Report of the Defense Science Board Task Force on the Technology Capabilities of Non-DoD Providers

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WASHINGTON, DC 20301-3140

DEFENSE SCIENCE BOARD

JUN 21 2000

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION, TECHNOLOGY, AND LOGISTICS)

SUBJECT: Report of the Defense Science Board (DSB) Task Force on the Technology Capabilities of Non-DoD Providers

I am pleased to forward the final report of the DSB Task Force on the Technology Capabilities of Non-DoD Providers. The Task Force was asked to support the Department's in-house study by an examination of non-DoD providers capability to provide warfighting technology, engineering, and test capabilities for future U.S. military forces.

Over the last two decades commercial science and technology capabilities have greatly expanded in the secure environment created by our military forces. Once a leader in technology development, the Department now finds itself increasingly reliant on this global private sector to provide critical new capabilities. In addition, the decade of Defense downsizing and use of outdated procurement processes have created market conditions such that portions of the private sector are no long willing to contract with DoD. The task force identified the utilization constraints and process issues with using non-DoD providers to supply critical military capabilities, as well as, made recommendations for the Department to effectively utilize the growing capabilities of private sector organizations.

I concur with their conclusions and recommend you forward the report to the Secretary of Defense.

Craig I. Fields
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
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WASHINGTON, DC 20301-3140

DEFENSE SCIENCE
BOARD

June 2, 2000

MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board Task Force on Capabilities of Non-DoD Providers

Attached is the report of the Defense Science Board Task Force on the Capabilities of Non-DoD Providers of Science and Technology, Systems Engineering and Test and Evaluation. This Study was requested by the Under Secretary of Defense (AT&L) in the Fall of 1998. The Terms of Reference directed that the Task Force make recommendations on :

- Non-DoD sources of Science and Technology and Systems Engineering
- Processes for out-sourcing of Science and Technology and System Engineering

Investigation of non-DoD sources of Test and Evaluation was not pursued because of the formation of a separate D.S.B. Task Force on that topic.

The recommendations of the Task Force can be summarized as:

- Under Secretary of Defense (AT&L) should establish an Office of Global Technology Acquisition.
- Secretary of Defense should direct the Service Acquisition Executives to increase to 50% the portion of Service R&D management and laboratory staff provided by the private sector, e.g., universities, industries, non-profits.
- Under Secretary of Defense (AT&L) should direct the Services to increase S&T funding of university defense related research by 30%.
- Secretary of Defense and the Chairman of the JCS should initiate a high level "Packard" Commission to develop and integrated requirements - acquisition process.

The Task Force believes that the implementation of these recommendations are important in bringing the extensive capabilities and experience of the private sector into the process of insuring the future military superiority of U.S. military forces in the 21st century.

The Task Force would like to express its appreciation for the extensive support provided by the OSD staff particularly Dr. Chuck Kimzey. I would also like to thank the other members of the Task Force for their very helpful contributions and advice.

Yours truly,

Walter E. Morrow

Walter E. Morrow, Jr.

Task Force Report Dedicated in Memory of

James M. Hurd

1948-2000

Co-founder Planar Systems

Beaverton, Oregon

EXECUTIVE SUMMARY

Introduction

In the years since WWII, the global private sector has come to dominate the development of technology and the manufacturing capabilities for a number of technologies of critical importance to the Defense Department and the Military Services. Examples include information systems, propulsion systems such as gas turbines and logistics systems.

In addition, the Department recently has been forced to reduce both its military forces and its civilian personnel because of funding reductions. This has led to a need for greater dependence on the private sector.

As a result, the Under Secretary of Defense asked the Defense Science Board to establish a Task Force devoted to an examination of private sector sources of technology, acquisition support and test and evaluation as well as processes for obtaining private sector support.

Such a Task Force was initiated in the winter of 1998-99 under the chairmanship of Mr. Walter Morrow. The findings and recommendations of this Task Force are contained in this report.

Background

Over the last two decades, global science and technology development expanded greatly compared to that pursued internally by the Department. As a result, the Department and the Military Services have turned increasingly to the private sector for the development of important new capabilities such as nuclear weapons and power systems, advanced radars, digital computer systems and space and missile systems.

Also in the decades following WWII, the federal government expanded its procurement regulations (Federal Procurement Regulations, F.A.R.) by more than tenfold, to the point where considerable portions of the private sector are no longer willing to contract with the Defense Department for defense technology development and manufacturing.

Finally, as defense funding declined in the decade of the 90s, the Department and the services were forced to more than proportionally reduce the size of U.S. military forces because the size of its base structure and its civilian acquisition forces could not be reduced in proportion due to political constraints.

As a result of these developments, the Congress requested, in the FY98 National Defense Authorization Act, Section 912, that the Department prepare a plan to streamline and improve the science, technology and acquisition organizations within the Department. This DSB Task Force was established in support of that DoD plan.

Non-DoD Providers

The Task Force examined the quality and availability of a number of different classes of private sector organizations. Included were:

- Universities
- University Affiliated Research Centers (UARCs), and Federally Funded Research and Development Centers (FFRDCs) and National Laboratories
- Non-Profit organizations
- Other government agency laboratories
- Defense industries
- Non-defense industries

Members of the Task Force had familiarity with these classes of private sector organizations. In addition to visits to representative private sources, a survey was made of which classes of organizations had significant representation as members of the National Science and Engineering Academies as well as in professional engineering societies. These surveys together with publication records indicated that universities and their affiliated laboratories represented a very strong source of talent for scientific research and technology development. Certain non-defense industrial research laboratories also have very significant professional strength. The representation of non-DoD government research centers was substantially less. The DoD laboratories and centers had the least of all representation with several notable exceptions.

It was discovered, however, that there are a number of constraints on the utilization of these non DOD organizations:

- Utilization of universities is limited by substantial reductions of 6.1 basic research funding over the past ten years.
- Utilization of university affiliated research centers and FFRDCs is severely constrained by Congressional limitations on total professional staffs.
- Utilization of other government laboratories is often limited by their sponsoring agencies to topics central to their missions.
- Utilization of non defense industrial laboratories and development organizations is often limited by such organization's lack of willingness to divert their very best talent from their core commercial programs as well as a lack of willingness to be subject to the onerous terms of the Federal Acquisition Regulations .
- Defense industry continues to be open to providing S&T and acquisition support to DoD, but in the process of the recent mergers, large portions of this industry's research and development capabilities have been disbanded. S&T and Systems Engineering support to the DoD is also limited by conflicts of interest should the firms also want to bid on production programs.

In spite of these difficulties, universities, their affiliated laboratories, and non defense industry organizations continue to offer superior sources of professional expertise for the

DoD S&T and acquisition programs. This is also true in the case of foreign organizations which are free of Congressionally mandated F.A.R. and other regulations. However, it is recognized that there are security issues involved in the utilization of foreign organizations to provide support for U.S. defense needs.

Process Issues

Several aspects of DoD current processes for dealing with non DoD sources of scientific and engineering support make it difficult for the Department and the Services to access private sector scientific and engineering capabilities. Principal among these are the following:

- The current Federal Acquisition Regulations have grown in complexity and intrusiveness to the point that many non DoD industries are unwilling to take a government contract because of the requirements for separate accounting systems, limitations on profits, insistence on social clauses, and occasionally demands for access to intellectual property. In the case of many prime contracts, these regulations also apply to second and even third tier subcontractors.
- In more recent times, some exclusions from these regulations have been allowed on an experimental basis but the great majority of the contracts remain under the F.A.R.
- In recent years, the Department and the Services have attempted to emulate the private sector Integrated Product Team approach to new system definition. Unfortunately, it has not been possible for DoD to reproduce a number of aspects of the private sector teams. In particular, private sector teams typically use:
  - Small teams of the order of dozen members - DoD teams tend to involve large numbers of participants many of whom are not empowered to commit to design decisions.
  - Inclusion on the teams of all concerned parties such as marketing (users), research, development, manufacturing, subcontractors, cost analysts, financial investments and logistical support - The DoD teams often are lacking representation by the actual users and especially manufacturing experts and related cost experts.
  - Complete information on the global state of component technology and availability - The DoD teams often know only the technology state of U.S. defense contractors and their primary subcontractors.

The result of these differences is that DoD and Service systems commonly have development difficulties resulting in development cost overruns. But even more serious are resulting production costs which usually exceed initial estimates by very significant amounts, thus leading to large reductions in the number of units than can be accommodated in the budget. The result of these miscalculations is an inevitable reduction in U.S. combat power.

Recommendations

As a result of the findings summarized above, the Task Force focused on the following recommendations as being most helpful in enabling the Department to better access the extensive and very proficient private sector science, technology development and engineering support capabilities:

A. Under Secretary of Defense (AT&L) Establish the Office of Global Technology Acquisition

This office would focus on:

- Militarily important technologies where industry leads such as: communications, computers, networking, robotics.
- Potentially "disruptive" new technologies
- Novel approaches to acquire technology
- Commercial contracting / licensing practices

The office would be funded with not less than $100 Million per year.

B. The Secretary of Defense Direct the Services to Increase to 50% the Portion of Their In-House S&T Management and Laboratory Staff Contracted from the Private Sector

This recommendation would make it possible for the Service S&T and Acquisition organizations to have access to high quality staff which they cannot now attract through the Civil Service System. These new staff would be acquired as retirements and resignations occurred from the civil service professional staff.

C. Under Secretary of Defense (AT&L) Direct the Services to Increase S&T Funding of DoD-Relevant University Research by 30%

A 30% increase is judged necessary to counter the increasingly short term focus of industrial R&D relating to DoD interests. It would also address shortfalls in technical talent of importance to DoD.

D. The Secretary of Defense and the Chairman of the JCS Initiate a High Level "Packard-Like" Commission to Develop an Integrated Requirements / Acquisition Process

The aim of this commission would be to insure that trade-offs are performed between the military requirements and available technology and manufacturing capabilities as well as costs. The goal would be to emulate industry's best practices in generating products that meet market needs at affordable costs.

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A. Motivation

During World War II, a large defense focused research development and manufacturing base was brought into being. This base consisted of a combination of government, academic related, and industrial organizations. During the Cold War these establishments continued to serve the nation but the commercial and academic sectors came to generate more and more of the advanced technology base during these years.

Since the end of the Cold War, these trends have accelerated especially with the decrease in defense funding. As a result of these changes, the Congress directed in Section 912 of the FY98 National Defense Authorization Act that the DoD submit an implementation plan to streamline and improve the Department's technology and acquisition capabilities.

B. Terms of Reference

As a result, the Under Secretary of Defense asked the Defense Science Board to organize a Task Force to examine the possibilities of non-DoD organizations to provide increasing levels of support to the DoD research and acquisition efforts as well as to examine the processes used by the Department to acquire these capabilities from the private sector. The Terms of Reference for this Task Force are included as Appendix A.

C. Membership

The Task Force was organized under the Chairmanship of Mr. Walter Morrow, MIT Lincoln Laboratory, with the following members:

Members:	Dr. Marc Durcan - Micron Technology
	Mr. Stanley Ebner - Boeing Co. (ret.)
	Mr. James Hurd - Planar Systems
	Prof. Kazuhiko Kawamura - Vanderbilt University
	Mr. Thomas Moore - Daimler-Chrysler
	Dr. Andrew Pettifor - Rockwell
	Dr. Raymond Leopold - Motorola
	Gen Bernard Randolph, USAF (ret.) - TRW
	Dr. Robert Selden - Los Alamos National Lab (ret.)
	Dr. Gary Smith - Applied Physics Lab, JH Univ
Exec Secretary:	Dr. Charles Kimzey - Defense Research & Engineering
DSB Secretariats:	LTC Don Burnett – USA, LTC Scott McPheeters - USA
Support Contractors:	Institute for Defense Analyses
	Dr. Richard Van Atta, Dr. Jack Nunn, Dr. David Louscher

D. Information Gathering

The Task Force held its initial meeting in January 1999. Over the following ten months it held eight additional meetings. The Task Force received briefings from Government and industry personnel and visited a number of facilities around the country. The following List of Meetings indicates the dates and locations of the meetings:

15 January 1999, IDA, Alexandria, VA

19 February 1999, IDA, Alexandria, VA

19 March 1999, Motorola, Phoenix, AZ

16 April 1999, TRW, Los Angeles, CA

17-18 May 1999, Sandia National Laboratory, Albuquerque, NM and Los Alamos National Laboratory, Los Alamos, NM

17-18 June 1999, Boeing Corporation, Seattle, WA

24 August 1999, MIT Lincoln Laboratory, Boston, MA

16-17 September 1999, IDA, Alexandria, VA

21-22 October 1999, IDA, Alexandria, VA

18-19 November 1999, IDA, Alexandria, VA

Complete agendas for each of the meetings are included as Appendix B. At each of these meetings, the Task Force members received briefings from Government and industry representatives. These briefings were extremely useful in assisting the Task Force in understanding the expected S&T, Systems Engineering and T&E needs of the Government; the capabilities of both DoD and Non-DoD providers to meet those needs; and the process for sourcing such capabilities from outside organizations.

A Task Force briefing was provided to Dr. Jacques S. Gansler on 13 December 1999. A copy of the briefing slides is at Appendix C. The report follows the outline of the briefing.

Section II of the report provides a brief background of the problem and a discussion of the DoD technology and acquisition base. Section III provides information on Non-DoD sources of S&T, Systems Engineering and T&E. Because there was a major report on T&E being released during the period in which this Task Force was operating, the Task Force decided to minimize its examination of T&E issues. Section IV discusses process issues. Section V summarizes the Task Force findings. Section VI presents the Task Force recommendations.

II. BACKGROUND

A. Prior Development of DoD's S&T and Systems Engineering Capabilities

One of the legacies of America's mobilization to fight World War II and its subsequent Cold-War containment of the Soviet Union, was a large defense technology and industrial base. Part of this base is owned and operated by the Government. These Government-owned/Government-operated (GOGO) facilities are now principally oriented toward conducting defense (and Service) specific research, production of specialized military systems that have no counterpart in the civilian sector, the testing of military systems, and the repair and maintenance of existing military systems. Another major portion of the base is owned by the Government, but operated by commercial contractors. These

Government-Owned/Contractor-Operated (GOCO) facilities are also principally oriented toward defense specific activities, but they often involve activities in which the U.S. defense establishment needed special expertise, or they resulted from the Government moving away from GOGO structure to a GOCO structure. A third element of the defense technology and industrial base is the privately owned and privately operated facilities at universities and commercial industrial organizations. Currently, this latter sector is by far the largest element of the overall base.[1]

Beginning in the Eisenhower Administration, many of the GOGO facilities were closed or sold. However, a relatively large DoD public sector has remained into the 1990s. Indeed, while the DoD relies primarily on private industry to support defense production, it is U.S. Government policy, based on the Defense Industrial Reserve Act (50 U.S.C. 451), to maintain "a minimum essential nucleus (industrial reserve) of government-owned plants and equipment to be used in an emergency."[2]

With the end of the Cold War there was renewed interest in reducing the size of this government owned element of the base. A number of internal and external studies have examined various portions of the technology and industrial base and made recommendations for change.[3] Concerns over the nature and speed of change and the capabilities of the resulting base continue. To aid the DoD in making decisions about these complex issues, this DSB Task Force on Technology Capabilities of Non-DoD Providers was established and asked to examine the ability of non-DoD suppliers to provide warfighting technology, engineering, and test capabilities needed for future U.S. military forces. The Task Force was subsequently also asked to make recommendations as to how the DoD should acquire technology applicable to new and upgraded product development, specifically addressing science and technology, systems engineering, and test and evaluation.[4] A copy of the Terms of Reference is included as Appendix A.

B. Transformation of the Defense S&T and Acquisition Environments

The Department of Defense is in the midst of a "Revolution in Business Affairs" to complement it's "Revolution in Military Affairs" (RMA). DoD has set out to transform its acquisition process for achieving affordable military capabilities that meet military requirements in a security arena that is both vastly different from that it prepared for a decade ago, and which is still rapidly evolving. There have been three inter-related fundamental shifts that DoD must accommodate in addressing this new environment—

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[1] U.S. Congress, Office of Technology Assessment, *Redesigning Defense: Planning the Transition to the Future U.S. Defense Industrial Base,* (Washington, DC: U.S. Government Printing Office, July 1991), pp. 39-61.
[2] *Ibid.*
[3] These include major DoD studies such as the Joint Logistics Commanders *Depot Maintenance Consolidation Study*, the DoD *Test and Evaluation Study*; Service reports such as the Army's *Vision 2000 Report*, and other reports such as the Defense Science Board's Task Force on *Defense Science and Technology Base for the 21st Century* Report.
[4] Jacques S. Gansler, USDA&T, Memorandum for Chairman, Defense Science Board, Subject: Terms of Reference – Defense Science Board Task Force on Technology Capabilities on Non-DoD Providers, 12 March 1999.

national security, economic, and technological. What has been termed the RMA is directed primarily at the fundamental shift in the global security arena and the transformed role it implies for the United States. The "Revolution in Business Affairs" (RBA) is directed mainly at the latter two.

In the economic arena the primary changes are [1] the transformation of national economies into a global economy, and [2] the diminishing size of the defense sector as a fraction of the economy, and the increasing importance of "affordability" in defense as budgets become more constrained and systems become more complex. The globalization of the economy is related to technological dynamics, especially in information technology, which have reduced the significance of national borders in defining economic activity. The diminished size and importance of the defense sector is related to the fundamental shift in the security environment caused by the collapse of the Soviet Union, and also the economic constraints of sustaining high defense budgets.

These major changes have led to focused efforts to change the way the Department of Defense develops and acquires its capabilities. Shrinking budgets, even with the changed security environment, have required DoD to seek more affordable weapons systems. The DoD focus on the "Revolution in Military Affairs" has placed increasing emphasis on information technologies, which in turn have become driven increasingly by commercial industry. As DoD has invested in many technology areas, such as flat panel displays and microelectronics, it has found that military-specific approaches are increasingly difficult and costly. Moreover, DoD's investments are often of short-lived value, as commercial industry is able to develop and create successive generations of products in the technology much more rapidly than can DoD-sponsored efforts.

On an economic basis, commercial industry is generally disinterested in developing products for DoD, as the opportunity costs are too great, and the cost of doing business too high, with poor returns as a result of either market size or profit restrictions. Defense-unique providers at the sub-system and component levels are finding it increasingly difficult to stay up with the latest technology developments or to meet development cost and production cost targets, as their sales volumes are too small to amortize these costs, even though their prices often are several multiples of those for similar but usually less specialized commercial products. Moreover they find it difficult to justify the increased overhead costs from the beed to comply with government acquisition regulations. In the mean time, prime contractors and systems program offices are pressuring their suppliers to reduce their costs substantially to meet affordability requirements, decreasing the prospects of economic viability for defense-unique sub-system providers.

C. Transformation of Commercial Industry

Firms in commercial industry have responded to major changes over the last decade as well. Economic globalization and technological developments have altered business approaches to developing products and sourcing components, subsystems, and processes. The number and types of cross-company relationships—within nations and across borders—have grown significantly. Firms have become focused on providing total quality of product and service with decreasing product cycle times. With global competitors accessing markets worldwide, competitive pressures are increasingly intense. As businesses, especially in high tech arenas, face higher costs of production facilities and technology development, they are seeking partners. These relationships occur amongst suppliers and integrators, and also as consortia or joint ventures of erstwhile competitors. Outsourcing of subsystems, components, and even product development and production has become increasingly prevalent. The production of laptop computers is a good example of outsourcing trends.

These competitive pressures have made businesses much more conscious of how they expend their resources across the whole range of product and process development including R&D. Firms are seeking to identify their core competencies and strategic advantages or enablers in which they must continue to excel in order to maintain world class capabilities. They also seek efficiency in the resource allocation by not investing in or conducting activities in which they are not world leaders—outsourcing these to others.

Large-scale advanced, long-term, generic research has become less attractive in this business environment. Firms have cut back substantially on funding long term unfocused corporate research and are focusing and narrowing the research they do—both focusing more on near term development and restricting the scope to more targeted technology areas.

D. Implications of These Changes in the Environment

The changes in the last decade of the international security situation, science and technology development, the acquisition system and, the international business situation all lead to a need to examine the future of the DoD's S&T efforts as well as its acquisition system.

In the international security area, the threats to the U.S. have diminished greatly since the end of the Cold War and the subsequent decline of Russian military capabilities. Countering this has been the need for the U.S. to become involved in a variety of overseas deterrence and policing actions which in their aggregate have stressed the capabilities of the U.S. military. Of particular concern is the growing capability of rogue nations to threaten neighboring allies of the U.S. and even in the coming decade to possibly threaten the continental U.S. as well.

The implication of these trends leads to the need for the U.S. to be able to quickly project dominant military forces to overseas trouble spots. In addition, the U.S. also needs to be able to protect itself from ballistic missile attacks from rogue nations involving weapons of mass destruction.

In the science and technology area the DoD no longer dominates as it did after WWII (see Figure 1). Today, the vast majority of S&T is performed by the civil sector with much of it being performed over seas. It should be noted that the overseas component shown in

Figure 1 is rising rapidly and does not include China and Russia. Potential enemies have essentially equal access to the latest commercial technology developments.

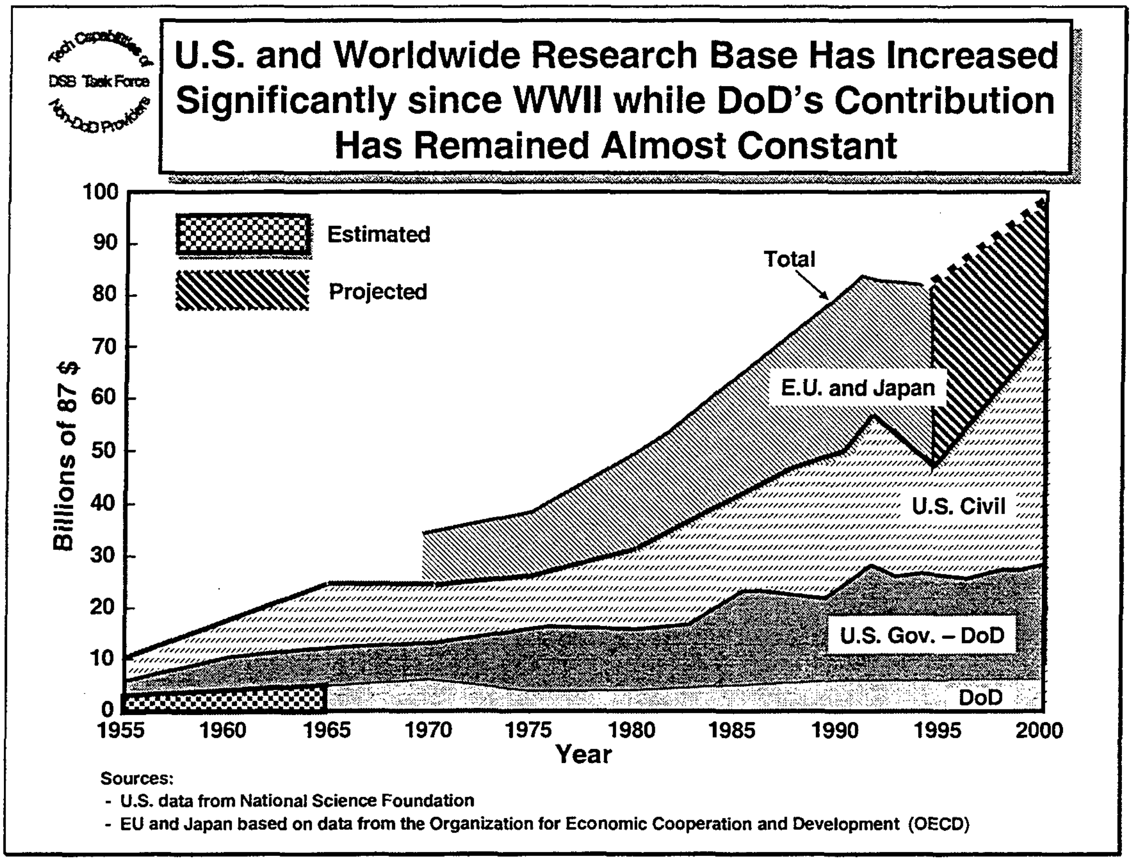

Figure 1. Worldwide research funding.

To counter these developments, the U.S. needs to be able to be knowledgeable about these science and technology developments and their implications for military capabilities. However, there are a number of technologies which are important only to military capabilities. In these specialized areas the DoD needs to be the dominant leader and to protect that leadership by strong security programs.

While worldwide industries have become dominant in total research and development, their research focus typically is very short term; of the order of three to five years, especially in the last decade.

In the system and product acquisition area, the commercial sector has moved well ahead of DoD and its defense contractors in terms of the cost and time to develop new capabilities. This is a serious problem in that the long DoD development times often lead to the use of obsolete technology when the systems are finally deployed.

To overcome this problem, the DoD and the services will have to adopt new acquisition practices based on commercial outsourcing and rapid engineering techniques.

E. The 912 Study

Section 912 of the National Defense Authorization Act for Fiscal Year 1998, directed the DoD to submit an implementation plan to streamline and improve acquisition organizations within the Department. The Secretary of Defense was directed to conduct a review of the organizations and functions of DoD acquisition activities and personnel with specific attention to opportunities for cross-service arrangements among the Services, areas of overlap, duplication and redundancy, and opportunities to further streamline the acquisition process. A full text of Section 912 is included as Appendix D.

More recently, Section 907 of the National Defense Authorization Act of Fiscal Year 1999 directed the Secretary of Defense to analyze the structures and processes of the Department of Defense for management of its laboratories and test and evaluation centers and to develop a plan for improving the management of these laboratories and centers. A full text of Section 907 is at Appendix E.

This DSB Task Force has been tasked to examine the possibilities of Non-DoD organizations to provide support to the DoD S&T, systems engineering, and test and evaluation efforts. These potential non-DoD sources include:

- Other U.S. government sources, such as: DOE, NASA, NIH, NSF, etc.
- Private industrial organizations, both defense and non-defense
- Academic research laboratories
- Non-Profit organizations, including University Affiliated Research Centers (UARCS), Federally Funded Research & Development Centers (FFRDCs), and DOE National Laboratories

The Task Force has also been asked to examine the process used to acquire S&T, Systems Engineering support and Test and Evaluation. It was to examine industry best practices on make-or-buy sourcing decisions in S&T, systems engineering and test and evaluation, and to make recommendations for any necessary improvements in current government practices.

F. Current Structure and Status of the Supporting Base

The Department of Defense currently uses both in-house and external capabilities to meet its S&T, Systems Engineering, and T&E needs. The DoD organization conducting the review of the RDT&E Infrastructure for the Section 912 report, developed specific definitions for DoD facilities that conducted S&T, engineering and T&E.[5] The definition of a laboratory is:

...any DoD activity that performs one or more of the following functions: science and technology, engineering development, systems engineering, and engineering support of deployed material and its modernization. Each Service and DoD agency organizes differently for such functions, but the term embraces laboratories; research institutions; and research, development, engineering, and technical activities.

The definition of a Test and Evaluation Center is:

> Any facility or capability that will be used for data collection; and will be DoD-owned or DoD-controlled property (air/land/sea or space) or any collection of equipment, platforms, automated data processing equipment, or instrumentation that conducts a T&E operation and provides a deliverable T&E product.

The Report lists 30 Army laboratories, 38 Navy laboratories, and 17 Air Force laboratories. It lists 12 Army T&E Centers, 18 Navy T&E Centers, and 7 Air Force T&E Centers. There are also 9 additional T&E Centers belonging to other DoD agencies and organizations. A list of all these facilities is at Appendix F.

The Defense Budget categories covered by the DSB Task Force Terms of Reference (S&T, Systems Engineering, and T&E) include 6.1, 6.2, 6.3, 6.4, 6.5, 6.6. The total funds obligated for these categories for FY98-FY00 are shown in Table 1.

Table 1[6]
DoD Acquisition Funding (FY1998-2000)

	FY98	FY99	FY00
6.1	1,011,935	1,107,943	1,113,151
6.2	2,910,319	3,150,745	2,959,014
6.3	3,789,993	3,532,392	3,314,086
Systems Engineering	25,955,881	26,721,185	24,803,484
T&E	3,515,855	2,930,370	2,405,889

While there is a large in-house S&T and T&E infrastructure, the Department also employs a vast array of non-DoD sources to meet its science and technology, systems engineering, and test and evaluation needs. For example, much of the Air Force's Space Systems

[5] U.S. Government, Department of Defense, *A Plan to Streamline DoD's Science and Technology, Engineering, and Test and Evaluation Infrastructure: Report of the Section 907 and Section 912 9c) Senior Steering Group for Review of the RDT&E Infrastructure*, July 1999.

[6] DoD *Budget R-1 Tables, FY 2000/2001 RDT&E Program*

systems engineering is done by the Aerospace Corporation, a non-profit Federally Funded Research and Development Center (FFRDC), and much of its communications systems engineering is done by MITRE Corporation, another FFRDC. Indeed, the vast majority of the work accomplished in each of the three categories is done by the private sector and the trend has been to increase the private sector percentage. Briefings provided to the Task Force by the Military Services provided estimates of the split between the government and the private sector. These estimates are shown in Table 2 below.

Table 2[7]
Public/Private Allocation of Activity

Category	In-House	Outside
S&T	≥ 30%	≤ 70%
Systems Engineering	≥ 10%	≤ 90%
T&E	≥ 30%	≤ 70%

The table shows that, in practice, most of the S&T work conducted through the Service laboratories is actually conducted by the private sector. Almost all of the systems engineering is conducted outside (often by quasi-government organizations, such as the DoD FFRDCs or by firms doing defense business). Finally, the firms developing individual military systems often conduct extensive system tests and evaluations on their own facilities.

The current work composition suggests that there are only limited opportunities for savings by simply making further reductions in the in-house spending. However, the available data tells little about the efficiency or effectiveness of the current process that the DoD is using to find and acquire S&T, Systems Engineering and T&E. Nor does it tell us whether sufficient incentives exist for seeking higher quality in these areas, or who (government or prime defense contractors) is best positioned to undertake the identification and acquisition process. In contrast to the commercial experiences presented to the Task Force, government employees may have little direct financial stake in improving the process. Indeed, in cases where additional money might be sent outside the government infrastructure there may be negative personal incentives. because there is no in-house expertise base and the labs are reluctant to contract-out further.

G. Trends in the DoD / Service Infrastructure

Since 1990, the size of the DoD / Service S&T and acquisition infrastructure has decreased by about 25%. At the same time, the over all DoD funding has decreased by about 35%. While the DoD RDT&E funding has decreased roughly by 25%, the procurement funding has decreased much more, about 50%. The impact of these funding decreases has been significant in that substantial cutbacks in the number of personnel have been required. Because of the Civil service rules, these cutbacks have fallen disproportionally on the

[7] Briefings by the Military Services and the Office of the Secretary of Defense

younger personnel who tend to have experience and education in the newer technologies of importance to DoD's RMA.

In addition, the civil markets for technical personnel have been very strong in recent years. These two factors have made it very difficult for the S&T and Systems Engineering infrastructure to maintain competence in the most recent technologies such as information and computer systems. An additional factor in this unfortunate decline in capabilities has been the failure of Civil service salaries to keep up with competitive technical personnel salaries by as much as $20,000 per year.

Under these circumstances, it is important for the Department to look increasingly to the private sector for competency in the newer fields of technology.

H. Identifying and Developing Non-Traditional Sources of Technology

The Department and the Services have already been addressing this problem by turning increasingly to the private sector for technical capabilities. Of special note is the DARPA program which for many years has focused on seeking out the best sources of technical innovation and personnel whether they be in the DoD laboratories, in academia, or industry.

In the following sections of this report, the Task Force's findings on this important topic will be presented.

III. NON-DOD PROVIDERS OF S&T AND SYSTEMS ENGINEERING

The Task Force investigated several different types of providers of research, studies and analysis and technology development as well as sources of system engineering for large scale procurements:

- Universities
- University Affiliated Research Centers (UARCs) and Federally Funded Research and Development Centers (FFRDCs)
- Non-Profit organizations
- National Laboratories
- Other government agency laboratories
- Defense industries
- Non-defense industries

Members of the Task Force were chosen for their familiarity with the capabilities of the various types of organizations cited above. In addition, a survey was made of which types of organizations had substantial representation on the National Science and Engineering Academies as well as membership in professional engineering societies such as the IEEE and the AIAA. A summary of the results is shown in Figure 2. Further details on the number of memberships in the individual organizations of various types are listed in Appendix G.

The Country's Intellectual Horsepower Is Concentrated in Universities and Selected Industries and Not in Government Laboratories

One indicator of where the highest quality innovative capabilities are located...

	Academy Memberships	
Organization Class	**National Academy of Science ***	**National Academy of Engineering ***
Total members	**1815**	**~2100**
Universities	**1370**	**812**
FFRDCs, Natl Labs UARCS, etc.	**80**	**31**
Corporations	**59**	**586**
Other Government Laboratories (e.g., NASA)	**12**	**36**
DoD	**4**	**21**
Individuals, etc.	**290**	**614**

* Derived from membership lists of the Academy of Science and Engineering

Figure 2. National Academy membership distribution.

The Academy memberships shown above mostly represents recognition of past accomplishments in science and engineering. While current contributors to science and technology are not listed for the most part, the institutions indicated continue to attract creative professionals who are laying down the technology foundations of the future. Therefore, it is believed that Academy membership is a reasonable indicator (among several) of the sources of creative professionals.

It will be noticed that universities have the dominant number of members in the field of science; clearly they are the prime performing organizations in the field of basic research. In the field of engineering and technology development, profit making corporations are a strong player along with the combination of FFRDCs, National Laboratories, University affiliated research organizations, as well as non-DoD government laboratories. It should be noted that only a few of the DoD / Service laboratories have significant membership in the academies.

The reasons for difficulties in the DoD civil service laboratories are complex. Some details are discussed in a prior DSB Task Force Study[8]. Among the prime factors are the following:

- Continued professional staff cutbacks over the past ten years have prohibited the hiring of recent graduates.
- Higher salaries in industry have led to resignations of many of the better staff.
- The Civil Service Personnel system hiring salaries are $10,000 to $20,000 below private sector levels.
- Under the Civil Service Personnel system, it is very difficult to discharge ineffective professional staff.

In spite of these problems, a few of the DoD laboratories have maintained high standards but with the intense demand for capable scientific and engineering personnel in the private sector, even these laboratories are facing difficult times.

A. Universities

Research universities provide a leading source of creative professionals for the pursuit of new knowledge. Their professors and graduate students constitute a premier pool of professionals for such research. The survey of Academy and professional society membership shown in Figure 2 and detailed in Appendix G, indicates the dominance of this class of organization in the basic research field. Universities also dominate in the area of engineering science which is the major focus of the DoD's 6.1 program.

While the absolute numbers of memberships by university faculty may reflect a tendency by such organizations to pursue faculty admittance to these prestigious academies, the research leadership of universities is supported by the extensive funding awarded to them by government basic research agencies such as NASA, NIH, NSF and DoE as well as by their extensive publication of refereed journal articles.

DoD utilization of this very important source of advanced technology has significantly declined in the past ten years as shown in Table 3 below.

Table 3
DoD Basic Research Funding (FY1991-2000)

FY	91	92	93	93	95	96	97	98	99	00
6.1 Funding ($M)	1481	1421	1587	1391	1342	1225	1125	1064	1136	1113
% of FY91 Funding	100	96	107	94	91	83	76	72	77	76

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

As can be seen from Table 3, the 6.1 basic research funding, most of which goes to universities, has declined by nearly 25% since 1991; yet these university research programs generate the long term future scientific knowledge that will enable the technologies that will allow the U.S. military forces to maintain their dominance in the future.

Perhaps an even more significant benefit of 6.1 funding of universities involves the training of science and engineering graduate students who then move on to provide the professional staff for government and industrial research laboratories as well as new faculty for the universities.

A major fraction of computer science, electronic and aeronautical engineering graduate student support is related to the 6.1 program. Thus, this program is a major factor in the support of the strength of the nation's high technology industry. A number of these new graduates will become employed by defense industries, university affiliated research laboratories, national laboratories and DoD laboratories.

This 6.1 support needs to be sustained and even increased, if the Department is to continue using technology to maintain its military leadership.

B. University Affiliated Research and Engineering Centers and FFRDCs

Although there is a total of about 70 FFRDCs and a number of university affiliated research centers (UARCs) supporting various Federal Departments, only about 11 FFRDCs and a lesser number of UARCs are in support of the Department of Defense and the Military Services. The Task Force met at one of these organizations to better understand their capabilities. These Centers operate with a special relationship with their sponsors to provide research and engineering capabilities together with unbiased advice. The types of services provided by this class of organization are three in number:

- Scientific Research and Technology Development
- System engineering and Technical Direction in support of acquisition programs
- Studies and Analyses of Issues of Concern to the Department and the Services

The S&T type FFRDCs and UARCs are generally associated with leading technical universities. The association with such universities enables the recruiting of world class technical staffs to attack very difficult military technical problems which are outside the experience and capability of industrial and government laboratories.

The system engineering type organizations are generally free standing nonprofit organizations which recruit experienced engineering staff from industry. The main purpose of this type of organization is the engineering of advanced military systems and technical assistance in the selection and assistance of contractors producing advanced military systems.

The Studies and Analysis type of organizations are usually smaller in size than the prior two described above. Such organizations typically perform studies of current or proposed military systems and operations with the aim of helping the DoD and the Services better understand the possibilities of new directions in the technology and tactics of military operations. This class of organization is also typically a stand alone nonprofit organization. Their staff is usually drawn from leading universities, industry and from retired military officers.

These organizations generally operate under multi-year contracts administered by one of the military services or by the Office of the Secretary of Defense. They are not allowed to compete with industry.

The total professional staff of the DoD FFRDCs was limited by Congress in FY99 to 6206 staff. The Office of the Secretary of Defense administers the distribution of this ceiling among the current FFRDCs. The staff size, nature of work, and amount of funding for University-Affiliated Research Centers are also regulated by DoD and monitored by Congress. It is unlikely that much additional assistance to the DoD can be provided by the FFRDCs. However, there is a possibility that the university affiliated organizations (UARCs) could provide substantial assistance at a very high professional level.

Because several members of the Task Force either were or are connected to FFRDCs, no recommendations for more extensive use of FFRDCs through relief of the Congressional ceilings have been proposed by the Task Force

C. Non-Profit Organizations

A number of independent nonprofit research and analysis organizations currently support the DoD and the Services through FFRDC activities. Those were discussed in the section above. In addition, there are a number of other non profits which also currently support the DoD. The activities of these organizations could be expanded as well as new efforts initiated at those non-profits not currently involved with the DoD. Generally the technical quality of these organizations is quite high since they often were formerly related to universities. They represent an sizeable untapped source of support to the DoD and the Services.

D. National Laboratories

A number of highly ranked laboratories are supported by the Department of Energy and by NASA. The Task Force met at one of these organizations and also heard from several others about their capabilities and constraints in providing assistance to the DoD. All of these laboratories including those operated for NASA are FFRDCs. Funding for the DOE laboratories from other than the primary DOE sponsors has to pass through the sponsoring agency. This leads to certain problems which will be discussed below.

The primary NASA FFRDC is the Jet Propulsion Laboratory operated by the California Institute of Technology. The Task Force learned that JPL would be agreeable to supporting the DoD providing such activities supported its main focus, namely the exploration of the planetary system. This constraint would tend to focus such programs to those involving space technology including launch vehicles.

The Department of Energy national laboratories are also FFRDCs. They are more numerous and divide into three types:

- Basic research laboratories
- Atomic energy engineering organizations
- Nuclear weapon design laboratories

All three types are of interest to DoD and some are currently supporting the DoD. Each of these organizations is operated either by a university, a consortium of universities or by a defense contractor. Because of their university connections and high reputations, they are able to attract technical personnel of the highest caliber.

The Task Force learned that the DoE national laboratory funding from other agencies than DoE must pass through and be approved by DoE. This process has often been lengthy and was felt to be an impediment in rapidly responding to an urgent DoD need. An alternative, that has occasionally been used in the past, are Memorandums of Agreement between the DoD and DoE. It was indicated that this process was much superior and more expeditious.

In the case of most of the DoE FFRDCs, the Task Force learned that only DoD programs having some technical relationship to the prime focus of the national laboratory were of interest. This policy would, of course, place some constraints on the nature of DoD R&D programs that might be placed at the DoE laboratories. However, it should be possible for the DoD to place with these very capable organizations a wide spectrum of important programs.

E. Other Government Agency Laboratories

The Task Force also considered other government agency laboratories as possible providers of technical assistance to DoD. The primary possibility is the set of NASA laboratories which cover a wide spectrum of aerospace technology both air breathing and space borne. Over the course of years, DoD has made use of these government organizations for aeronautical research as well as for space launch technology. DoD and Service funding of these organizations can be easily provided by interagency fund transfers, thus obviating the necessity of separate contracts.

F. Defense Industries

Defense industries have a wide range of expertise in defense technology and engineering. In addition, they are able to hire very high quality staff for their programs. Another advantage is their involvement in commercial projects. These often provide experience and technology applicable to the solution of DoD or Service technology problems. The reverse is also of interest to these firms. Although profits may be limited on DoD projects, the technology is often of great interest for use on commercial projects.

One issue that often arises in connection with DoD or Service use of industry for System Engineering and Technical Direction (SE & TD) programs is that of potential conflicts of interest. This problem has been addressed a number of times in the past by hardware exclusions imposed on the SE & TD firm. In these days of massive consolidations, such exclusions could be applied to individual segments of a large defense industry.

Another concern with large defense industries is that they may have shed significant numbers of their technical staff in an effort to lower costs. One of the members of the Task Force surveyed the current level of R&D in these firms and found levels of R&D of 4% to 6%. Most of this is focused on development of new products. It appears that much of defense industry's research efforts have been curtailed with the recent consolidation and reduction in defense procurement.

G. Non-Defense Industries

Commercial industries worldwide have very extensive experience with technologies of interest to the DoD. This is especially so in the area of information technology which is felt to be of major importance to the success of future military operations. Such industries therefore offer a significant opportunity to DoD as a source of expert knowledge and production capability.

However, in the United States commercial industries exhibit a significantly different culture than those that primarily deal with the Defense Department. There are many reasons for these differences. Non-defense industries are driven by the global market place which not only chooses the preferred goods and services but also drives the capital investments in these industries. Expectations of returns on investments exceed 10%.

In contrast the defense "market" is primarily driven by government policy decisions, some in the executive branch and some in the Congress. These decisions are driven in part by national security issues, but also by regional self interest and various social programs as well as a desire to intensely regulate defense contracts so that any possibility of error is eliminated. Finally, profits are rigidly forced to levels well below 10%.

As a result, non-defense industries are generally not interested in taking DoD contracts. Such contracts usually involve the application of the Federal Acquisition Regulations (F.A.R.). Such regulations require an entirely different accounting system than that typically used for commercial business. Of even more concern are such additional factors as the intense intrusion of government inspectors, limited profits, and demands for access to commercial intellectual property. The result is that many firms have strict policies against taking government contracts.

The significant difference in possible profits has another serious effect; namely that the best and brightest technical staff are naturally placed on commercial projects which offer large profits and the possibility of gaining an advantage in future commercial market share.

Under these circumstances, for the DoD or the Services to obtain access to the capabilities of non-defense industries, it will probably be necessary for the DoD leadership to appeal directly to the leaders of non-defense firms. It may also be necessary to waive the F.A.R. to gain such access. It is interesting to point out that access to foreign firms is not limited by the F.A.R. since it cannot be applied in such cases.

IV. PROCESSES FOR UTILIZING "NON-TRADITIONAL" SOURCES

In this section, a number of issues with respect to the processes that DoD and the Services use in obtaining support from non government sources will be discussed. Included are discussions on the following:

- Early experiences in WWII and the years afterward
- Issues in dealing with the private sector
- Issues concerning government integrated product teams
- Focus of DoD research and development

A. Earlier DoD and Services Initiatives

As far back as WWII the military services obtained technology, acquisition, and manufacturing support from private sector sources. The sources employed included:

- University related R&D laboratories
- Nonprofit organizations established to support the military services
- Defense industries
- Commercial industries (during WWII)

Prior to those days, most of the research, development, and production occurred in government laboratories, development centers, and arsenals / shipyards. In WWII and the years afterward, the advent of new technologies such as microwave radar, nuclear weapons and proximity fuses required the skills not available in the government sector. As a result, teams of scientists and engineers organized by universities and industries were enlisted.

The military services funded these private sector organizations through simple cost contracts having no fees where universities were involved or with fixed low fees for commercial organizations. In this process the best brains in the country were employed with the best technology and production facilities.

Today, the situation is much different as will be discussed in the next section.

B. Current Issues in DoD's Accessing the Private Sector

Over the past decade or two, an adversarial relationship has tended to build up between the Government and private sector organizations.

The first and perhaps the most important problem is the issue of excessive contractual regulations imposed by the Government under the Federal Acquisition Regulations (F.A.R.). Since the fateful days of WWII, the complexity and intrusiveness of these regulations have increased by at least an order of magnitude. These regulations require the creation of entirely separate accounting systems if corporations are to take on a government contract. In addition, a very intrusive government inspection system is required, along with numerous social contract clauses that are entirely missing from commercial contracts.

The result of imposing this overly complex and intrusive set of regulations is that large numbers of private sector industries no longer are willing to take contracts from the government. This, in effect, cuts the DoD off from large sectors of the modern technology scene. Examples include most of the advanced U.S. semiconductor manufacturers as well as the leading U.S. pharmaceutical firms. These firms continue to be willing to sell their commercial products to the government but they are unwilling to disrupt their financial systems, manufacturing processes, intellectual property, and personnel systems to accommodate the F.A.R. regulations.

A notable exemption to the F.A.R. exists for government contracts with foreign commercial firms. The writ of the F.A.R. does not extend to foreign nations and thus the services of foreign industries can be obtaining without imposition of the F.A.R. The possibility of DoD accessing foreign technology through contracts with foreign industries and laboratories is important because more than half of all technology development in the world is now foreign, a very different situation than during and after WWII.

DoD access to U.S. defense industries is assured because of their past agreements to operate under the F.A.R. but it should be noted that such industries are now diminishing players in the U.S. and foreign high technology world.

In the past year, DoD has received permission from the Congress to experiment with non-F.A.R. procurements on a limited basis. Every attempt should be made to broaden this capability to insure the capability of DoD to access technology from which it is now excluded because of the F.A.R. If the DoD is to have access to the very significant technology advances in the private sector, substantial changes in the F.A.R. will be needed including the possibility of total exemption.

Another issue relating to DoD access to commercial capabilities involves the restraint of profits under government contracts. Typically, the more successful high technology industries are able to realize profits well above 10%. As a result, they have little interest in diverting their capabilities to DoD contracts where the profits are limited typically to at most 6% and often result in losses.

DoD access to the intellectual property of commercial firms is also an issue. F.A.R.-based subcontracts under government prime contracts often require access to private industrial manufacturing process data for reasons of quality control inspections. In the course of such access, intellectual property is often lost to the government or to prime contractors. The possibility of such losses makes the private sector firms all the more concerned about taking contracts under the F.A.R.

Finally, there is the issue of technology transfer from the civil sector to the DoD. While a great deal of such transfer is occurring in fields such as information sciences, there are additional transfer opportunities which could benefit the DoD. This is especially the case where foreign technology is involved. Examples of important foreign technologies are fuel cells, robots, aircraft displays and controls, and high-strength material production. One of the recommendations is aimed at discovering such technology and aiding in its transfer to important DoD applications.

C. Integrated Product Teams

Over the past decade, many industries have initiated the use of integrated product teams for establishing the performance parameters and design of new products. These teams are typically kept small (a dozen or so staff) to allow good team interaction. They are usually composed of representatives from marketing, research, development, manufacturing, finance, and maintenance support. The teams act interactively, trading off estimates of the market as a function of price taking into account inputs from manufacturing on the feasibility to produce the product at the target price.

Seeing the success of industry in the use of these teams, the DoD has attempted to replicate their success in the past few years. Unfortunately, the DoD form of these teams is different from the industrial form. In particular, two classes of participants are usually missing. The first are the customers or requirements representatives. While typically a military requirements representative is present, he or she cannot speak directly for the fighting command that will use the new equipment thus making trade-offs difficult. The second missing participant is a representation from the organization(s) that will have to develop and manufacture the system and who are also very knowledgeable on the feasibility of its production and on the likely costs. Because a procurement is ultimately involved, representatives of potential manufacturers are not allowed to be members of the DoD IPT teams.

The result is that these DoD teams have great difficulty in trading off requirements against realistic costs based on expert knowledge of the capabilities of manufacturing processes and costs as well as the availability and costs of components from subcontractors. An unfortunate result is that the production of a number of military systems end up by being canceled or bought in only small quantities because of excessive costs and/or poor military capabilities. The B2 stealth bomber is a classic example.

D. Focus of DoD Research and Development

Another issue in recent years is the focus of the DoD Science and Technology program (6.1 through 6.3). One view of this issue is that the commercial market so dominates the technology scene that the DoD should simply buy COTS (commercial off-the-shelf) equipment. Unfortunately, some needs of the DoD and the Services are not on the commercial shelf. For instance, neither stealth air vehicles, nor ballistic missiles, nor air defense systems are to be found on commercial shelves.

In thinking about this issue, it is helpful to refer to Figure 3. This figure indicates that DoD and the Services should only invest in military technology and should utilize commercial technology when non-defense goods are involved. An important exception to note is that commercial firms today have greatly reduced their funding of long term, generic technology development, meaning technology that may not find applications until ten years and beyond. The reason for this short term view is that it is very hard to recover costs of long term research since it tends to get broadly published and can be used by competitors, while commercial applications are as yet unspecified.

For commercial technologies that are important to DoD such as gas turbines and new semiconductor technologies, there may well be a rationale for DoD sponsorship of long term research in those areas of technology. Such has been the case for gas turbine technology for the past forty years. The result is that the DoD has access to the highest performance aircraft engines in the world. Similar past DoD investments in the integrated circuit technology has positioned the U.S. as first in the world in this technology as well.

Sources for DoD Technology Innovation

	DoD Sources	**Non-DoD Sources**
Non-DoD Unique S&T	**DoD should not fund (use non-DoD sources)**	**Use commercially developed S&T and products**
DoD Unique S&T	**DoD should fund (but no longer attracts the "best and brightest")**	**DoD should utilize, but DoD must change its procurement regulations (F.A.R., profits, intellectual property)**

Figure 3.

The types of long term DoD technology investments described above have served the nation well in the past. What about the future? It is clear that DoD needs to refocus its technology investments on the militarily critical technologies of the future as well as continuing to improve the current technologies such as gas turbines. Of late, some of these critical technologies have been identified as disruptive technologies. The use of the term "disruptive" means technologies as would fundamentally change the nature of warfare as have prior technologies such as the airplane, tank, ballistic missile, and nuclear submarines.

The most recent attempt to identify such "disruptive" technologies was the Defense Science Board Summer Study in 1999. This study identified four such "disruptive" technologies:

- Microsystems -- such as: advanced very high speed integrated circuits, micro-mechanical components and quantum computation logic.
- Advanced Algorithms -- such as: high performance identification of concealed objects and the analysis of alternative battle tactics.
- Bio-chemical systems -- such as: rapid detection and identification of biological warfare agents and the development of broad spectrum vaccines to treat biological attacks.
- High energy density power systems and super-strength materials -- sufficient to permit very high speed ships for rapid military response to crises, new high performance forms of rocket launchers and air vehicles with very long un-refueled endurance.

Combinations of these and other "disruptive" technologies could produce entirely new forms of military systems which could be important in keeping the United States the dominant military power well into the 21st century.

It will be important therefore to not only focus a substantial fraction of the DoD Technology Base (6.1 through 6.3) on these new technologies but to also establish a program to systematically search for such developments in other countries and in those portions of the commercial sector of the U.S. where long term research continues to be supported.

V. SUMMARY of FINDINGS

A. Worldwide Investments in Research Are Outstripping DoD's Research Investments

Figure 1, in Section II, Background, shows that while the DoD research base has remained relatively level in constant dollars since 1955, the world wide investment in research has risen from about <u>twice</u> DoD's investment to more than <u>ten times</u> today. Not included in Figure 1 data are the investments of China and Russia. It is evident that in some areas critical to DoD, such as semiconductors and information systems, the non-DoD research dominates over DoD's efforts and often is much more advanced at least in research that has short term applications. Only in generic information research that is long term, beyond ten years in application, is the DoD's 6.1 program comparable to commercial research.

The basic conclusion that is drawn from these data is that DoD needs to increase its focus on commercial research investments including foreign efforts in areas of importance to military capabilities. But at the same time it should also focus in research efforts on longer term technologies which can support entirely new military capabilities.

B. A Number of High Quality Non-DoD Sources of Innovation and Development Exist

An examination of non-DoD sources, discovered that a variety of very high quality sources of innovation and development exist. These include:

- Universities
- University affiliated research centers and FFRDCs
- Other non-profit organizations
- Other government agencies
- Defense industries
- Non-defense industries

Although there are several exceptions, the quality of these sources generally exceeds by a significant margin that of the DoD laboratories and centers. As indicated by Figure 3, DoD should concentrate the efforts of its limited laboratory and center resources on those unique military technologies and systems which are of crucial importance to maintaining U.S. military preeminence. Some examples would include armament systems, surveillance, identification, and targeting systems, undersea warfare and nuclear matters. In order to assure continuing U.S. military leadership in these critical areas, the quality of the DoD laboratories and centers needs to be brought up to that of leading industrial and university laboratories and development organizations. Conversely, the DoD and the Services should depend on outside sources for those technologies and developments where the civil sector dominates. The only exception would be research of military importance with a long term application horizon.

C. The Civil Service Personnel System Impairs the Quality of DoD Laboratories and Centers

The existing Civil Service Personnel System severely inhibits the ability of DoD laboratories and centers to attract and retain high quality professional personnel. The current system fails to allow:

- Prompt salary offers to new graduates that are comparable with those offered by industry (current offering levels for advanced degree graduates are $10,000 to $20,000 below the market)
- Salary increases that are related to accomplishment (current practice tends to give uniform increases regardless of accomplishments)

- Removal of non-performing professionals without extremely excessive bureaucratic processes (years of effort are often necessary involving a large fraction of a supervisors time)

In the past few years some relaxation of Civil Service Personnel practices has been allowed on an experimental basis. Generally, the relaxation has not been sufficient to substantially improve the quality of the DoD laboratories. In particular, no relaxation of the rules for discharge has occurred.

A further problem with attracting high quality professional personnel to the DoD laboratories is that of the lack of technical challenge in the DoD S&T programs. While many of the DARPA programs represent very significant technical challenges, most of these efforts are placed at leading universities, industries and non-profits. Very few challenging technical programs are designated for in-house research at the DoD laboratories. One way to attract high quality staff would be to give them some of the difficult defense technology problems.

Examples might include detection and identification of military targets located under foliage or in buildings, high-energy density fuels and rocket propellants, and stand-off detection of biological and nuclear weapons.

D. Support for U.S. Expertise in Physical Sciences, Engineering and Information Technology Is Being Eroded

The DoD provides the majority of support for university research and associated graduate student support in the fields of the physical sciences, engineering fields and information technology associated with military systems. However, such support has decreased by nearly 30% in the last ten years. As a result, recently trained professional personnel in these fields are in very short supply resulting in the use of foreign professionals as well as the use of overseas engineering of components of DoD systems. In addition, the number of scientific and engineering professionals graduated in foreign countries now greatly exceeds that graduated in the United States. As a result the U.S. may be in danger of losing its leadership in fields which are of critical importance to maintaining the superiority of U.S. military systems.

E. DoD's S&T and Acquisition Processes Differ Substantially from Those of Industry

DoD's management processes differ widely from those in leading edge high technology commercial industries. Commercial research and technology developments are closely coupled to marketing, product development and manufacturing through the use of <u>integrated product teams.</u> In particular, new product realization is closely coupled to potential markets and involves iterative tradeoffs of markets vs costs and performance.

On the other hand, DoD and the Service requirements definition are statutorily disconnected from the definition of new military systems by virtue of the Goldwater Nichols

Act. Furthermore, although DoD employs groups called Integrated Product Teams (I.P.T.s), these organizations typically do not involve inputs from organizations that will have to do the development and manufacturing. The result is that the DoD / Service I.P.T.s have great difficulty in matching up the requirements with affordable costs.

VI. RECOMMENDATIONS

A. Under Secretary Of Defense (AT&L) Establish the Office of Global Technology Acquisition

With most of the world's technology development occurring outside of DoD's organizations as well as defense contractors, it is important for DoD to access this technology. This recommendation would establish an Office devoted to development of the means and methods to exploit global technology including U.S. commercial technology. It would focus on:

- Technologies where industry leads military developments (e.g. communications, computers, networking, robotics)
- Potentially "disruptive" technologies
- Novel approaches to acquire externally developed technology
- Commercial contracting / licensing practices

This Office would be funded with not less than $100 Million per year.

B. The Secretary Of Defense Direct the Service Acquisition Executives to Increase to 50% The Portion of Service R&D Management and Laboratory Technical Staff Derived from the Private Sector, Non-Profits and Academia

The purpose of this recommendation would be to make it possible for the DoD S&T and acquisition organizations to have access to high quality staff which they cannot now attract through the Civil Service Personnel System.

This transition would be accomplished by freezing civil service hires and as retirements and turnover occurred, replacing staff with non-government personnel. Interagency Personnel Act (I.P.A.) and other temporary appointments could be used along with temporary contract appointments and utilization of the new G.S.A. Engineering Services Schedule.

C. Under Secretary Of Defense (AT&L) Direct the Services to Increase S&T Funding of University Defense Related Research by 30%

A 30% increase is judged necessary to counter the increasingly short term focus of industrial R&D relating to DoD interests and also to address future shortfalls in technical talent, especially in DoD - unique areas. To achieve this goal, 6.1 funding should be increased by 10% per year for the next three years and then maintained at that level. Funding should be obtained from the 6.3 (or higher) programs.

A significant portion of the revitalized 6.1 program should be focused on "disruptive" technology which had the potential for revolutionary change in military capabilities.

D. The Secretary of Defense and the Chairman JCS Initiate a High Level "Packard" Commission to Develop an Integrated Requirements/ Acquisition Process

The Secretary of Defense and the Chairman should convene a Blue Ribbon Panel of senior civilian and military experts to address revising the requirements process to insure that military requirements can be interactively traded off with respect to technology and manufacturing capabilities as well as costs . This change would emulate industry' best practices in generating products that meet markets needs and at affordable costs.

The new process would involve teams of military operational personnel, technologists, developers, component suppliers, manufacturers, and maintenance personnel.

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-3010

ACQUISITION AND TECHNOLOGY

2 8 SEP 1998

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference--Defense Science Board Task Force on Technology Capabilities of Non-DoD Providers

Under Section 912c of the National Defense Authorization Act for FY 98, the Secretary of Defense is directed to conduct a review of the Department's acquisition activities and personnel. In the Secretary's letter to Congress on Section 912c, he committed to a study to develop a plan to streamline the Science and Technology, Engineering, and Test and Evaluation Infrastructure.

You are requested to form a Defense Science Board (DSB) Task Force on Technology Capabilities of Non-DoD Providers. The Task Force is to support the Department's in-house study by an examination of the ability of non-DoD providers to provide warfighting technology, engineering, and test capabilities needed for future U.S. military forces.

The Task Force will assist the in-house study with information on the following:

a. technology, engineering and test capabilities that will be important for future U.S. military forces;

b. potential sources for providing needed DoD technology, engineering and test capabilities including:

(1) other government sources including DoE, NASA, NSF, and NIH laboratories,

(2) industrial laboratories including both defense and non-defense,

(3) academic research laboratories,

(4) universities associated research centers including Federally Funded Research & Development Centers, and

(5) non-profit research organizations;

c. costs of such non-defense organizations providing needed technology, and;

d. estimates of the productivity of the various sources of technology.

Information should be provided to the DoD in-house study as it is obtained. A preliminary report will be given by April 1, 1999 and a final report will be submitted by June 1, 1999.

The Task Force will be sponsored by the Under Secretary of Defense for Acquisition and Technology. Mr. Walter E. Morrow, Jr., will serve as Chairman of the Task Force. Mr. Charles Kimzey of the Office of the Director of Defense Research and Engineering, will serve as Executive Secretary; and LTC Don Burnett, USA will serve as the DSB Secretariat Representative.

The Task Force will be operated in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DoD Directive 5105.4, "The DoD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, U.S. Code, nor will it cause any member to be placed in the position of acting as a procurement official.

Jacques S. Gansler

APPENDIX B

Meeting Agendas

AGENDA
Defense Science Board Task Force
Technology Capabilities of Non-DoD Providers

January 15. 1999
at the Institute for Defense Analyses
2001 N. Beauregard St.
Alexandria, Va.

Welcome and Introductions – Walt Morrow, Task Force Chairman

DoD environment for applied technology - Joseph Eash, Deputy Undersecretary of Defense (Advanced Systems & Concepts)

- Advanced Concept Technology Demonstration (ACTD) program
- Policy and experience regarding non-traditional sourcing

DoD environment for test, systems engineering, and evaluation - Dr. Patricia Sanders, Director, Test, Systems Engineering & Evaluation

- 912 study and schedule
- TSE&E functions and mechanisms
- Non-traditional sources of test, systems engineering & evaluation

DoD environment for science and technology -

Dr. Delores Etter, Deputy Undersecretary of Defense (Science & Technology)

- DoD science and technology policy/practice
- Key R&D functions and mechanisms
- Current R&D support structure
- Attitude and experience toward non-traditional suppliers

Service perspectives, Navy – Rear Admiral Paul Gaffney, Chief of Naval Research

Service perspectives, Army – Hon. Paul J. Hoeper, Assistant Secretary of the Army, Research, Development & Acquisition

Service perspectives, Air Force - Dr. Helmut Hellwig, Deputy Assistant Secretary of the Air Force, Science, Technology, and Engineering

Working lunch – Chairman's perspective on task force – Walt Morrow, Chairman

- Mission
- Schedule
- Organization and approach
- Precursor activity (S&T Base for 21st Century)
- Self-introductions of members
- Questions/answers

Defense Science Board defined – John Ello, Executive Director, DSB

- History
- Methods of operation
- Examples of contribution
- Legal requirements – conflict of interest

Related activities: Defense Science Board

- **Task Force on Globalization and Security – Everett D. Greinke, Consultant, Member of Task Force**

Related activities: Strategic Studies Group

- **Sustaining Military Superiority into the 21st Century - Col. Ron Reichelderfer (USA) - Strategic Studies Group**

Task force information management - Jack Nunn

- **Procedures for obtaining background information**
- **Procedures for obtaining task force member input**

Future task force activities - Walt Morrow

- Future meeting agendas
- Subcommittee activities

Adjourn

FINAL AGENDA
Defense Science Board Task Force
Technology Capabilities Of Non-DoD Providers
February 19, 1999
at the Institute for Defense Analyses
2001 N. Beauregard St., Alexandria, Va. 22311

OBJECTIVE: to understand current management practices within each of the Services regarding the sourcing of S&T, systems engineering, and test & evaluation

Continental breakfast

Welcome and general discussion	**Walt Morrow, Chairman**
Navy sourcing strategy	**Mr. Michael Hammes** .Deputy Asst. Secretary of the Navy for Ships
Navy Destroyer DD21 development	**Mr. Tom Steger** **Director of Acquisition** **DD21 Program Office**
Army sourcing strategy	
Science and technology	**Dr. Michael Andrews** **Chief Scientist, US Army**
(working lunch at 12:00)	
Test and evaluation	Mr. Fred McCoy Deputy Director, Test & Evaluation Management Agency
Systems engineering	BGen Joseph Yakovac Deputy Director, Systems Management & Horizontal Technology Integration
Acquisition Reform Programs	Dr. Jay Mandelbaum, Office of Dep. Under Secretary of Defense (Acquisition Reform)
Task force Web site update	Dr. Jack Nunn
Members discussion	Walt Morrow, Chairman

- new charter and schedule
- direction and future agenda meetings
- comments/opinions

Adjourn

AGENDA
Defense Science Board Task Force
Technology Capabilities of Non-DoD Providers

March 19, 1999

Room 5102A
Motorola Ocotillo
2501 South Price Road
Chandler, AZ 85004
602-732-3832

Objective: To gain insight into how private industry identifies and acquires technologies from outside their organizations.

Continental Breakfast	
Opening Comments	Mr. Walt Morrow, Chairman
Welcome	Mr. Bary Bertiger, Senior VP & GM, Motorola
Motorola's Iridium Technology Strategy	Dr. Ray Leopold, Vice President, Motorola;
Motorola's Iridium Sourcing Strategy	Mr. Andrew Feller, Motorola
Micron's Technology Identification and Acquisition Strategy	Dr. Mark Durcan, Chief Technology Officer Micron Technology
Case Example: Perspective of a Small Business Unconventional Technology Provider	Dr. James St. Ville President Hawthorne & York International
Boeing's Process for Acquiring Technology, Engineering & Test Support from Outside Organizations	Mr. James Sinnett, V.P., Boeing Phantom Works
Boeing's JSF Approach	Mr. James Oneill, Boeing Chief Engineer JSF
Lockheed Martin's JSF Technology and Acquisition Approach	Dr. Wayne McGregor-- Advanced Technology Dr. James Engelland, V.P., JSF Lockheed Martin
Wrap-up Discussion	Mr. Walt Morrow, Chairman
Adjourn	

AGENDA

Defense Science Board Task Force
Technology Capabilities of Non-DoD Providers

TRW Space and Electronics Group
One Space Park
Redondo Beach, CA

April 16, 1999

Objective: To explore alternative models of technology development

Welcome	Walt Morrow, chairman
Space Communications S&T	Preston Campbell, TRW
Importance of having access to global technology	Prof. Mike Kelly, Ca. State Univ @ LA
Commercial companies as non-traditional DoD sources	Tei Iki, Sr. VP, Sony Electronics
DaimlerChrysler approach to technology development	Tom Moore, VP, DaimlerChrysler
Executive session and working lunch	Walt Morrow, chairman
Planar approach to technology development	Jim Hurd, CEO, Planar
Potential role of the DoD in stimulating non-traditional technology sources	Gen. (Ret) Bernard Randolph, TRW John Spargo, Program Mgr, TRW Mark Pentleton, Pgm Mgr, TRW Jim Nelson, Pgm Mgr, TRW Dwight Streit, Pgm Mgr, TRW
Closing discussion and chairman's remarks	Walt Morrow, chairman
Adjourn	

Defense Science Board Task Force Meeting
Sandia National Laboratories
Albuquerque, NM
May 17, 1999
Meeting Location:
Lockheed Martin Building
1155 University Blvd. SE, Albuquerque, NM

AGENDA

Chairman's Introduction	Walt Morrow DSB Task Force Chair (Former Director, Lincoln Laboratories)
Welcome	Jim Tegnelia, Vice President, DOD Programs Sandia National Laboratory
Introductions	All
Sandia Presentation	Jim Tegnelia
Intel Presentation	Scott Sibbett, External Programs Manager Intel Corporation
BREAK	
Los Alamos Presentation	Don Cobb, Associate Laboratory Director for Threat Reduction, Los Alamos National Laboratory
Lawrence Livermore Presentation	Roger Fisher, Director of DOD Programs Office Lawrence Livermore National Laboratory
LUNCH	
Weapons Labs Panel Discussion	Sandia, Los Alamos, Lawrence Livermore
JPL Presentation	Larry Dumas, Deputy Director Jet Propulsion Laboratory
BREAK	
Applied Physics Lab	Gary Smith, Director of Applied Physics John Hopkins University
Wrap Up	
Group Departs for Los Alamos	

AGENDA
Los Alamos National Laboratory

Defense Science Board Task Force
Tour Of Selected LANL Facilities

May 17-18, 1999

Monday, May 17th

Van from Sandia National Laboratory to Santa Fe (Eldorado Hotel) *Sandia Laboratory pick up point: Lockheed Martin Building 1155 University Blvd. SE*	Peggy S. Vigil Edward W. Pogue
No host dinner in Santa Fe	Edward W. Pogue

Tuesday, May 18th

Meet visitors in the lobby of the Eldorado Hotel, travel to the Los Alamos National Laboratory, Badge Office	Edward W. Pogue
Badge visitors, escort to the Advanced Simulation Laboratory,TA-3, SM-43, Room D38A	Peggy S. Vigil
Welcome/Introductions	Donald D. Cobb
Modeling & Simulation Briefing/Demonstration	James D. Morgeson
Escort visitors to LDCC, TA-3, 1498, Room 319	
ASCI Briefing/Tour	TBD
Remote Sensing Programs	William M. Hodgson David J. Simons

Divide group into two separate groups - DE Group and Chem/Bio Group

Directed Energy (DE) Group

Travel to TA-53, Bldg. MPF-14, Room 105 *Dihn will meet the group at the entrance of the building* Directed Energy Briefing/Tour, escort to TA-53, Bldg. 6, Aviary Conference Room 304 *(3rd floor)*	Peggy S. Vigil Edward W. Pogue Dihn C. Nguyen Michael V. Fazio

Chem/Bio Group

Chem/Bio Briefing and Tour	Gary C. Salzman J. Wiley Davidson
Travel to TA-53, Bldg. 6, Aviary Conference Room 304	Peggy S. Vigil
Wrap-up Working Lunch (by invitation only)	DoD visitors Ken Mckenna James D. Morgeson Edward W. Pogue Dihn C. Nguyen Michael V. Fazio Gary C. Salzman J. Wiley Davidson William M. Hodgson David J. Simons
Visitors depart by van for the Albuquerque Airport	Peggy S. Vigil

AGENDA
Defense Science Board Task Force
Technology Capabilities of Non-DoD Providers

Boeing Headquarters
Building 2-25.4
Seattle, Washington
June 17-18, 1999

Objective: 1) To explore commercial models of technology development
2) Plan for remaining task force activities

June 17, 1999

Depart Westin Hotel for Everett tour	Bob Kiga, Boeing
747/767/777 Final Assembly Plant tour	April Wilson, Boeing
Depart Everett facility for Boeing headquarters	
Working lunch for tour members	
Pick-up at Westin Hotel for non-participants of tour	
Welcome	Stan Ebner, Boeing
Announcements	Walt Morrow, Chairman
Acquiring International Sources of Technology	Ron Bengelink, Boeing Director, Int'l Pgms Engrg
External Technology Insertion into Products	Larry Winslow, Boeing VP, Engrg Tech, Phantom Works
Technology Sourcing Decision Processes	Larry Siefert, VP, ATT&T Wireless
Adjourn – depart for hotel Depart hotel for dinner at Salty's On Alki	

AGENDA
Defense Science Board Task Force
Technology Capabilities of Non-DoD Providers

Boeing Headquarters
Building 2-25.4
Seattle, Washington

June 17-18, 1999

Objective: 1) To explore commercial models of technology development
2) Plan for remaining task force activities

June 18, 1999

Depart Westin Hotel for Boeing headquarters

Technology Acquisition Process – Present and Future	Mark Anderson, Boeing Enabling Technology Engineering
Make/buy decision processes for developing technology	Dr. Jack Breese, Asst. Dir, Microsoft Research Lab
Make/buy decision process for advanced products	Atul Bhatnagar, Gen Mgr, Information Appliance Operation, Hewlett Packard
Committee discussions Working lunch	Walt Morrow Chuck Kimzey

- Discussion and approval of final report outline
- Sources of information to be used to write report
- Task force decision on future emphasis
- Identification of gaps/plans to fill
- Plans for remaining meetings

Adjourn until Sept 16-17	Walt Morrow

AGENDA
Defense Science Board Task Force
Technology Capabilities of Non-DoD Providers

Lincoln Laboratory
Main Entrance
Lexington, MA

Objective: 1) To examine commercial and military systems engineering processes
2) Develop preliminary task force recommendations re: systems engineering

August 24, 1999

Depart Sheraton Lexington on Lincoln Lab van	
Welcome and announcements	Walt Morrow, chairman Ray Leopold, SE subcommittee chairman
Systems engineering from a diversified supplier perspective	Phil Cheney VP, Engineering Raytheon
Navy systems engineering process	Tom Pendergraft Executive Dir & Chief engineer Dahlgren, Navy Surface Warfare Center
Military lessons from commercial systems engineering experience	Eric Honour, Past President Int'l Council on Systems Engineering
Reaching new sources – GSA Engineering Service Schedule	William Gormley Assistant Commissioner for Acquisition, GSA FSS
Working lunch	
Leading edge SE practice	Vincent Chan, MIT (invited)
Committee discussion	Members and speakers
Adjourn – return to airport via Lincoln Labs van	

AGENDA
Defense Science Board Task Force
Technology Capabilities Of Non-DoD Providers

September 17, 1999
at the Institute for Defense Analyses
2001 N. Beauregard St., Alexandria, Va. 22311

OBJECTIVES: To review non-U.S. sources capabilities, to consider alternative structures for government S&T management, and to discuss Task Force findings and recommendations.

Acting Chair: Dr. Gary Smith

Continental breakfast	
U.K. Experience with Private/Public Partnerships	Mr. Terence Jagger Director Defence Evaluation and Research Agency Partnering Team United Kingdom
Opportunities for Commercial Technology Cooperation in Korea	Dr. Kwan Rim Chairman, Samsung Advanced Institute of Technology Suson, Korea
Alternative Ownership Structures	Dr. Timothy Coffey, Director of Research Naval Research Laboratory
Working lunch	
Technology Sourcing Strategies	Colonel Amir Ellenbogen Research and Development Attaché, Embassy of Israel
Discussion of Findings and Recommendations	Task Force
Adjourn	

Appendix C

Report of the
Defense Science Board Task Force
on
Technology Capabilities of Non-DoD Providers

December 1999

Walter E. Morrow, Jr.
Chairman

Briefing Outline

- Tasking and Membership
- Background
  - Statement of the problem
  - The 912 study effort
  - Changes in the base
- Survey of Non-DoD Sources
  - FFRDCs, DOE National Laboratories, UARCs, Universities, other Government Agencies
  - Traditional defense industry
  - Non-defense industry
- Process Issues
  - DoD's capabilities to source commercially
  - Contract issues
- Findings
- Recommendations

Tasking Summary

- The scale and pace of technology development outside of DoD are substantially greater than that supported by DoD. Therefore, evaluation should be made of the needs for better access to non-DoD sources of technology, engineering and test capabilities to maintain the technology superiority of future U.S. military forces
- Examine potential non-DoD sources
  - Other U.S. government sources
    - DOE, NASA, NSF, etc.
  - Industrial organizations both defense and non-defense
  - Academic research laboratories
  - University Affiliated Research Centers (UARCs), Federally Funded Research & Development Centers (FFRDCs), Non-DoD government laboratories
- Develop a process model for how the DoD should acquire new technology and systems
  - Establish a DoD benchmark of relevant practices
  - Establish an understanding of industry best practices on make-or-buy sourcing decisions in S&T, engineering and testing

Membership of the DSB Task Force on Technology Capabilities of Non-DoD Providers

Chair:	Prof. Walter E. Morrow, Jr. - Lincoln Laboratory
Members:	Mr. Marc Durcan - Micron Technology Mr. Stanley Ebner - Boeing Co. (ret.) Mr. James Hurd - Planar Systems Prof. Kazuhiko Kawamura - Vanderbilt University Mr. Thomas Moore - Daimler-Chrysler Dr. Andrew Pettifor - Rockwell Dr. Raymond Leopold - Motorola Gen Bernard Randolph, USAF(ret.) - TRW Dr. Robert Selden - Los Alamos National Lab (ret.) Dr. Gary Smith - formerly Applied Physics Lab
Exec Secretary:	Dr. Charles Kimzey - Defense Research & Engineering
DSB Secretariat:	LTC Don Burnett / LTC Scott McPheeters- USA
Support Contractors:	Institute for Defense Analyses Dr. Richard Van Atta Dr. Jack Nunn

Data Gathering

- Site visits
  - Defense industry - electronics and communications, aerospace
  - Non-defense industry - electronics, communications, aerospace
  - Other government agencies - national laboratories
  - FFRDC/UARC - radar, sensors
- Government and private sector briefings
  - Senior DoD R&D, Systems Engineering, T&E management
    - OSD and all Military Services
  - Traditional defense industry
  - World leading commercial (non-defense) industry
    - Domestic and foreign
  - Research institutions
    - National (DOE) Laboratories
    - Universities
    - Non-profit, FFRDC, and UARC
  - Foreign governments - R&D organizations

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Background

- Section 912 of the National Defense Authorization Act of FY98 directed the SecDef to examine current organizations and functions
  - This Task Force initially chartered to support DoD 912 response by examining non-DoD alternatives to in-house activities and examining the process for acquiring these alternatives
- Even though S&T, acquisition, and T&E staffing levels have been reduced by more than 30% since FY90, potential exists for further efficiencies and greater effectiveness
- Some internal DoD studies[1] indicate need to improve Service laboratories and technical infrastructure
  - Excess capacity
  - Technology gaps
  - Questionable ability to sustain technological leadership

1. *Report of the Defense Science Board Task Force on Defense Science and Technology Base for the 21st Century*, June 1998.
   A Plan to Streamline DoD's Science and Technology, Engineering, and Test and Evaluation Infrastructure, May 1999.

Recent Trends

The DoD Acquisition Force Has Been Decreasing

- Overall
  - Between September 1989 and July 1999, the total government workforce in Defense acquisition organizations declined from about 613,000 to just over 312,000 (about 49%)
  - Government strategy sought to retain more of the technical staff, e.g., S&T and acquisition workforce fell from 131,000 to 93,000 between FY90 to FY97 (~30%), with plans for a further 10% reduction by 2005
- Science and Technology
  - From 10-50% of DoD S&T is done in Service laboratories and centers
  - Civil service employment practices and laboratory downsizing make it difficult for Service labs to compete for and retain best technical talent
- Systems Engineering
  - Both private contractors and DoD perform systems engineering
  - DoD's share of systems engineering work declining and work force aging
  - DoD's system engineering remaining capabilities are stressed by the complexity and scale of future "system-of-systems"
- Test and Evaluation
  - Now largely conducted by contractor personnel
  - Government workforce is being reduced and is aging
  - Facilities are aging

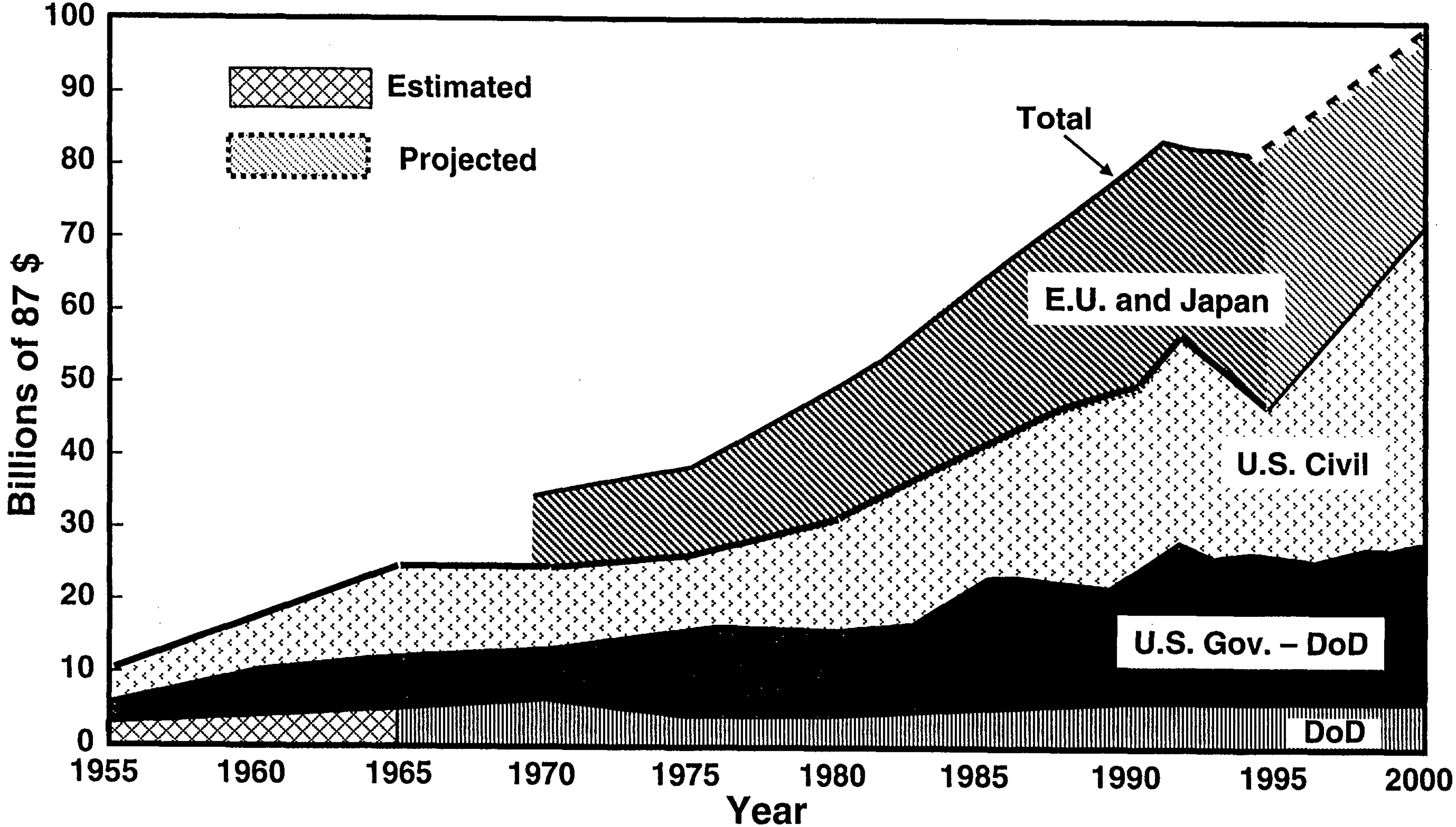
The Country's Intellectual Horsepower Is Concentrated in Universities and Selected Industries and Not in Government Laboratories

One indicator of the where the highest quality innovative capabilities are located...

	Academy Memberships	
Organization Class	National Academy of Science *	National Academy of Engineering *
Total members	1815	~2100
Universities	1370	812
FFRDCs, Natl Labs UARCS, etc.	80	31
Corporations	59	586
Other Government Laboratories (e.g., NASA)	12	36
DoD	4	21
Individuals, etc.	290	614

* Derived from membership lists of the Academy of Science and Engineering

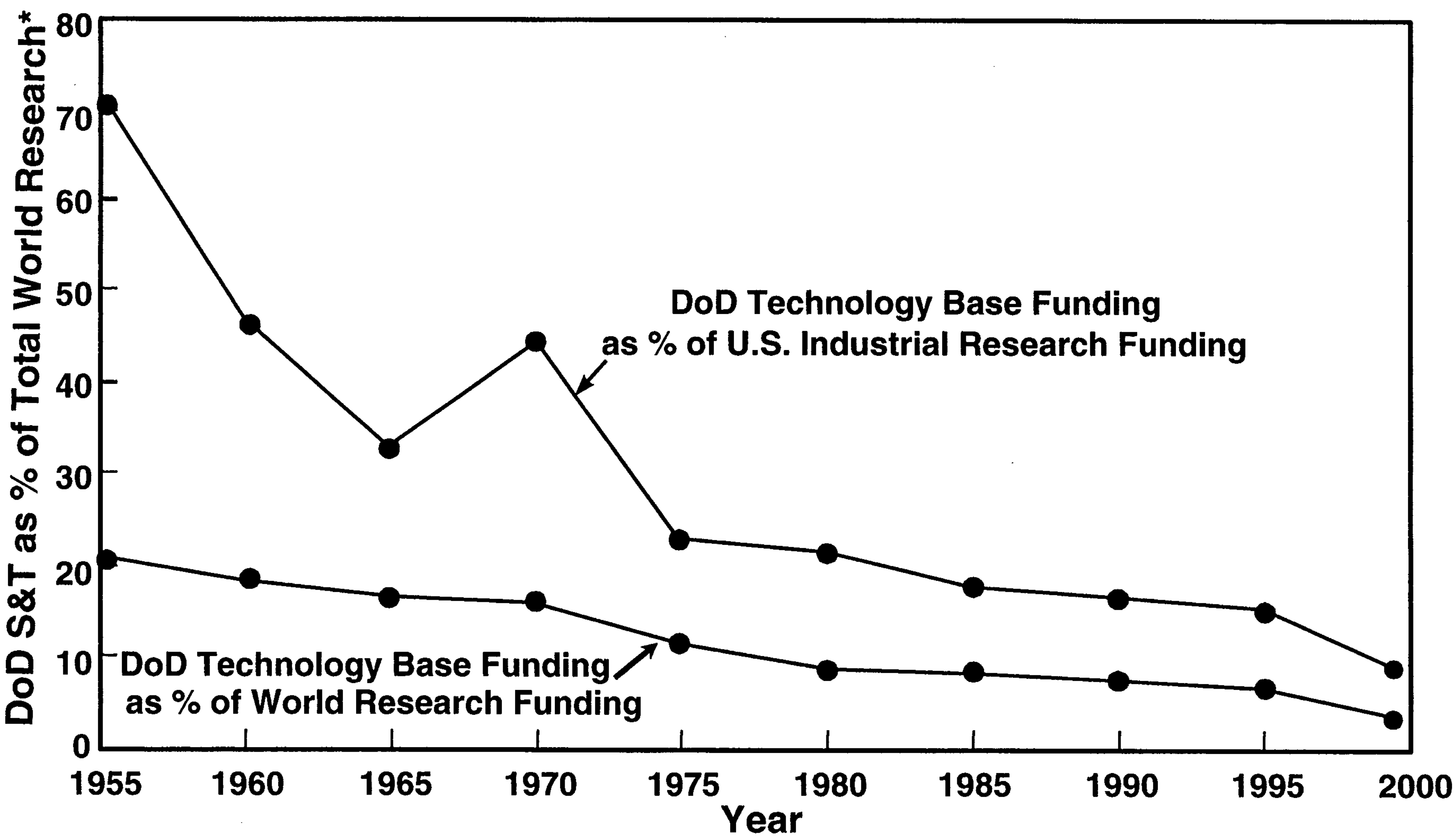
U.S. and Worldwide Research Base Has Increased Significantly since WWII while DoD's Contribution Has Remained Almost Constant



Sources: U.S. data from National Science Foundation
EU and Japan based on data from the Organization for Economic Cooperation and Development (OECD)

Tech Capabilities of DSB Task Force Non-DoD Providers

DoD Technology Base Funding Has Decreased Significantly as a Fraction of Total Worldwide and U.S. Industrial Research Funding



* Excluding USSR

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Sources for DoD Technology Innovation

	DoD Sources	Non-DoD Sources
Non-DoD Unique S&T	X	+
DoD Unique S&T	Issue: DoD no longer attracts "best & brightest"	Issue: May have capabilities But, how can DoD attract?

Non-DoD Sources: External Sources Offer Very Capable S&T, SE and T&E Resources

- External sources include industry, FFRDCs, National Laboratories, UARCs, Universities, and other Government Agencies
- These sources are generally well staffed and have greater personnel flexibility than DoD
- They currently provide significant S&T, SE and T&E support
- Commercial industry remains underutilized by DoD
- Universities are a rich (but under funded) source for the conduct of basic and applied research
- DOE National Labs report some capacity to meet DoD needs, but the contract process currently inhibits their greater use
- Other government labs (e.g., NASA's JPL) have far less capacity to rapidly respond to DoD
- Additional FFRDC support to DoD is limited by Congress

Non-DoD Sources: Universities and Affiliated Laboratories

- Universities and their affiliated laboratories (FFRDCs, UARCs, and Department laboratories) are the focus of much of the Nation's scientific and engineering talent
- Many university faculty and affiliated laboratory staff are pursuing science and technology research of importance to DoD
- They represent an excellent source of talent (e.g., professors, graduate students, research fellows) for DoD's S&T programs including 6.3 efforts
- They also can be a source of temporary skilled scientific personnel for DoD's laboratories and centers

Non-DoD Sources: Defense Industry

- Defense firms provide all three functions to DoD
  - Perform over half of DoD S&T (6.2 and above)
  - Perform significant systems engineering and T&E support
- Private contractors have more personnel flexibility than government organizations
- Defense consolidations have greatly reduced defense contractor laboratories
- Remaining defense industrial S&T focus more short term than in past
- Defense industries have expressed interest in performing more DoD RDT&E activities
- Recent developments imply some increased risk of reliance on defense industry
  - Launch failures
  - Severe cutbacks in R&D investments
  - Industry liquidity

Non-DoD Sources: Commercial Industry

- DoD R&D investment is a small percentage of world R&D investment
- Commercial industry has large reservoir of technical talent, but by definition, little business with the DoD
- Admin/cultural barriers need to be reduced, with improved business predictability
- Many non-defense industries refuse to take DoD contracts under the Federal Acquisition Regulations
- Non-defense industries are reluctant to use their most capable technical staff outside their core market areas
  - payoff too small and uncertain for market driven organizations
- Competitive pressures generally have reduced the size of corporate laboratories and forced increasingly near term product focus

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DoD Technology Acquisition Processes Lag Those Employed by Commercial Industry

- DoD management processes differ widely from those of leading edge high technology commercial industry
  - Commercial research and technology development closely coupled to product development and manufacturing
  - New product realization is closely coupled to market and involves iterative trade-offs of cost and performance. DoD requirements are statutorily disconnected from system development
- Non-defense industry management processes lead in:
  - Efficiency
    - Achieving budget and schedule goals
    - Inventing new management techniques to keep reducing cycle time and cost
    - Utilizing the best technology regardless of source
  - Innovation
    - Responding to technological change (those that don't die)
    - Creating very capable technology development organizations
    - Cycle time for evolutionary derivatives (e.g., 1-3 years vs. 10 years for DoD)
    - Cycle time to new platforms (e.g., 7 years vs. 15 years for DoD)

DoD Out-Sourcing Processes (continued)

- In spite of acquisition reform, the government system remains isolated from commercial practices resulting in substantial barriers to accessing external technology and system design expertise
  - Remains risk averse rather than focusing on risk management
  - DoD contracting practice remains too burdensome to keep up with changing global technology developments -- reluctance to use discretion allowed by FAR
- Foreign commercial sources seldom considered
  - Security issues significant but manageable
- Mixed experience in adopting industry models
  - Rapid prototyping - ACTDs working well
  - IPTs - overdone, losing influence, do not include industrial based manufacturing and cost experts

Historically, "Disruptive Innovations" Come from Sources External to Established Organizations

- Many concepts and initial developments originated external to Services or existing dominant commercial firms
- Military
  - jet engine
  - atomic bomb
  - ballistic missiles
  - nuclear power
  - stealth technology
- Commercial
  - diesel locomotive
  - antibiotics
  - photocopier
  - personal computer
  - internet
- "Disruptive"external developments are usually threats to existing technology and organizations
  - Pursued late and with reluctance
  - Opportunities missed for early advantage
- External sources have been a primary means of developing breakthrough capabilities
- DoD's process for addressing "disruptive" technology lags behind commercial industry's

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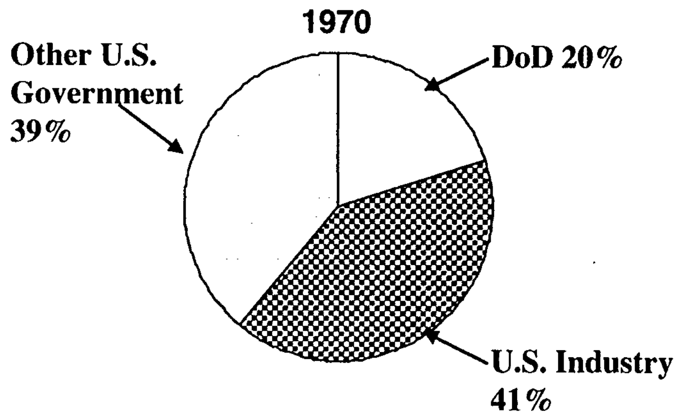
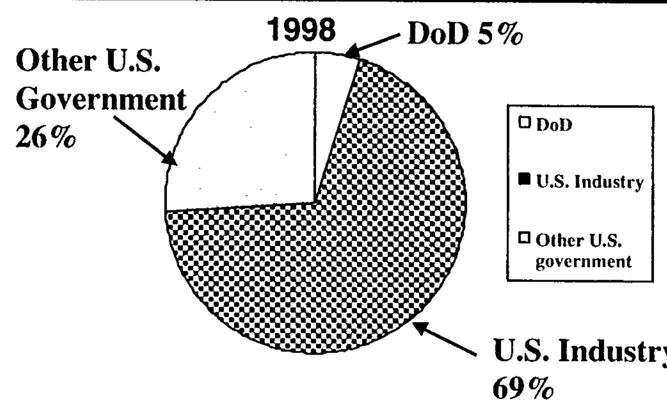
FINDING 1: Worldwide commercial (non-defense) industry investments in research and development and systems engineering are outstripping DoD investments





- Partnering with global commercial technology companies could greatly benefit DoD
- Emerging national security challenges (e.g., homeland defense) are not covered by current DoD expertise -- capabilities must be drawn from private sector (e.g., pharmaceutical industries)
- Incentives lacking for DoD managers to seek non-traditional sources, S&T and systems engineering

DoD has not recognized the significance of this change, nor determined how to fully exploit it.

FINDING 2: The existing DoD laboratory personnel system impairs DoD's ability to sustain necessary world class capabilities

- Civil service system reduces lab management's ability to hire and keep best quality scientists & engineers*
- Service laboratory personnel initiatives are a start, but not yet sufficient (lab demo projects)
- New problems facing defense require technical skills and knowledge beyond those currently at DoD labs (e.g., biological warfare defense, information sciences)
- R&D personnel initiatives by other government agencies (e.g., NIST, NIH, NASA & CIA) provide examples of possible approaches
  - — Involve both reform of and exceptions to government personnel systems as well as establishing private sector organizations

* *Report of DSB Task Force on Defense Science and Technology Base for the 21st Century*, 1998.

FINDING 3: Long term support for physical sciences, engineering, and information technology is being eroded

- Increasingly short term R&D focus of both DoD and industry
  - Elimination / reduction of corporate laboratories
  - Immediate product oriented
- DoD academic research funding declined 30% from 1993 to 1997
  - As percent of total federal academic research funding DoD share has declined from over 16.7 percent in 1980 to 10.4 percent in 1997
  - Negative impact primarily on universities in areas of expertise most needed by DoD in future
- Future shortfalls in technical talent will occur if funding is not replenished
  - Seed corn being consumed
- Shortages of scientists and engineers already exist in areas of particular interest to the DoD, e.g., information technology

FINDING 4: DoD's systems requirements definition process too isolated from feasibility and life cycle cost tradeoffs

- Requirements set and locked too high which results in significant cost/schedule penalties
- Commercial industry's iterative product realization process offers more effective model for DoD
  - Involves all key stakeholders: users, technologists, developers, suppliers, manufacturers, and maintainers

Briefing Outline

- Tasking and Membership
- Background
  - Statement of the problem
  - The 912 study effort
  - Changes in the base
- Survey of Non-DoD Sources
  - FFRDCs, National Laboratories, UARCs, Universities, other Government Agencies
  - Traditional defense industry
  - Non-defense industry
- Process Issues
  - DoD's capabilities to source commercially
  - Contract issues
- Findings
- Recommendations

Recommendation 1: USD (AT&L) establish the Office of Global Technology Acquisition

- Objective: access world-wide sources of research & technology for DoD needs
  - Find and license global technology for defense use
    - Focus on:
      - Technologies where industry leads military development (e.g. communications, electronics, networking, robotics)
      - Potentially "disruptive" technologies
  - Exploit non-traditional sources & methods of acquiring technology
    - Focus on foreign and domestic commercial industry
    - Conduct experiments and explore novel approaches to acquire externally developed technology
    - Use commercial contracting/licensing practices
- Fund office at not less than $100M/year

Recommendation 2: The Secretary of Defense should direct the Service Acquisition Executives to increase to 50% the portion of Service R&D management and laboratory technical staff from the private sector, non-profits, and academia

- Encompasses Service laboratories and R&D management (e.g., ONR, AFOSR, ARO)
- Accomplish by freezing civil service hires and adding or replacing staff with non-government personnel
  - Use IPA and other temporary appointments
  - Expand congressional authority for temporary government hire
  - Use term contracts
- Utilize new GSA Engineering Services Schedule as conduit to external sources

Recommendation 3: USD (AT&L) should direct the Services to increase S&T investment in universities by 30%

- 30% increase judged necessary to
  - Counter increasingly short term R&D focus of both DoD and industry
  - Address future shortfalls in technical talent, especially in DoD-unique areas
- To achieve this goal 6.1 funding should be increased 10% per year for next three years, and then maintained at this level, with the increase exclusively allocated to university programs
- Funding should be drawn from reduction in 6.2 (or higher) programs
- Focus on approaches that will educate students in areas of concern to DoD
  - Support student research through scholarships, grants work/study, loans and other innovative methods

Recommendation 4: The Secretary of Defense and the Chairman JCS should initiate a high level "Packard" Commission to develop an integrated requirements / acquisition process

Industry-led panel needed to develop approach that:

- Emulates industry's best practices in product realization
  - employs "product platform" approach
  - uses iterative interactive process
  - involves integrated team of operators, technologists, developers, suppliers, manufacturers, and maintenance personnel
- Assures flexible, feasible, affordable requirements

Summary

- NEEDS: DoD will need to access cutting edge technologies to meet future challenges. DoD cannot adequately meet these needs using current in-house and contractor sources.

-- Identify and apply disruptive technologies from non-traditional sources--

- SOURCES: Current sources are limited in scope and their capabilities are eroding. Outside sources are underutilized and offer broader and often superior talents and capabilities.

-- Acquire 50% in-house S&T personnel from private sector --

-- Increase defense basic research --

- PROCESS: DoD needs new management and technical skills to exploit worldwide commercial technologies and to counter new threats. Recommendations provide a model for addressing these needs.

-- Establish Office of Technology Acquisition --

Appendix D

National Defense Authorization Act for Fiscal Year 1998

SEC. 912. DEFENSE ACQUISITION WORKFORCE.

(a) REDUCTION OF DEFENSE ACQUISITION WORKFORCE.--(1) The Secretary of Defense shall accomplish reductions in defense acquisition personnel positions during fiscal year 1998 so that the total number of such personnel as of October 1, 1998, is less than the total number of such personnel as of October 1, 1997, by at least the applicable number determined under paragraph (2).

(2)(A) The applicable number for purposes of paragraph (1) is 25,000. However, the Secretary of Defense may specify a lower number, which may not be less than 10,000, as the applicable number for purposes of paragraph (1) if the Secretary determines, and certifies to Congress not later than June 1, 1998, that an applicable number greater than the number specified by the Secretary would be inconsistent with the cost-effective management of the defense acquisition system to obtain best value equipment and would adversely affect military readiness.

(B) The Secretary shall include with such a certification a detailed explanation of each of the matters certified.

(C) The authority of the Secretary under subparagraph (A) may only be delegated to the Deputy Secretary of Defense.

(3) For purposes of this subsection, the term ``defense acquisition personnel'' means military and civilian personnel (other than civilian personnel who are employed at a maintenance depot) who are assigned to, or employed in, acquisition organizations of the Department of Defense (as specified in Department of Defense Instruction numbered 5000.58 dated January 14, 1992).

(b) REPORT ON SPECIFIC ACQUISITION POSITIONS PREVIOUSLY ELIMINATED.--Not later than 30 days after the date of the enactment of this Act, the Secretary of Defense shall submit to Congress a report on reductions in the defense acquisition workforce made since fiscal year 1989. The report shall show aggregate reductions by fiscal year and shall show for each fiscal year reductions identified by specific job title, classification, or position. The report shall also identify those reductions carried out pursuant to law (and how the Secretary implemented any statutory requirement for such reductions, including definition of the workforce subject to the reduction) and those reductions carried out as a result of base closures and realignments under the so-called BRAC process. The Secretary shall include in the report a definition of the term "defense acquisition workforce" that is to be applied uniformly throughout the Department of Defense.

(c) IMPLEMENTATION PLAN TO STREAMLINE AND IMPROVE ACQUISITION ORGANIZATIONS.--(1) Not later than April 1, 1998, the Secretary of Defense shall submit to Congress a report containing a plan to streamline the acquisition organizations, workforce, and infrastructure of the Department of Defense. The Secretary shall include with the report a detailed discussion of the recommendations of the Secretary based on the review under subsection (d) and the assessment of the Task Force on Defense Reform pursuant to subsection (e), together with a request for the enactment of any legislative changes necessary for implementation of the plan. The Secretary shall include in the report the results of the review under subsection (d) and the independent assessment of the Task Force on Defense Reform pursuant to subsection (e).

(2) In carrying out this subsection and subsection (d), the Secretary of Defense shall formally consult with the Chairman of the Joint Chiefs of Staff, the Director of Program Analysis and Evaluation, the Under Secretary of Defense (Comptroller), and the Under Secretary for Acquisition and Technology.

(d) REVIEW OF ACQUISITION ORGANIZATIONS AND FUNCTIONS.--The Secretary of Defense shall conduct a review of the organizations and functions of the Department of Defense acquisition activities and of the personnel required to carry out those functions. The review shall identify the following:

(1) Opportunities for cross-service, cross-functional arrangements within the military services and defense agencies.

(2) Specific areas of overlap, duplication, and redundancy among the various acquisition organizations.

(3) Opportunities to further streamline acquisition processes.

(4) Benefits of an enhanced Joint Requirements Oversight Council in the acquisition process.

(5) Alternative consolidation options for acquisition organizations.

(6) Alternative methods for performing industry oversight and quality assurance.

(7) Alternative options to shorten the procurement cycle.

(8) Alternative acquisition infrastructure reduction options within current authorities.

(9) Alternative organizational arrangements that capitalize on core acquisition competencies among the military services and defense agencies.

(10) Future acquisition personnel requirements of the Department.

(11) Adequacy of the Program, Plans, and Budgeting System in fulfilling current and future acquisition needs of the Department.

(12) Effect of technology and advanced management tools in the future acquisition system.

(13) Applicability of more flexible alternative approaches to the current civil service system for the acquisition workforce.

(14) Adequacy of Department of Defense Instruction numbered 5000.58 dated January 14, 1992.

(e) DUTIES OF TASK FORCE ON DEFENSE REFORM TO INCLUDE CONSIDERATION OF ACQUISITION ORGANIZATIONS.--(1) The Secretary of Defense shall require that the areas of study of the Task Force on Defense Reform (established by the Secretary of Defense on May 14, 1997, and headed by the Deputy Secretary of Defense) include an examination of the missions, functions, and responsibilities of the various acquisition organizations of the Department of Defense, including the acquisition workforce of the Department. In carrying out that examination of those organizations and that workforce, the Task Force shall identify areas of duplication in defense acquisition organization and recommend to the Secretary options to streamline, reduce, and eliminate redundancies.

(2) The examination of the missions, functions, and responsibilities of the various acquisition organizations of the Department of Defense under paragraph (1) shall include the following:

(A) An assessment of benefits of consolidation or selected elimination of Department of Defense acquisition organizations.

(B) An assessment of the opportunities to streamline the defense acquisition infrastructure that were realized as a result of the enactment of the Federal Acquisition Streamlining Act of 1994 (Public Law 103 355) and the Clinger-Cohen Act of 1996 (divisions D and E of Public Law 104 106) or as result of other acquisition reform initiatives implemented administratively during the period from 1993 through 1997.

(C) An assessment of such other options for streamlining or restructuring the defense acquisition infrastructure as the Task Force considers appropriate and as can be carried out under existing provisions of law.

(3) Not later than March 1, 1998, the Task Force shall submit to the Secretary a report on the results of its review of the acquisition organizations of the Department of Defense, including any recommendations of the Task Force for improvements to those organizations.

Appendix E

National Defense Authorization Act for Fiscal Year 1999

SEC. 907. MANAGEMENT REFORM FOR RESEARCH, DEVELOPMENT, TEST, AND EVALUATION ACTIVITIES.

(a) ANALYSIS AND PLAN FOR REFORM OF MANAGEMENT OF RDTE ACTIVITIES.—(1) The Secretary of Defense, acting through the Under Secretary of Defense for Acquisition and Technology, shall analyze the structures and processes of the Department of Defense for management of its laboratories and test and evaluation centers. Taking into consideration the results of that analysis, the Secretary shall develop a plan for improving the management of those laboratories and centers. The plan shall include such reorganizations and reforms as the Secretary considers appropriate.

(2) The analysis under paragraph (1) shall include an analysis of each of the following with respect to Department of Defense laboratories and test and evaluation centers:

(A) Opportunities to improve efficiency and reduce duplication of efforts by those laboratories and centers by designating a lead agency or executive agent by area or function or other methods of streamlining management.

(B) Reform of the management processes of those laboratories and centers that would reduce costs and increase efficiency in the conduct of research, development, test, and evaluation activities.

(C) Opportunities for those laboratories and centers to enter into partnership arrangements with laboratories in industry, academia, and other Federal agencies that demonstrate leadership, initiative, and innovation in research, development, test, and evaluation activities.

(D) The extent to which there is disseminated within those laboratories and centers information regarding initiatives that have successfully improved efficiency through reform of management processes and other means.

(E) Any cost savings that can be derived directly from reorganization of management structures of those laboratories and centers.

(F) Options for reinvesting any such cost savings in those laboratories and centers.

(3) The Secretary shall submit the plan required under paragraph (1) to the congressional defense committees not later than 180 days after the date of the enactment of this Act.

(b) COST-BASED MANAGEMENT INFORMATION SYSTEM.—(1) The Secretary of Defense shall develop a plan, including a schedule, for establishing a cost-based management information system for Department of Defense laboratories and test and evaluation centers. The system shall provide for accurately identifying and comparing the costs of operating each laboratory and each center.

(2) In preparing the plan, the Secretary shall assess the feasibility and desirability of establishing a common methodology for assessing costs. The Secretary shall consider the use of a revolving fund as one potential methodology.

(3) The Secretary shall submit the plan required under paragraph (1) to the congressional defense committees not later than 90 days after the date of the enactment of this Act.

Appendix F

List of DoD Laboratories and Test & Evaluation Centers

DoD Laboratories

Affiliation	Laboratory
Office of the Secretary of Defense	Armed Forces Radiological Research Institute, Bethesda, MD
Army	Army Research Laboratory, Adelphi, MD
	Army Research Laboratory, Aberdeen Proving Grounds, MD
	Army Research Laboratory, White Sands Missile Range, NM
	Army Research Laboratory, NASA, Langley Research Center, VA
	Army Research Laboratory, NASA, Glenn Research Center, OH
	Natick Research, Development and Engineering Center, Natick, MA
	Aviation Research, Development and Engineering Center, St. Louis, MO
	Aviation Troop Command, Aeroflight Dynamics Directorate, Moffett Field, CA
	Aviation Troop Command, Aviation Applied Technology Directorate, Fort Eustis, VA
	Edgewood Research, Development and Engineering Center, Aberdeen Proving Ground, MD
	Communications Electronics Command Research, Development and Engineering Center, Ft. Monmouth, NJ
	Communication Electronics Command Research, Development and Engineering Center-Night Vision Electro-Optics Directorate, Ft. Belvoir, VA
	Missile Research, Development and Engineering Center, Redstone Arsenal, AL
	Armaments Research, Development and Engineering Center, Picatinny Arsenal, NJ
	Armaments Research, Development and Engineering Center, Benet Labs, Watervliet Arsenal, NY
	Tank-Automotive Command Research, Development and Engineering Center, Warren, MI
	USA Research Institute of Infectious Diseases, Ft. Detrick, MD
	Walter Reed Army Institute of Research, Washington, DC
	Institute of Surgical Research, Ft. Sam Houston, TX

Affiliation	Laboratory
	Aeromedical Research Lab, Ft. Rucker, AL
	Medical Research Institute of Chemical Defense, Aberdeen Proving Ground, MD
	Research Institute of Environmental Medicine, Natick, MA
	Construction Engineering Research Laboratory, Champaign, IL
	Cold Regions Research and Engineering Lab, Hanover, NH
	Topographic Engineering Center, Alexandria, VA
	Waterways Experiment Station, Vicksburg, MS
	Research Institute for Behavioral & Social Sciences, Alexandria, VA
	Simulation, Training and Instrumentation Command, Orlando, FL
	High Energy Laser Systems Test Facility, White Sands Missile Range, NM
Navy	
	Naval Air Warfare Center, Weapons Division, China Lake, CA
	Naval Air Warfare Center, Weapons Division, Point Mugu, CA
	Naval Air Warfare Center, Aircraft Division, Patuxent River, MD
	Naval Air Warfare Center, Aircraft Division, Lakehurst, NJ
	Naval Research Lab, Washington, DC
	Naval Research Lab Detachment, Bay St. Louis, MS
	Naval Surface Warfare Center, Carderock Division, Bethesda, MD
	Naval Surface Warfare Center, Crane Division, Crane, IN
	Naval Surface Warfare Center, Dahlgren Division, VA
	Naval Surface Warfare Center, Dahlgren Detachment, Panama City, FL
	Naval Surface Warfare Center, Indian Head Division, MD
	Naval Surface Warfare Center, Port Hueneme Division, Port Hueneme, CA
	Naval Surface Warfare Center, Bayview, ID
	Naval Command, Control, and Ocean Surveillance Center, San Diego, CA
	Naval Command, Control, and Ocean Surveillance Center, In-Service Engineering Division, Charleston, SC
	Naval Command, Control, and Ocean Surveillance Center, In-Service Engineering Division, Pearl Harbor, HI
	Naval Aerospace Medical Research Center, Pensacola, FL

Affiliation	Laboratory
	Naval Dental Research Lab, Great Lakes, IL
	Naval Health Research Center, San Diego, CA
	Naval Undersea Warfare Center, Keyport Division, Keyport, WA
	Naval Surface Warfare Center, Carderock Division, Philadelphia Det., Philadelphia, PA
	Naval Undersea Warfare Center, Newport, RI
	Naval Research Lab, Monterey Det., Monterey, CA
	Naval Air Systems Command (engineering functions)
	Naval Sea Systems Command (engineering functions)
	Naval Air Warfare Center Training Systems Division, Orlando, FL
	Naval Clothing and Textile Research Facility, Natick, MA
	Naval Facilities Engineering Service Center, Port Hueneme, CA
	Naval Submarine Medical Research Laboratory, Groton, CT
	AEGIS, Wallops Island, VA
	AEGIS, Morristown, NJ
	Naval Warfare Assessment Division, Corona, CA
	Explosive Ordnance Disposal Technical Center, Indian Head, MD
	Naval Ordnance Center, Indian Head, MD
	Naval Sea Logistics Center, Mechanicsburg, PA
	Fleet Technical Support Center, Mayport, FL
	Fleet Technical Support Center, San Diego, CA
	Fleet Technical Support Center, Pearl Harbor, HI
Air Force	
	Air Force Research Laboratory, Wright-Patterson AFB, OH Operating Locations:
	Wright-Patterson AFB, OH
	Brooks AFB, TX
	Mesa, AZ
	Eglin AFB, FL
	Tyndall AFB, FL
	Kirtland AFB, NM
	Hanscom AFB, MA
	Edwards AFB, CA

Affiliation	Laboratory
	Griffiss AFB, Rome, NY
	Aeronautical Systems Center, Wright-Patterson AFB, OH (engineering functions)
	Electronic Systems Center, Hanscom AFB, MA (engineering functions)
	Space & Missile Center, Los Angeles AFB, CA (engineering functions)
	Air Armament Center, Eglin AFB, FL (engineering functions)
	Oklahoma City Air Logistics Center, Tinker AFB, OK (engineering functions, excluding supply, depot maintenance, and host base support)
	Ogden Air Logistics Center, Hill AFB, UT (engineering functions, excluding supply, depot maintenance, and host base support)
	Warner-Robins Air Logistics Center, Robins AFB, GA (engineering functions, excluding supply, depot maintenance, and host base support)

DoD Test and Evaluation Centers[1]

Affiliation	Test and Evaluation Center
Army	
	Aberdeen Test Center, Aberdeen Proving Ground, MD
	Redstone Technical Test Center, Redstone Arsenal, AL
	White Sands Missile Range, NM
	Yuma Proving Ground, AZ
	Dugway Proving Ground, UT
	Aviation Technical Test Center, Ft. Rucker, AL
	Kwajalein Atoll, Marshall Islands
	Test and Experimentation Command, Ft. Hood, TX
	Operational Threat Support Activity
	Yuma Proving Ground, Cold Regions Test Center, Fort Greely, AK
	Yuma Proving Ground, Tropic Test Activity, Panama
	White Sands Missile Range, Electronic Proving Ground, Fort Huachuca, AZ
Navy	

[1] Includes Navy RDT&E Centers with major T&E capabilities.

Affiliation	Test and Evaluation Center
	Naval Air Warfare Center, Weapons Division, China Lake, CA
	Naval Air Warfare Center, Weapons Division, Point Mugu, CA
	Naval Air Warfare Center, Aircraft Division, Patuxent River, MD
	Naval Air Warfare Center, Aircraft Division, Lakehurst, NJ
	Naval Research Lab, Washington, DC
	Naval Surface Warfare Center, Carderock Division, Bethesda, MD
	Naval Surface Warfare Center, Crane Division, Crane, IN
	Naval Surface Warfare Center, Dahlgren Division, VA
	Naval Surface Warfare Center, Dahlgren Detachment, Panama City, FL
	Naval Surface Warfare Center, Indian Head Division, MD
	Naval Surface Warfare Center, Port Hueneme Division, Port Hueneme, CA
	Naval Command, Control, and Ocean Surveillance Center, San Diego, CA
	Naval Command, Control, and Ocean Surveillance Center, In-Service Engineering Division, Charleston, SC
	Naval Undersea Warfare Center, Keyport Division, Keyport, WA
	Naval Surface Warfare Center, Carderock Division, Philadelphia Det., Philadelphia, PA
	Naval Undersea Warfare Center, Newport, RI
	Pacific Missile Range Facility, Kauai, HI
	Atlantic Fleet Weapons Training Facility, Naval Station Roosevelt Roads, PR
Air Force	
	Air Force Flight Test Center, Edwards AFB, CA
	Air Force Development Test Center, Eglin AFB, FL
	Air Force Flight Test Center (AFEWES), Ft. Worth, TX
	Arnold Engineering Development Center, Arnold AFS, TN
	46th Test Group, Holloman AFB, NM
	Nellis Range Complex, Nellis AFB, NV
	Air Force Reserve Test Center, Tucson, AZ
Defense Threat Reduction Agency	
	DECADE, Arnold AFS, TN
	Tonapah Test Range, Tonapah, NV
	Thermal Radiation Simulator, Kirtland AFB, NM
	Advanced Research Electromagnetic Simulator, Kirtland AFB, NM

Affiliation	Test and Evaluation Center
	PI X-Ray Simulator (DOUBLE EAGLE), San Leandro, CA
	X-Ray Simulator (PITHON), San Leandro, CA
Defense Information Support Agency	
	Joint Interoperability Test Command, Ft. Huachuca, AZ
Ballistic Missile Defense Organization	
	Joint National Test Facility, Schriever AFB, CO
Director, Test Systems Engineering and Evaluation	
	Precision Guided Weapons Countermeasures Test and Evaluation Directorate (OTD), White Sands Missile Range, NM

Appendix G

The following tables indicate total membership by organization in the National Academy of Science and Engineering as well as membership totals for Fellows of the Institute of Electrical and Electronic Engineers as well as for the American Institute of Aeronauts and Astronautics.

The data was obtained from the membership publications of these societies.

Also included is a table from a National Science Board, Indicator Report, which shows the number of citations by U.S. patents in 1993 and 1994 to research reports generated by leading research laboratories.

Collectively, this data tends to indicate the dominance of the scientific and technical staffs in university and industrial laboratories followed by university affiliated research centers, FFRDCs, and national laboratories. It also indicates relatively little membership from government laboratories especially those of the Department of Defense.

The citations in recent U.S. patents also follow the same trends. Only a very few of the Department of Defense laboratories are noteable in this data.

National Academy Membership* at Leading U.S. Universities

University	Total NAS/NAE Membership	University	Total NAS/NAE Membership
Mass. Institute of Technology	184	University of Michigan	29
University of Cal. Berkley	170	University of Pennsylvania	29
Stanford University	157	University of Southern Cal.	28
University of Cal. Santa Barbara	127	Northwestern University	25
Harvard University	119	Purdue University	21
Cal. Institute of Technology	84	University of Cal. Davis	20
Cornell University	63	University of Colorado Boulder	20
Princeton University	56	Pennsylvania State University	19
University of Illinois	55	Rice University	18
University of Cal. San Diego	54	Rutgers University	18
University of Wisconsin	53	University of Cal. San Francisco	18
University of Texas	51	Georgia Institute of Technology	17
Yale University	49	University of Cal. Irvine	17
University of Cal. Los Angeles	42	North Carolina State University	16
University of Utah	35	Johns Hopkins University	15
Columbia University	34	Carnegie Mellon	15
University of Minnesota	31	University of North Carolina	14
		University of Maryland	13

*National Academy of Sciences and National Academy of Engineering

Industrial Members* of National Academies

Industry	Total Membership	Industry	Total Membership
IBM Laboratories	43	Hughes Aircraft Company	6
Bell Laboratories - Lucent	41	Xerox Corporation	6
AT&T Bell Laboratories	27	Raytheon Company	5
Lockheed	27	Sarnoff Laboratory (RCA)	5
TRW	19	3M	5
GE Company	13	Chevron Corporation	5
Dupont	11	Bechtel Group	5
Ford Motor Company	9	Mobil Research & Development Corp.	4
Hewlett Packard	9	Chrysler Corporation	4
Northrop Corporation	8	Varian Associates	3
Intel Corporation	7	Motorola, Inc.	3
Exxon	7	Comsat Corporation	3
Microsoft Corporation	7	Honeywell	3
United Technologies	6	Rockwell International Corp.	3
Merck	6		

*National Academy of Sciences and National Academy of Engineering

National Laboratories & Government Members* of National Academies

National Laboratories**	Total Membership	Government Laboratories**	Total Membership
Scripps	22	Naval Research Laboratory	6
Brookhaven National Laboratory	12	NASA Langley Research Center	6
Argonne National Laboratory	9	Department of the Navy	5
Sandia National Laboratories	8	NIST	5
Oak Ridge National Laboratory	8	NASA Ames	3
Lincoln Laboratory	7	NASA Goddard	3
Lawrence Berkeley	7	NASA Johnson	3
Los Alamos National Laboratory	6	Department of the Air Force	3
Jet Propulsion Laboratory	5	DoD OSD	3
Southwest Research Institute	4	U.S. Army Corps of Engineers	3
Draper Laboratory	3		
Fermi National Accelerator Laboratory	3		
Illinois Institute of Technology	3		

*National Academy of Sciences and National Academy of Engineering
**Non-profit, URACs, FFRDCs, GOCOs

IEEE Fellow Membership at Leading U.S. Universities
(20% Sample)

University	IEEE Fellow Membership
University of California (several campuses)	18
Massachusetts Institute of Technology	9
University of Texas	7
Stanford University	6
Cornell University	5
Arizona State University	4
Iowa State	4
Rensselaer Polytechnic Institute	4
Michigan State University	3
Northwestern University	3
Texas A&M	3
University of Southern California	3
University of Michigan	3
University of Pennsylvania	3
University of Illinois	3
University of Virginia	3
Virginia Polytechnic University	3

University	IEEE Fellow Membership
Auburn University	2
Boston University	2
Clemson University	2
California Institute of Technology	2
Georgia Institute of Technology	2
George Washington University	2
Rutgers University	2
Rice University	2
Syracuse University	2
University of Minnesota	2
University of Massachusetts	2
University of Pittsburgh	2
University of New Mexico	2
University of Arizona	2
Yale University	2

Tech Capabilities of DSB Task Force Non-DoD Providers

IEEE Fellow Membership at Industries
(20% Sample)

Industry	IEEE Fellow Membership	Industry	IEEE Fellow Membership
IBM	12	Comsat Corporation	1
Bell Tel Labs - Lucent	7	Computer Research	1
AT&T	5	Center for Engineering Research	1
General Electric	4	Communication Research Inc.	1
David Sarnoff Research	3	Cleveland Electric	1
Lockheed - Martin	3	Consolidated Edison	1
Raytheon	3	Channel Products	1
Amp. Corporation	2	Corning	1
Hughes	2	Digital Equipment Corp.	1
Intel	2	Electronic Research & Development	1
SAIC	2	Four Sigma Corporation	1
Analogic	1	Gamma Metrics	1
Adaptive Sensor	1	General Motors	1
Allen Bradley	1	Hf Plus	1
Anidigics Inc.	1	Hib Enterprises	1
Astropower Of Delaware	1	Harris Corporation	1
Bell South	1	Hmj Corporation	1
Bell Communications	1	Hazeltine Corporation	1
C-Dot Digital Microwave	1	Litton Electron Devices	1

IEEE Fellow Membership at National Laboratories & Government
(20% Sample)

National Laboratories	IEEE Fellow Membership	Government	IEEE Fellow Membership
Sandia National Laboratory	2	U.S. Air Force	3
SRI	3	NSF	1
Lincoln Laboratory	3	NRL	1
Institute for Defense Analysis	2	NIST	1
MITRE	2	Non-OSD	1
Jet Propulsion Laboratory	1		
RAND	1		

AIAA Fellow Membership at Leading U.S. Universities

University	AIAA Fellow Membership
University of California (several campuses)	13
Massachusetts Institute of Technology	9
Stanford University	9
California Institute of Technology	7
University of Maryland	6
University of Texas	6
Princeton University	5
University of Colorado	4
University of Cincinnati	4
Georgia Institute of Technology	3
Iowa State University	3
University of Illinois	3
University of Michigan	3
North Carolina State	3
Purdue University	3
Virginia Polytechnic University	3

University	AIAA Fellow Membership
University of Washington	3
Columbia University	2
Cornell University	2
Washington University	2
Boston University	2
Case Western Reserve University	1
Duke University	1
George Washington University	1
Harvard University	1
Howard University	1
Johns Hopkins University	1
Oklahoma State	1
Pennsylvania State University	1
Rice University	1
Wichita State University	1
Western Reserve University	1

AIAA Fellow Membership at Industries

Industry	AIAA Fellow Membership	Industry	AIAA Fellow Membership
Lockheed Martin	21	Digisim Corporation	1
Boeing Corporation	20	Energy Matter Conversion	1
Rockwell International	10	Eagle Aeronautics Corporation	1
General Electric	7	Four Sigma Corporation	1
Raytheon	6	Fairchild Industries	1
United Technologies	5	Geckler Industries	1
Northrup	5	GM - Allison	1
Pymatuning Group	5	INMARSAT	1
Space Technology	3	Kalman Corporation	1
Orbital Sciences	3	Orion Inc.	1
GM - Hughes	2	Piasecki Aircraft	1
Micro Craft Corporation	2	PRC Aviation	1
TRW	2	Pacific Applied Research	1
Thiokol Utah	2	Rann Inc.	1
Airship Development Corporation	1	SEOS Displays LTD	1
Atlantic Aerospace	1	System Development Corporation	1
Aviation Consultants	1	Space Systems	1
Bekey Designs	1	Sverdrup Technology, Inc.	1
Beech Aircraft	1	Stone Engineering	1
Commercial Space Business Development	1	Satellite Communications Corporation	1
CD Radio	1	Science Applications International, Inc.	1
CACI International Inc.	1	Techmatics, Inc.	1
CISCO Systems	1	Teams LLC	1
Communication Center	1	USA Dual Service Grouping	1
De Vore Aviation	1	Winzen Engineering, Inc.	1

AIAA Fellow Membership at National Laboratories & Government

National Laboratories	AIAA Fellow Membership	Government	AIAA Fellow Membership
Jet Propulsion Laboratory	5	NASA Langley	18
Aerospace Corporation	3	U.S. Air Force	14
Draper Laboratory	3	NASA Ames	9
Sandia National Laboratory	2	NASA Headquarters	8
Calspan	2	NASA Lewis	4
New Mexico Research Institute	1	NASA Dryden	3
Battelle Memorial Institute	1	NASA Johnson	3
Institute for Defense Analysis	1	Department of Defense	3
Scott Science & Technology Institute	1	U.S. Navy	3
Southwest Research Institute	1	NASA Goddard	2
Space Guild	1	U.S. Army	2
		NASA Marshall	1
		Congressional Staff	1

U.S. Patent Citations 1993-1994* from Top Fifteen Author Institutes

Organization	Number of Citations	Organization	Number of Citations
Harvard University	2700	University of Illinois	260
Bell Laboratories	1450	→ Naval Research Laboratory	255
Stanford University	1400	Bellcore	250
National Cancer Institute	1300	Lincoln Laboratory	245
Mass. Institute of Technology	1250	Cornell University	240
Veterans Administration	1050	North Carolina State	220
University of Cal. San Francisco	900	University of Texas Austin	220
University of Washington	850	Xerox	200
University of Cal. Los Angeles	760	Pennsylvania State University	200
Scripps Clinic and Foundation	700	Dupont	200
Mass. General Hospital	650	General Electric	170
Johns Hopkins University	640	University of Cal. Santa Barbara	170
University of Pennsylvania	640	Texas Instruments	150
Washington University	620	Texas A&M	150
Merck & Company, Inc.	620	Cal. Institute of Technology	150
University of Cal. San Diego	550	University of Wisconsin	150
University of Cal. Berkeley	420	Purdue University	150

*National Science Board, Indicator Report