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Report
of the
Defense Science Board
1987 Summer Study on

TECHNOLOGY BASE MANAGEMENT

December 1987

OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301-3140

DEFENSE SCIENCE BOARD

December 31, 1987

MEMORANDUM FOR SECRETARY OF DEFENSE
THROUGH: UNDER SECRETARY OF DEFENSE FOR ACQUISITION

SUBJECT: Report of Defense Science Board Summer Study on Technology Base Management

The attached final report of the Defense Science Board Summer Study on Technology Base Management was prepared under the Chairmanship of Dr. John M. Deutch. This study focused on two main issues: 1) how effective is DoD's Technology Base program at producing technology options for various users and operations; and 2) how effectively is new technology being transitioned to the field. The Study Group evaluated the management of DoD's Technology Base program including the processes by which resource allocation decisions are made.

The principal findings of this study are as follows:

1. Over the long term, the leadership and vitality of the U.S., both economically and militarily, depend extraordinarily on the quality and vision of the program of basic research. In recent years, DoD's research program has been reduced in perceived importance in favor of large development programs, with their high visibility and insatiable demand for more financial resources. Where once the Office of the Secretary of Defense exerted a centralized point of unified leadership and budgetary authority and control for the 6.1 program, the Study Group is concerned that now the 6.1 program lacks top management attention.

2. This nation has long been well served by its defense laboratories. The quality of the DoD laboratories and their technical leadership are of supreme importance to DoD. The Study Group is greatly concerned about the quality of many DoD laboratories and believes that their problems will likely worsen in the future. The Group is also greatly concerned about the technical competence of the personnel who manage DoD's Technology Base program.

3. Finally, the Study Group found the Defense Department seriously deficient in its ability to rapidly transition

technology into systems and products. This situation is a primary contributor to the growing crisis in military competition as Soviet weapons system performance approaches and, in some cases, exceeds that of U.S. and Allied forces.

Specific recommendations are made by the Study Group to address the problems identified:

- For the DoD basic research program, the Under Secretary for Acquisition should delegate his Acquisition Executive leadership to an individual with his staff. This individual should be vested with full authority and responsibility for the integration and execution of 6.1 program as a corporate asset.

- For improving the DoD laboratories, three recommendations are made, two outlining DoD-wide changes (expanding the NOSC/NWC personnel demonstration to all DoD laboratories and directing minimum five-year assignments for laboratory/technical directors) and the third suggesting Service laboratory demonstration projects which embody more radical changes.

- To deal with the technology transition problem, the Study Group recommends that budget category 6.3A be revitalized and focused on the transition of technology through Advanced Technology Transition Demonstrations.

As noted in John Deutch's forwarding letter, the Services have expressed concern over several of these recommendations. We have received comments from the Services and have incorporated appropriate changes into the attached final report.

I believe that the implementation of these recommendations will strengthen the management of DoD's Technology Base. I recommend that you review the Executive Summary and take necessary actions to implement these recommendations.

Charles A. Fowler

Charles A. Fowler
Chairman

Attachment

OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301-3140

DEFENSE SCIENCE BOARD

23 December 1987

Mr. Charles A. Fowler
Chairman
Defense Science Board, OUSD(A)
The Pentagon,
Room 3D1020
Washington, D.C. 20301-3140

Dear Bert,

Enclosed please find the report of the 1987 Defense Science Board Summer Study on Technology Base Management. The findings and recommendations of the study, if implemented, will in my judgement serve to strengthen significantly the critical technology base activities of the DoD.

You are aware that this Summer Study generated concern among the Services about the wisdom of some of our recommendations. I trust that the Services will be given an opportunity to comment on the final before the Secretary of Defense acts on our recommendations.

It has been a pleasure to work with so many talented and dedicated individuals on a subject which is so vital to this nation's long-term national security. I and the Study Group stand ready to work with the Department to implement the Study's recommendations.

Sincerely,

John M. Deutch
Chairman
DSB Summer Study on
Management of the Technology Base

EXECUTIVE SUMMARY

This report presents the results of the 1987 DSB Summer Study on Technology Base Management. This study focused on two issues:

- Is the Technology Base efficiently producing technology options adequate in number and quality for DoD users and operators?
- How can the transition of new technology to the field be accomplished most effectively?

There have been many studies of the Technology Base over the past fifteen years; these studies have come to conclusions similar to those of this Study Group and made similar recommendations. This Summer Study has relied heavily upon these prior reports and we have attempted to formulate our recommendations in a manner that will improve the chances of implementation.

The new circumstances which justify a new Technology Base study at this time are:

- The growing perception of a diminishing margin of U.S. technological advantage.
- The concern that the DoD is receiving less value for its R&D dollar.
- A growing appreciation for the overlap between technology advances in the commercial and defense sectors.
- The major reorganization of the DoD Acquisition System which is underway.

The Study Group focussed its attention on the management of the Technology Base and the process by which resource allocation decisions are made. Our concern was how efficiently available resources are being employed; we did not examine the adequacy of the present level of resources. Since no precise objective estimates are possible for the performance of the Technology Base, the Study Group relied upon its judgement of the strengths and weakness of the existing program in reaching its conclusions and recommendations.

MANAGEMENT OF RESEARCH

Over the long term, the leadership and vitality of the U.S., both economically and militarily, depend extraordinarily on the quality and vision of our program of basic research. It is essential that this central tenet be understood and endorsed at the highest levels of our national leadership. The Study Group concurs with a widely held perception and concern that our national technological advantage has eroded significantly in recent years. Even recognizing the growth of other government research activities, the size and performance of the DoD 6.1 research program has not kept pace with scientific opportunities and needs related to defense interests.

Where once OSD exerted a centralized point of unified leadership and budgetary authority and control for the 6.1 program, the Study Group is concerned that this leadership is fragmented by too much delegation to the Services and agencies; the 6.1 program has, in effect, been relegated to a position of second order importance and lacks top management attention.

TECHNICAL MANAGEMENT AND LABORATORIES

This nation has long been well served by defense laboratories in innovative research and in the support of national emergencies. These contributions have resulted largely from the quality of the scientists and engineers at these laboratories, together with the leadership, resources and organizations supporting them. The quality of the laboratories and their technical leadership are of supreme importance to DoD. Given the current circumstance of many DoD laboratories, and the belief that current problems will likely worsen in the future, the focus of this Study Group was on formulating recommendations which could increase the effectiveness and continuity of DoD laboratories.

The Study Group also focussed attention on the technical competence of the personnel who direct and manage our technology program. We formulated recommendations which will upgrade significantly the technical management skills available within DoD for management of its technology base programs.

TECHNOLOGY TRANSITION

Present and past national research and exploratory development programs have demonstrated an abundance of innovative ideas within the U.S. scientific and engineering communities. However, the Study Group believes that both the Defense Department and commercial industry are seriously deficient in rapid technology transition from R&D to systems and products. This situation is a primary contributor to the growing crisis in military competition as Soviet weapons system performance approaches and, in some cases, exceeds that of U.S. and Allied forces.

The Study Group concluded the greatest opportunity to improve the rate and effectiveness of this transition process is by increasing focus on the early advanced development phase of the S&T program, that is, Budget Category 6.3A. In order to overcome the barriers to effective transition the Study Group believes that DoD should strengthen and employ its 6.3A program to emphasize the careful selection and timely execution of system and major sub-system Advanced Technology Transition Demonstrations to build and test experimental systems in a field environment.

OTHER CENTRAL IMPORTANT ISSUES

The Study Group also discussed several other topics which we believe to be important to DoD on Technology Base:

- International Technology Base Cooperation
- Dual Use Technology and the Technology Base
- Independent Research and Development (IR&D)
- Contracting for Technology Base R&D
- Biomedical R&D
- Microelectronic and Optoelectronic Production Start-Ups

These issues are discussed in the attached report.

RECOMMENDATIONS

For the DoD basic research program, the Undersecretary of Defense (Acquisition) should delegate his Acquisition Executive function to an individual within his staff. This individual should be vested with full authority and responsibility for the 6.1 program. Specifically:

> *USD(A) should restate the purpose and mission for the 6.1 program of basic research and explicitly reaffirm its importance, emphasizing its long-range focus.*
>
> *USD(A) should explicitly recognize the 6.1 program as an integrated corporate program and should re-assert the corporate budget and managerial authority already resident within OSD.*

For improving the DoD laboratories, three recommendations are made. The first two recommendations outline DoD-wide changes. The third recommendation suggests demonstration projects which embody more radical changes.

> *USD(A) should take immediate positive action to expand the NOSC/NWC (China Lake) personnel experiment to encompass all DoD laboratories for all scientists and engineers (S&E's). In addition, necessary changes in law and regulations should be made to extend the probationary period for laboratory S&E hires from one year to three years.*
>
> *USD(A) should direct that the individual Services establish a clear line of responsibility, authority and accountability to each laboratory/technical director and that these laboratory/technical directors be appointed for five years, renewable upon review.*
>
> *USD(A) direct each Service to create at least one demonstration laboratory project which attracts and retains highest quality staff; improves contracting effectiveness; improves personnel management; and provides local laboratory management authority and accountability.*

To improve the quality of personnel involved in the management of the DoD Technology Base, the Group recommended another demonstration project.

> *USD(A) should establish an experimental Senior Scientific Technical Acquisition Executive Program. This initiative would consist of up to 100 non-tenured appointments within DoD with the goal of significantly strengthening critical technology skills, Technology Base management, and Defense Acquisition management. Compensation for such non-tenured employment would be based on comparability. Legislative action would be required to permit the appointees to return to their positions at the end of their appointments.*

The transition of militarily cost effective technology from R&D to the field was the issue of greatest concern to the Study Group. The Study Group notes that the 6.3A budget category is key to this transition if properly utilized to facilitate the technology transition. The Study Group recommends that the 6.3A activities be refocussed by the establishment of a program of Advanced Technology Transition Demonstrations (ATTD's).

> *USD(A) employ 6.3A for ATTD projects to sharpen DoD's focus on technology transition.*
>
> - *Building and testing experimental systems in field environment -to establish technical feasibility and field utility before a system commitment and Full Scale Engineering Development (FSED) decision are made.*
> - *Use specific management principles to guide these projects.*
> - *Direct (by FY91) half or more 6.3A funding to ATTD projects -- approximately $1B (in FY 1988) or 2-1/2% of RDT&E (do not use 6.1 or 6.2 funds).*
> - *For all ATTD projects request Vice Chairman JCS to review annually to assure projects address future military user needs.*

1.0 INTRODUCTION

1.1 OVERVIEW

The 1987 Defense Science Board Summer Study on Technology Base Management was charged with evaluating the management of the Technology Base of the Department of Defense (DoD) and with making recommendations to improve the effectiveness and efficiency of that management. The Terms of Reference of the study appear in Annex A. Study participants are listed in Annex B. This group has extensive experience with Technology Base Management within DoD, industry and academia. Other participants in the study are listed in Annex C.

The Technology Base encompasses research and development (R&D) efforts funded under budget categories 6.1, 6.2 and 6.3A. These efforts:

- Provide new technology options for the near (6.2 and 6.3A) and long term (6.1 and 6.2);
- Support later R&D stages; e.g., system engineering (6.2 and 6.3A); and
- Contribute to improved technology utilization and technology transfer (6.3A).

Although the DoD currently invests only 2.9% of annual expenditures in 6.1 through 6.3A categories, this small number should not be taken as a measure of its importance. There was unanimous agreement among Study members that today's Technology Base is essential to ensuring war-fighting superiority of future U.S. military systems and operations. There was less agreement about what should be done to improve performance of the Technology Base.

The Study Group focused on two issues:

- Is the Technology Base efficiently producing technology options adequate in number and quality for DoD users and operators?
- How can the transition of new technology to the field be accomplished most effectively?

While both issues are important, there was general agreement that the second issue is currently more pressing. Basically, the system is better at generating new technology than exploiting it.

1.2 HISTORY - WHY ANOTHER STUDY?

There have been many studies of the Technology Base. For sixteen such studies, Annex D summarizes the major recommendations and subsequent implementation actions. These studies came to conclusions similar to those of this Group and made similar recommendations, most of which have not been implemented. This Study Group considered these prior studies and attempted to formulate recommendations in a manner that improve their chances of adoption.

There are several changed circumstances which justify a new Technology Base study at this time:

- There is an increasing risk that the U.S. is losing the technological advantage on which it bases its strategy for military superiority.
- There is a growing perception that the DoD is getting progressively less for its R&D dollar.
- There is a growing overlap between technology advances in the commercial and defense sectors. Accordingly, improved performance of the DoD Technology Base can contribute to the ability of the U.S. to compete in the international marketplace.
- And, most importantly, a major reorganization of the DoD Acquisition System is underway as a result of the Packard Commission and the 1986 Goldwater-Nichols Act.

From the perspective of this study, the reorganization of the DoD acquisition system has two implications. First, the new Acquisition System is directed by an Under Secretary of Defense with strengthened authority. This strengthened authority can provide the mechanisms for implementing needed changes. Second, the reorganization establishes a Vice Chairman of the Joint Chiefs of Staff who, among other things, is responsible for representing the needs of the Commanders of the Unified and Specified Commands in the acquisition process, the ultimate users of new technology. Although, there will be substantial demands on the Vice Chairman's attention, he can act as an important influence to improve the technology transition process.

1.3 WHAT THE SUMMER STUDY DOES AND DOES NOT ADDRESS

The Study Group decided to focus on three major Technology Base management areas: management of research, technical management and laboratories, and technology transition. Based on today's circumstances it is in these areas that the Study Group believes particularly effective action can be taken.

This Summer Study did not address certain important specific issues. The Study did not consider the question of adequacy of the present level of Technology Base resources (6.1 + 6.2 + 6.3A), but rather focused on utilizing available resources more effectively and efficiently. Also, the Study did not consider the balance of support among key technical areas. The focus of this inquiry was on the process of choice, rather than on specific technology opportunities. Other issues of importance which the Study did not address include technical management of SDI and support for the U.S. semiconductor industry.

Several recommendations deal with leadership - ensuring that wise individuals chart management and technical courses which will optimize the results produced by the Technology Base investment. There is no mechanism to ensure that wise leadership and sustaining vision are asserted except to find experienced, excellent leaders, assign them responsibility and authority, and equip them with adequate resources for a duration long enough so that they may succeed.

It was evident that implementation of some recommendations will face institutional or political resistance. To reduce such resistance, the Study Group has, in some cases, proposed "experiments" or "demonstrations" that effect a major management change, but in a limited, localized organization. If successful, such "experiments" provide a well-defined blueprint for making the management change on a wider scale.

1.4 ORGANIZATION OF THE REPORT

Section 2 discusses the Technology Base, its importance to the Acquisition System and its current performance. Section 3 includes a summary of major findings and recommendations in the areas of:

- Management of Research
- Technical Management and Laboratories
- Technology Transition.

Section 4 discusses other important issues addressed by the group: international technology base cooperation; dual-use technologies; industrial research and development; contracting; biomedical R&D; research facilities and equipment; and microelectronic and optoelectronic production line startup. There was not sufficient time available for the panel to arrive at conclusive findings and recommendations in these areas.

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2.0 TECHNOLOGY BASE IN THE ACQUISITION SYSTEM

The Acquisition System is charged with managing the life cycle of a military system or activity from early R&D, design and integration, test, and procurement through operation and maintenance. The R&D which takes place within this system is a means to an end and is not an end in itself and it should be managed accordingly. R&D is not only concerned with new technology leading to new weapon systems; R&D is also concerned with innovation which improves performance and/or lowers cost in any aspect of the life cycle of a deployed weapon system or a military activity.

It is research, the exploitation of technological advances and solutions to scientific problems, that offers the opportunity for large improvement in warfighting systems. To reveal and assay such opportunities, Technology Base research must pursue high-risk, high-payoff options. An atmosphere which inhibits risk-taking will result in a research program which has a short-term focus. This compromises the ability of the program, over time, to identify and pursue major new technological opportunities. There is a growing concern that weak R&D leadership and bureaucratic forces are creating an environment which progressively discourages appropriate technical risk-taking within DoD.

2.1 CATEGORIES OF R&D ACTIVITY AND R&D PERFORMERS

The Study Group found the current budget categorization for DoD R&D activity to be conceptually appropriate and useful. Categories within the Technology Base R&D activity are:

- 6.1 - Research
- 6.2 - Exploratory Development
- 6.3A - Advanced Technology Development (Feasibility)

Beyond that are the categories:

- 6.3B - Advanced Development (Based on System Application)
- 6.4 - Engineering Development
- 6.5 - Management and Support

While categorizing activity is useful, it is not always the case that new technology is developed via a sequentially staged program involving activity in each category beginning with 6.1 research. There are important examples where a 6.1 discovery has found prompt application in fielded systems. There are also cases where technical work in engineering development has uncovered fundamental phenomena and methods. Likewise, 6.3A and higher category projects have uncovered unanticipated knowledge gaps which need to be bridged via 6.1 or 6.2 activity. For these reasons the Study Group believes that 6.2 and 6.3A and higher budget categories should include budgeting for resolution of knowledge gaps.

Tables 2.1 and 2.2 list FY87 and FY88 resources devoted to the Technology Base.

Category	Army	Navy	Air Force	Defense Agencies	Total $M
6.1	218	334	223	96	891
6.2	636	435	549	722	2342
6.3A(w/o SDI)	401	131	642	516	1690
Subtotal	1255	920	1414	1334	4923
6.3A (w/SDI)				3724	3724
Total					8647

Table 2.1: FY87 Technology Base Funds By Source

Category	Army	Navy	Air Force	Defense Agencies	Total $M
6.1	199	381	227	111	918
6.2	625	460	605	813	2503
6.3A (w/o SDI)	401	259	929	376	1965
Subtotal	1225	1100	1761	1300	5386
6.3A (w/SDI)				5199	5199
Total					10585

Table 2.2: FY88 Technology Base Funds by Source

The performers of DoD R&D are:

- Industry
- Universities
- DoD Laboratories
- Government-owned, contractor operated (GOCO) laboratories; federally funded research and development centers (FFRDC); and not-for-profit laboratories.

Table 2-3 shows FY87 6.1 and 6.2 funding levels by performer.

Category	FY87 Total ($M)	Percentage University	Industry	Gov't Labs	GOCO Labs
6.1	891	52	11	32	1
6.2	2342	9	39	43	7

Table 2.3: FY87 6.1 and 6.2 Funds by Performer

Although there is no precise alignment between performers and the R&D category or activity, a rough alignment is discernable: universities are relatively more involved in 6.1 work. With 6.2 and 6.3A categories, all four performers make major contributions. The Study Group does not believe that it is fruitful to associate any type of performer with any specific category of R&D activity. Moreover, there is an appropriate diversity of practice among the Services. The very high percentage of R&D performance in government laboratories is one measure of their importance to the overall DoD acquisition process.

The Study Group is, however, concerned with the correct classification of R&D activity. Misclassification obfuscates the balance of expenditures as represented by categories of activity. Examples of misclassification are:

- System-oriented or short-term technical work funded in 6.1 and 6.2.
- 6.2 activity intended in large part or entirely to support 6.4 engineering development.
- Assignment of all costs of R&D program direction (overhead) to the 6.2 category instead of 6.5.
- All SDI sponsored R&D classified as 6.3A while, in fact, and we believe quite appropriately, SDI R&D activity spans all categories.

When a decision is made to increase effort in one Technology Base category, the system sometimes responds simply by transferring existing funds and activities, without modification, from one category to another.

2.2 PEOPLE

The Study Group was unanimous in its view that a central problem with the current Technology Base is the quality of technical and management people at all levels. Without good technical people, the entire system suffers. In general, the Study Group concluded that, for a variety of reasons -- salary levels, freedom to carry out significant technical work and conflict of interest provisions--the general level of technical competence throughout the DoD Technology Base has been declining. The most critical people are the decision makers, those people - technical and management - who decide what to do and how to do it, must be excellent, if the Technology Base R&D activity is to deliver up to its potential.

At OSD and Military Department Level

Although OSD and Service headquarters staff contain some outstanding individuals, the average talent is not as strong as in the past and this influences both the design, execution, and leadership of the DoD Technology Base.

At the Government Laboratories

Civil Service personnel practices are making it progressively more difficult for the government laboratories to compete with the outside world for top technical talent. In the absence of such top talent, laboratory technical performance will eventually suffer. The system needs more flexibility.

At the Uniformed Military Level

The Study Group is concerned that the Services are not assigning a sufficient number of officers to R&D positions with the technical experience and education required for modern technology. Likewise, officers who possess technical experience and knowledge are often assigned to positions which cannot utilize that expertise. Attention should be given to assessing the dimensions of this problem. Some improvement may be possible at low cost.

At the University Level

DoD sponsored basic research should be carried out in a manner that assures that colleges and universities continue to be a source of bright and motivated young people concerned with technical subjects of significance to national security.

2.3 EVALUATING THE PERFORMANCE OF THE DOD TECHNOLOGY BASE SYSTEM - ITS STRENGTHS AND WEAKNESSES

It is important to ask "How is the Technology Base system performing compared to the level of resources it receives?" A precise answer to this question was not formulated. In fact, quantitative, objective, output-oriented measures of the performance of the Technology Base system simply do not exist. Instead, the Study Group relied upon the judgment of its members.

The group noted the following strengths and weaknesses of DoD's Technology Base program:

Strengths

- The level of resources devoted to the Technology Base indicate that DoD and Congress accept the importance of supporting the Technology Base.
- There are pockets of technical excellence in the DoD laboratories.
- DoD laboratories maintain a good institutional memory.
- Overall, the Technology Base system is quite robust. There are many kinds of laboratories, overlapping capabilities, many sources of funding, and many independent technical judgments made throughout the system.
- In selected technology areas, the laboratories are capable of rapidly applying expertise to solving technical problems with fielded systems.

Weaknesses

- Needed technology goes undeveloped.
- The menu of research options has become restricted. The focus on short-term, low-risk objectives is driving out investment in long-term, high-risk, high-payoff objectives, especially in 6.1 research.
- Transition of available technology into operational systems is too slow.
- Declining technical competence at all levels of Technology Base management often results in poor selection of opportunities, problems and performers.
- With a few exceptions, DoD laboratories cannot compete for top technical people and the laboratories do lose good people quickly. Many DoD laboratories do not have the needed critical mass of first rate technical leaders.
- With a few exceptions, government laboratory management is bureaucratic and over-regulated. In-house managers and contract monitors are neither given adequate authority, nor held accountable, for technical decisions. More attention is given to avoiding mistakes than producing results. Risk-taking is neither encouraged nor rewarded.
- Contracting procedures are overly burdensome and often inappropriate to Technology Base activity.

- No useful, well-understood and well-accepted measures of merit have been developed to judge results, performers or managers. Therefore, there is anxiety that any measures likely to be used would be the wrong ones, applied by the wrong people.
- There is too much redundancy and too much fragmentation throughout the DoD program due in part to the large number of laboratories. But it is politically difficult to close laboratories.
- Industry investment in the Technology Base is being constrained by recent DoD acquisition changes such as reduced progress payment rates, excessive review, cost sharing requirements for development, the new profits policy, and longer depreciation schedules for R&D equipment.

These observations lead to a number of important management questions:

- How can DoD speed up technology transition? Is the problem mainly outside the Technology Base arena?
- How can DoD protect, capitalize on, and extend existing pockets of excellence?
- How can DoD recruit and retain good people, especially good technical managers?
- Have some DoD laboratories or military departments found a more effective way to manage? Can the DoD build on these methods?
- Should new institutions be established or old ones closed?
- Should work be consolidated at new or existing institutions?
- How can DoD ensure that the right problems are addressed?

Note that here and below, the term laboratories means both government laboratories and government owned, contractor operated (GOCO) laboratories. When a distinction is intended among these types of laboratories, it is indicated.

3.0 FINDINGS AND RECOMMENDATIONS

This section presents findings and recommendations for three major areas:

- Management of Research
- Technical Management and Laboratories
- Technology Transition

Within each area are one or more statements of findings followed by the Study Group recommendations. Recommendations are indented and in italics. In some cases, additional discussion of intent or implementation follows the specific recommendations.

3.1 MANAGEMENT OF RESEARCH

Over the long term, the leadership and vitality of the U.S., both economically and militarily, depends extraordinarily on the quality and vision of our program of basic research. This has been true in the past, and will continue to be in the future. It is essential that this fundamental principle be understood and endorsed at the highest levels of our national leadership.

The need to understand and re-affirm this fundamental proposition is made critical by the increasing challenge from other nations who are more effectively creating and applying technology for both economic and military objectives. The U.S. no longer can enjoy a comfortable position of leading the world in this arena. It can no longer expect that the rich rewards which come to those who create new technology and successfully apply it will automatically come to the U.S. We have witnessed how whole industries can be wiped out by sudden "technological surprise". Similarly, in the military sphere, we have witnessed how technological surprise can alter very rapidly the balance of power both in specific areas of warfare and in the aggregate.

Japan has, by a recent national policy decision, articulated a plan for emphasis on basic research to sustain their long-range economic growth and enhance their goal of world economic leadership. This objective will complement their already formidable strength in applied technology. Similarly, the Soviet Union believes in the strategic importance of basic scientific inquiry and supports a massive research program. Their shortcoming is in the translation of such research results into technological application.

To repeat, the leadership and vitality of the U.S., both economically and militarily, depends extraordinarily on the quality and vision of our program of basic research. In particular, the DoD must pursue basic research in militarily-relevant technologies to assure that the best new ideas are available to it, and that it maintains communities of the very best researchers who can immediately begin to investigate new technological opportunities or problems whenever or however they become known.

3.1.1 THE PROBLEM WITH BASIC RESEARCH

Excellent basic research depends upon sustained pursuit of visionary, long-term objectives. In the military arena, as in some U.S. industry, basic research performance has been degraded by expedient, short-sighted leadership. The need for short-term results and immediate "relevancy" have become the governing criteria in framing a program. We have experienced a "research menu squeeze" in which only the most popular programs, justifiable in terms of clearly perceived near-term military relevancy survive the cut. Often left untapped are the longer range but inherently higher leveraged research programs as well as the genius of many scientists working on subjects of ultimately much greater potential importance.

In retrospect, during and after World War II, an inspired program of basic research was created within DoD. It fueled an aggressive national effort for development of military technology which led the world. A concomitant benefit was that the highest quality technical people became involved in defense objectives. For example, the formation of the Office of Naval Research with its support of basic research in universities served as a powerful stimulus in terms of new scientific concepts and innovation as well as growth of vital people resources. The Study Group concurs with a widely held perception and concern that this strength has been attenuated seriously over the last twenty-five years. Even recognizing the growth of the National Science Foundation, the Department of Energy, and the National Aeronautics and Space Administration research activities, the size of the DoD 6.1 basic research program has not kept pace with scientific opportunities and needs related to defense interests; this has, of course, been compounded by inflation and the increasing cost of research.

Basic research areas do not observe military organization lines. The Army has identified ten critical, pervasive long-range technologies:

- Sensors
- Signal Processing
- Information Processing
- Survivability
- Advanced Materials
- Directed Energy Weapons
- Robotics
- Artificial Intelligence
- Biotechnology
- Human Factors

The potential application of these technologies transcends Service interests. Therefore, DoD corporate perspective, commitment, and guidance in their initial exploration is needed to ensure robust, broadly applicable research results.

Compounding the process of incremental deterioration in the quality and focus of the DoD basic research program has been its over-management, even micromanagement, within DoD, and the constraints imposed by the increasingly complex DoD contracting process. The trend has been towards detailed "management" rather than visionary leadership, leading inexorably towards mediocrity, frustration, and contradiction of the very underlying purpose of the 6.1 research program itself.

Further, in recent years the 6.1 program has become lost in the shuffle of the large development programs, with their high visibility and insatiable demand for more resources. It is particularly short-sighted to reallocate 6.1 and 6.2 funds to bail out later stage R&D projects having financial difficulty.

Where once OSD exerted a centralized point of unified leadership and budgetary authority and control for the 6.1 program, the Study Group is concerned that this leadership is fragmented by delegation to the Services and agencies; the 6.1 program has, in effect, been relegated to a position of second or third order of importance and lacks top management attention. Stated bluntly, DoD "corporate management" has essentially abrogated some of its responsibility for long range vitality and competitiveness.

3.1.2 REVITALIZING BASIC RESEARCH

Having expressed this serious concern, what can we do about regaining the long-range vision for DoD's 6.1 research program. The answer is "take charge." At appropriate levels of the Technology Base management there must be an individual with authority, responsibility, and accountability to decide what research is pursued, using what strategy, and by whom. Work program execution should then be continually evaluated against its specified objectives.

Within DoD responsibility for the 6.1 "corporate asset" begins with the Under Secretary of Defense for Acquisition (USD(A)), who has the ultimate authority for the entire Technology Base. In particular USD(A) should reassert corporate budget and managerial authority for the 6.1 programs. The USD(A) can, and indeed must, delegate portions of the overall authority. This delegation should be done with the objective of reducing the levels between the performers and significant management authority, in keeping with the recommendations of the Packard Commission. Our recommendation is:

> *USD(A) should restate the purpose and mission for the 6.1 program of basic research and explicitly reaffirm its importance, emphasizing its long-range focus. This can be done by a DoD-wide policy*

statement or directive. Such a statement will constitute guidance for all DoD elements involved in executing the program.

USD(A) should explicitly recognize and state that the 6.1 program is an integrated corporate program, regardless of where it may be executed in the Services and DoD agencies. As such, USD(A) should re-assert the corporate budget and managerial authority already resident within OSD. A specific individual at the deputy under secretary or assistant secretary level should be named and delegated to exercise this authority and take responsibility for the centralized management and leadership process. That individual's responsibilities, inter alia, are to:

- *Structure the DoD-wide 6.1 program and be responsible for its quality, balance and long-range focus.*
- *Establish budgets and guidance for all participating elements of DoD with full delegated authority over these budgets.*
- *Articulate the integrated DoD 6.1 program in terms of an annual posture statement whose audience is Congress and the U.S. technical community.*
- *Define what is meant by "broad defense relevancy," as guidance for DoD and advice to Congress.*
- *Present the 6.1 program to Congress together with key leaders from the Offices of Scientific Research, DARPA and other performing agencies.*
- *Conduct broad oversight of the program with strong outside participation to assure a balanced, visionary and highest quality program.*
- *Coordinate with other federal agencies that undertake related basic research activity.*

With strong top management support, the designated DoD leader is vested with final decision authority and budgetary control. Full participation of DoD performing elements in an integrated program planning and review process is essential.

3.2 TECHNICAL MANAGEMENT AND LABORATORIES

Since the founding of the first defense laboratory in 1842, the Naval Observatory, this nation has been well served by defense laboratories in innovative research as well as in the support of the operational forces given by laboratory personnel during national emergencies. These significant contributions have resulted from the quality of the scientists and engineers at these laboratories, together with the resources and organization supporting them.

Now, more than ever, our nation calls upon the leverage of technological advantage for its security. The challenge is to maximize the effectiveness of our defense laboratories, and thus of their staffs, by removing barriers to and providing incentives for efficient operation. The potential payoff is large, as seen by the size of laboratory staffs and budgets. In-house DoD laboratory programs are in excess of $5.5B per annum, with professional staffs of approximately 38,000 scientists and engineers. The importance of the DoD laboratories to DoD's total acquisition program is not always appreciated. Not only do they perform a high fraction of the 6.1 and 6.2 work (32% of 6.1 - $300M; 43% of 6.2 - $1B) but they also control or manage much of the rest of the Technology Base and are principal technical monitors for later stage acquisition programs. Thus, the quality of the laboratories and their technical leadership are of supreme importance to DoD.

The Study Group believes that there is significant advantage for use of the GOCO laboratory mechanism in contrast to the government laboratory mechanism for performing technical R&D work. Where existing government laboratories are not performing well, conversion to a GOCO laboratory has some attractive properties. Such conversion would involve significant disruption and political opposition. However, the Study Group believes that such a conversion should be considered in certain circumstances. Further, the GOCO mechanism is the mechanism of choice for establishing any new laboratory or center which undertakes significant amounts of technical work.

Every laboratory must have a specified mission. This requires a focus in the laboratory's R&D program as well as an appropriate level of resources. If laboratory resources are too diffuse or if the laboratory is not performing technically at standards required to meet its objectives, it should be rapidly strengthened and re-oriented, or it should be closed.

A successful laboratory requires discretionary basic research funds for its long term vitality. These resources permit a laboratory to undertake long-term projects as well as to engage in technical interaction with the outside scientific community. The group affirms the recommendation of the 1983 Federal Laboratory Review Panel, chaired by David Packard, that "at least 5%, and up to 10%, of the annual funding of the Federal laboratories should be devoted to a program of independent research and development at the laboratory directors' discretion" to maintain vitality in the laboratory's mission area. Additional allocation of monies and tasks must depend upon the laboratory's ability to compete against other performers on the basis of technical excellence.

Given the current situation of many DoD laboratories and the belief that their problems will likely worsen in the future, the focus of the Study Group was on formulating recommendations which could increase the effectiveness of DoD laboratories. The Study Group formulated two kinds of recommendations. The first kind recommends making DoD-wide laboratory changes. The second kind proposes limited experiments with additional promising management mechanisms to test their efficacy before implementation more broadly.

3.2.1 DOD-WIDE PERSONNEL MANAGEMENT CHANGES

The dominant factor in the quality of the in-house laboratories is the quality of their personnel, especially their scientists and engineers. The Study Group concluded that improvements to the personnel system are critically needed to assure that DoD laboratories can attract and retain top quality technical people.

The following factors are important in attracting and retaining high quality technical personnel:

- High quality colleagues.
- The opportunity to work on exciting, significant projects.
- An environment conducive to high quality technical work, including management, equipment, technical support, and procurement support.
- Adequate salaries and opportunities for advancement, including continuing education.

The Group believes that the level of compensation allowed by the Civil Service system is a major inhibitor to attracting and maintaining quality technical staff within in-house DoD laboratories. The inability to compete with industrial R&D centers for the best technical talent is graphically illustrated by Figure 4.1 which plots salaries for scientists and engineers (S&E) for one government laboratory against thos of a GOCO laboratory.

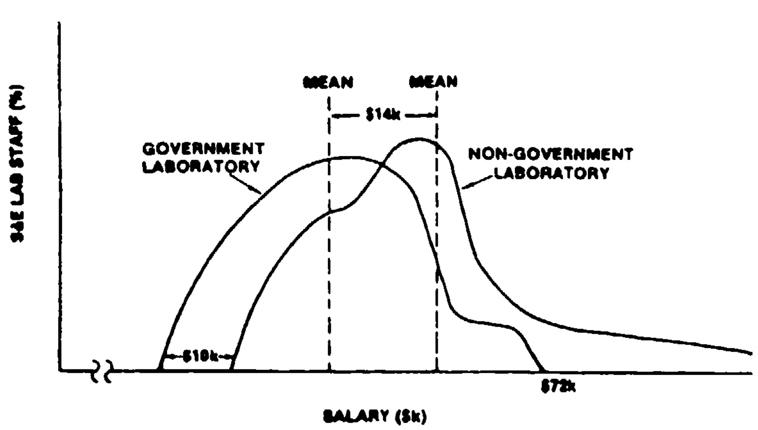

Figure 4.1: S&E Salary Comparison

The lower end of the curves shows that starting salaries for representative newly graduated S&E's with bachelors degrees differ by roughly $10,000. This comparison indicates that they are probably not hiring the same quality of person unless the Government laboratory is exceptionally strong along some other dimension that attracts S&E personnel. The difference in the mean salary is $14,000, again indicating a potential difference in personnel quality. At the high end, government laboratory S&E salaries are capped at $72,000, by law. Premier technical achievers at the GOCO laboratory are paid twice, or possibly more, than that amount. This difference is crucial since it is generally agreed that research and development relies heavily on the leadership and wisdom of a small number of unusually talented individuals.

The Civil Service Reform Act of 1978 authorized the use of experimental personnel systems to demonstrate improved personnel management in government. One such demonstration program has been conducted at two Navy laboratories, the Naval Ocean Systems Center, San Diego, California and the Naval Weapons Center (NWC), China Lake, California. This "Demonstration Program" was designed to test the introduction of representative private sector personnel practices into public sector laboratories.

The Demonstration Program contained six elements which are important to improvement of the quality of personnel in laboratories:

- A simplified classification system which allows optimal development and use of scientists and engineers and which minimizes the personnel system process. (See Figure 4.2.)
- A simplified and improved performance evaluation system.
- A performance-based pay system, allowing laboratory management to reward excellent performance.
- Provision for starting salaries for new professional scientists and engineers that are competitive with those of the private sector.
- Performance-based retention in time of a reduction in force.
- Rewards for bench-type S&E's (non-management) for technical contribution rather than management.

GS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
DEMO	A				I				II			III		IV		V		

Figure 4.2: Personnel Categorization (China Lake)
Fewer Categories Increase Management Flexibility

The Study Group reviewed this demonstration project and finds that it has been highly successful in the two laboratories. Similar findings have been made by others including the Packard Commission.

A further improvement in personnel management would be to change the probationary period for newly hired laboratory S&E personnel from the current one year period to a more meaningful and useful three year period. In industry, termination action can be implemented at any time in an employee's career. In government, termination action is very difficult after the probationary period. It is also very difficult to intelligently evaluate a new S&E employee's real worth and true potential in the first year, which is typically taken up with orientation and learning rather than performance against assigned responsibilities and work objectives. This change in probationary period will require a change in law and may require the inclusion of a termination benefit payment to those S&E personnel terminated within the three year probationary period.

> ***USD(A) should take immediate positive action to expand the NOSC/NWC (China Lake) personnel experiment to all DoD laboratories for all scientists and engineers (S&E's). In addition, the probationary period for laboratory S&E hires should be extended from one year to three years.***

The planning and implementation of this recommendation -- including orchestration of the required Congressional action -- should be a matter of importance to and under the direct cognizance of the Under Secretary of Defense for Acquisition. The additional cost of this program should be very small -- depending on the termination benefit specified in the required Congressional enactment.

3.2.2 STABILIZE LABORATORY TECHNICAL DIRECTION

A successful Technology Base program requires stable goals and leadership so that (multi-)disciplined research teams can be established and equipped to perform the necessary work. This process requires stability in the technical leadership of the programs as well as sufficient authority in the laboratory direction to maintain program continuity. For the Technology Base system to operate effectively, each laboratory/technical director must be given the responsibility and authority to manage his program and be held accountable for the productivity of that program. His authority must include technical program content and execution, laboratory personnel practices, and budget formulation and oversight.

The laboratory/technical director must typically remain in his position long enough to sustain his program and to be held accountable for its productivity. Some DoD in-house laboratory/technical directors have been reassigned as frequently as once every 10 months which precludes such a central, sustained direction of the technical program.

The Study Group recommends:

> *USD(A) should direct that the individual Services establish a clear line of responsibility, authority, and accountability to each laboratory/technical director in charge of the technical program for program content and execution, for laboratory personnel policies, and for budget formulation and execution. Further, the group recommends that the Service Program Executive Officer appoint these laboratory/technical directors for 5-year appointments, renewable upon annual review and with provisions for removal.*

3.2.3 DOD LABORATORY MANAGEMENT DEMONSTRATION PROJECTIONS

The Study Group strongly believes that laboratory problems with personnel, contracting, and the lack of authority of the laboratory directors, strongly inhibit productivity. Even the highly successful personnel demonstration projects conducted at the Naval Ocean Systems Center and at the Naval Weapons Center China Lake do not go far enough.

Changes are needed to address the remaining problems with personnel, facility and equipment, contracting, and director authority. However, the Study Group did not believe that substantive, additional changes to all laboratories would be accepted and implemented without demonstrable proof that such changes would be effective in the laboratory context. Consequently, the Study Group recommends a strategy of making such changes in representative laboratories. Later, those changes demonstrated to be successful can be applied across the DoD laboratories. The recommendation is:

> *USD(A) direct each Service to create a demonstration laboratory project: Select at least one laboratory, representative in size and function of that Service's laboratory system, and alter its management and organization as to :*
>
> - *Attract and retain highest quality staff.*
> - *Improve contracting effectiveness.*
> - *Improve personnel management.*
> - *Provide local laboratory management authority and accountability*

Although the detailed attributes of these demonstration laboratory projects should be tailored to the needs of the Service and to the specific laboratories selected, each project should incorporate, as a minimum, the following:

- A basic personnel system similar to those demonstrated at NOSC and NWC, with perhaps broader pay bands.
- A provision for hiring senior scientific and technical staff at salaries higher than for Executive Level V. The number of such positions should not exceed ten percent of the laboratories scientific and

technical staff and should be considered to be in the Excepted Service (untenured) as defined in Title IV, Section 2103, of the United States Code. These positions should be filled through national competition. A mechanism for setting and adjusting pay should be provided through a market survey. In this regard consideration should be given to methods used to set pay for the Uniformed Services University of the Health Sciences (see Public law 92 - 426) and to those described in Senate Bill 1477 entitled "Federal Science, Technology, and Acquisition Revitalization Act."

- A laboratory director with direct hire authority for all laboratory personnel as well as simplified removal procedures.
- Installation of a private sector methodology for procurement with all necessary procurement authorities vested in the laboratory director.
- Employment of financial systems that provide local authority to utilize overhead funds for renewal and maintenance of the laboratory's research facilities and equipment.

The demonstration projects may either be accomplished within the federal system or through the conversion of the demonstration laboratories from the federal service to government-owned, contractor-operated (GOCO) laboratories. In the event that it is concluded that the desired objectives of the demonstration projects cannot be met within the federal service, then they should be carried out through conversion to GOCO. Laboratories chosen for demonstration projects should include both research laboratories and product or systems laboratories.

3.2.4 ESTABLISH SENIOR SCIENTIFIC, TECHNICAL AND ACQUISITION EXECUTIVE INITIATIVE

The objective of the second "demonstration" recommendation, the Senior Scientific, Technical and Acquisition Executive Initiative, is to upgrade significantly the technical management skills available within DoD for management of its Technology Base programs.

The Study Group recommends:

> *USD(A) establish an experimental Senior Scientific, Technical, and Acquisition Executive initiative. This initiative should establish up to 100 non-tenured appointments in DoD with the goal of significantly strengthening critical technology skills, Technology Base management, and Defense Acquisition management. The effectiveness of this initiative should be evaluated over a 6 year period.*

Candidates for such appointments could come from industry, from private laboratories or from universities, with appointees serving 3-year terms, renewable after review. Compensation should be comparable to that received in similar positions in industry and the universities. Compensation could be established and administered in a manner similar to that established in P.L. 92-426 or proposed in Senate Bill S-1477. This demonstration project should be administered out of the USD(A) office.

Senior personnel hired through this demonstration could be used to:

- Provide special S&E expertise to assist in the management and oversight of the Technology Base Program.
- Provide an adjunct and linkage between the Office of the Vice Chairman of the JCS and the DoD Technology Base Program.
- Provide liaison and linkage with the CINCs and the worldwide family of Service users.
- Provide an increased interface between international technology activities and the DoD Technology Base Program.
- Provide specialized on-call technical expertise to support individual DoD Laboratories or technology programs as might be mutually agreed to by USDA and the requesting Service activity.
- Provide proven and effective acquisition skills in OSD and the Services staffs.

The 100 positions are to be allocated within OSD, the Services, and defense agencies as determined by USD(A) but the sense of the Group was that OSD, OJCS, Army, Navy, Air Force, and DARPA would each share the positions approximately equally.

The conflict of interest issue is seen as the most serious impediment to the implementation of this experiment. Although management of job assignments can resolve a subset of this issue, some form of conflict of interest waiver -- requiring legislative action -- will be required to make the demonstration truly effective.

3.3 TECHNOLOGY TRANSITION

Present and past national research and exploratory development programs have demonstrated an abundance of innovative ideas within the U.S. scientific and engineering communities and have significantly contributed to our defense systems capabilities. Some improvements have been incremental, others were major leaps forward in warfighting capability. Many examples of steady improvements exist in the areas of materials, propulsion systems, radar and electro-optic sensors, medical, and space technologies, for example. Nevertheless, major opportunities for quantum advances in the areas of directed energy weaponry, remote stand-off weaponry, stealth technology, microelectronics and submarine laser communication, remain largely untapped.

This DSB Study as well as previous Technology Base studies have concluded that the problem of rapid technology transition to fielded systems is a primary objective of successful R&D management.

The Study Group believes that both the Defense Department and industry are seriously deficient in rapid technology transition into systems and products. This situation is a primary contributor to the growing crisis in military competition as Soviet weapons system performance approaches and, in some cases, exceeds that of U.S. and Allied forces. Because we can anticipate general numerical inferiority to Eastern Bloc and other potentially hostile forces, outcomes of conflict with these forces could be disastrous for the U.S. in the future unless this situation is reversed or otherwise offset by technology. The Study Group found that the greatest opportunity to improve this situation is to accelerate the transition of technology to existing or emerging systems. The rate and effectiveness of transition can be accelerated in the early advanced development phase, that is activity in Budget Category 6.3A.

Incremental improvements to existing systems are the easiest to accomplish within the DoD system because they are generally cheaper and less risky. Radical new technology embodied in new systems often yields the greatest performance advantages over our adversaries, but achieving acceptance is far more difficult. The underlying reason for this is that new concepts carry greater risk, incur higher costs, and often affect existing doctrine or tactics. In order to overcome these barriers the Study Group believes that DoD should emphasize the following within its 6.3A program:

- Careful selection and timely execution of system(s) and major subsystem(s) Advanced Technology Transition Demonstrations (ATTD) to build and test experimental systems in a field environment. Such ATTDs must be focussed on establishing both:

  – technical feasiblity, and

  – field utility.

  Further, ATTDs must be conducted before the system commitment and Full Scale Engineering Development (FSED) decisions are made.

- Use of selection criteria and management principles that have proven effective during past technology development and demonstration efforts.

3.3.1 NATURE OF TRANSITION DEMONSTRATION EXPERIMENTS

This concept of Advanced Technology Transition Demonstrations (ATTDs) is consistent with the views on technology transition and prototyping expressed by the Packard Commission. Conceptually, the ATTDs can be viewed as an extension of the Packard Commission prototyping recommendation to include technology demonstrations without being committed to a defined system development program. The characteristics of ATTD projects should include:

- Risk reducing "Proof of Principle" demonstrations to be conducted at the system or major subsystem level in an "operational" environment rather than the "laboratory" environment.

- Potential for new or enhanced military operational capability or a significant improvement in cost effectiveness.
- Duration of three years (typically).
- Total program cost of $10M to $100M (typically).
- A transition plan in place at the outset of the ATTD. Potential systems applications and transition windows should be identified at this time.
- Participation by the user (operator). The user should normally serve as the program sponsor.
- Participation by the developer (systems command). The developer should serve as project manager for the demonstration.

Establishing ATTD programs using these characteristics will provide a more rational basis for setting 6.3A program priorities, acceleration of technology throughput in 6.3A, and transition through team building, transition planning, and resource commitment.

There have been a number of successful programs in the past which have had the characteristics of an ATTD. The following examples are considered representative of successful ATTD-type programs:

Past Successes:

- SIMNET - Netted Training Simulator
- Shape Stable Reentry Vehicle
- SURTASS - Long Towed Array
- Teal Dawn - Advanced Cruise Missile

On-going ATTD-type Activities include:

- Supermaneuver Fighter Aircraft
- Submarine Laser Communications
- SAC Survivable Adaptive Planning Experiment
- Teleoperated Anti-Armor Vehicle
- Ultra Low Loss Fiber Optics
- Quiet Torpedo Propulsion

3.3.2 ATTD MANAGEMENT PRINCIPLES

Prototyping and other advanced technology demonstration projects have proven their value in past years as a mechanism for injecting new technology into operational military hardware. Nevertheless, because the Advanced Technology Transition Demonstrations (ATTDs) recommended here are to be specifically aimed at accelerating technology transition, close attention must be paid to the attributes that distinguish them from other 6.3A projects. The formulation process for each Advanced Technology Transition Demonstration project should embody the following principles:

- Stimulate clear definition of the operational military capability to be demonstrated.
- Evoke strong acceptance and sponsorship for the demonstrated capability among operational military commanders.
- Include representatives of the research, development, production, and operational viewpoints in selection of the technologies and concepts to be demonstrated.
- Ensure that selection of ATTD projects is based upon competition for the best ideas to be pursued within overall ATTD funding constraints.
- Assure that the demonstration, if successful, clearly proves both the maturity of the technology and the satisfaction of a perceived military need.
- Provide appropriate visibility for such demonstration projects to OSD, senior military operational commanders, and to the Congress.
- Provide adequate financial resources to meet all the goals specified for the project and initiate follow-on development if the demonstration is successful.

As a corollary to this last principle, the Study Group believes it is essential that management action be taken to insulate budgets for ongoing research and exploratory development work funded in 6.1 and 6.2 from these ATTD projects. Financial problems arising incident to such projects must not be allowed to create more severe financial problems for the many smaller research and technology projects pursuing longer range goals, that typify the earliest work in the defense Technology Base.

The ATTD provides an opportunity to prove feasibility. It tests technology in the field environment rather than the laboratory, demonstrating operational utility. Field demonstrations may give insight into reliability and maintainability costs and problems, as well as operator usability characteristics prior to entering program development.

ATTDs provide the opportunity for military requirement writers to try new technologies with less risk because such demonstrations do not require formal program start, nor do they jeopardize on-going development programs. ATTDs provide a team building environment with collaboration by the researchers, developers, the industrial performer, and the operator. As a result technology can be matured and accepted more rapidly.

The Study Group concluded that a clear statement of these management principles will help focus attention on the essential characteristics that must be embodied in an ATTD if it is to achieve the objectives. It is the view of the Study Group that most ATTDs should be selected and managed in a less rigid and more streamlined manner than current DoD prototyping projects. ATTDs which are joint or multi-Service in nature may require expanded senior management attention; however, most others should be managed at the individual Service/agency level.

Although the ATTD is logically an extension of the Packard Commission recommendation on prototyping, the two should not be combined under the current DoD prototyping process and management structure. ATTDs should be conducted within existing military department and agency acquisition management practices.

To ensure that ATTD projects address joint/unified command needs as well as technological opportunities, the group believes that the Vice Chairman of the JCS should develop a mechanism whereby he can be kept aware of Service intentions and opportunities for such projects. He should be made aware of projects in the planning phase so that he can provide guidance and direction prior to program execution. Use of the Joint Requirements Oversight Committee (JROC) to conduct an annual review of planned Service and agency ATTD projects is an option he might consider for this purpose.

3.3.3 LEVEL OF RESOURCES FOR ATTDS

By tradition and individual Service and agency interpretation of the purpose for 6.3A funds, much of the current $2 billion annual investment in 6.3A activity does not fall within the broad prescriptions the Group has offered for management of Advanced Technology Transition Demonstrations. Currently, the 6.3A program is characterized as being less focussed, less field-oriented, and more lengthy. The Study Group felt that most current 6.3A activity does not have sufficient ATTD characteristics.

The DoD's historical difficulty in transitioning new technology to its operational forces in peacetime is so severe, and the promise of ATTDs in facilitating this transition is so clear that the Study Group concluded that each Service should restructure its 6.3A budget to place much greater emphasis on ATTD projects. Specifically, by 1991 the Study Group believes that each Service should devote at least one-half of its 6.3A funding to ATTD projects. As a department, therefore, DoD would be spending roughly $1 billion each year, or about 2.5% of its RDT&E expenditures, in facilitating technology transition into military capabilities. Considering the $10M-$100M total program cost of ATTD projects, this would fund approximately 20-30 such projects.

The execution of an effective ATTD program is a particularly tough problem in today's environment. DoD must ensure that all ATTD procurements be based on a "competition of ideas" with an overall project cost target specified. "Best and Final Offer" (BAFO) - type procedures inhibit such competitions. In addition, DoD activities should place a premium on team building which involves: 1) performers of research, 2) developers, 3) industry (the producers), and 4) military operators.

In summary, the Study Group recommends:

USD(A) employ 6.3A for Advanced Technology Transition Demonstration projects (ATTD) to sharpen focus on Technology Transition:

- *Building and testing experimental systems in field environments to establish technical feasibility and field utility before a system commitment or full scale engineering development decision (FSED) are made.*
- *Use specific management principles to guide these projects.*
- *Direct (by FY91) half or more 6.3A funds to ATTD projects. This approximately $1B (FY 1988) or 2-1/2% of RDT&E should not use 6.1 or 6.2 funds.*
- *Request Vice Chairman JCS review all ATTD projects annually to ensure to his satisfaction that projects address future military user needs.*

4.0 OTHER IMPORTANT ISSUES

This section discusses several additional issues that the Study Group considered to be important: International Technology Base Cooperation, Dual Use Technology and the Technology Base, IR&D, Contracting for the Technology Base, Biomedical R&D, Research Facilities and Equipment, and Microelectronic and Optoelectronic Production Line Start-Ups. Many of these issues are very complex and require more attention than this Summer Study permitted. Recommendations are not given for these areas.

4.1 INTERNATIONAL TECHNOLOGY BASE COOPERATION

The fundamental goal of the Department's Technology Base program must be to develop those technologies that will yield fielded capabilities to keep our national defense posture strong. The technological capability offered by our Allies can provide strong and sometimes dominant supplements to the Department's program. A complication is the need to control access to such technology sufficiently well to assure the success of the current policy to offset the Soviet's numerical superiority through technologically more effective defense systems.

As indicated by the substantial contribution made by foreign scientists to the open scientific literature, the DoD Technology Base can be enriched in many areas through international cooperation and the exchange of technical information. It is timely to invest more effort in locating and utilizing knowledge from international sources.

Exposure of DoD scientists and engineers to superior foreign sources of science and technology will become increasingly important to maintaining awareness of frontier concepts critical to defense applications. DoD's international cooperation mechanisms can be more effectively utilized:

- Data exchange agreements
- Scientist and engineer exchange
- Overseas research liaison offices
- Technology assessment teams
- Cooperative research with Allies/friends

The Deputy Under Secretaries for International Programs and Technology and for Research and Advanced Technology should review the effectiveness of these international programs with a goal of strengthening their contribution to the DoD Technology Base program.

4.2 DUAL USE TECHNOLOGIES AND THE TECHNOLOGY BASE

Most high-leverage defense technologies can be categorized as dual-use technologies in that they are critical to U.S. industrial competitiveness in global markets as well as to defense. Accelerating technological advancements in commercial products also accelerates their availability for use in military equipment. As emphasis on the use of commercial components in military equipment increases, the importance of commercial advancement of dual-use technologies will likewise increase.

In the future, the U.S. will be contributing a declining fraction of the world's technology base because of accelerated worldwide investment in science and advanced technologies. As a consequence, the risk of becoming "blind-sided" by technological surprise increases.

The U.S. Federal investment in civilian R&D for industrial growth has been the lowest among the major western industrialized countries as shown by Table 4.1.

United States	0.2%
Japan	6%
FRG	14%
France	13%
U.K.	7%
Sweden	6%

Table 4.1: National Average Percentages of Federal R&D Investment Devoted to Domestic Civilian R&D for Industrial Growth (1983-1986)*

The DoD currently has a number of roles in dual-use technologies:

- Strengthening the national scientific and engineering infrastructure to generate new technological options.
- Improving the coupling of DoD investment in the national technology base to complement the Defense Technology Base investment.
- Assuring a domestic industrial base for advanced technology materials, components, end products, and services of importance to defense applications.

In the face of growing international competition in advanced dual-use technologies, the Study Group advises DoD to review its role in fostering dual-use technologies. Specifically DoD should address the following questions.

- In what ways should the DoD increase its outreach activities to better tap superior sources of advanced technologies in the commercial market place?

* *Source: "A Comparative Analysis of the Science and Technology Organization, Policies, and Priorities: France, Germany, Japan, Sweden, United Kingdom, and United States", May 1987, Leonard L. Lederman National Science Foundation Conference on National Research and Technology Systems in Western Industrialized Countries–An International Comparison.*

- What roles should the DoD play in strengthening the U.S. commercial position in dual-use technologies through direct investment, technology sharing as well modification of DoD's acquisition policies and procedures?

4.3 INDEPENDENT RESEARCH AND DEVELOPMENT (IR&D)

When properly directed, IR&D results and products complement the DoD 6.1, 6.2 and 6.3A program. In addition, IR&D is an important mechanism for transferring technology and intellectual property between the commercial and military sectors. The Study Group believes that problems with IR&D are reaching crisis proportion.

Recent acquisition system changes which have increased the pressure for industry cost sharing, reduced data rights, and lowered profits have also reduced industry's incentive to spend "over ceiling" for IR&D. Further, the pressure for increased competition and the joint cap on IR&D/Bid and Proposal (B&P) funds have forced industry to shift expenditures from IR&D to B&P.

There are also signs of increasing bureaucratic review of the IR&D program at a level of detail which impairs its fundamental purpose. Increasing pressure for justification of short-term military relevance results in shifts from research toward development in industry's IR&D programs. This Study Group believes that the purpose of IR&D should be for industry to undertake long-term research of high quality and national significance. The DoD should thoroughly evaluate its position on these issues.

4.4 CONTRACTING FOR TECHNOLOGY BASE R&D

Application of the regulations developed to implement the Competition in Contracting Act (CICA) to contracting for Technology Base activities has created a number of significant and far-reaching problems. Procuring agencies, from defense agencies to laboratories, are unable to procure needed services in a timely and useful fashion. Scientists and engineers in the defense community at large are finding contracting constrained and an increasingly burdensome impediment to the introduction of new and innovative concepts into the defense R&D mainstream.

Competition per se is not the root cause of these problems; rather, what is at fault is the inflexible application of the regulations which are designed for multi-million dollar competitive procurements to relatively small and innovative Technology Base procurements. Procurement officers, whose authority in many cases is absolute, are guided by a set of criteria that are quite different from those needed for Technology Base procurement. Agencies and laboratories with no control over these criteria find themselves unable to procure services in a timely fashion and unable to apply appropriate criteria to the ultimate award of contracts for these services.

From the vantage point of the Study Group, there are at least two needed changes to Technology Base contracting. First, final authority for the procurement of 6.1 and 6.2 services must somehow be returned to the responsible official, namely the laboratory or agency director. These managers need the authority to determine the criteria under which R&D is procured. They need the authority to procure the best, not the cheapest, R&D talent for the particular task at hand. The country cannot afford to settle for the lowest cost, least risk option when seeking innovative new technology. In some cases they need to be able to assure protection of proprietary ideas.

Second, the competitive contracting mechanism known as the Broad Agency Announcement (BAA) should be applied in a broader context. Results for those agencies that have adopted this procedure have been dramatic. Under the BAA, a government agency or laboratory advertises its requirement for technical approaches to some problem. There is sufficient response time to allow interested parties to formulate and submit new ideas to meet the requirements of the BAA. The agency involved then evaluates responses and chooses competitively those ideas it believes best meet its needs.

The BAA contracting mechanism satisfies congressional concerns about competition. It advertises for all to see, that the agency involved has a problem and is seeking ideas to address that problem. It competes the ideas against a broad set of needs as opposed a narrowly defined, usually overspecified solution to a problem as required under the current set of procurement criteria. The BAA should be extended to 6.3A procurements to ensure a "competition of ideas."

4.5 DOD BIOMEDICAL TECHNOLOGY BASE

The DoD Biomedical R&D program is a small, but productive contributor to the DoD Technology Base. For many years this program consisted of only 6.1 and 6.2 research efforts, with industry paying to transition drugs and vaccines to products in return for licensing privileges. Today, the Biomedical R&D program receives significant 6.3 and 6.4 funding (see Table 4.2) which allows DoD to fund development of selected products.

	Army ($ in Millions)	Navy ($ in Millions)	Air Force ($ in Millions)
6.1	45	19	7
6.2	115	50	106
6.3	102	23	40
6.4	20	2	11
6.5	20	10	11
Total	302	104	175

Table 4.2: DoD Biomedical/Human Systems FY87 RDT&E Funding Totals

The Biomedical Technology Base program has strength. In-house S&E personnel are strong professionally, with stature in their civilian national scientific societies. The DoD is competitive for the best biomedical scientists. As a result some of the DoD science is front-rank, as in arthropod-borne infections and aerospace medicine.

However there are problems facing the DoD biomedical program. First, certain facilities are antiquated, for example Walter Reed Army Institute of Research. The present process for military construction of medical laboratories places them in competition with hospital construction, a competition they invariably lose.

Second, the military scientific personnel complement of the biomedical R&D effort is under constant pressure for reassignment outside of medical R&D, which dilutes excellence. One reason for this is that promotion comes more readily to non R&D officers.

Third, civilian scientific personnel in the biosciences have great difficulty fitting their specific scientific skills into the outdated classification system.

Fourth, the timely transition of proven drugs and vaccines into testing and production is a serious problem. Deciding what research developments should be taken into production has been relatively easy because the 6.2 activity has typically provided "proof of principle." However, the pharmaceutical industry now participates poorly, if at all, because of major disincentives such as low profits, small market, and government contracting requirements including DoD auditing of contractor cost/pricing of products. In addition companies are unable to buy liability insurance on the commercial market.

The Study Group believes that these and other problems require the attention of USD(A) in cooperation with ASD (Health and Medicine) and others.

4.6 FACILITIES AND EQUIPMENT

Research and development depends upon the use of state-of-the-art equipment and facilities. Providing such facilities and equipment is made difficult by rapidly changing technology which results in equipment becoming quickly outmoded and by the increasing costs of renewing such equipment and facilities. The Study Group is concerned that managers at the performance level do not have local authority to make rational tradeoffs within their budgets with respect to people, facilities, and equipment. For example, it may make more sense in the long run to purchase a significant piece of equipment, e.g., a molecular beam epitaxial machine, than to continue to fund a group of researchers to milk the remaining results from an existing instrument. Local management should be permitted to make and implement such decisions.

In the case of the R&D equipment and facilities whose cost exceeds local budget limits, acquisition is very difficult. Under present procedures such requirements are addressed through the Military Construction Appropriation (MILCON). This places R&D needs in direct and explicit competition with requirements for operating forces such as family housing, hospitals, etc. In general, R&D needs do not fare well in a competition. This has led to a decline in physical facilities supporting R&D and has slowed their renewal. Without very good facilities and equipment, in some arenas, even an excellent researcher cannot compete with a mediocre researcher who does have the facilities.

4.7 MICROELECTRONIC AND OPTOELECTRONIC PRODUCTION LINE START-UPS

Another important technology transition issue considered by the Study Group is DoD sponsored and supported semiconductor processing initiatives. These initiatives include very high speed integrated circuits (VHSIC), gallium arsenide (GaAs) digital integrated circuits, and GaAs microwave monolithic integrated circuits processing lines, as well as proposed new optoelectronic device production facilities, such as , mercury cadmium telluride, HgCdTe. The rationale for supporting these technology development initiatives is to provide DoD with needed electronic and optoelectronic components which are unavailable from domestic commercial sources. However, in transitioning from the technology development of semiconductor processing to cost-effective production of high performance components, it is necessary for these processing lines to be operated full time for an extended period to be able to achieve design yields and outputs, necessary ingredients for economic production.

The DoD needs for component piece parts are not large enough in volume by themselves to enable optimization of these processing lines. In some cases DoD demand is not sufficient even to assure production rates necessary to achieve reliable production. This problem is discouraging program managers from incorporating such advanced technology components in their new system developments. Since DoD investments of hundreds of millions of dollars are involved in facilitizing these lines and in developing the processes, the Study Group believes this is a major technology transition problem. Table 4.3 shows current production capacity and production rates for the VHSIC program.

Many potential approaches exist to facilitating technology transition in this unique and important area. They range from subsidizing early pilot production to stimulating use of the lines for production of commercial components. The Study Group was not able to devote adequate attention to this issue to provide a recommended solution. However, the group believes that this issue is of sufficient importance to deserve near term attention by the Under Secretary of Defense for Acquisition.

VHSIC Contractor	Capacity Wafers per month	Chips per year	% of Capacity Currently
Company 1	1,200	150K	60%
Company 2	2,000	240K	50%
Company 3	3,000	300K	18%
Company 4	1,500	180K	33%
Company 5	4,000	480K	33%
Company 6	1,000	120K	90%
Company 7	8,000	960K	33%

Assumptions:

1. 4 inch wafers
2. 300 mil x 300 mil chip
3. 100 chips per 4 inch wafer
4. 10% yield - 10 chips per wafer

Table 4.3: VHSIC Production Capacity and Current Use

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ANNEX A

TERMS OF REFERENCE

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, DC 20301

ACQUISITION

2 7 APR 1987

MEMORANDUM FOR THE CHAIRMAN DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference, DSB Summer Study on Technology Base Management

You are requested to organize a Defense Science Board Summer Study on Technology Base Management.

The continuing exploration and development of a broad range of advanced technologies is of utmost importance to the Department of Defense. Technological progress is vital for ensuring that we maintain desired offensive and defensive military capabilities--for both tactical and strategic forces at affordable cost. However, development of advanced technology is expensive in terms of funding, facilities and human resources. Management of defense technology base activity must be properly structured and coordinated to facilitate the most efficient use of available resources to general technology and stimulate technical innovation in military systems. Specific areas to be addressed include:

(a) What is the best DoD-wide management structure and decision-making process that will identify and emphasize those technology areas most likely to have major impacts on future defense capabilities?

(b) How do we more effectively coordinate advanced technology development activities within and among the Services and their laboratories, the defense agencies, the Strategic Defense Initiative Organization, national laboratories, industry, the university community, and our Allies?

(c) For those technology areas considered to have the greatest potential, how do we establish "critical mass" in terms of funding, facilities, and human resources? Specific attention should be given to the adequacy of DoD wide planning for availability of resources to support the technology base and to the appropriate roles of the various performers: laboratories, industry and university.

(d) How do the current management structure and alternatives, developed as part of the study, compare in facilitating the transition of emerging technologies to military systems?

I will sponsor this Summer Study. The Chairman will be Dr. John M. Deutch. The Vice Chairman will be Dr. Edward A. Frieman. Dr. Joseph V. Osterman, ADUSD (R&AT), will be the Executive Secretary. The DSB Secretariat Representative will be LCDR George A. Mikolai, USN. It is not anticipated that your inquiry will involve any "particular matters" within the meaning of Section 208 of Title 18, U.S.C.

ANNEX B

MEMBERS OF THE 1987 DSB SUMMER STUDY ON TECHNOLOGY BASE MANAGEMENT

MEMBERS OF THE 1987 DSB SUMMER STUDY

Panel Chairman

Dr. John M. Deutch*
Provost
Massachusetts Institute of Technology

Panel Vice Chairman

Dr. Edward A. Frieman*
Director
Scripps Insititue of Oceanography

Panel Members

Mr. William A. Anders*
Senior Executive Vice President
Operations
Texton, Inc

VADM Albert J. Baciocco, Jr.
USN, Ret.

Dr. Arden L. Bement, Jr.
Vice President Technical Resources
TRW, Inc.

Dr. Ivan L. Bennett*
Professor of Medicine
New York University Medical Center

Dr. Solomon J. Buchsbaum*
Executive Vice President Customer Systems
AT&T Bell Laboratories, Inc.

MGEN Gerald K. Hendricks,
USAF, Ret.
Director, Washington Operations
UTC/Norden Systems

Mr. Robert Howard
Office of Management and Budget

Dr. Anita K. Jones*
Vice President of Development
Tartan Laboratories, Inc.

ADM Isaac C. Kidd, Jr.*
USN, Ret.

Mr. Robert L. Cattoi.
Senior Vice President R&E
Rockwell International Corp.

Dr. Tim Coffey
Director of Research
Naval Research Laboratory

Mr. Vincent Cook*
IBM Vice President and
Assistant Group Executive,
Asia/Pacific Group

Dr. Robert S. Cooper
President/Chief Executive Officer
Atlantic Aerospace Electronics
Corporation

Mr. Malcom R. Currie*
President
Delco Electronics Corporation

Dr. Kumar Patel
Executive Director, Research
Materials Science, Engineering and
Academic Affairs Division
AT&T Bell Laboratories

* DSB Members

Panel Members (Cont'd)

Dr. William H. Press*
Chairman, Astronomy Department
Harvard University

MGEN Garrison Rapmund
USA, Ret.

Dr. John P. McTague
Vice President - Research
Ford Motor Company

Dr. William A. Nierenberg
Director Emeritus
Scripps Institution of Oceanography

Dr. Harold Rosenbaum*
Harold Rosenbaum Associates, Inc.

Executive Secretary

Mr. Raymnond F. Siewert
OUSD(A)/R&AT

Military Assistant

LCDR G. A. Mikolai, USN
OUSD(A) Defense Science Board

Government Advisors

OSD
Mr. Everett D. Greinke
Deputy Under Secretary for
International Programs and Technology

Dr. Ronald L. Kerber
Deputy Under Secretary for Research
and Advanced Technology

Army
BGEN Richard D. Beltson
Deputy for Technology and
Assessment
Office of the Assistant Secretary of
the Army for RDA

Army (Cont'd)
Dr. Louis Cameron
Acting Director for Research and
Technology
Office of the Assistant Secretary
of the Army (RDA)

Air Force
BGEN Thomas Honeywill
Director of Program Management
and Technology
Office of the Assistance Secretary
of the Air Force for Acquisition

Navy
Captain William Miller
Commanding Officer
Naval Research Laboratories

* DSB Members

ANNEX

SUMMER STUDY PARTICIPANTS

SUMMER STUDY PARTICIPANTS

LGEN James Abramhamson
Director
Strategic Defense Initiative Office

Mr. John Blair
Executive Secretary
Joint Directors of Laboratories

Mr. Allen Carley
Office of Scientific and Weapons Research
CIA

Dr. Gilbert Decker
Chairman, Army Science Board

RADM C. Dorman
U.S. Navy Space and Warfare Command

Dr. Robert C. Duncan
Director Defense Advanced Research Projects Agency

Mr. Michael E. Flynn
Deputy for Science & Technology
HQ, U.S. Air Force

Dr. George Heilmeier
Texas Instruments

Dr. Robert J. Hermann
United Technologies Corporation

Dr. Charles Herzfield
Private Consultant

Dr. Robert Hillyer
Technical Director, Naval Ocean Systems Center

Col. James McCormack
Asst. DCS, Science and Technology
HQ, U.S. Air Force Systems Command

Mr. David P. McGraw
Honeywell

Mr. John Metzko
Institute for Defense Analysis

Dr. Hugh E. Montgomery
Deputy Chief Scientist
Office of Research, Development, and Acquisition
(OP-0987)

RADM J.B. Mooney, Jr.
Chief of Naval Research

Mr. Robert Moore
Deputy Director
Defense Advanced Research Projects Agency

Dr. Walter E. Morrow, Jr.
Director, Lincoln Laboratory

Dr. M.K. Moss
Director of Naval Research
OCNR

Mr. William Noll
Staff Specialist
Office of Research and Laboratory Management

Mr. Jesse Orlansky
Institute for Defense Analysis

Dr. Bernard Palewonski
Deputy for Advanced Technology
Office of the Secretary of the Air Force

Dr. William Perry
Hambrecht and Quist

Dr. Robert M. Sasmor
Chief, Policy Division
AMSLC--PP--PO
U.S. Army Laboratory Command

Dr. Philip A. Selwyn
Director of Naval Technology
OCNR

Mr. Frank E. Shoup
Director, Technology Assessment Division
Office of Research, Development and Acquisition
(OP-0987)

Mr. Bradford L. Smith, Jr.
Strategic Analysis, Inc.

Dr. Harold Sorenson
Chief Scientist
U.S. Air Force

BGEN Charles Stebbins
DCS/Science and Technology
HQ, AF Systems Command

Mr. Lloyd Thorndyke
ETA Systems

Dr. Richard Vitali
Technical Director
U.S. Army Laboratory Command

ANNEX D

AN OVERVIEW OF PAST STUDIES OF THE DOD SCIENCE AND TECHNOLOGY PROGRAM

AN OVERVIEW OF PAST STUDIES OF THE DOD SCIENCE AND TECHNOLOGY PROGRAM

INTRODUCTION

This annex summarizes substantive recommendations and resulting actions of sixteen prior studies of the DoD Science and Technology program. The studies reviewed here occurred since 1966 and focused on the planning, management, coordination and execution of the program and on the relative importance of its technical area components. These do not include studies of individual technologies or individual Service or Defense Agency studies of their program components.

Figure D-1 lists the reports reviewed. All were performed by high-level committees or task forces functioning under the auspices of the White House Office of Science and Technology Policy or the Office of the Secretary of Defense. The task forces included many expert individuals renowned in science and technology. These reports have been prepared in response to a need or a problem perceived by the sponsoring office and all seem to have been done with a sense of urgency thus indicating the degree of importance.

TITLE	AUTHOR	DATE
Report on Funding Recommendations	FCCSET Funding Working Group Chaired by R. Oswald	May, 1984
President's Private Sector Survey on Cost Control	R&D Task Force Co-Chaired By David Packard	December, 1983
Federal Laboratory Review Panel	White House Science Council's Federal Lab Review Panel Chaired By David Packard	May, 1983
USDRE Independent Review of DoD	Robert Hermann	March, 1982
Report of the Defense Science Board Task Force on University Responsiveness to National Security Requirements	DSB Task Force Chaired by Ivan Bennett	January, 1982
Report of the Defense Science Board 1981 Summer Study Panel on Technology Base	DSB Study Chaired by George Heilmeier	November, 1981
Report of the DoD Laboratory Management Task Force	Arden Bement	July, 1980
A R&D Management Approach: Report of the Committee on Application of OMB Circular A-76 to R&D	FCCSET Committee Chaired by Gerald Griffen	October, 1979
Institutional Barriers on DoD Laboratories	Service Senior Laboratory Reps	October, 1979
Report of the Acquisition Cycle Task Force Defense Science Board 1977 Summer Study	Acquisition Cycle Study Chaired by Dick DeLauer	March, 1978
DSB Task Force on Federal Contract Center Utilization	DSB Task Force, Chaired by Robert Duffy	February. 1976
DoD Medical and Human Resources Laboratory Utilization Study	John McCambridge and Stanley White	September, 1976
DSB Summer Study Task Force on Technology Base Strategy	DSB Study, Chaired by Normal Rasmussen	September, 1976
DoD Laboratory Utilization Study	John Allen	April, 1975
Task Group on Defense In-House Laboratories	Task Group Chaired by Edward Glass	July, 1971
DoD In-House Laboratories	DSB Task Force Chaired by Leonard Sheingold	October, 1966

Figure D-1: Reports Reviewed

The recommendations of these many studies can be categorized by the following technology base management areas: Science and Technology Strategy; Personnel; Management/Organization Initiatives; Funding; Peer Review/Performance; Facilities and Equipment; University/Industry/Services Interaction; Technology Transfer; and Contracting. Each area is discussed below. Figure D-2 shows the linkage between these areas and the reports reviewed. Note that some of the reports, such as the Packard and Hermann reports, were very broad ranging, whereas others were much more narrowly focused.

	S&T Strategy	Person-nel	Mgmt. & Org	Funding	Peer Review	Fac. & Eqpmt.	Univ/Ind/ Services	Tech Transfer	Contract-ing
FCCSET Funding Grp Rprt 1984				X					
Grace Comm. R&D Tsk Foe Rprt 1982/83		X	X				X		
Packard Report on Fed Labs 1982/83		X	X	X	X			X	X
Hermann Report 1981/82	X	X			X	X	X	X	X
Bennett DSB 1981/82				X		X	X		X
Heilmeier DSB 1981	X	X	X	X		X	X		X
DoD Lab Mgmt Tsk Force (Bement) 1980			X			X			X
Griffen FCCSET 1979			X						
Institutional Barriers (Davis) 1979		X	X						
DeLauer DSB 1978									X
Duffy DSB 1975/76			X						X
McCambridge/White 1975/76	X		X	X					
Rasmussen DSB 1976	X		X	X					
Allen 1974/75	X	X	X	X					
Glass Report on In-House Labs 1971	X	X	X						X
Sheingold 1966			X						

Figure D-2: Linkage Between Areas Studied and Reports Reviewed

SCIENCE AND TECHNOLOGY STRATEGY

Many of the studies addressed the allocation of priority and funding to the various technologies in the Science and Technology Program. The recommendations stressed closer consideration of operational needs in planning, the adoption of a modernized technology investment strategy, and the designation of lead laboratories for specific technologies. Joint planning in defined areas and the creation of vertically integrated programs with fenced funding were also recommended. Closer interaction between DARPA and the Services was recommended as a catalyst for joint planning. Specific programmatic recommendations included strengthening logistics R&D programs and establishing R&D centers in simulation, electronic warfare, and C3. Several reports over the years recommended expansion of the 6.3A Advanced Technology Demonstration Program.

As a result of these recommendations, logistics R&D was strengthened, and the 6.3A Technology Demonstration Program was created in 1975 and increased to $1.7B in 1987. The Heilmeier "Top 17" Technologies List was used to guide investment. Lead laboratories were established in several select technologies. The Forecast II, Air Land Battle Environment, and Army 2000 are example of studies performed to link operational needs to planning and to guide technology investment. Finally, the VHSIC and MMIC programs are examples of vertically integrated programs that utilize "fenced" funding.

PERSONNEL

Most of the studies made major recommendations in the personnel area, including recommendations to define each laboratory's mission, to select very well qualified individuals as Laboratory Director -- whether military or civilian -- and give him the responsibility, flexibility, and authority to perform the mission and "hire and fire." Surprisingly, the studies made few specific recommendations concerning the quality of laboratory personnel at other than the director level. The studies also recommended creating a separate scientist and engineer personnel system and that the Naval Ocean Systems Center and Naval Weapons Center (China Lake experiment) personnel management technique be implemented DoD wide.

Over the past several years, there has been concerted action on the part of OSD and the Services to improve the "personnel system". To date, however, few significant changes have occurred. There has been a trend toward selecting the best qualified person (military or civilian) to be the laboratory director. However, there appears to be a continued requirement for sufficient tenure to assure scientific program stability.

MANAGEMENT AND ORGANIZATION

Almost all the studies made recommendations to improve Technology Base management and organization. Major recommendations included initiatives to: give laboratory directors more authority and responsibility, streamline the organizational structure of the Technology Base, and raise productivity. In the latter case, productivity would be raised by achieving a better balance of the Technology Base program across performers; by adopting a more cooperative and efficient use of human and material resources; and by reducing the number of audits, inspections, and reviews. Finally, there were recommendations to establish advisory groups that would provide independent advice to SPO directors, to increase laboratory participation in weapon system planning, and to endorse DoD's FFRDC Policy.

These recommendations have resulted in a better balancing of in-house laboratory manpower, the confirmation of continued FFRDC operations, and the provision of Technology Base advice in the Defense Acquisition Board process.

FUNDING

Higher funding of the Technology Base is a perennial concern of many of the studies. These recommendations are generally expressed as a need for increased funding levels in several specific technologies, as in the Heilmeier Report, or for various "causes," as in the Bennett Report on University Responsiveness. The Packard Report of 1982 and the FCCSET Funding Group Report of 1984 recommended that funding be appropriated for research and development on a predictable two-year basis so that staffing levels and research activities at federal laboratories can be more optimally planned.

DoD and Congress are moving closer to adopting a two year budget cycle. Funding for various high priority technologies has been increased. Funding levels in the 6.1 and 6.3A programs are increasing; 6.2 funding has remained level.

PEER REVIEW AND PERFORMANCE

Little was said about the peer review process and resulting performance. The Packard Report viewed current oversight procedures as requiring an excessive amount of reporting and paperwork (stressing measurable criteria such as time and cost), but providing inadequate scrutiny of the quality and relevance of the laboratories' activities. The Packard Report recommended that the competitive peer review process for funding basic research be further adopted to ensure quality and relevance of research.

As a result of the Packard Report, additional peer review panels have been formed by the DoD laboratories.

FACILITIES AND EQUIPMENT

Some of the more recent studies noted the need for modernization of facilities and equipment. Providing better university and industry access to laboratory facilities, as well as upgrading university equipment, are two high priority recommendations. The DoD Laboratory Management Task Force report of 1980 (Bement Report) recommended the establishment of in-house laboratory facility and equipment modernization policies whose funding totaled about $300 million per year. Finally, there were recommendations to provide flexibility by raising laboratory director funding authority for facilities and equipment.

The DoD University Research Instrumentation Program was created as a result of previous study recommendations. This program, initiated in FY83, provides $150 million over five years for university research equipment. The Bement Report recommendation for the establishment of in-house laboratory facility and equipment modernization policies has not been implemented.

UNIVERSITY/INDUSTRY/SERVICE INTERACTION

A number of studies noted the dependence of a healthy Defense Technology Base upon the interaction and cooperation of the Services with the R&D community in the university and industry sectors. Supporting recommendations included creating additional university-based centers of R&D excellence, awarding additional graduate fellowships, establishing a DoD-University Forum, and continued effort to resolve the tension between the advantages of open scientific communication and the imperatives of national security.

Over the past few years, many of these recommendations have been acted upon. Industry interaction with universities was made a factor in determining IR&D ceilings. A DoD-University Forum was created to foster a dialogue with universities. A DoD-University Research Initiative and an instrumentation program were established. Funding to universities was increased. A scientific paper review and publishing policy was formulated to lessen the dilemma of open scientific communication and national defense imperatives.

TECHNOLOGY TRANSFER

There were major concerns over the inadequacy of the flow of knowledge from the laboratory to the field and from universities to government/industry and vice versa. Most recommendations were stated broadly and included provisions for collaborative projects as well as increased exchange of knowledge and personnel between DoD, universities and industry.

These recommendations are partially implemented in the Federal Technology Transfer Act of 1986 which encourages the use of Federal government developed technology by state and local governments and by the private sector.

Recommendations on the broad subject of contracting have become prominent in recent studies. Seven of the last eight studies expressed a desire to streamline procurement practices. The prime concern has been the length of the procurement process which adds cost and substantially delays the development of new technology. The major recommendation was to treat science and technology procurement differently from other procurement.

Another specific recommendation was the need to raise the "Determination and Findings" (D&F) limits. This is the dollar ceiling, which if exceeded, requires Service Secretarial approval prior to contracting. Raising the ceiling would provide laboratory directors more latitude and reduce the administrative burden of reapproving procurements.

Some streamlining of the contracting process has been provided for the 6.1 and 6.2 programs. Though not fully implemented, the D&F limit has been raised to $1 million.

The Competition in Contracting Act (CICA) initially created significant unintentional delays in Technology Base contracting; however, recent interpretations of CICA are easing contracting for 6.1 and 6.2 efforts.

SUMMARY

Several recommendations have led to actions taken to address the particular situation in question. Significant steps have been taken to provide proper balance among the various Technology Base performers (in-house laboratories, universities, industry, and FFRDCs) and to stimulate greater interaction between DoD and universities. A separate budget category, 6.3A, was established in 1975 for Advanced Technology Demonstrations and has grown to nearly $2B (excluding SDI) in 1987. Formal peer review processes have been established. Two-year budget cycles may be implemented in the 1988-89 budget cycle.

Several recommendations remain open to further action. The Technology Base organization and management structure and contracting practices need to be streamlined. A number of recommendations have not been implemented: to select the "best qualified" laboratory directors (military or civilian), to provide programmatic stability, to give more authority and responsibility to laboratory directors, to create a separate personnel system for scientists and engineers, to designate lead laboratories with specific missions, and to pursue joint service planning.