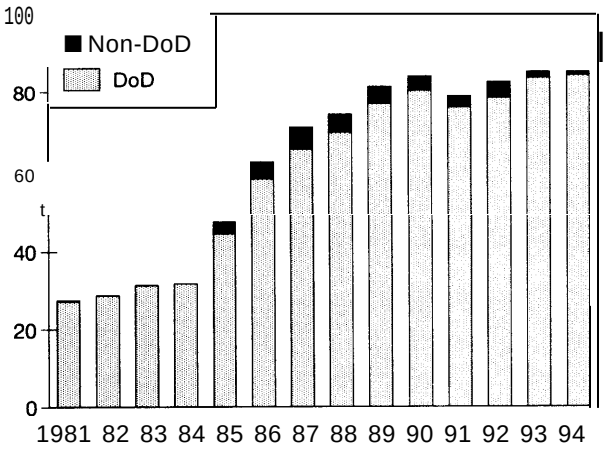
IDA's primary sponsor is still OSD (especially the Undersecretary of Defense (Acquisition and Technology)), but it does considerable work for defense agencies such as ARPA and the NSA, as well as the Joint Staff. It does a small amount of work for other federal agencies, but none for other not-for-profits or industry (29). The research of the three IDA divisions working for the NSA is generally considered laboratory research.

Figure 1-6 shows the Institute's expenditures, both DoD and non-DoD, in constant dollars.

Logistics Management Institute

The Logistics Management Institute was formed in 1961 on the recommendation of the Secretary of Defense and became an FFRDC in 1984 (52). The corporate charter of LMI permits it to work only for government agencies and other not-for-profit organizations (34). Its primary sponsor is the Undersecretary of Defense (Acquisition and Technology) and its executive agent is the Undersecretary of Defense (Logistics), but it also does work for a variety of other organizations in DoD, particularly the Air Force and Army Corps of Engineers. It does some work for other federal government agencies such as the Department of Veterans Affairs, Department of State, and Department of Transportation. All of its work is logistics related. Its revenues for 1993 were $30 million,

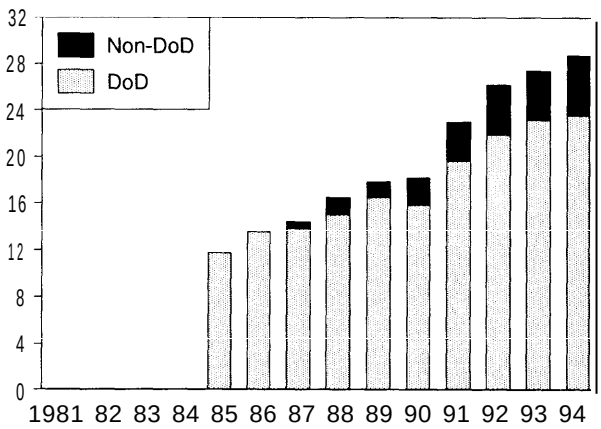
FIGURE 1-6: Institute of Defense Analyses Total Expenditures ($ millions in 1987 $)



SOURCE: Institute for Defense Analyses, 1995

with five-sixths of that work from DoD sources and one-sixth from non-DoD federal agencies (33,35,30). Figure 1-7 shows the Institute's DoD and non-DoD funding in constant dollars.

FIGURE 1-7: Logistics Management Institute Annual Funding ($ millions in 1987 $)



SOURCE: Logistics Management Institute, 1995

The RAND Corporation

RAND now manages four FFRDCs Three are DoD FFRDCs and one, the Critical Technologies Institute, is a civilian FFRDC, created at the request of Congress in 1992. RAND's three DoD FFRDCs are the Air Force's Project Air Force, the Army's Arroyo Center, and OSD's National Defense Research Institute. In addition, RAND has some defense work not included those three FFRDCs and has a domestic policy department.

The work load for the whole RAND organization is roughly broken into quarters. For example, in FY 1992, the RAND revenues were split almost equally between the National Security Research Division ($27.5 million, with $25.9 million from the National Defense Research Institute); Project Air Force ($25. 1 million); the Domestic Research Division ($27.0 million); and the Army Research Division ($23.3 million, including the Arroyo Center) (48, p. 13).

Each of RAND's FFRDCs is supported by a five-year contract. Project Air Force and the Arroyo Center receive line-item funding from their service sponsors, while NDRI receives funds primarily from its sponsor, the Office of the Secretary of Defense. This mechanism is intended to provide the organization some insulation between the recipients of the studies and those who make the funding decisions. Additional budget monies are obtained from agencies within DoD that wish to fund specific research.

Each RAND FFRDC has a board that determines the general direction of the research and the level of budget. For Project Air Force and the Arroyo Center, the majority of the members of the board are general officers, with some senior civilian members. In 1994, the board for the National Defense Research Institute was composed entirely of senior civilian members of OSD.

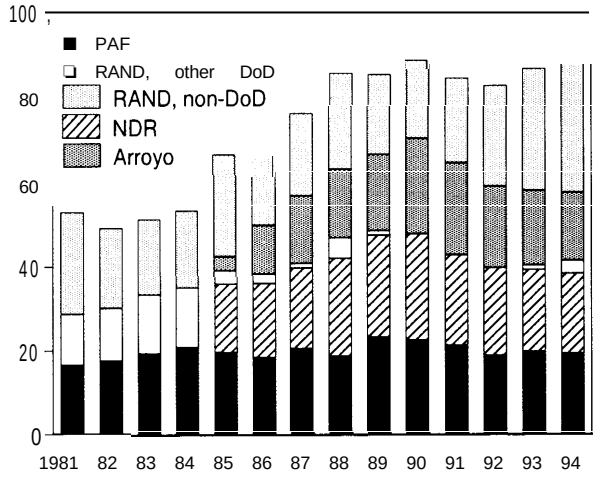
The supporting professional staff of RAND consists of approximately 600 personnel organized into six research departments. Operations researchers, statisticians, mathematicians, and the physical scientists account for approximately 20 percent of the staff. The social sciences (e.g., political science, humanities, sociology, public policy, and behavioral sciences) account for over 40 percent of the staff. Economists and engineers each make up over 10 percent of the staff.

Domestic research began at RAND in the early 1960s and by 1970 was nearly 25 percent of RAND's work. In the late 1970s, concurrent with the reduction in RAND's Air Force work, it made up 50 percent of RAND's work. Since that time, it has declined as a percent of RAND's work, partially due to increases in RAND's other defense work, until by the late 1980s, its share returned to about 25 percent of RAND's work. At that level, RAND has the largest domestic policy analysis program of any not-for-profit firm (67,64,48).

RAND has ensured that its reports receive wide distribution. In the case of unclassified reports, RAND set up (in 1953) 40 public libraries as deposit libraries throughout the United States and seven repositories for its reports overseas (62).

Figure 1-8 shows the aggregate DoD and non-DoD expenditures for all of RAND, including the four FFRDCs and non-FFRDC expenditures in constant dollars.

FIGURE 1-8: RAND Total Expenditures
($ millions in 1987 $)



KEY: Arroyo = Arroyo Center; PAF = Project Air Force; NDRI = National Defense Research Institute

SOURCE: RAND Corporation, 1995.

Project Air Force

Project RAND was at its largest in the late 1950s and early 1960s. The Air Force was just beginning to develop technological and systems analysis capabilities of its own; therefore, it depended more heavily on RAND for these functions.

In 1950, when RAND began expanding from its Project RAND contract, it established, at the suggestion of the Air Force, a smaller contract with the Atomic Energy Commission (68). RAND reached its peak employment in 1957 when it had 2,605 people. However, this included the significant training effort for the Air Defense Directorate that was later spun off to form the Systems Development Corporation. In 1959, it began work with ARPA and NASA. At that point, the Air Force announced that it intended to freeze its support of RAND at its current dollar level. In 1961 it added NSF and the National Institutes of Health to its clients.

RAND had also done work for OSD, jeopardizing the special relationship with its Air Force customer by doing work for the Air Force's superior. In particular, it developed the Program Planning and Budgeting System to which Secretary of Defense McNamara made all the services conform. It was also at this time that OSD expanded and became more civilianized. RAND also did major projects for the Office of the Assistant Secretary of Defense for International Securit y Affairs. This office was not always on the best of terms with members of the Air Force.

As the decade continued, RAND worked for the U.S. Agency for International Development and the Defense Atomic Support Agency and received grants from other not-for-profit organizations to do studies in urban transportation, heuristic programming, and simulation of cognitive processes. Project RAND support shifted from being 95 percent of RAND's budget to 68 percent: RAND had over a dozen different clients. Parallel to the shift to a more diversified client base, RAND was forced to acquire all the functions of a large corporation. In 1951, with only two clients and almost all its work from the Project RAND contract, 51 percent of its staff were researchers. In 1963, the proportion of researchers in the organization had dropped to 40 percent, the rest being taken up with departmental and corporate support staff (68).

During the 1960s, the Air Force work declined by nearly 50 percent, but up until 1968 work with other agencies was able to keep the staff doing defense work at a stable level of approximately 450 professionals. After 1968, that work continued to drop until a nadir was reached from 1972 through 1974 of about 250 professionals involved in defense work (60). In 1975 Project RAND was renamed Project Air Force and set up as a separate FFRDC within the RAND Corporation. During this period, RAND's work in the domestic sector continued to expand until it constituted a program of nearly equivalent size.

During the 1960s and 1970s, RAND added a range of sponsors both within and outside of the DoD, including state and local governments and private foundations. Only later in its history did it sign contracts with the other services. One internal Air Force study in 1952 had declared that it was inappropriate for RAND to represent more than

one of the services because the three branches of the armed forces compete for budgets, facilities, and military responsibilities (68, p. 83), though of course today RAND's Arroyo Center is an Army-sponsored FFRDC.

Oversight of Project Air Force is conducted by a panel of senior civilian members of the Department of the Air Force and general officers. This panel determines the research priorities and the budget for Project Air Force. In 1993, this panel consisted of 11 general officers and two senior civilians. The RAND budget is primarily passed by Congress as a single line item in the Air Force budget. There is some direct funding of research. Project Air Force also provides some direct assistance to the Air Force. In FY 1993, direct assistance was estimated to cover about 20 percent of its work.

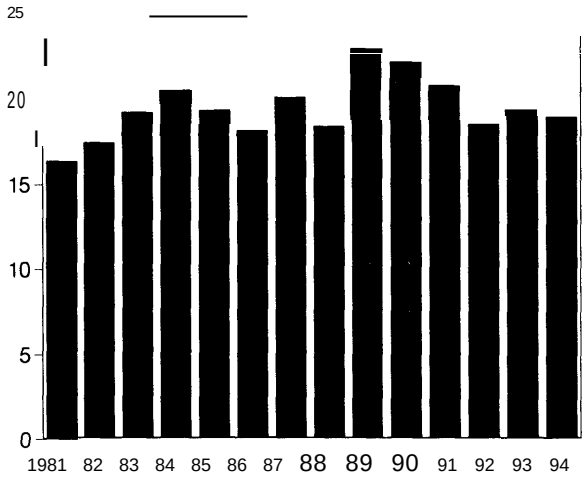
Since 1991, funding for Project Air Force has declined. In FY 1993, the funding supported 116 years of labor for professional staff, down from its usual 1980s level of approximately 140.

Project Air Force, after a 1992 reorganization, consists of seven major projects:

- strategy and doctrine,
- force structure,
- force modernization,
- force employment,
- command, control, communications, and intelligence (C^3I)/space,
- logistics, and
- acquisition.

Figure 1-9 shows Project Air Force (PAF) funding in constant dollars.

FIGURE 1-9: Project Air Force Annual Funding ($ millions in 1987 $)



SOURCE. RAND Corporation, 1995

The Arroyo Center

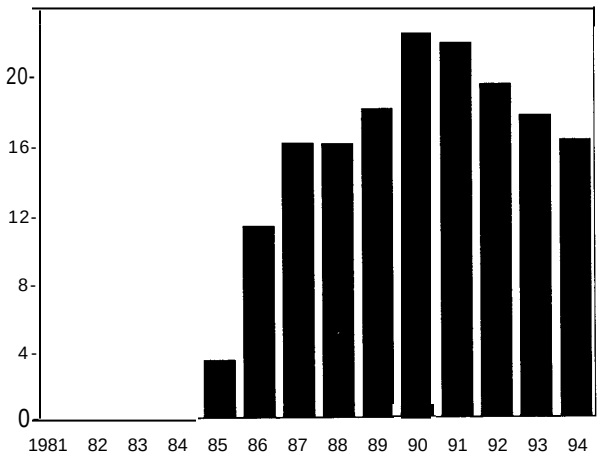
The Arroyo Center came to RAND in 1984 at the request of the Chief of Staff of the Army. The Arroyo Center had originally been established in the early 1980s within a NASA FFRDC, the California Institute of Technology's Jet Propulsion Laboratory (JPL). In 1984 the university, at the urging of its faculty, decided to divest itself of the Arroyo Center. RAND and the Army agreed that the research agenda pursued at JPL did not fully match the Army's needs. Therefore anew agenda was developed, a new director was chosen, and only 13 employees made the transfer from the Center's old incarnation to its new one (23). Since its research was developing an emphasis on policy as opposed to technical matters, it was decided to locate the Center at RAND as a new FFRDC (61, p. 57).

The Center's purpose is to provide the Army with objective, independent analysis of medium- and long-term problems. The potential for objectivity is enhanced by having much of its funding as a separate line item within the DoD budget. The funding decisions are not made by all the same people within the Army that receive the studies. The Arroyo Center also receives a portion of its budget from individual agencies within the Army.

The annual allocation for the Arroyo Center's research is assigned to projects based on priorities set by the Arroyo Center Policy Committee, consisting in January 1994 of three senior civilian members of the Department of the Army and nine general officers from the various commands.

The work is managed within four programs: 1) Strategy and Doctrine, 2) Force Development and

FIGURE 1-10 Arroyo Center Annual Funding
($ millions in 1987 $)



SOURCE: RAND Corporation, 1995

Technology, 3) Military Logistics, and 4) Manpower and Training (8).

Figure 1-10 shows Arroyo's funding in constant dollars.

The National Defense Research Institute

The National Defense Research Institute (NDRI) was established in 1984 at RAND by amalgamating the various programs already being done at RAND for OSD, the Joint Staff and other defense agencies. It was established as a separate FFRDC to assemble all the work being done for DoD (as opposed to the Army and Air Force) into one independent organization. RAND had been working directly for OSD since the late 1950s.

NDRI serves the long-term analytic, planning and innovation needs of OSD, the Joint Staff, and other defense agencies. It is intended to fulfill the following objectives:

- to conduct a sustained research program,
- to establish a reservoir of expertise,
- to allow flexible response, and
- to provide unbiased analysis.

The research program for NDRI is established by a policy board consisting (in September 1992) of 11 senior DoD civilians, usually at the level of an undersecretary and assistant secretary. They determine both the research program and the DoD budget request for NDRI. Additional funding for NDRI (usually about 30 percent of its budget) comes from the additional budget monies awarded to it, usually from the departments of its policy board members.

The NDRI is organized with four programs and a center. The programs are 1) International Security and Defense Strategy, 2) International Economic Policy, 3) Applied Science and Technology, and 4) Acquisition and Support Policy. The center is the Defense Manpower Research Center. The NDRI also does some limited independent research and operates some facilities jointly supported by all the RAND FFRDCs (Project Air Force, the Arroyo Center, and NDRI). NDRI researchers are drawn from the corporate staff at RAND (48).

Figure 1-11 shows NDRI's funding in constant dollars.

Laboratories

Lincoln Laboratory

The Massachusetts Institute of Technology Lincoln Laboratory was established as a federal research center in 1951 at the joint request of the Air Force, Navy, and Army to conduct research in advanced electronics pertinent to national defense. In 1958, when ARPA was created, it also became a sponsor (75), although Air Force-related work continued to provide more than 50 percent the work of the laboratory. Non-DoD sponsorship currently amounts to 18 percent of staff and is limited by policy to 30 percent (30,40,75). Contracting is primarily done through the Air Force Systems Command, Electronics Systems Division. Until recently all programs were sponsored by federal agencies, but Cooperative Research and Development Agreements (CRADAs) are now permitted with industry, subject to federal government approval for pre-competitive technology transfer.

The mission of Lincoln Laboratory is to carry out a program of research and development pertinent to national defense, with particular emphasis

on advanced technology. The thrust of the Laboratory's activity is in the areas of surveillance, identification, and communication. Mission areas include ballistic missile defense, space surveillance, air defense, and communication (76).

MIT has management oversight and participates in mutual research activities with Lincoln Laboratory. MIT management provides general policy, financial accountability, and review of Laboratory activities. A DoD Joint Advisory Group reviews and approves the Laboratory program annually. Like many other university FFRDCs it is effectively an independent organization. MIT has never received a fee for the operation of Lincoln Laboratory. Student interaction is limited: the interns, graduate students, and visiting researchers from the university make up less than 5 percent of the staff (42). Currently the Laboratory employs 2,300 people with just under 800 principal members of the technical staff. Almost all hold advanced degrees in scientific and engineering fields (40).

Lincoln Laboratory particularly prides itself on technology transfer through having companies created by its former employees. These spin-offs include the MITRE Corporation, which currently runs two FFRDCs Lincoln Laboratory also claims to have spun off more than 60 other companies that employ over 130,000 people nationwide, of which the largest is Digital Equipment Corporation (DEC), founded by two former employees of the Lincoln Laboratory in 1957. DEC employs just under 121,000 people worldwide (39,38,41).

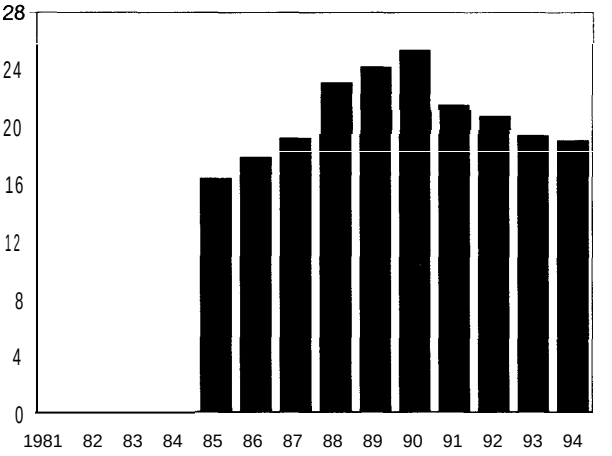
Figure 1-12 shows Lincoln Laboratory's total funding, including both DoD and non-DoD, in constant dollars.

Software Engineering Institute, Carnegie-Mellon University

The Software Engineering Institute (SEI) is sponsored by DoD through ARPA and administered by the Air Force. The SEI contract was competitively awarded to Carnegie-Mellon University in December 1984. It is staffed by approximately 270 technical and support people from industry, academia, and the federal government.

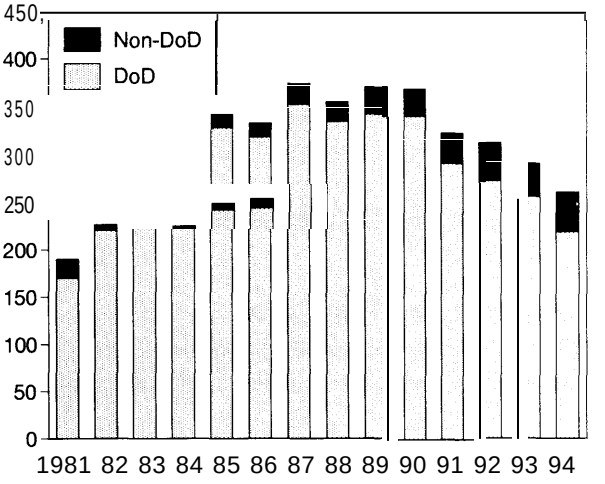
Software has become an increasingly critical component of U.S. defense systems. DoD established the Software Engineering Institute with a charter to advance the practice of software engineering, so as to produce quality software on schedule and within budget. The SEI mission is to provide the means and leadership to bring the ablest professional minds and the most effective technology to bear on rapid improvement of the

FIGURE 1-11: National Defense Research Institute Annual Funding ($ millions in 1987 $)



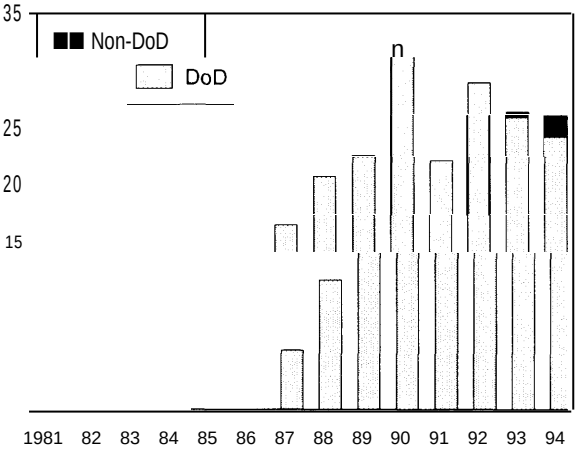
SOURCE. RAND Corporation, 1995

FIGURE 1-12: Lincoln Laboratory Annual Funding ($ millions in 1987 $)



SOURCE: Lincoln Laboratory, 1995

FIGURE 1-13: Software Engineering Institute Annual Funding ($ millions in 1987 $)



SOURCE: Software Engineering Institute, 1995

quality of operational software in software intensive systems, accelerate the introduction to practice of modem software engineering technology, promulgate the use of this technology throughout the software community, and establish standards of excellence for improving software engineering practice.

In pursuit of its mission, SEI's fundamental emphasis is on technology transfer, and all efforts undertaken by SEI reflect this emphasis. SEI is also allowed to receive funding from other federal agencies for work consistent with its charter (70,69,72,36,71).[11] The non-DoD work constitutes less than 4 percent of its effort (30).

Figure 1-13 shows SEI's total funding, including both DoD and non-DoD, in constant dollars.

Engineering and Technical Direction Centers

The Aerospace Corporation

The Aerospace Corporation is primarily involved in the Air Force space programs, including almost all of its space launch and satellite programs. It was also involved in launch vehicles for Projects Mercury and Gemini, the one- and two-man space capsules and for NASA's Viking and Voyager programs. It was involved in the Ballistic Missile Program and in establishing the design of the Space Transportation System (the Shuttle) and in supporting Air Force activities that used that vehicle. Aerospace's role in space has been increased with the increased use of other launch vehicles since the Challenger disaster. It has been involved in the current major efforts of the Air Force including military communications satellites, weather satellites, early-warning satellites, the Global Positioning System (GPS), other National Security space systems, and ballistic missile defense.

In 1969, Secretary of Defense Melvin Laird encouraged Aerospace to increase work in nondefense programs, as DoD expected its funding of federal centers to be reduced: DoD wanted the civilian economy to benefit from some of the technology developed for military and space uses. Participation in domestic programs, including NASA, reached its peak in the early 1970s but never exceeded 20 percent of the company's business (2). It is currently less than 5 percent of its total effort (30).

Currently Aerospace has a staff of 3,100, almost two-thirds of whom are scientists and engineers. Of the technical staff, two-thirds hold advanced degrees and one-fourth have doctorates. Its gross revenue for 1993 was $422 million. Its estimated revenue for FY 1994 is $380 million (5, pp. 3,7). Aerospace carries out work for DoD, NASA, the Department of Transportation, the Environmental Protection Agency, and some foreign countries. Its primary customer is the Air Force Space and Missile Systems Center. By 1994, DoD funding in the face of stable military space budgets had declined 19 percent in real terms since 1990, but Aerospace is trying to expand by offer-

[11] The SEI charter states in part, "Systems developments are still typically plagued by schedule slippage and cost overruns. In addition, software intensive systems frequently fail due to poor quality and an inability to be rapidly modified to meet changing needs."

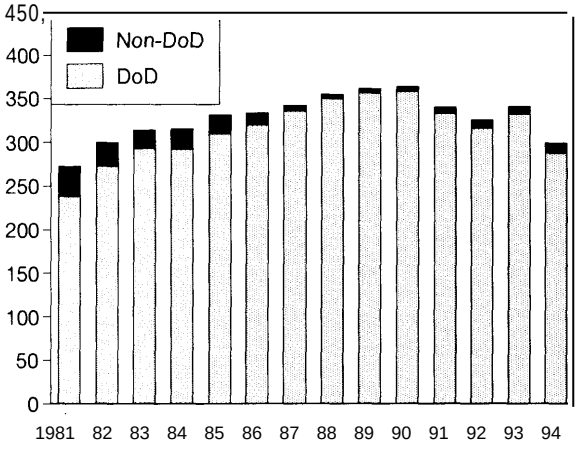
ing its expertise in space and environmental technology to other federal government agencies (3,2,5). Aerospace clearly prides itself on its 7-year record of 71 consecutive launches of launch vehicles developed with Aerospace Corporation technical oversight with no major failures, while commercial systems have an average of one failure every six launches (6, p.2; 4, p. 2; 5, pp.2,8).

Figure 1-14 shows Aerospace's funding, including both DoD and non-DoD, in constant dollars.

The MITRE Corporation

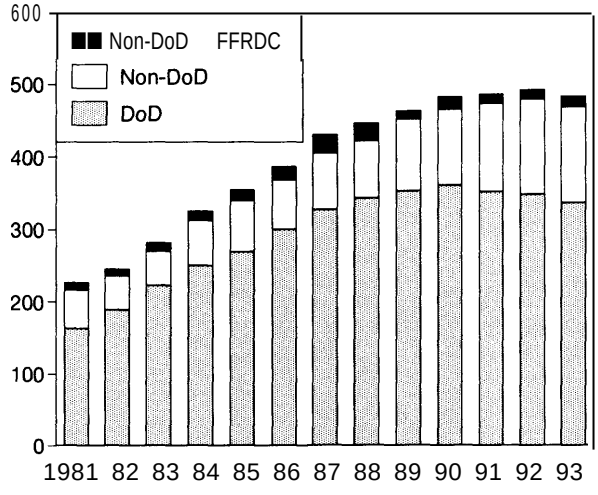
The MITRE Corporation operates two FFRDCs the DoD's C³I FFRDC and the Federal Aviation Administration's Center for Advanced Aviation System Development. It supports more than 50 additional clients, most of which are agencies of the federal government (notably the Federal Bureau of Investigation and the General Services Administration), or foreign, state, or local governments. No part of MITRE competes with service companies, manufactures products, or works for a supplier of information system components (47). In 1994, MITRE's overall revenues were almost $600 million and its staff about 5,000, of whom about two-thirds were technical staff.

FIGURE 1-14: Aerospace Corporation Annual Funding ($ millions in 1987 $)



SOURCE: Aerospace Corporation, 1995,

FIGURE 1-15: MITRE Corporation Annual Funding ($ millions in 1987 $)



SOURCES: MITRE Corporation, 1995; President's Council of Economic Advisors, *Economic Report of the President,* Transmitted to the Congress (Washington, DC: US Government Printing Office, February 1994),

About three-fourths of MITRE's work in 1994 was performed by the C³I FFRDC, of which more than 90 percent was for the Department of Defense and about half was for the Air Force (67).

Originally, the entire MITRE Corporation was one FCRC, funded by the Air Force (44). MITRE is now organized into six centers. DoD's C³I FFRDC (sponsored by the Assistance Secretary of Defense (C³I)) is composed of three centers: the Center for Air Force systems, which performs Air Force C³I work; the Center for Integrated Intelligence Systems, which does work throughout the intelligence community; and the Washington C³ Center, which works for the Army, Navy, Defense Information Systems Agency, and others. The Center for Advance Aviation System Development is the Federal Aviation Administration's FFRDC. The Center for Environment, Resources, and Space and the Center for Information Systems do non-FFRDC work, including some work for DoD that falls outside the C³I mission area (47).

Figure 1-15 shows MITRE's funding.

Appendix A: List of Current FFRDCs for FY 1995

A

NAME	ADMINISTERED BY	TYPE	SPONSOR
The Aerospace Corporation		Nonprofit	USAF
Ames Laboratory	Iowa State University of Science and Technology	University	DOE
Argonne National Laboratory	University of Chicago	University	DOE
Arroyo Center	RAND Corporation	Nonprofit	Army
Brookhaven National Laboratory	Associated Universities Inc.	University	DOE
Center for Advanced Aviation System Development	MITRE Corporation	Nonprofit	FAA
Center for Naval Analyses	CNA Corporation	Nonprofit	Navy
Center for Nuclear Waste Regulatory Analysis	Southwest Research Institute	Nonprofit	NRC
Continuous Electron Beam Accelerator Facility	Southeastern Universities Research Associates	University	DOE
Critical Technologies Institute	RAND Corporation	Nonprofit	NSF
C³I Federally Funded Research & Development Center	MITRE Corporation	Nonprofit	OSD
Energy Technology Engineering Center	Rockwell International Corporation	Industrial firm	DOE
Fermi National Accelerator Laboratory	Universities Research Association Inc.	University	DOE
Idaho National Engineering Laboratory	Lockheed Idaho Technologies Inc.	Industrial firm	DOE
Inhalation Toxicology Research Institute	Lovelace Biomedical and Environmental Research Institute	Nonprofit	DOE
Institute for Defense Analyses		Nonprofit	OSD
Jet Propulsion Laboratory	California Institute of Technology	University	NASA
Lawrence Berkeley Laboratory	University of California	University	DOE
Lawrence Livermore National Laboratory	University of California	University	DOE

NAME	ADMINISTERED BY	TYPE	SPONSOR
Lincoln Laboratory	Massachusetts Institute of Technology	University	USAF
Logistics Management Institute		Nonprofit	OSD
Los Alamos National Scientific Laboratory	University of California	University	DOE
National Astronomy and Ionosphere Center	Cornell University	University	NSF
National Center for Atmospheric Research	University Corporation for Atmospheric Research	University	NSF
National Defense Research Institute	RAND Corporation	Nonprofit	OSD
National Optical Astronomy Observatories	Association of Universities for Research in Astronomy	University	NSF
National Radio Astronomy University	Associated Universities Inc.	University	NSF
National Renewable Energy Research Laboratory	Midwest Research Institute	Nonprofit	DOE
NCI Frederick Cancer Research and Development Center	Program Resources Inc.; Advanced Bioscience Laboratories Inc.; Charles River Laboratories Inc.; Data Management Services Inc.	Nonprofit	NIH
Oak Ridge Institute for Science and Education	Oak Ridge Associated Universities Inc.	University	DOE
Oak Ridge National Laboratory firm	Martin Marietta Energy Systems Inc.	Industrial	DOE
Pacific Northwest Laboratory	Battelle Memorial Institute	Nonprofit	DOE
Princeton Plasma Physics Laboratory	Princeton University	University	DOE
Project Air Force	RAND Corporation	Nonprofit	USAF
Sandia National Laboratory	Sandia, subsidiary of Martin Marietta Inc.	Industrial firm	DOE
Savannah River Laboratory	Westinghouse Electric Corporation	Industrial firm	DOE
Software Engineering Institute	Carnegie-Mellon University	University	ARPA
Stanford Linear Accelerator Center	Leland Stanford, Jr. University	University	DOE
Tax Systems Modernization Institute	IIT Research Institute	Nonprofit	IRS

Abbreviations:

ARPA-Advance Research Projects Agency; DOE-Department of Energy; FAA=Federal Aviation Administration, Department of Transportation; IRS=Internal Revenue Service, Department of Treasury; NASA-National Aeronautics and Space Administration; NIH=National Institute of Health, Department of Health and Human Services; NRC=Nuclear Regulatory Commission; NS=National Science Foundation; OSD=Office of the Secretary of Defense; USAF=U.S. Air Force.

SOURCE: Mary V. Burke, National Science Foundation, Washington, DC, 1995.

Appendix B: Number of Federal Research Centers Each Year

B

In the back of the National Science Foundation reports, *Federal Funds for Science*, there is usually a list of Federal Research Centers, FCRCs, or FFRDCs. The actual number in each report is shown below. The reports do have errors and omissions in them, and are not always clear as to exactly what year they are reporting on. The first column total of federal research centers includes other centers besides DoD, DOE, AEC, and ERDA centers.

FISCAL YEAR	TOTAL	DoD	AEC/ERDA/DoD	NOTES
1950	23			from 1st report
1951	24			from 1st report
1952	No count provided			
1953	No count provided			
1954	No count provided			
1955	No count provided			
1956	46	27	18	count from 1956-58 report
1957	45	27	18	count from 1956-58 report
1958	52	32	18	
1959	No list in report			
1960	No list in report			
1961	66	43	20	
1962	63	37	21	
1963	66	36	25	
1964	61	32	25	
1965	58	27	26	
1966	47	23	19	
1967	45	20	19	
1968	73	16	19	“As of 1 June 1968”
1969	74	16	20	“As of 1 August 1969”
1970	69	15	20	
1971	68	13	21	
1972	66	13	21	

FISCAL YEAR	TOTAL	DoD	AEC/ERDA/DoD	NOTES
1973	39	11	21	
1974	39	10	22	
1975	39	9	22	
1976	37	8	20	
1977	37	8	20	
1978	35	6	20	
1979	35	6	21	
1980	35	6	21	
1981	35	6	21	
1982	34	6	20	
1983	34	6	20	
1984	36	10	20	
1985	36	10	20	
1986	36	10	20	
1987	36	10	20	
1988	37	10	21	
1989	38	10	22	
1990	40	10	23	
1991	41	11	22	
1992	42	11	22	
1993	39	11	19	
1994	39	10	19	
1995	39	10	19	

Abbreviations:

AEC=Atomic Energy Commission; DoD = Department of Defense; DOE = Department of Energy; ERDA = Energy Research and Development Administration.

Appendix C: List Of All Identified DoD Federal Research Centers

C

NAME	ADMINISTERED BY	TYPE	SPONSOR	NOTES
Aerospace Corporation	Aerospace Corporation	Nonprofit	USAF	FCRC, FFRDC
Aircraft Nuclear Power Plant Facility	General Electric Corporation	Profit	USAF	
Aircraft Nuclear Propulsion Plant Facility	General Electric Corporation	Profit	USAF	FCRC
Aircraft Nuclear Test Facility	Convair Division, General Dynamics Corp.	Profit	USAF	FCRC
USAF Shock Tube Facility	University of New Mexico	University	USAF	FCRC
Allegheny Ballistics Laboratory	Hercules Powder Company	Profit	Navy	FCRC
ANSER	Analytic Services Inc.	Nonprofit	USAF	FCRC, FFRDC
Applied Physics Laboratory	Johns Hopkins University	University	Navy	FCRC, FFRDC
Applied Physics Laboratory	University of Wisconsin	University	Navy	FCRC, FFRDC
Applied Research Laboratory	Pennsylvania State University	University	Navy	FFRDC
Arctic Research Laboratory	University of Alaska	University	Navy	FCRC
Army Mathematics Center	University of Wisconsin	University	Army	FCRC, FFRDC
Arnold Engineering Development Center	ARO, Inc.	Profit	USAF	FCRC
Arroyo Center	RAND Corporation	Nonprofit	Army	FFRDC
Battelle Memorial Institute	Battelle Memorial Institute	Nonprofit	USAF	FCRC
Boston University Physical Research Laboratory	Boston University	University	USAF	
Center for Naval Analyses	Franklin Institute	Nonprofit	Navy	FCRC
Center for Naval Analyses	Franklin Institute	Nonprofit	Navy	FCRC, FFRDC
Center for Naval Analyses	University of Rochester	University	Navy	FFRDC
Center for Naval Analyses	Hudson Institute	Nonprofit	Navy	FFRDC
Center for Research in Social Systems	American University	University	Army	FFRDC
Chicago Midway Laboratories	University of Chicago	University	USAF	
Columbia Radiation Laboratory	Columbia University	University	Army	FCRC

NAME	ADMINISTERED BY	TYPE	SPONSOR	NOTES
Connecticut Aircraft Nuclear Engine Laboratory	Pratt & Whitney Aircraft Division, Profit United Aircraft Corp.		USAF	FCRC
Control Systems Laboratory	University of Illinois	University	Army	FCRC
coordinated Science Laboratory	University of Illinois	University	Army	FCRC
Cornell University Laboratory	Cornell University	University	USAF	FCRC
Cruft Laboratory	Harvard University	University	Army	FCRC
C^3I Division	MITRE Corporation	Nonprofit	USAF	FFRDC
Defense Metals Information Center	Battelle Memorial Institute	Nonprofit	USAF	FCRC
Electromagnetic Compatibility Analysis Center	Illinois Institute of Technology Research	Nonprofit	USAF	FCRC, FFRDC
Electronics Defense Laboratory	Sylvania Electric Products Inc.	Profit	Army	FCRC
Electronic Defense Group	University of Michigan	University	Army	FCRC
Electronic Research Laboratory	Stanford University	University	Army	FCRC
Electronic Research Laboratory	University of California	University	Army	FCRC
Fuels and Lubricants Research Laboratory	Southwest Research Institute	Nonprofit	Army	FCRC
Georgia Nuclear Aircraft Laboratory	Lockheed Aircraft Corporation	Profit	USAF	FCRC
Hartford Research Facility	Pratt & Whitney Aircraft Division, United Aircraft Corporation	Profit	USAF	
Hudson Institute	Hudson Institute	Nonprofit	OSD	FCRC
Hudson Laboratories	Columbia University	University	Navy	FCRC, FFRDC
Human Resource Research Office	George Washington University	University	Army	FCRC, FFRDC
Human Resource Research Office	Human Resource Research Office	Nonprofit	Army	FFRDC
Institute for Advanced Technology	Universities of Texas	University	Army	FFRDC
Institute for Defense Analyses	Institute for Defense Analyses	Nonprofit	OSD	FCRC, FFRDC
IT&T Communication Systems	International Telephone & Telegraph Co.	Profit	USAF	FCRC
Itek Corporation	Itek Corporation	Profit	USAF	FCRC
Jet Propulsion Laboratory	California Institute of Technology	University	Army	
Laboratory for Insulation Research	Massachusetts Institute of Technology	University	Army	FCRC
Laboratory of Insulation Research	Massachusetts Institute of Technology	University	Navy	FCRC
Lincoln Laboratory	Massachusetts Institute of Technology	University	USAF	FCRC, FFRDC
Logistics Management Institute	Logistics Management Institute	Nonprofit	OSD	FCRC, FFRDC
Microwave Research Institute	Polytechnic Institute of Brooklyn	University	Army	FCRC
MIT Instrumentation Laboratory	Massachusetts Institute of Technology	University	USAF	FCRC
MITRE Corporation	Mitre Corporation	Nonprofit	USAF	FCRC, FFRDC
National Defense Research Institute	RAND Corporation	Nonprofit	OSD	FFRDC
Naval Biological Laboratory	University of California	University	Navy	FCRC
Navy Oceanographic Research Laboratory	Woods Hole Oceanographic Institution	University	Navy	

NAME	ADMINISTERED BY	TYPE	SPONSOR	NOTES
Nuclear Aerospace Research Facility	Convair Division, General Dynamics Corp.	Profit	USAF	FCRC
Operations Evaluation Group	Massachusetts Institute of Technology	University	Navy	
Operation Research Group	Massachusetts Institute of Technology	University	Navy	
Operations Research Office	Johns Hopkins University	University	Army	
Ordnance Aerophysics Laboratory	Convair Division, General Dynamics Corp.	Profit	Navy	FCRC
Ordnance Research Laboratory	Pennsylvania State University	University	Navy	FCRC, FFRDC
Physical Research Laboratory	Boston University	University	USAF	FCRC
Prevention of Deterioration Center	National Academy of Science	Nonprofit	Army	FCRC
Project Air Force	RAND Corporation	Nonprofit	USAF	FFRDC
Project Doan Brook	Case Institute of Technology	University	USAF	FCRC
Project Lincoln	Massachusetts Institute of Technology	University	USAF	
Project Michigan	University of Michigan	University	Army	FCRC
RAND Corporation	RAND Corporation	Nonprofit	USAF	FCRC, FFRDC
Research Analyses Corp.	Research Analyses Corp.	Nonprofit	Army	FCRC, FFRDC
Research Laboratory of Electronics	Massachusetts Institute of Technology	University	Army	FCRC
Rocket and Propellent Laboratory	Rohm & Haas, Inc.	Profit	Army	FCRC
Software Engineering Institute	Carnegie Mellon University	University	USAF	FFRDC
Space Technology Laboratory	Thompson Ramo Wooldridge, Inc.	Profit	USAF	FCRC
Special Operations Research Office	American University	University	Army	FCRC
Systems Development Corp.		Nonprofit	USAF	FCRC
Thiokol Project	Thiokol Chemical Corp.	Profit	Army	FCRC
Weapon Systems Evaluation Group	Institute for Defense Analysis	Nonprofit	OSD	FCRC

Abbreviations:
OSD=Office of the Secretary of Defense; USAF=U.S. Air Force..

Appendix D: Ceiling Limits for FFRDCs

D

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
3030 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3030

17 OCT 1994

Honorable Ronald V. Del lures
Chairman, Committee on Armed Services
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

Section 217 of the National Defense Authorization Act for Fiscal Year 1995 requires the submission of the proposed funding and the estimated personnel level for each Federally Funded Research and Development Center (FFRDC) during the current fiscal year, Fiscal Year 1995, not later than 30 days after the date of the enactment of the Authorization Act.

Section 8054(c) of the Department of Defense Appropriations Act for Fiscal Year 1995 limits obligations of the amount available for defense FFRDCs, until the congressional defense committees receive the annual funding ceiling for FY 1995 for each defense FFRDC or significantly unique subcomponent thereof.

The required data is provided in the enclosure.

Sincerely,

Anita K. Jones

Enclosure

cc:
Honorable Floyd D. Spence
Ranking Republican

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
3030 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3030

17 OCT 1994

Honorable Sam Nunn
Chairman, Committee on Armed Services
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

Section 217 of the National Defense Authorization Act for Fiscal Year 1995 requires the submission of the proposed funding and the estimated personnel level for each Federally Funded Research and Development Center (FFRDC) during the current fiscal year, Fiscal Year 1995, not later than 30 days after the date of the enactment of the Authorization Act.

Section 8054(c) of the Department of Defense Appropriations Act for Fiscal Year 1995 limits obligations of the amount available for defense FFRDCs until the congressional defense committees receive the annual funding ceiling for FY 1995 for each defense FFRDC or significantly unique subcomponent thereof.

The required data is provided in the enclosure.

Sincerely,

Anita K. Jones

Enclosure

cc:
Honorable Strom Thurmond
Ranking Republican

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
3030 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3030

17 OCT 1994

Honorable David Obey
Chairman, Committee on Appropriations
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

Section 217 of the Department Defense Authorization Act for Fiscal Year 1995 requires the submission of the proposed funding and the estimated personnel level for each Federally Funded Research and Development Center (FFRDC) during the current fiscal year, Fiscal Year 1995, not later than 30 days after the date of the enactment of the Authorization Act.

Section 8054(c) of the Department of Defense Appropriations Act for Fiscal Year 1995 limits obligations of the amount available for defense FFRDCs until the congressional defense committees receive the annual funding ceiling for FY 1995 for each defense FFRDC or significantly unique subcomponent thereof.

The required data is provided in the enclosure.

Sincerely,

Anita K. Jones

Enclosure

cc:
Honorable Joseph M. McDade
Ranking Republican

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
3030 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3030

17 OCT 94

Honorable Robert C. Byrd
Chairman, Committee on Appropriations
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

Section 217 of the Department of Defense Authorization Act for Fiscal Year 1995 requires the submission of the proposed funding and the estimated personnel level for each Federally Funded Research and Development Center (FFRDC) during the current fiscal year, Fiscal Year 1995, not later than 30 days after the date of the enactment of the Authorization Act.

Section 8054(c) of the Department of Defense Appropriations Act for Fiscal Year 1995 limits obligations of the amount available for defense FFRDCs until the congressional defense committees receive the annual funding ceiling for FY 1995 for each defense FFRDC or significantly unique subcomponent thereof.

The required data is provided in the enclosure.

Sincerely,

Anita K. Jones

Enclosure

cc:
Honorable Mark O. Hatfield
Ranking Republican

Enclosure

FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTERS
FY 1995 DATA

	FY 95 Allocation ($M)	FY 95 Manpower (MTS) Est.
RAND ARROYO CENTER	20.10	95
PROJECT AIR FORCE	24.00	115
NATIONAL DEFENSE RESEARCH INSTITUTE	22.90	112
CENTER FOR NAVAL ANALYSES	45,90	229
INSTITUTE FOR DEFENSE ANALYSES (S&A)	53.60	293
LOGISTICS MANAGEMENT INSTITUTE	27.23	146
TOTAL - Studies and Analyses	**193.73**	**990**
AEROSPACE	335.00	1,893
INSTITUTE FOR DEFENSE ANALYSES (OT&E)	12.92	71
MITRE (C3I)	373.80	2161
TOTAL - Systems Engineering	**721.72**	**4125**
INSTITUTE FOR DEFENSE ANALYSES (C3I)	33.60	144
MIT LINCOLN LABS	274.00	926
SOFTWARE ENGINEERING INSTITUTE	29.60	162
TOTAL - Laboratory	**337.2**	**1232**
TOTAL	**1252.65**	**6347**

Appendix E: Abbreviations

E

AEC	Atomic Energy Commission
ANSER	Analytic Services, Inc.
APL	Applied Physics Laboratories
ARL	Applied Research Laboratory
ARPA	Advanced Research Projects Agency
ASD	Applied Science Division
AWACS	Airborne Warning and Control System
BMEWS	Ballistic Missile Early Warning System
CAA	U.S. Army Concepts Analysis Agency
CDEC	Combat Development Experimentation Center
C^3I	Command, Control, Communications, and Intelligence
CICA	Competition in Contracting Act
CNA	Center for Naval Analyses
COCO	contractor-owned, contractor-operated
CORG	Combat Operations Research Group
CRADA	cooperative research and development agreement
CRESS	Center for Research in Social Systems
DDR&E	Director of Defense Research and Engineering
DEC	Digital Equipment Corporation
DoD	Department of Defense
DOE	Department of Energy
FAA	Federal Aviation Administration
FAR	Federal Acquisition Regulations
FCRC	Federal Contract Research Center
FFRDC	Federally Funded Research and Development Centers
GOCO	government-owned, contractor-operated
GOGO	government-owned, government-operated
GPS	Global Positioning System
HumRRO	Human Resources Research Office
IDA	Institute of Defense Analyses
INS	Institute of Naval Studies
IPR	Institute for Public Research
JPL	Jet Propulsion Laboratory
LMI	Logistics Management Institute
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
NAVWAG	Naval Warfare Analysis Group
NDRC	National Defense Research Committee
NDRI	National Defense Research Institute
NORAD	North American Air Defense Command
NSF	National Science Foundation
OEG	Operations Evaluation Group
OFPP	Office of Federal Procurement Policy
ONR	Office of Naval Research
ORG	Operations Research Group

ORO	Operations Research Office
OSD	Office of the Secretary of Defense
OSRD	Office of Scientific Research and Development
PPBS	Program Planning and Budgeting System
PRC	Planning Research Corporation
RAC	Research Analysis Corporation
RDT&E	Research, Development, Test and Evaluation
SAGE	Semi-Automatic Ground Environment
SDC	Systems Development Corporation
SDI	Strategic Defense Initiative
SDS	Students for a Democratic Society
SEI	Software Engineering Institute
SMEC	Strategic Missiles Evaluation Committee
SORO	Special Operations Research Office
SRI	Stanford Research Institute
STL	Space Technologies Laboratory
STAG	Strategy and Tactics Analysis Group
TAG	Technical Advisory Group
WSED	Weapon Systems Evaluation Division
WSEG	Weapons Systems Evaluation Group

References

1. The Aerospace Corporation, *The Aerospace Corporation, Its Work: 1960-1980* (El Segundo, CA: 1980).
2. The Aerospace Corporation, *Aerospace Origins and Operations* (El Segundo, CA: 1992).
3. The Aerospace Corporation, *The Aerospace Corporation, 1992 Annual Report* (El Segundo, CA: 1993)
4. The Aerospace Corporation, *Space System Risk Management* (El Segundo, CA: 1993).
5. The Aerospace Corporation, *The Aerospace Corporation, Annual Report, 1993* (El Segundo, CA: 1994).
6. The Aerospace Corporation, *The Role of The Aerospace Corporation FFRDC* (El Segundo, CA: 1994).
7. Anger, Thomas E., Vice President and Treasurer, CNA Corporation, Alexandria, VA, letter to Brian McCue, Director of Assessment of Defense Modeling and Simulation, the Office of Technology Assessment, U.S. Congress, Washington, DC, Sept. 27, 1994.
8. The Arroyo Center, *The Arroyo Center Annual Report, Research Year 1993-1994* (Santa Monica, CA: 1994).
9. Bureau of the Budget, *Report to the President on Government Contracting for Research and Development* (Washington, DC: U.S. Government Printing Office, 1962).
10. Burke, Mary V., Division of Science Resource Studies, National Science Foundation, Washington, DC, personal communication, Jan. 11, 1994.
11. Burke, Mary V., Division of Science Resource Studies, National Science Foundation, letter to the Office of Technology Assessment, U.S. Congress, Washington, DC, Sept. 28, 1994.
12. Center for Naval Analyses, *Annual Report 1984* (Alexandria, VA: 1984).
13. Center for Naval Analyses, *A Brief History* (Alexandria, VA: 1993).
14. Clark, Joe, Office of Science and Technology Policy, the Executive Office of the President, memorandum for the file, "GOCO and FFRDC Facilities," Washington, DC, Jan. 22, 1982.
15. Conley, Wayne, Center for Naval Analyses, Alexandria, VA, personal communication, Oct. 31, 1994.
16. Defense Acquisition Regulations Council, "Defense Acquisition Regulation Supplement," 48 CFR ch. 2, subpart 215.9.
17. Department of Defense, "Research and Development Contracting," "Miscellaneous Amendments," FAR, Part 35, Clause 35.017, final regulations 48 CFR ch. 1, "Rules and Regulations," *Federal Register* 55 (24):3883-3886, Feb. 5, 1990. (Also *Federal Acquisition Circular* 84-56.)
18. Dickson, Paul, *Think Tanks* (New York, NY: Atheneum, 1971).

19. Everett, Robert R., President, MITRE Corporation, Bedford, MA, letter to members of the board of trustees, Bedford, MA, Sept. 13, 1976.
20. Foster, John S., Director of Defense Research and Engineering, Office of the Secretary of Defense, Department of Defense, statement on the Federal Contract Research Centers before the Ad Hoc Subcommittee on Research and Development, Senate Committee on Armed Service, U.S. Senate, U.S. Congress, Washington, DC, Apr. 5, 1972.
21. Friedman, Norman W., "Diary Note," Subject: Federally Funded Research and Development Centers and Government-Owned Contractor-Operated facilities, signed note attached to Jan. 22, 1982 letter by Joe Clark, Jan. 12, 1982.
22. Greenstein, Ruth, IDA Executive Offices, Institute for Defense Analyses, "Institute for Defense Analyses Summary of Revenue FY1981 Through FY1994," fax to Christopher Lawrence, Arlington, VA, Nov. 1, 1994.
23. Harris, Scott, Associate Director, Washington Research Department, RAND Corporation, Washington, DC, "How did the Arroyo Center Arrive at RAND?" fax to Christopher Lawrence, Arlington, VA, Feb. 6, 1995.
24. Harris, Scott, Associate Director, Washington Research Department, RAND Corporation, Washington, DC, "Project Air Force, Arroyo Center, National Defense Research Institute Funding Authority," fax to Christopher Lawrence, Arlington, VA, Feb. 8 and 10, 1995.
25. Hawkins, Charles F., Dumfries,VA, "SOROns, OROns and RACoids: An Assessment, The Elusive Audit Trail of Intellectual Property of Federally Funded Operations Research Centers," unpublished paper prepared for the Office of Technology Assessment, U.S. Congress, 1993).
26. Hawkins, Charles F., Dumfries,VA, "Additional SORO/CRESS Detail," unpublished paper prepared for the Office of Technology Assessment, U.S. Congress, Washington, DC, Nov. 24, 1993.
27. Herken, Gregg, *Counsels of War* (New York, NY: Oxford University Press, 1987).
28. Hostetler, James S., attorney, Kirkland and Ellis, "Federally Funded Research and Development Centers, A Proper Role in the 1990s," a position paper prepared for the Professional Services Council trade association, July 24, 1990.
29. Institute for Defense Analyses, *Institute for Defense Analyses, Annual Report 1992* (Alexandria, VA: 1992).
30. Jones, Anita K., Director of Defense Research and Engineering, Office of the Director of Defense Research and Engineering, Office of the Secretary of Defense, Department of Defense, letter to John Warner, Senator, U.S. Congress, Washington, DC, June 23, 1994.
31. Jones, Anita K., Director of Defense Research and Engineering, Office of the Secretary of Defense, Department of Defense, series of letters discussing FFRDC FY 1995 funding ceilings to Ronald V. Dellums, Chairman, Committee on Armed Services, House of Representatives; David Obey, Chairman, Committee on Appropriations, House of Representatives; Sam Nunn, Chairman, Committee on Armed Services, Senate; and Robert C. Byrd, Chairman, Committee on Appropriations, Senate; U.S. Congress, Washington, DC, Oct. 17, 1994.
32. Lawrence, William A., retired colonel, formerly assigned to U.S. Army Concepts Analysis Agency, Bethesda, MD, personal communication, Feb. 1994.
33. Logistics Management Institute, *Logistics Management Institute, 1992 Annual Report* (Bethesda, MD: 1992).
34. Logistics Management Institute, "Logistics Management Institute," Bethesda, MD, ca. 1993.
35. Logistics Management Institute, *Logistics Management Institute, Nineteen Ninety Three Annual Report* (McLean, VA: 1993).
36. McFalls, Maureen D., Manager, Government Communication, Software Engineering Institute, letter to Brian McCue, Director of Assessment of Defense Modeling and Simulation, Office of Technology Assessment, U.S. Congress, Oct. 7, 1994.
37. McFalls, Maureen D., Manager, Government Communication, Software Engineering Institute, letter to Brian McCue, Director of Assessment of Defense Modeling and Simulation, Office of Technology Assessment, U.S. Congress, Nov. 7, 1994.
38. MIT Lincoln Laboratory, *Selected Technologies Transferred from MIT Lincoln Laboratory* (Lexington, MA: April 1992).

39. MIT Lincoln Laboratory, *Technology Transfer*, vol. I, (Lexington, MA: May 1990) and Technology Transfer, vol. II, (Lexington, MA: April 1992).
40. MIT Lincoln Laboratory, *Lincoln Laboratory, Massachusetts Institute of Technology* (Lexington, MA: ca. 1993).
41. MIT Lincoln Laboratory, *Spin-off Companies from MIT Lincoln Laboratory* (Lexington, MA: April 1993).
42. MIT Lincoln Laboratory, "A Description of the MIT Lincoln Laboratory," unpublished paper, Lexington, MA, Feb. 8, 1994.
43. MITRE Corporation, *MITRE, The First Twenty Years, A History of the MITRE Corporation 1958-1978*, (Bedford, MA: 1979).
44. MITRE Corporation, *The MITRE Corporation, Challenge and Response, 1958-1988* (Bedford, MA and McLean, VA: ca. 1989).
45. MITRE Corporation, "The MITRE Corporation," Bedford, MA and McLean, VA, December 1992.
46. MITRE Corporation, *The MITRE Corporation, 1992 Annual Report* (Bedford, MA and McLean, VA: January 1993).
47. MITRE Corporation, *The MITRE Corporation, 1994 Annual Report* (Bedford, MA and McLean, VA: 1995).
48. National Defense Research Institute, *Annual Report, Fiscal Year 1992* (Santa Monica, CA: RAND, 1993).
49. National Science Foundation, "Federally Funded Research and Development Centers," unpublished and incomplete draft background report, Washington, DC, 1968.
50. National Science Foundation, *Directory of Federal R&D Installations, for the Year Ending June 30, 1969* (Washington, DC: 1970).
51. National Science Foundation, "Sponsoring Institutions of Consortia Administering Federally Funded Research and Development Centers," a hand-corrected draft list from the National Science Foundation files provided by Mary V. Burke, keeper of the list, National Science Foundation, Jan. 27, 1977.
52. National Science Foundation, *Federal Funds for Science, Federal Funds for Research, Development, and Other Scientific Activities*, and *Federal Funds for Research and Development*, vols. I through XLII. This is an annual publication originally published under the title *Federal Funds for Science*. (Washington, DC: 1952 through 1994).
53. National Science Foundation, *Master Government List of Federally Funded Research and Development Centers, Fiscal Year 1995*, (Arlington, VA: National Science Foundation, 1994).
54. Newhart, Robert L., Director of Research and Studies, Office of the Deputy Undersecretary of Defense (Logistics), Office of the Secretary of Defense, Department of Defense, Washington, DC, "Memorandum to Mr. R. Newhart," Nov. 15, 1994, fax to Christopher Lawrence, Arlington, VA, Nov. 17, 1994.
55. Office of the Director of Defense Research and Engineering, Office of the Secretary of Defense, Department of Defense, *Report of the Defense Science Board Task Force on Federal Contract Research Center Utilization* (Washington, DC: February 1976).
56. Office of the Director of Defense Research and Engineering, Office of the Secretary of Defense, Department of Defense, *Management of the Federal Contract Research Centers* (Washington, DC: Department of Defense, June 1976).
57. Pay, Rex G., Assistant to the Executive Vice President, The Aerospace Corporation, letter to Brian McCue, Director of Assessment of Defense Modeling and Simulation, Office of Technology Assessment, U.S. Congress, Washington, DC, Nov. 7, 1994.
58. President's Council of Economic Advisors, *Economic Report of the President, Transmitted to the Congress, February 1994* (Washington, DC: U.S. Government Printing Office, 1994).
59. RAND Corporation, *The RAND Corporation, the First Fifteen Years* (Santa Monica, CA: 1963).
60. RAND Corporation, *RAND, 25th Anniversary Volume* (Santa Monica, CA: 1974).
61. RAND Corporation, The RAND Corporation, 40th Year (Santa Monica, CA: 1989).
62. RAND Corporation, *RAND, 1991-1992* (Santa Monica, CA: ca. 1992).
63. RAND Corporation, *Facts About RAND* (Santa Monica, CA: 1994).
64. RAND Corporation, *RAND 1993 Annual Report* (Santa Monica, CA: 1994).

65. Rodgers, Gary, Center for Naval Analyses, Alexandria, VA, personal communication, October 1994.
66. Rumbaugh, Lynn H. *A Look at U.S. Army Operations Research—Past* (McLean, VA: Research Analysis Corporation, technical paper RAC-TP-102, April 1964).
67. Sharfman, Peter, Director of Policy Analysis, the MITRE Corporation, McLean, VA, personal communication, Apr. 13, 1995.
68. Smith, Bruce L. R., *The RAND Corporation, Case Study of a Nonprofit Advisory Corporation* (Cambridge, MA: Harvard University Press, 1966).
69. Software Engineering Institute, "SEI Contributions" (Pittsburg, PA: February 1993).
70. Software Engineering Institute, "Software Engineering Institute" (Pittsburg, PA: August 1993).
71. Software Engineering Institute, Software Engineering Institute charter, signed by the Director of Advanced Research Projects Agency, Arlington, VA, May 11, 1994.
72. Software Engineering Institute, "Strategic Context," chapter 1 of undated, unpublished working document, *Draft SEI Program Plans: 1994-1998*, Document No. CMU/SEI-93-SR-19 (Pittsburg,PA: undated) fax to Christopher Lawrence, Arlington, VA, Feb. 15, 1994.
73. Sowle, Donald E., Office of Federal Procurement Policy, Office of Management and Budget, the Executive Office of the President, Washington, DC, "OFPP Policy Letter 84-1 to the Heads of Executive Departments and Establishments, Subject: Federally Funded Research and Development Centers," letter, April 4, 1984. Registered in *Federal Register*, 49(71), Apr. 11, 1984.
74. Sudbury, Roger W., Assistant to the Director, Lincoln Laboratory, Lexington, MA, personal communication, November 1994.
75. Sudbury, Roger W., Assistant to the Director, Lincoln Laboratory, Lexington, MA, letter to Brian McCue, Director of Assessment of Defense Modeling and Simulation, Office of Technology Assessment, U.S. Congress, Washington, DC, Nov. 8, 1994.
76. Sudbury, Roger W., Assistant to the Director, Lincoln Laboratory, Lexington, MA, letter to Brian McCue, Director of Assessment of Defense Modeling and Simulation, Office of Technology Assessment, U.S. Congress, Washington, DC, Jan. 26, 1995.
77. Thompson, Charles A. H., *The Research Analysis Corporation, A History of a Federal Contract Research Center* (McLean, VA: Research Analysis Corporation, 1975).
78. Tidman, Keith R., *The Operations Evaluation Group* (Annapolis, MD: The Naval Institute Press, 1984).
79. U.S. Army Concepts Analysis Agency, *Annual Historical Summary RCS CSHIS-6 (R2). US Army Strategy and Tactic Analysis Group, 1 July 1972 to 15 January 1973* (Bethesda, MD).
80. U.S. Army Concepts Analysis Agency, *Annual Historical Summary (RCS CSHIS-6 (R-2)) US Army Concepts Analysis Agency, 1 July 1973 to 30 June 1974* (Bethesda, MD).
81. U.S. Army Special Operations Research Office, "Special Operations Research Office," unpublished background paper located in the U.S. Army's Office of the Chief of Military History Library, Arlington, VA, Mar. 1, 1962.
82. U.S. Congress, General Accounting Office, *Competition: Issues in Establishing and Using Federally Funded Research and Development Centers* (Washington, DC: 1988).
83. U.S. Congress, Office of Technology Assessment, unpublished database, FFRDC.R2D, created primarily from National Science Foundation reports, provided by Christopher A. Lawrence, Arlington, VA, 1994.
84. U.S Congress, Office of Technology Assessment, *Virtual Reality and Technologies for Combat Simulation—Background Paper*, OTA-BP-ISS-136 (Washington, DC: U.S. Government Printing Office, September 1994).
85. Walsh, John, "Pentagon Papers: Repercussions for RAND and Other Think Tanks?" *Science*, 173:313-314, 1971.
86. Whitley, Howard, Chief of Tactical Analysis Division, U.S. Army Concepts Analysis Agency, and a member of the Board of Directors of the Military Operations Research Society, Bethesda, MD, personal communication, February 1994.
87. Yahraes, Herbert, "The Mysterious Mission of ORO," *The Saturday Evening Post*, 224(34):36, 37, 75, 77, 80, 82, Feb. 23, 1952.