Copy 22 of 59 copies

IDA PAPER P-3038

LABORATORY INFRASTRUCTURE CAPABILITIES STUDY: PHASE I REPORT

Part I: Introduction and Summary

David R. Graham
Paul H. Richanbach
Edwin S. Townsley

Richard J. Bergemann
Harold E. Bertrand
H. Jerome Bracken
Al E. Brenner
Robert J. Bontz
Joan F. Cartier
L. Kirk Lewis
Karl H. Lowe
John Metzko
Karen J. Richter
David A. Sparrow
Robert D. Turner

November 1994

Prepared for
Office of the Director, Defense Research and Engineering

IDA

INSTITUTE FOR DEFENSE ANALYSES
1801 N. Beauregard Street, Alexandria, Virginia 22311-1772

IDA Log No. HQ 94-46091

DEFINITIONS

IDA publishes the following documents to report the results of its work.

Reports

Reports are the most authoritative and most carefully considered products IDA publishes. They normally embody results of major projects which (a) have a direct bearing on decisions affecting major programs, (b) address issues of significant concern to the Executive Branch, the Congress and/or the public, or (c) address issues that have significant economic implications. IDA Reports are reviewed by outside panels of experts to ensure their high quality and relevance to the problems studied, and they are released by the President of IDA.

Group Reports

Group Reports record the findings and results of IDA established working groups and panels composed of senior individuals addressing major issues which otherwise would be the subject of an IDA Report. IDA Group Reports are reviewed by the senior individuals responsible for the project and others as selected by IDA to ensure their high quality and relevance to the problems studied, and are released by the President of IDA.

Papers

Papers, also authoritative and carefully considered products of IDA, address studies that are narrower in scope than those covered in Reports. IDA Papers are reviewed to ensure that they meet the high standards expected of refereed papers in professional journals or formal Agency reports.

Documents

IDA Documents are used for the convenience of the sponsors or the analysts (a) to record substantive work done in quick reaction studies, (b) to record the proceedings of conferences and meetings, (c) to make available preliminary and tentative results of analyses, (d) to record data developed in the course of an investigation, or (e) to forward information that is essentially unanalyzed and unevaluated. The review of IDA Documents is suited to their content and intended use.

The work reported in this document was conducted under contract DASW01 94 C 0054 for the Department of Defense. The publication of this IDA document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that Agency.

IDA PAPER P-3038

LABORATORY INFRASTRUCTURE CAPABILITIES STUDY: PHASE I REPORT

Part I: Introduction and Summary

David R. Graham
Paul H. Richanbach
Edwin S. Townsley

Richard J. Bergemann
Harold E. Bertrand
H. Jerome Bracken
Al E. Brenner
Robert J. Bontz
Joan F. Cartier
L. Kirk Lewis
Karl H. Lowe
John Metzko
Karen J. Richter
David A. Sparrow
Robert D. Turner

November 1994

IDA

INSTITUTE FOR DEFENSE ANALYSES

Contract DASW01 94 C 0054
Task T-AI6-655

PREFACE

This paper was prepared for the Director of Laboratory Management in the Office of the Director for Defense Research and Engineering, as part of the "Laboratory Infrastructure Capabilities Study." This paper is submitted in partial fulfillment of the task order. This paper was reviewed by Michael Donley and Christopher Jehn.

The authors wish to thank Teresa Dillard, Eileen Doherty, and Jim Churchill for their contributions to this task.

CONTENTS

TABLES

EXECUTIVE SUMMARY

The Laboratory Infrastructure Capabilities Study brought together parallel panels of experts from inside and outside the government to provide perspectives on the nation's capabilities to perform DoD's science, technology, and engineering functions. From May to July, 1994, these panels met to address questions about the roles of DoD's laboratories, the extent to which DoD relies upon industry and academia in collaboration with the laboratories, and the potential for shifting more work from the laboratories to these "outsource" performers. On July 19, 1994, the panels briefed Dr. Anita Jones, the Director of Defense Research and Engineering, on their findings, and provided written reports, which form the body of this report.

Their reports show that most of the funding for DoD's science, technology, and engineering functions is already outsourced: The labs receive about 25 percent of DoD's RDT&E funding ($9 billion in FY 1992), and outsource about one-half of this to universities and contractors. There are, however, significant differences across the twelve product and technology areas examined, both in how the laboratories are structured and the extent of outsourcing. Some of the 81 DoD laboratories examined perform mainly science and technology functions (funding categories 6.1 to 6.3), some focus on development and in-service engineering (6.4 to 6.7), and others perform the full range of functions. The laboratories' use of outsourcing ranges greatly across areas, from under 50 percent to nearly 90 percent.

The government panels defined nearly two-dozen functions they believe should be performed within the laboratories. These fall into four areas: providing corporate memory and serving as a trusted in-house advisor (i.e. a "smart buyer"); maintaining capabilities that are uniquely needed by DoD; serving as a legal representative in the weapon acquisition process and in meeting other government responsibilities; and providing a stable nexus for the modernization ideas coming from military users, the intelligence community, industry, and academia. Although the government and non-government panels agree that the laboratories perform essential functions, there is substantially less agreement as to whether the laboratories *must* perform all these functions. Many panels believe this is not an all-or-nothing choice. The real question is: What is the "critical mass" of in-house capability needed to execute these functions for DoD?

The panels propose that DoD consider structural changes in nine of the twelve product and technology areas. Five panels propose increases in outsourcing. Eight suggest structural changes *internal* to the DoD laboratory system, sometimes combined with increases in outsourcing. Table ES-1 summarizes the recommendations. The entries reflect ideas offered by *either* the government *or* non-government panel.

Table ES-1. Potential Structural Changes

Consolidate or Make Other Internal Structural Changes	Increase Outsourcing	
	No	**Yes**
No	– Ground Vehicles* – Materials* – Computers, Software, Modeling & Simulation*	– NBC Counterproliferation
Yes	– Electronics & Sensors – C3I & Electronic Warfare – Weapons – Space	– Human Systems* – Environment & Civil Engineering* – Air Vehicles* – Ships and Watercraft*

* Government and non-government panels agreed on the qualitative outsourcing recommendation in this product and technology area.

The panels also articulated a number of long-standing laboratory management issues, and raised some issues created by the changing security and budget environments. Some of the common themes included: the need to take a more fundamental look at the roles and missions of the laboratories than could be done in Phase I, perhaps through an extension of the Reliance process; the need to improve the collaboration of the laboratories with industry, academia, and other government agencies; and the need to reform laboratory procurement and personnel management regulations.

Substantial further efforts will be needed to flesh out and implement the extensive agenda defined by the panels. Their proposed structural changes should be examined by the Service action teams preparing DoD's submission to the Base Closure and Realignment Commission. The remaining agenda items will require sustained OSD leadership.

PART I: INTRODUCTION AND SUMMARY

The Laboratory Infrastructure Capabilities Study examined the nation's capabilities to perform the Defense Department's science, technology, and engineering functions. DoD initiated this study to help ensure its continued ability to draw upon the best mix of available talent and facilities as missions and national priorities continue to evolve. The Defense Department also is seeking to improve working relationships among its laboratories, private industry, academic institutions, and other government performers of these functions. Sound collaborative relationships will allow the DoD laboratories to contribute effectively to national economic security and continue to take full advantage of the rapid technological progress in the commercial world.

This introduction and summary describes the approach taken along with the study's main findings and recommendations. Phase I focused on three issues: (i) defining the roles and missions of the DoD laboratories and describing how the Defense Department is organized to perform its science, technology, and engineering functions; (ii) understanding the extent to which DoD "outsources" these functions, that is, funds the work within industry and academia, and exploring the possibility of outsourcing more work to industry and academia in the future; and, (iii) creating an agenda of the structural, management and policy issues that the science, technology, and engineering communities believe should be addressed by the Director of Defense Research and Engineering.

In addition to laying the groundwork for long-term management of the laboratory system, this study also serves three specific, near-term purposes: First, it will help DoD respond to the National Science and Technology Council's government-wide review of laboratories. Second, it suggests a process for systematically reviewing the Department's laboratories and outsource providers, consistent with the recommendation of the Defense Science Board Task Force on Laboratory Management. Third, it contributes to DoD's ability to respond to the Congressional reporting requirements for a Defense Technology Base Assessment under Chapter 148 of Title 10 U.S.C.

A. STUDY OVERVIEW

The Phase I review convened panels of knowledgeable individuals with ready access to information, and with informed views based on their experience within the laboratory system or in similar activities in the private sector. Parallel government and non-government study panels were formed in order to obtain the views both of those within the government and those from outside the government.

1. The Product and Technology Areas

The panels examined twelve product and technology areas, which define a comprehensive set of the science, technology, and engineering disciplines supported by the DoD laboratories. Table 1 lists the twelve areas; they are a combination of the 20 technology areas that form the taxonomy for DoD's Science and Technology planning process.[1] (Appendix A provides the terms of reference for the study, which includes the formal definitions of these technology areas.)

Table 1. Product and Technology Areas*

Human Systems	C3I & Electronic Warfare
Environment & Civil Engineering	Weapons
NBC Counterproliferation	Space
Materials & Processes, Structures, and Manufacturing	Air Vehicles
Electronics & Sensors	Ground Vehicles
Computers, Software, Modeling and Simulation	Ships & Watercraft

* These panel areas use the taxonomy of DoD's Science and Technology Plan. S&T categories are combined to yield twelve panel areas. See footnote 1.

The science, technology, and engineering functions within these areas are performed within 81 DoD activities that are defined as "laboratories." (Appendix A provides a list of those activities.) In total, these laboratories receive about $17 billion in total funding (FY 1992 data), of which about $9 billion is from the RDT&E budget account, and the remainder is from procurement or operations and maintenance accounts.[2] The labs receive about one-quarter of all DoD's RDT&E funding; the remainder is spent within headquarters activities or outsourced directly to industry or universities.

---

1 The one exception is the Nuclear, Biological, and Chemical Nonproliferation area. It is not an S&T planning area, but was added because of its growing importance for national security.

These laboratories are diverse in terms of their size, the range of science, technology, and engineering functions they perform, as well as in their organizational structures and accounting methods. Some labs focus on a single technology area, as for example some medical labs; others are multidisciplinary, dealing with a wide range of technologies. For example, the Naval Air Warfare Center, Weapons Division, China Lake deals with a broad range of technologies that support the development of weapons. As discussed in this report, this creates uncertainty in describing which organizations are performing work in each technology, how much total work is being done in the area, and estimating the share of the work that is being done in-house and the share being outsourced.

2. The Panels

Each government panel included DoD representatives, as well as representatives from other government agencies, where appropriate. The military departments, defense agencies, and civilian agencies selected members and chairs. Approximately 200 government officials participated in the panels, supported by many more people in their home organizations. The government panels provided the depth of familiarity with missions, organizations, and programs needed to describe DoD's current organization and management approach; they provided extensive information on the Department's current practices and the roles and missions of the DoD laboratories.

In parallel with the government panels, IDA established non-government panels to obtain a perspective on national science, technology, and engineering capabilities from outside the government community. To identify participants, IDA wrote leading professional and trade associations to solicit nominations. More than 50 organizations responded, offering nearly 500 nominees. The IDA Executive Secretary for each panel area reviewed these nominees, contacted prospective panel chairs and participants, and recruited participants. In all, more than 120 non-government panelists represented the perspectives of industry, academia, and not-for-profit defense contractors. The IDA Executive Secretaries participated in the panels' deliberations, served as a liaison with the government panels, and assisted in preparing the panels' briefings and reports.

A steering committee chaired by the Deputy Director of Defense Research and Engineering for Laboratory Management, Dr. Craig Dorman, maintained cognizance over

---

2 These data are based on the "DoD In-House RDT&E Activities Report, FY 1992."

Phase I. Steering committee members included SES-level representatives from each of the Services, NASA, and the Department of Energy.

3. The Questions Addressed

The government panels first met in an organizational meeting chaired by Dr. Dorman on May 25th and 26th, 1994. To focus the panels' activities, they were asked the six questions summarized in Table 2.[3] They conducted the initial phase of their work in individual working sessions over the next four weeks, and then briefed Dr. Dorman on their interim findings on June 21, 1994. At that time, the non-government panels met for the first time. They received orientation briefings from Dr. Dorman and the government panels. Each government and non-government panel then met independently to prepare its report. They briefed their findings and recommendations to Dr. Dorman and Dr. Anita Jones, Director for Defense Research and Engineering (DDR&E), on July 19, 1994.

Table 2. Questions Addressed in Phase I

(1) What technologies, missions and major programs are supported by the laboratories?

(2) What are the roles of the laboratories, and how is work presently shared with other science, technology, and engineering performers?

(3) Which functions currently performed by the laboratories would it be technically feasible to outsource:

- Other government agencies or Federally Funded Research and Development Centers
- Private industry or universities

(4) What are the non-technical constraints on additional outsourcing?

(5) What fraction of the science, technology, and engineering functions currently performed for DoD fall into each of the following categories:

a. Inherently governmental
b. Other functions that must remain organic (reasons)
c. Could be outsourced with some problems
d. Could be outsourced

(6) What other issues should the DDR&E address?

---

[3] The terms of reference in Appendix A provides the full text of the questions addressed.

Two important limitations in the scope of Phase I should be noted. First, programs involving special access information were not examined. In areas such as electronic warfare, where a large proportion of programs are special access, this seriously limited the ability of the panels to describe current practices. Second, test and evaluation functions were outside the scope of this Phase I review. Because these functions often are closely tied with engineering functions, they should be included within the scope of future laboratory assessments.

In the short time available to them, these experts — from inside and outside the government — provided a useful picture of how DoD conducts business in each of the product and technology areas. Important differences were revealed across Services and among product and technology areas. Although they were not asked to identify specific structural changes needed in the laboratory system, they identified a large number of issues for DoD to explore further. The panels also articulated a number of long-standing issues relating to the laboratories, and raised some new issues created by the changing security and budget environments. Their efforts have yielded a clear, and ambitious, set of agenda items for laboratory restructuring, laboratory management improvements, and government-industry-university collaboration.

4. Report Framework

Each government and non-government panel prepared an independent report for its respective product and technology area. A volume has been published for each area, which includes the government and non-government reports, preceded by a synopsis of both panels' action items. This introductory volume integrates the findings and recommendations across the twelve areas. This section has described the Phase I study. Section B briefly surveys the panels' views on the security missions supported by DoD's science, technology, and engineering functions. Sections C, D, and E summarize the panel's findings on the existing extent of outsourcing and report their main recommendations. Section F concludes with some next steps in pursuing the action items identified in the panels' recommendations.

B. SCIENCE, TECHNOLOGY, AND ENGINEERING SUPPORT FOR DOD'S MISSIONS

The government panels were asked to describe the military missions supported by their product and technology areas. They provided statements of these missions, by drawing on the mission statements under development in DoD's ongoing Science and

Technology Planning Process. Each panel had a preliminary draft of the relevant Technology Area Plans to work with. This study was thus able to build upon an ongoing planning process, and employ the intellectual and policy framework DoD has been building in recent years.

The broad principles guiding DoD's Science and Technology Planning Process, and this review, have been stated by President Clinton and detailed in DoD's Bottom Up Review of the defense program. The objectives are that the DoD:

- Keep US forces ready to fight,
- Recruit and retain high quality personnel, and
- Maintain the technological superiority of US weapons and equipment.

When applied to the defense technology and industrial base, these objectives imply several goals, which recently have been codified by Congress. Their statutory guidelines dictate that the US must strive to maintain a technology and industrial base that is able to (i) supply and equip the armed forces in peacetime, (ii) provide adequate production, maintenance, repair, and logistics support for military operations, (iii) retain American leadership in military technologies, and (iv) provide a base for reconstituting a larger military force, if needed, within a reasonable time period.[4] These goals provide useful criteria for all of DoD's technology and industrial base programs and policies.

DoD's security objectives also imply several long-range war-fighting goals, which provide focus for these modernization activities; the Joint Staff has articulated the "Top 5" joint war-fighting capability objectives:

- to maintain near perfect real-time knowledge of the enemy and communicate to all forces in near real time;
- to engage regional forces promptly in decisive combat, on a global basis;
- to employ a range of capabilities more suitable to actions at the lower end of the full range of military operations which allow achievement of military objectives with minimum casualties and collateral damage;
- to control the use of space; and
- to counter the threat of weapons of mass destruction and future ballistic and cruise missiles to the Continental United States and deployed forces.

4 These are Congress's criteria for the Defense technology and industrial base. See Section 2501 of Chapter 148 of Title 10, U.S.C.

The DoD laboratories conduct a broad spectrum of activities in support of these goals. These include research, exploratory development, and advanced development activities designed to enrich the DoD scientific and technology base and create a climate for innovation. They also include engineering development, which supports the defense acquisition process in translating scientific and technical achievements into equipment and systems that support military capability objectives. In addition, in-service engineering enables new technologies to be inserted into proven, fielded systems.

These war-fighting goals, the Bottom Up Review, and DoD's science and technology strategy define the broad missions supported by DoD's science, technology, and engineering functions. They also provide an important context for this review of the organizations who perform these functions.

C. THE CURRENT MIX OF IN-HOUSE AND OUTSOURCE PERFORMERS

DoD's RDT&E functions are performed by a wide range of activities, including the laboratories, private industry, universities, not-for-profit institutions, and other government laboratories. The mechanisms used to fund these activities vary substantially: in some cases the laboratories fund outsource activities; in others, work is outsourced at the headquarters level and the funds never touch the labs. It was noted earlier that the labs receive about one-quarter of all RDT&E funding. Of the funding provided to the labs, they outsource just under one-half in industry and the universities. Hence, spending within the labs themselves accounts for about 14 percent of total RDT&E funding.

The panels were asked to describe the organizational structures and funding mechanisms used within each of the product and technology areas listed in Table 1. This section reports the panels' estimates of the laboratories' current mix of funding between in-house and outsource performers. It then discusses some of the important differences across areas and suggests possible ways to obtain better data in the future.

1. Panel Findings on Current Outsourcing Practices

The estimated percentage of funding outsourced by the laboratories in each area is reported in Table 3. The outsourcing estimates presented here should be viewed as preliminary because there are differences across panels in their basis for reporting outsourcing; nevertheless, these preliminary data are indicative of the rough magnitude of outsourcing in each area and the differences across areas. The data show that there are significant differences across the twelve product and technology areas.

As noted above, it is important to recognize that outsourcing in a technology area is often done at headquarters levels and therefore never touches the laboratories. Hence, the data presented in Table 3 provide a picture of the labs' use of their funds, which is the focus of our study, but should not be interpreted as a measure of the overall extent of outsourcing in the area.

Table 3. Estimated Laboratory Outsourcing by Technology Area

Area	Share of Lab Funding that is Outsourced (%)
Human Systems	70
Environmental & Civil Engineering	48
NBC Counterproliferation	51
Materials & Processes, Structures and Manufacturing	86*
Electronics & Sensors	70*
Computers, Software, Modeling and Simulation	87*
C3I & Electronic Warfare	75
Weapons	59
Space	79
Air Vehicles	46
Ground Combat	65
Ships	51

* This panel dealt only with S&T programs. Engineering programs in this area are covered in system or platform areas.

The data show that the laboratories outsource three-quarters or more of their work in four areas: materials, computers, C3I & EW, and space. As we shall discuss later, the panels generally felt that the extent of outsourcing was maximized in these areas. A second tier, including areas with outsourcing between about 60 and 75 percent, accounts for another four areas: human systems, electronics and sensors, weapons, and ground combat. The third tier, with outsourcing ranging from about 55 percent to under 50 percent, includes environmental and civil engineering, NBC counterproliferation, air vehicles, and ships.

Obviously, it is impossible to say — based on these ratios alone — whether the outsourcing ratio is too high, or too low, in a given product and technology area. Is the computer ratio too high? Is the shipbuilding ratio too low? A more in-depth review of all the technology areas and the DoD functions served is needed to make such a determination. The findings do suggest, however, that a comparative study across areas would be very useful. The observed variation in outsourcing ratios, both across areas and between S&T and engineering, suggests that the laboratory activities face different tasks or are using significantly different management approaches. A comparative "benchmarking" analysis of the different approaches used by the various activities might reveal the "best practices" in various functional areas.

2. Toward a Better Understanding of Laboratories and Technology Areas

The lack of correspondence between laboratories and technology areas poses a challenge that must be addressed in future technology base assessments. Neither technology area nor activity provides, in isolation, a fully adequate unit of analysis. Assessments focusing on activities cannot take a strategic view of the product and technology areas supported by the activity. Cost drivers relating to excess capacity, consolidation, critical mass, and coordination therefore cannot be addressed using the activity as the unit of analysis. On the other hand, an analysis focusing only on technology areas cannot address cost issues relating to the operation of a given activity. Questions relating to economies of scale or scope, or relating to the interactions among functions within a given activity, do not arise when the unit of analysis is a product and technology area. In the long run, both perspectives — activities and product and technology areas — and an understanding of their interrelationships are needed for examining the appropriate mix of performers for science, technology, and engineering functions.

A second variation across laboratories stems from the lack of consistent accounting methods and management information systems both between government and industry and across government activities. This creates uncertainty in measuring the levels of in-house and outsourced work performed within a product and technology area. Several panels offered recommendations for increasing the consistency of accounting methods and management information systems; these are discussed in the concluding section of this section.

A third important difference across laboratories lies in the range of functions they perform. These activities perform science and technology investigations and in many cases also perform engineering development and in-service engineering functions.[5] Some laboratories conform to the traditional definition of "laboratory" in that they deal primarily with science and technology functions (budget programs 6.1 - 6.3). Others could be called "full-service laboratories" inasmuch as they deal with the full range of research,

---

5 The following discussion draws on the report of the C3I/EW non-government panel.

development, and acquisition functions (budget programs 6.1 through 6.7). Other activities perform mainly engineering functions (6.4 -6.7) and thus can be called "engineering centers."

Unfortunately, organizational titles do not always correspond with this taxonomy. In the Navy, only two activities use the term "laboratory": the Naval Research Laboratory and the Naval Biodynamics Laboratory. As part of its recent reorganization, the Navy has organized its activities into "Warfare Centers" as, for example, the Naval Surface Warfare Center. Some Centers have divisions, such as Weapons Division, China Lake. These weapons divisions resemble traditional laboratories because they carry out 6.1 - 6.3 activities and support engineering activities when tasked to do so.

The Air Force has organized around four separate laboratories (with facilities at ten locations): the Phillips Labs, the Rome Labs, the Wright Labs, and the Armstrong Labs. Each is assigned a product or technology focus. The Air Force also has Centers with a product or technology focus, such as the Aeronautical System Centers or Space and Missile Centers. Also included in the Air Force is the Electronics Systems Center at Hanscom AFB, which is responsible for buying electronic systems; it does no 6.1 - 6.3 work. The Air Force also has logistics centers responsible for operational system upgrades, maintenance, and other engineering support activities.

The Army's consolidated laboratory structure, the Army Research Laboratory (ARL), has major facilities at five locations. As with the Naval Research Laboratory (NRL), it deals with a broad spectrum of Army S&T interests. The Army has organized around several Research and Development and Engineering Centers (RDECs), which are full-function organizations that perform science and technology as well as engineering work. These are "industrially funded" activities, which means that they must either sell their services or go out of business. The Communications Electronics Command (CECOM) RDEC is an example. These Centers conform closest to the category "full-service laboratory."

Just as each Service has adopted its own organizational principle, they also define somewhat different roles for their laboratories, different justifications for retaining in-house capabilities, and different working relationships with industry and academia. These roles, justifications, and working relationships also vary across functions. In particular, it is important to understand how the reasons for maintaining in-house capabilities differ among science and technology functions, developmental engineering functions, and in-service engineering functions.

D. PANEL VIEWS ON OUTSOURCING AND OTHER STRUCTURAL ISSUES

The panels addressed specific questions regarding DoD's reasons for maintaining in-house capabilities, the availability of technically competent organizations that could take on work currently being done within the laboratories, and the feasibility and advantages of shifting a greater share of future work outside the laboratories. These specific questions were intended to elicit factual data describing the roles of the labs and their relationship with other performers in the national science and technology base. Most panels broadly interpreted the questions relating to outsourcing potential; thus a wide range of responses was received.

1. Reasons for In-House Performance

The government panels defined nearly two-dozen laboratory functions that they believe belong within the government. Table 4 lists the functions identified by one or more of the government panels. These fall into four broad areas. First among these is providing corporate memory and serving as the trusted in-house advisor on technology issues. The panels believe a core of knowledgeable government people is needed both to nurture needed technologies and to recognize opportunities for applying advanced technologies regardless of where they are developed.

A second role of the laboratories is creating and maintaining capabilities that are uniquely needed by DoD. These include physical facilities to which the laboratories can guarantee access. The laboratories also can serve as the government's responsible agents in fulfilling safety and security requirements relating to these facilities.

A third major role stems from the wide range of support the laboratories provide for the weapon acquisition process. This involves a number of specific functions: serving as an expert non-proprietary advisor to acquisition officials, providing the linkage between military users and the technology community, serving as a source selection agent, and serving as fiduciary agents, contract monitors and administrators. In addition, laboratory personnel also serve as agents of the government in dealings with foreign governments, in handling proprietary information, and in representing the government in organizations responsible for developing technical and product standards. As noted, laboratory personnel also are able to fulfill certain governmental safety and environmental responsibilities.

Table 4. Roles of the Laboratories*

Advisor and Repository of Corporate Memory	Source of Unique Capabilities	Acquisition and Policy Agent	Institutional Liaison
Source of corporate memory and stability -- nurturer of technology Expert on defense-unique research Smart buyer -- non-proprietary advisor or broker Technology integrator Requirements translator -- link user to technology Smart user support for fielded systems Repository of knowledge of legacy systems	Low cost owner of unique facilities Provider of guaranteed access to unique facilities Repository of unique military expertise Ready supporter of deployed combat troops Trusted repository for export-sensitive & proprietary information	Source selection agent Acquisition agent for contractual oversight & budgeting Legally responsible agent for regulatory responsibilities & safety Legally responsible agent for physical security Legal representative in standards groups Legal representative in international government-to-government dealings	Liaison between technology community and fielded forces -- mission over profits Link between engineering and testing communities Liaison between technology and intelligence communities Broker for Service interoperability concerns Technology training ground for military leaders

* The four categories used as column headings in this table were created by the government materials panel. The column entries include those presented by the materials panel along with additional roles and missions identified by other panels.

A fourth important role of the laboratories is that they provide a technology nexus for the modernization ideas coming from military users, the intelligence community, industry, and academia. Their close working relationships with a range of communities allow them to serve as liaison between the technology community and the other communities with important stakes in the modernization process. No other kind of organization offers the breadth of perspective and continuity of involvement that is provided by the laboratories.

Although the government and non-government panels generally are in agreement that the labs perform a wide range of important functions, there is substantially less agreement as to whether the labs *must* perform these functions. For example, some panels questioned the importance of the laboratories as "smart buyers" in the acquisition process. The C3I panel and the Clothing, Textiles, and Food sub-panel observed that the labs in their respective areas are not effectively used for these acquisition functions today. Some panels also asked whether in-house capabilities are needed to manage science and technology programs, given the success of other management models that rely far less on in-house capabilities for commissioning science, technology, and engineering tasks. They offered as alternatives the management approaches used by the National Science Foundation, ARPA, and the National Institutes of Health.

Many panels noted that it is fruitless to debate these roles-and-missions questions as all-or-nothing qualitative choices. The real question that ultimately must be addressed is: What is the "critical mass" of laboratory capability needed to execute these functions for DoD? This question of defining the critical mass is, of course, the inverse of the question posed in this study, which asks the panels to identify functions DoD does *not* have to do in-house. Most panels recognized it as such.

2. Structural Recommendations

Nine of the twelve non-government panels recommended that DoD consider structural changes in their product and technology area; these included the potential for increases in outsourcing in five areas. In addition, there were numerous recommendations to consider structural changes *internal* to the DoD laboratory system. Some of these were in combination with increases in outsourcing, and some independent of changes in outsourcing. Table 5 displays the panels' findings regarding outsourcing and internal structural changes.

The panels were not asked to offer specific recommendations for change; thus their approach was to identify areas for further, in-depth review, and potential change. In some cases the government and non-government panels reached qualitatively similar conclusions on the need for structural change; in others they disagreed or simply did not comment on the same issues. Because the panels merely identified areas where the potential for change deserved further investigation, and did not identify specific changes, the entries in Table 5 reflect areas identified by *either* the government *or* non-government panel. Some insight into the areas of agreement and disagreement is provided by Table 6, which offers brief descriptions of the proposed structural changes outlined by each panel. To understand the reasoning underlying these recommendations, a careful reading of the panels' reports is recommended.

Table 5. Potential Structural Changes

Consolidate or Make Other Internal Structural Changes	Increase Outsourcing: No	Increase Outsourcing: Yes
No	– Ground Vehicles* – Materials & Processes, Structures and Manufacturing* – Computers, Software, Modeling & Simulation*	– NBC Counterproliferation
Yes	– Electronics & Sensors – C3I & Electronic Warfare – Weapons – Space	– Human Systems* – Environment & Civil Engineering* – Air Vehicles* – Ships and Watercraft*

* Government and non-government panels agreed on the qualitative outsourcing recommendation in this product and technology area.

Of the nine areas where possible structural changes were identified, only NBC counterproliferation focused exclusively on increases in outsourcing. In this area, the non-government panel took issue with the government panel's conclusion that existing in-house capabilities should be retained, and found that virtually the entire program could be outsourced. The remaining eight (in the lower two quadrants of the table) recommended internal structural changes — usually laboratory consolidation — either in addition to, or instead of, increases in outsourcing. Four of these panels proposed both internal structural changes and additional outsourcing. The proposed changes were substantial in the areas of air vehicles and ships and watercraft. More modest changes (about 10 percent) were proposed in the human systems and the environmental and civil engineering area. The remaining four panels found that additional outsourcing would be harmful in their area, but nevertheless believed internal structural changes would be desirable (electronics, C3I/EW, weapons, and space).

Table 6. Comments on Outsourcing and Restructuring

Area	Additional Outsourcing		Other Restructuring	
	Gov't	Non-Gov't	Gov't	Non-Gov't
Human Systems	13% reduction in organic efforts feasible			Biomedical -- needs review Human systems -- Current structure seems appropriate Manpower, Personnel, and Training -- needs review Clothing, Textiles, and Food -- review exists; recently consolidated
Environment and Civil Engineering	Environmental Quality -- 10% increase in outsourcing is feasible Battlespace Environment -- 4% Civil Engineering -- 4%	Environmental Quality -- Outsourcing should be pursued in common problem areas Battlespace Environment -- more outsourcing is possible		Environmental Quality -- DoD-specific S&T areas should be consolidated to establish critical mass Civil Engineering work should be expanded significantly
NBC Counterproliferation		All organic work could be done by industry		
Materials and Manufacturing	No technical limits on outsourcing. Non-technical considerations limit further outsourcing	Agree with government assessment		Real costs of in-house vs outsource must be determined If some functions unique, should be done by GOCO
Electronics and Sensors	Current 25% organic needed			Labs must be resized and reorganized if decline in funding exceeds current predictions. Opportunities exist to reduce duplicate infrastructure

Area	Additional Outsourcing		Other Restructuring	
	Gov't	Non-Gov't	Gov't	Non-Gov't
Computers, Software, Modeling and Simulation	Reductions below current 15% organic would be dangerous, because coverage is already marginal	Current ratio seems appropriate		Labs should be more involved in DoD acquisition efforts CSMS under-funded, considering pervasive nature
C3I and Electronic Warfare	Labs are at critical mass; should not be reduced			Jointness needs to be emphasized Should consolidate C3I labs into three main activities EW should also be consolidated, but the appropriate model is not clear
Weapons	Current outsourcing ratio is appropriate	IR&D cuts have effectively reduced outsourcing; the effects should be studied		Centers of excellence tied to DoD's strategic objectives should be created Overlap and excess capacity should be studied
Space	Organic reductions beyond those planned would threaten program viability However, additional outsourcing is possible in some areas	Outsourcing to FFRDCs and Other Government Agencies is undermining the commercial production base; need to remedy this		Possible consolidation into single lab should be studied

Area	Additional Outsourcing		Other Restructuring	
	Gov't	Non-Gov't	Gov't	Non-Gov't
Air	S&T outsourcing could increase from 71% to 79%. Engineering development outsourcing could increase from 20% to 21%. In-service engineering outsourcing could increase from 62 to 64%.	S&T outsourcing could increase to 85 - 95% Engineering development outsourcing could increase to 50 - 60% In-service engineering outsourcing could increase to 90 - 97%		Aeronautics research is in bad shape
Ground	Use of on-site contractors would not harm labs	No recommendation		Government labs not unique Industry will drop areas of expertise unless supported
Ships and Watercraft	The panel identifies specific areas for further outsourcing	Concurs with government panel		Proposes collaborative government-industry relationships

Generally, the proposed internal structural changes identified in Table 5 were motivated by one of two concerns. The first is that there is excess capacity and duplication of facilities in an area. One statement of this concern came from the electronics and sensors panel. The non-government panel said that if the budget for this area is cut below current projections, then DoD should examine possible consolidations and the elimination of programs. The human systems panel, the space panel, and the air vehicles panel expressed similar views, either in terms of current or anticipated excess capacity. In general, the panels warned that across-the-board budget cuts should be avoided, because they fear that proportionate cuts could leave areas without the critical mass capability needed to perform their functions. Thus, an informed approach based on an overall strategy is needed.

The second concern is that some areas lack a clear definition of their roles. In these areas, laboratory realignments might be needed to improve focus on this role, to provide a critical mass of internal capability in a single center of excellence, or to encourage joint approaches and interoperability. One well-articulated example of this concern is in the C3I area, where the non-government panel found the current structure does not adequately support joint interoperability. The weapons panel, the human systems panel (biomedical), the environmental panel (environmental quality), and the shipbuilding panel expressed similar concerns.

Three of the areas offered no recommendations for structural change. The ground vehicles non-government panel said it had insufficient information for such a recommendation, and the government panel made a vigorous case for retaining existing capabilities. In the materials area, both the government and non-government panels found that there were no technical limits on outsourcing, but that the area is already heavily outsourced and non-technical management considerations preclude further outsourcing. Similarly, in the computer area, outsourcing is already at about 85 percent and both panels maintained that any cuts in in-house capabilities would jeopardize the government's ability to tap commercial technology.

E. OTHER RECOMMENDATIONS

In addition to their comments on structural issues, the panels provided comments and recommendations on a wide range of other issues. These are briefly summarized in this section. Table 7 highlights the main recommendations. To appreciate the full range and depth of the panels' thinking, an examination of each of the panel's reports is recommended. The following discussion focuses on themes that were common across several of the panels.

Table 7. General Recommendations

Area	Government Panel	Non-Government Panel
Human Systems	Ease outsourcing restrictions Create consistent definition of "smart buyer"	Avoid across-the-board cuts Establish in-depth outside review Base criteria for review on threats, customer input, outside alternatives, and unique capabilities Increase lab management flexibility
Environment and Civil Engineering	Reduce barriers to outsourcing and partnering	Exploit dual-use applications of Civil Engineering capabilities
NBC Counterproliferation		Need to determine real costs of organic versus outsource performers Avoid funding other government agencies: these funds don't contribute to DoD's critical mass or to industrial base
Materials and Manufacturing	Need to emphasize organic capabilities that are responsive to changing environment	Need to optimize government collaboration with industry and universities -- new paradigms are needed to reflect new manufacturing approaches Establish pilot programs to study quality of organic and outsourced programs Establish ongoing review process with long-range view of outsourcing
Electronics and Sensors		Establish top-down approach for downsizing based on modernization strategy Increase flexibility of lab managers; civil service, procurement, outside review

Area	Government Panel	Non-government Panel
Computers, Software, Simulation and Modeling	Review whether existing programs support the critical mass needed to take advantage of commercial advances	Avoid across-the-board cuts; develop metrics to continually review and reassign assets Create pilot S&T programs Piggyback on industrial IPPD efforts
C3I and Electronic Warfare	Involve labs in major acquisition decisions Remedy current decoupling of industrial funding and personnel assignments	DDR&E should lead labs toward "best in world" status DDR&E should consider more common accounting standards and MIS systems to improve comparability DDR&E should lead efforts to improve laboratory-industry relationships
Weapons		Create centers of excellence tied to strategic objectives Increase laboratory directors' management discretion -- reduce formal reporting requirements and introduce peer review -- improve personnel system
Space	Preserve long-term viability of the space program; consider whether current programs preserve a critical mass	Create government-industry partnership; give preference to industry over FFRDCs and other government laboratories Create a pilot project demonstration for procurement reform Establish metrics of laboratory performance

Area	Government Panel	Non-government Panel
Air Vehicles		Look beyond traditional arms-length government-industry roles to create synergistic teams Use virtual engineering to support teaming Create a continuous flow of trained people Propose that government give facilities, particularly wind tunnels, to industry and universities in return for the right to use these facilities
Ground	Give or loan some government facilities to universities or industry	Preserve the unique industrial base in this area Make accounting principles more comparable between government and private sector Stabilize programs, so that demands are more predictable Maintain government capability to manage best value competition
Ships and Watercraft	Establish and support a pilot program to demonstrate a collaborative government-industry working relationship	Establish three pilot programs as suggested by government panel Reduce user costs for government facilities

Define Roles and Provide Strategic Guidance: The most common theme among the panels was the need to take a more fundamental look at the roles and missions of the laboratories. Some panels stressed the need for OSD leadership in a strategic management process for defining roles and issuing guidance. Such a process needs to start with a strategy for force modernization as a guide for configuring fewer, stronger, and more empowered labs around those that are already the highest in quality. Several panels recommended defining a critical mass laboratory capability for retaining key competencies and outsourcing remaining functions; others indicated the need to create world-class centers of excellence linked with strategic objectives. In either case, the panels believed DoD should clarify the science, technology, and engineering functions it needs in the future; these should form the basis for sizing in-house capabilities. One panel noted that clarifying the laboratories' functions would be most useful if they were derived from a coherent DoD modernization strategy.

One important question is how the panels' proposed strategic management process should relate to existing mechanisms with similar missions. The Project Reliance process already coordinates S&T programs among the Service laboratories.[6] The panels cite several significant successes for Reliance in eliminating redundancies in the Services' S&T programs. The human systems panel was unsure whether Reliance has been fully effective in their area, which led it to recommend further review. If Reliance is ever to be fully effective in addressing laboratory concerns, it will have to be expanded in two directions. First, to address all of the laboratories' functions, it would have to be expanded to cover engineering functions in addition to science and technology functions. Second, a broader range of organizations must be involved, including ARPA, the Ballistic Missile Defense Organization, the Service OXRs, NASA, and the DoE laboratories.

The role of the current S&T planning process raises similar questions about participation and coverage. As with the Project Reliance, the S&T planning process is generally considered a success. It provides a nominal plan for the programs needed to meet DoD's long-range technology leadership objectives. It also has limitations, however. As with Reliance, S&T planning does not cover engineering functions. In part, this is because the Director for Defense Research and Engineering has oversight responsibility for S&T programs but not for engineering programs; these are the responsibility of the Service Acquisition Executives who report directly to the Under Secretary of Defense for

---

6 Project Reliance was instituted by the Joint Directors of Laboratories (JDL) to coordinate science and technology programs across Service laboratories.

Acquisition. This raises the question of who within the USD(A) would take the lead responsibility for a strategic management process covering *all* of the laboratories' functions. Another similarity with Reliance is that the S&T planning process has not included the full set of government agencies that are working in each area.

No doubt a host of specific issues will need to be addressed in creating such a strategic management process. Three such issues commented on by the panels are of particular importance in determining the appropriate mix of laboratory and outsource performers in a product and technology area. One relates to limitations the Services now face in using government-owned, contractor-administered (GOCA) facilities. Both the human systems and ground vehicles panels believe they could rely more on private support if these contracting restrictions were lifted. A second issue is how DoD calculates the relative costs of government and non-government activities. Several of the panels raised this as a basic issue in determining desirable levels of outsourcing. Some also argued there is a need for greater comparability within the government as well as between government and non-government activities.

Several panels argue that the heart of DoD's strategy should be to build on and enhance government-industry collaboration, because the roles of the defense laboratories outlined above are complemented by industry's ability to produce things. This raises the question of what roles other government laboratories should play in performing DoD's science, technology, and engineering functions. While the panels think that DoD should coordinate and collaborate with the other government agencies so that work supporting DoD's missions complements the work of the agencies, they also think DoD should not dilute its support for its primary performers in an attempt to underwrite the survival of other government laboratories. The panels maintain that any attempt to set-aside funds to support other government laboratories would neither serve DoD's need to retain in-house capabilities nor serve the need to retain the industrial base required for production.

In sum, there is strong agreement among the panels that improvements in strategic management are needed. An important remaining question is that of determining the best mechanism for implementing such a process, and how it should relate to the existing Project Reliance and S&T planning processes.

Set Criteria and Establish External Review: Several panels felt that an important part of the strategic management approach outlined above is to give laboratory managers the flexibility to manage their activities, while providing an external review process to ensure strategic objectives are being pursued most effectively. The panels recommended that the laboratories be given management criteria to guide their activities and that metrics be established to judge performance. External peer review would examine operations periodically, and provide recommend changes as needed to both laboratory and DDR&E managers. The panels would be composed of independent experts in the area's technologies, along with military operators who could judge the potential military worth of proposed lines of research.

Increase Flexibility for Laboratory Management of Procurement and Personnel: In conjunction with introducing an external review process, some panels proposed giving laboratory managers greater discretion in formulating their programs, along with increased management flexibility. One key element of flexibility could come from the reform of DoD's procurement regulations. This has been a long-standing issue in DoD. Procurement regulations limit the laboratories' flexibility to contract with private firms, and they discourage establishing long-term, collaborative working relationships. Currently, the Congress is considering reforms to the acquisition process that will alleviate some of these restrictions. The space panel outlined a proposed pilot program to test reformed procurement practices.

Another long-standing issue with the DoD laboratories is inflexibility in personnel management. Laboratory managers require flexibility in hiring, firing, promotion, and pay if they are to maintain world-class technologists happy in their government organizations throughout the upcoming process of downsizing, realignment, and consolidation.

Create New Partnering Relationships: A very common theme across the panels was the need to improve the collaboration of the laboratories with industry, academia, and other government agencies. There are several points of view on this issue. Dual use is one. The environment and civil engineering panel suggested that DoD play a larger role in national research and development in the civil engineering area, because DoD possesses unique expertise that could improve private sector technology and productivity. The shipbuilding and ground vehicles panels made similar arguments. They recommended providing private firms improved access to unique government facilities. Legal mechanisms exist for making such facilities available; NASA has long made its facilities more readily available to non-government organizations than has DoD.

A second facet of government-industry relations is the role of the government labs in implementing new development approaches, such as integrated product and process development (IPPD). The materials, computers, shipbuilding and air vehicles panels all cited the need for the laboratories to participate more effectively on development teams. They believe technology can help, by improving the communications tools available to team members. They recognize, however, that management considerations are paramount in establishing teaming relations, and that teaming runs counter to the culture of arms-length, adversarial government-industry relationships that has been prevalent in recent years. The basic question is how to exploit the benefits of teaming without violating Congress's goal of maintaining free and open competition among private organizations in serving the government market.

A range of ideas has been proposed by the panels, including (i) an expansion of collaborative government-private research agreements, (ii) the shared use or privatization of government facilities, and (iii) the establishment of privately owned "federated" laboratories where government personnel work on assignment. Some panels discussed mechanisms for enhancing government-private interactions that draw on technological advances in communications and computer networking. They cited the growing management literature on "virtual" enterprises—which comprise teams of firms interconnected through a common information architecture—as providing management models for how research organizations can work more closely together in the future.

F. NEXT STEPS

This first phase of the Laboratories Infrastructure Capabilities Study has yielded an improved understanding of the DoD laboratories' functions, how the laboratory system is organized and funded, and how it interacts with industry, universities, and other government agencies. Phase I also has identified a number of courses of action that DoD can pursue in defining the future functions and structure of the Defense laboratories. These define an agenda of possible next steps for the Department.

Five broad agenda items are outlined here. The first two build directly on Phase I in that they would continue to focus on improving our understanding of the laboratory system and examining how the system might be restructured. The second group of three agenda items addresses the other policy issues presented in Section E.

1. Define and Collect the Data Needed to Understand the Laboratories' Functions and their Contributions

There are no simple answers to any of the questions posed in Phase I, because DoD's organizational, funding, and management approaches vary both across Military Departments and across product and technology areas. While Phase I provides a basic understanding of DoD's broad S&T and engineering organizational structures, it also raises a number of questions that will require more investigation. This preliminary analysis highlights certain difficulties in describing current practices that arose from limitations in available data. These were discussed in Section C, where a number of specific data limitations and possible remedies were discussed. One action area is to continue building the data base needed to better understand DoD's science, technology, and engineering programs and the mix of organizations performing science, technology, and engineering functions.

Related to this task is the need to create a framework and metrics for assessing the appropriate mix of organizations for performing science, technology, and engineering functions. One way to develop this needed framework and metrics is to undertake a benchmarking study to define the "best practices" used by the most progressive organizations to perform functions like those of the laboratories. Commercial firms commonly use benchmarking to create management improvement strategies for all kinds of organizations, and this approach applies to the laboratories as well.

2. Conduct In-Depth Reviews in Areas Where Structural Changes Are Proposed

Nine of the panels proposed ways to restructure the laboratory system. Five proposed increases in outsourcing; eight proposed internal structural changes, either in combination with or independent of increases in outsourcing. These proposals are summarized in Section D above, and discussed in more detail in the report on each product and technology area. In citing these possible changes, the panels agreed that a more in-depth understanding is needed before any specific actions are undertaken. For each science, technology, and engineering function performed by the laboratories (Table 4), a functional analysis is needed to assess DoD's requirement of that function, as well as the effectiveness of the various laboratories in performing it. Such an analysis will help identify those laboratory capabilities that must be preserved, and those that can safely be consolidated or eliminated. Such in-depth functional reviews of these areas are a second important action agenda item.

Areas of focus would include those where:

- The greatest potential outsourcing payoffs are identified
- Consolidation has been recommended
- Stronger joint focus is recommended
- Stronger linkages with the acquisition process are needed
- Stronger linkage with other government agencies is needed.

An ideal near-term forum for the needed reviews is the 1995 Base Closure and Realignment Commission (BCRC) process. The Service action teams preparing DoD's submissions to the Commission should be directed to examine the structural changes proposed by the panels.

3. Create an Ongoing Strategic Management Process for Defining the Laboratories' Roles

Several of the panels cited the need to establish a more in-depth review process to address the structural issues raised in this study. The panels have offered a number of general ideas; these are discussed in Section E. It would make sense to establish such a process once the near-term decisions of the BCRC have been made. One important question is how to relate such a process to ongoing management processes such as DoD's Science and Technology Planning Process, the Services' Project Reliance, or other governmental review processes. A third agenda item is to begin to design an ongoing process. In addition, it will be essential to define clear roles and leadership responsibility within OSD and the Services for the strategic management of laboratory functions.

A reasonable next step would be to begin to build the necessary framework using one or more panel areas as a test case. The area chosen could be one where problems in coordination have been cited by the panels; or one where the existing process seems to be working well, and it thus provides a sound foundation for expansion into related functions or areas.

4. Establish Pilot Programs for Improved Government-Industry-University Collaboration

Each of the panels that discussed the need to improve collaborative relationships also proposed to help foster a pilot demonstration program in its area. An example of one such program is the National Automotive Center, a joint effort between the Army Tank-Automotive RDEC, the "big three" auto makers, and a number of universities. As noted above, specific proposals have been offered in the shipbuilding and civil engineering areas. Continued panel activity would be useful and readily forthcoming, because the panels are very enthusiastic about the benefits of improved collaboration. The proposed programs would assess the benefits of the collaborative arrangements. They also would identify the legal, regulatory, and cultural barriers to instituting broader government-industry collaboration. As noted in Section E, the motivations for collaboration differ across product and technology areas. It may be desirable, therefore, to explore undertaking such programs in two or more areas.

5. Establish Pilot Programs Exploring Reformed Laboratory Management Approaches

The panels raised long-standing laboratory management issues stemming from the inflexibility in DoD's existing procurement and personnel management practices. Procurement reform is an area where DoD has been working for legislative change, which is likely soon to come to fruition. Personnel management changes also need to be fostered. In both areas, pilot programs have been undertaken in the past. The outcome has been mixed.

The President's Reinventing Government Initiative provides an ideal mechanism for instituting the kinds of changes that the panels are proposing. The current environment offers reason for optimism that action can be taken in addressing these perennial problems.

G. CONCLUDING REMARKS

From the outset of Phase I of this study, none of the panelists believed his or her work would provide quick and easy answers to DoD's laboratory management concerns. The questions posed to the panels, and the issues they raised in their deliberations, have been examined and debated scores of times in the past. The five agenda items proposed here open opportunities for revolutionary changes in the structure and operations of the laboratories. But, as always, the devil is in the details. Substantial further efforts will be needed to flesh out and implement these agenda items. Some of the structural changes could be addressed by the Service action teams preparing DoD's submission to the Base Closure and Realignment Commission. Others will require sustained OSD leadership. A goal for Phase II of this study is to develop specific action plans for these agenda items.

May 11, 1994

LABORATORY INFRASTRUCTURE CAPABILITIES STUDY

TERMS OF REFERENCE

Background: The Deputy Director of Defense Research and Engineering for Laboratory Management, Dr. Craig Dorman, is reviewing the nation's capabilities for performing the functions required to meet DoD's science, technology, and engineering needs. This study will examine the capability of current organic and outsourced performers of these functions as well as the potential for additional outsourcing by performers from US industry, academia, and other government laboratories. The study will also consider alternatives for establishing an ongoing process for reviewing alternative performers of science, technology, and engineering functions.

This study will serve three purposes: First, an understanding of the capabilities of the current and potential performers of DoD's science, technology, and engineering needs is required to support DoD's programs in upcoming budget reviews. Second, this assessment is also expected to help establish and support DoD's position for the National Science and Technology Council review of the national laboratory system. The third purpose for this study is to begin to establish a process for systematically reviewing the capabilities of these providers. Such a process can be incorporated, in the longer term, within the ongoing science and technology strategic planning process.

Scope: The study will include each DoD activity that has the mission to perform at least one of the following functions: science and technology investigations, engineering development, and in-service engineering functions. (Attachment A provides a list of the organic activities to be reviewed.) In addition, current, non-DoD performers to which DoD currently outsources these functions will be included. Beyond this current base of performers, the review will consider other potential performers of these functions, to include other government laboratories, commercial firms, not-for-profit organizations, and universities.

Each of 12 product and technology areas will be examined. (Attachment B provides the definitions of these product and technology areas.) "Black" programs will not be examined in this study.

<u>Questions</u>: The study is intended to provide information that will be helpful in evaluating the roles and missions of organic performers, the technological feasibility of additional future outsourcing, and the comparative advantage of alternative providers. This information will support the Department of Defense in determining which capabilities should remain organic within DoD's laboratory system, and those that might be outsourced. The study will address the following six questions for each of DoD's product and technology areas:

(1) What are the major subareas within each of the product and technology areas under review? For each subarea, what are the DoD missions and major programs supported?

(2) Who performs DoD's current science, technology and engineering programs? What portion of work is done organically, and what portion is already outsourced? What are business areas and programs supported by the existing performers in this area? What is the rationale for functions done organically?

(3) For which functions currently needed by DoD are there performers with similar technical capabilities in other government agencies, industry, non-profits, or academia? Identify these organizations and their capabilities. For which functions currently performed organically within DoD would it be technically feasible to outsource to those organizations with similar technical capability? What are the comparative advantages of organic and other organizations in performing these functions?

(4) For which of the functions identified in item (3) would there be potential constraints on additional outsourcing? For example, is the function inherently governmental, or one that must be tightly controlled for reasons of security or responsiveness? Describe the potential constraints in each case.

(5) Estimate what fraction of the science, technology, and engineering functions currently performed for DoD fall into each of the following categories:

a. Inherently governmental

b. Other functions that must remain organic (reasons)

c. Could be outsourced with some problems

d. Could be outsourced

(6) Indicate the lessons learned from this review, and their implications for establishing an ongoing process for reviewing the performers of science, technology, and engineering functions. Recommend as appropriate a framework for such ongoing assessments. What issues raised in this review require further data, analyses, or evaluation in evaluating the proper long-run balance of organic and outsourced performers in this technology area? What policy issues or guidance are needed to rationalize decisions regarding the performer base in this technology area?

Study Approach: The study will proceed in three phases. Phase I (May - July, 1994) will provide preliminary assessments of current activities and outsourcing potential. Phase II (August - October, 1994) will provide quantitative data by technology and product areas, and examine specific issues identified in Phase I. Phase III (November, 1994 - January 1995) will prepare a final report to the DDR&E.

Phase I Tasks: The specific tasks that have been identified for Phase I of the study include the following:

- Task I: The Institute for Defense Analyses, the DDR&E organization, and a Service working group will assemble available data and analyses needed to address questions 1 and 2.
- Task II: A government panel will meet to review the data for questions 1 and 2, and will develop their answers to questions 3, 4, and 5 for each technology area. Each panel will prepare a draft report on its findings, and will brief its findings to the Deputy DDR&E for Laboratory Management. These panel reports will be incorporated in an integrated report to be prepared by IDA.
- Task III: A non-government panel will review each technology area in order to provide a non-government perspective on questions 3, 4, and 5. Each of these panels will also provide a draft report on its findings. These panels will be assisted in preparing their reports by an executive secretary to be provided by IDA.
- Task IV: The Institute for Defense Analyses will prepare a final draft report that integrates and summarizes the panel reports.

Study Organization: The study will include three main sets of organizational participants. These are:

- Steering Committee: A steering committee chaired by The Deputy Director of Defense Research and Engineering for Laboratory Management, Dr. Craig Dorman, will oversee this study. Members will include Flag/SES level representatives from each of the Services, along with other officials appointed by the Chairman.

- Government Panels: Each panel will include DoD representatives, as well as representatives from other government agencies when appropriate. The military services, defense agencies, and civilian agencies will select members for the government panel.
- Non-Government Panels: The Institute for Defense Analyses will identify participants and chairpersons for the panels of non-government participants. These will include representatives from industry, academia, and not-for-profit defense contractors.

Time Frame: Attachment C provides a schedule for the project. The time phasing of the four phase I tasks is as follows:

- Task I: Background Data and Analysis — April - May
- Task II: Government Panels Meet — May - June
- Task III: Non-government panels — June - July
- Task IV: Report Integration and Review — July-August

Products: Each panel will report its findings using a common format, in order to ensure consistency and uniformity of analysis and presentation. IDA will integrate the panels' reports into a final report.

Definitions: Attachment D provides definitions of some of the key terms to be used in this study.

TOR ADDENDUM 1: ADDITIONAL GUIDANCE -- 6/5/94

This addendum to the TOR answers a number of the questions that were raised in the government panel meetings. We will issue guidance such as this as new questions are raised in the course of the project.

1. Labs in Context of Service Organizations

There has been much concern that the different organizational structures of the Services could impart a biased picture of overall outsourcing patterns. For example, in some areas outsourcing is done through headquarters activities; whereas in others the funds flow through the labs. It therefore will be necessary to attempt to provide a view of how the labs fit into the overall organizational scheme for each Service. Two approaches for doing this are recommended.

a. The first is to create an organizational chart for your product and technology area. The purpose of the organizational chart is to show how the funds flow in the area in each service.

b. The second recommended approach is to provide a table that roughly accounts for all the funding in each broad budget category (see Table 1 below). This table would provide a picture of the disposition of all funding in each product and technology area. In this way, we can assess the overall Service strategy for supporting each area.

One problem raised with this approach is that it is difficult to account for a Service's total engineering, and in-service engineering funding, so it is impossible to know for certain how much is outsourced at the headquarters level. This problem should be handled in one of two ways: (1) The preferred approach is to provide the best estimate you can, and footnote your estimate to describe its source and the quality of the estimate. (Estimating a reasonable range is acceptable.) Or (2) if you simply cannot estimate this variable, then insert a NA, and include a footnote explaining why it is not being reported.

Table 1. Funding Distribution in Product and Technology Area

	6.1	6.2	6.3a	6.3b to 6.7	Other (ISE) Includes Proc & O&M Funding
Service Total					
- Hdqtrs Level Outsourcing (etc.)					
- Labs' Funding					
-- In house					
-- Outsourced					
(Cat I)					
(Cat II)					

* It is anticipated that these quantities will have to be estimated by the panel and may not be readily available since they lie outside the domain of the labs. Please footnote sources and qualifications. See the discussion above.

2. MILPERS

It has been noted that military personnel are not paid out of laboratory funds. Consequently, activities that rely on substantial numbers of military personnel will have a biased assessment of in-house capability. Where MILPERS are a significant factor, a footnote should be included to indicate the estimated (implicit) addition to in-house laboratory funding associated with an estimated cost of military personnel.

3. Guidance for Responding to Chapter Template Table 3

The discussion in Table 3 needs to deal as specifically as possible with technologies, because general statements about broad technologies are not helpful.

4. Embedded Systems

Platform specific systems are to be included with the platform areas, as is product specific manufacturing technologies. It is up to the panel chairpersons to resolve potential conflicts. It is our understanding that the panel chairpersons have already resolved uncertainties in most areas.

June 13, 1994

MEMORANDUM FOR GOVERNMENT PANEL CHAIRMEN, LABORATORY INFRASTRUCTURE CAPABILITIES STUDY

SUBJECT: ADDITIONAL INFORMATION AND PROJECT PLANS

From: Lab Review Process Team through Dave Graham, IDA

Attached is some additional guidance on number of questions that have come up in the last week.

1. Inherently Governmental: A report by the Federal Coordination Council for Science, Engineering, and Technology, dated October 1979, addresses the question of what is "inherently governmental." It is too lengthy to FAX (91 pgs) and so we will send it by Federal Express to the governement panel chairpersons and give a copy to the IDA executive secretaries.

2. Annex Table 1: This table is meant to provide a framework for an approximate description of outsourcing activity at all levels. The entries do not need to be precise: plus or minus ten percent is good enough for the purposes of this review. The table is not intended to require a significant fraction of your time.

4. Chapter Templates: The Tables in the Chapter Templates are intended to provide a degree of consistency in the issues addressed as well as in the presentation format across panels. It is intended that these tables be augmented by textual explanations. The Templates are not straightjackets. If there is information that you want to convey that is not asked for in a table, or if there are qualifying comments you wish to make about a table entry, please feel free to footnote your table entries as required.

5. Executive Summaries: It appears that some of the chapters will be quite long, with a large amount of supporting materials. This is OK. You should feel unconstrained in providing information you believe is relevant in answering the questions. Because the chapters will be quite long, it will be necessary, however, for you also to provide a concise executive summary for your chapter. The executive summary should be no longer than 5 pages. (However, if your panel combines two or more S&T product and technology areas -- as for example we have combined C3I and Electronic Warfare into one panel -- allow an additional 2 to 3 pages in the executive summary if you choose to answer questions 2,3, or 4 separately for each technology area. Under this rule, the maximum pages for the Executive Summary for each area are shown in the Table below.

Executive Summary Page Limits

Air Vehicles (& propulsion)	8
Ships and Watercraft	5
Ground Vehicles	5
Space (& propulsion)	8
Weapons	5
Nuclear, Chem, Bio	5
C3I/EW	8
Computers/Soft/Sim	11
Materials/Mfg	8
Env Qual/Civ Eng/Sci	11
Human Systems	14
Electronic Dev/Sensors	8

5. Dorman Briefing Format: As you know, there will be limited time available for briefing Dr. Dorman on the morning of June 21. For your consideration, a notional outline for a 9-slide briefing (for which you will have only 10 minutes to present) is shown below.

Notional Briefing Outline

Slide 1	Panel Approach and Progress
Slide 2-3	Panel Subject Area Content & Important DoD Missions Supported
Slide 4-5	Description of Current Performers
	-- Pie Chart of Funding Distribution
	-- Description of Important/Major Performers
	-- Description of Remaining Performers
Slide 6	Tentative Findings on Feasibility of Outsourcing
	-- Unique Capabilities
	-- Comparative Advantage
Slide 7	Tentative Findings on Non-Technical Constraints on Outsourcing
Slide 8	Overall Potential for Outsourcing (Funding Pie Chart that can be contrasted with "as-is" distribution)
Slide 9	Panel Plans, Issues, and Questions

LABORATORY INFRASTRUCTURE CAPABILITIES STUDY:

APPENDIX A:
TERMS OF REFERENCE

LIST OF ACTIVITIES

AIR FORCE

1. Armstrong Lab, Brooks, AFB
2. Armstrong Lab, Tyndall AFB
3. Armstrong Lab, Wright-Patterson AFB
4. Armstrong Lab, Williams AFB
5. Human Systems Center, Brooks AFB
6. Wright Lab, Wright-Patterson AFB
7. Wright Lab, Eglin AFB
8. Aeronautical Systems Center, Wright-Patterson AFB
9. Aeronautical Systems Center, Eglin AFB
10. Oklahoma City Air Logistics Center, Tinker AFB (In-service engineering)
11. Ogden Air Logistics Center, Kelly AFB (In-service engineering)
12. San Antonio Air Logistics Center, Kelly AFB (In-service engineering)
13. Sacramento Air Logistics Center, McClellan AFB (In-service engineering)
14. Warner-Robins Air Logistics Center, Robins AFB (In-service engineering)
15. Phillips Lab, Kirtland AFB
16. Phillips Lab, Hanscom AFB
17. Phillips Lab, Edwards AFB
18. Space & Missile Center, Los Angeles AFB
19. Space & Missile Center, Norton AFB
20. Sacramento Air Logistics Center, Peterson AFB
21. Rome Lab, Griffiss AFB
22. Rome Lab, Hanscom AFB
23. Electronic Systems Center, Hanscom AFB
24. Sacramento Air Logistics Center, Peterson AFB (In-service engineering)

ARMY

1. Army Research Lab (ARL), Adelphi, MD
2. ARL, Aberdeen Proving Grounds (APG), MD
3. ARL, White Sands Missile Range, NM
4. ARL, NASA Langley, VA
5. ARL, NASA Lewis, OH
6. Natick Research, Development and Engineering Center, Natick, MA
7. Aviation Research, Development and Engineering Center, St. Louis, MO
8. Aviation Troop Command, Aeroflight Dynamics Directorate, Moffitt Field, CA
9. Aviation Troop Command, Aviation Applied Technology Directorate, Fort Eustic, VA
10. Edgewood Research, Development and Engineering Center, Aberdeen Proving Ground, MD
11. Communications Electronics Command Research, Development and Engineering Center, Ft. Monmouth, NJ

12. Communication Electronics Command Research, Development and Engineering Center-Night Vision EO Directorate, Ft. Belvoir, VA
13. Missile Research, Development and Engineering Center, Redstone Arsenal, AL
14. Armaments Research, Development and Engineering Center, Picatinny Arsenal, NJ
15. Armaments Research, Development and Engineering Center, Benet Labs, Watervliet Arsenal, NY
16. Tank-Automotive Command Research, Development and Engineering Center, Warren, MI
17. USA Research Institute of Infectious Diseases, Ft. Detrick, MD
18. Walter Reed Army Institute of Research, Washington, DC
19. USA Institute of Surgical Research, Ft. Sam Houston, TX
20. USA Aeromedical Research Lab, Ft. Rucker, AL
21. Medical Research Institute of Chemical Defense Aberdeen Proving Grounds, MD
22. USA Research Institute of Environmental Medicine, Natick, MA
23. Construction Engineering Research Laboratory, Champaign, IL
24. Cold Regions Research and Engineering Lab, Hanover, NH
25. Topographic Engineering Center, Alexandria, VA
26. Waterways Experiment Station, Vicksburg, MS
27. USA Research Institute for Behavioral & Social Sciences, Alexandria, VA
28. Simulation, Training and Instrumentation Command (STRICOM), Orlando, FL

NAVY

1. Naval Air Warfare Center, Weapons Division, China Lake
2. Naval Air Warfare Center, Weapons Division, Point Mugu
3. Naval Air Warfare Center, Aircraft Division, Patuxent River
4. Naval Air Warfare Center, Aircraft Division, Indianapolis
5. Naval Air Warfare Center, Aircraft Division, Lakehurst
6. Naval Research Lab, Washington, DC
7. Naval Air Warfare Center, Training Systems Division, Orlando, FL
8. Naval Surface Warfare Center, Carderock Division, Bethesda, MD
9. Naval Surface Warfare Center, Carderock Detachment, Annapolis, MD
10. Naval Surface Warfare Center, Crane Division
11. Naval Surface Warfare Center, Crane Detachment, Louisville
12. Naval Surface Warfare Center, Dahlgren Division
13. Naval Surface Warfare Center, Dahlgren Detachment, Panama City
14. Naval Surface Warfare Center, Indian Head Division
15. Naval Surface Warfare Center, Port Hueneme Division
16. Naval Command, Control, and Ocean Surveillance Center, RDT&E Division, San Diego
17. Naval Command, Control, and Ocean Surveillance Center, In-Service Engineering, West Coast Division, San Diego
18. Naval Command, Control, and Ocean Surveillance Center, In-Service Engineering Division, Charleston
19. Naval Aerospace Medical Research Center, Pensacola
20. Naval Biodynamics Lab, New Orleans

21. Naval Dental Research Institute, Great Lakes
22. Naval Health Research Center, San Diego
23. Naval Medical Research Institute, Bethesda
24. Naval Undersea Warfare Center, Keyport Division, WA
25. Naval Surface Warfare Center, Carderock, Philadelphia Detachment
26. Naval Undersea Warfare Center, Newport, RI
27. Naval Undersea Warfare Center (Newport), New London, CT
28. Naval Personnel Research and Development Center, San Diego, CA

DEPARTMENT OF DEFENSE

1. Armed Forces Radiobiology Research Institute (AFRRI), Bethesda, MD

Panel	Technologies Covered
Air Platforms	Includes efforts directed specifically toward: rotary-wing and fixed-wing aircraft (including unmanned air vehicles), and cruise missiles; efforts include those in aeromechanics, flight controls, powered lift, mechanics of flight, vehicle subsystems, and integrated technology demonstrations. Excludes efforts directed toward: generic materials and structures, which are included in Materials, Processes and Structures; crew systems (e.g., cockpits), which are included in Human-System Interfaces; and system avionics, which are included in Sensors. Includes efforts directed specifically toward: aircraft propulsion systems and their components, including prime power transmission; aircraft power generation systems and their components; and the associated fuels and lubricants. Includes platform-specific Integrated Product and Process Development, but excludes basic science and technology aspects of manufacturing process development, which are included in Manufacturing Science and Technology. Excludes efforts directed toward: generic materials, which are included in Materials, Processes and Structures.
Space Platforms	Includes efforts directed specifically toward: Intercontinental Ballistic and Space Defense missiles, and space vehicles; efforts include those in attitude control, orbital changes, flight controls, powered lift, mechanics of orbital flight, vehicle subsystems, and integrated technology demonstrations. Excludes efforts directed toward: generic materials and structures, which are included in Materials, Processes and Structures; and system avionics, which are included in Sensors. Includes efforts directed specifically toward: missile and space vehicle propulsion systems and their components; space vehicle power generation systems and their components; and the associated fuels and lubricants. Includes platform-specific Integrated Product and Process Development, but excludes basic science and technology aspects of manufacturing process development, which are included in Manufacturing Science and Technology. Excludes efforts directed toward: generic materials, which are included in Materials, Processes and Structures.
Ships and Watercraft	Includes efforts directed specifically toward: amphibious vehicles; ships; submarines; and other underwater craft. Efforts include those associated with: propulsion and power; hydrodynamics; vessel subsystems; signature reduction; and fuels and lubricants. Excludes efforts directed toward: crew systems and stations, which are included in Human-System Interfaces; technology development of generic structures and materials, which are included in Materials, Processes and Structures.
Ground Vehicles	Includes efforts directed specifically toward: Land combat vehicles and armored amphibious vehicles. Efforts include those associated with: propulsion and power; tracks and suspension; vehicle subsystems; signature reduction; and fuels and lubricants. Excludes efforts directed toward: crew systems and stations, which are included in Human-System Interfaces; those vetronics which are included in Sensors; technology development of generic structures and materials, which are included in Materials, Processes and Structures.

Nuclear, Chemical, and Biological Defense and Counterproliferation	Includes those technology efforts that maximize a strong defensive posture in a chemical biological environment using passive and active means to serve as a deterrent to the use of weapons of mass destruction and should deterrence fail, sustain combat operations by protecting the force and maintaining system effectiveness. These technologies include those in the area of chemical biological detection; information assessment, which includes identification of the challenge; modelling, intelligence and contamination avoidance; protection of both the individual and equipment as well as collective protection; and finally, decontaminants both to enable continued operations and for retrograde. The area excludes the medical aspects of chemical biological defense. Includes those technologies for the location, tracking, safing, disarming, neutralizing, moving, disposing, or non-nuclear destruction of nuclear weapons.
C3I and Counter C3I	Includes efforts directed specifically toward: communications systems of all types; data processing hardware and software dedicated to operational planning, monitoring, or assessment, including information fusion, distributed processing, distributed data storage, and distributed data management. Excludes efforts directed toward: general purpose computer hardware and high performance computers, which are included in Computers; general purpose software, languages, software engineering, and environments, which are included in Software; and communications and processing elements considered subsystems in vehicles, which are included in Sensors (avionics). Includes efforts directed specifically toward: devices and methods to detect, locate, analyze, exploit, disrupt, or deceive acoustic, radio frequency, infrared, ultraviolet, or electro-optical communications, weapons, or sensor systems; electronic counter-countermeasures and vulnerability assessments for the protection of weapons, sensors, and electronic systems. These efforts include those associated with jamming, deception, passive surveillance, warning, expendable and captive decoys, and high-power microwaves. Excludes generic efforts in electronic devices and sensors, which are included in their own technology areas. Excludes directed energy weapons which are included in Weapons.
Computers, Software, Simulation, and Modeling	Includes efforts directed specifically toward: digital computing system elements such as processors, accelerators, memories, interconnect meshes, and integrated systems; scalable general purpose high performance computing (HPC) systems; specialized computer systems for harsh and/or unusual environments; generic signal processors; associated storage and peripheral equipment; and aspects of other technologies (e.g., computer networking) necessary for complete HPC systems. Includes efforts directed specifically toward: software engineering process improvement, information engineering, artificial intelligence, human computer interaction, and assured computing. Efforts include those in programming languages, tools and environments; reuse; reengineering; domain-specific software architecture's; models and techniques for information storage, access, and sharing; machine learning; and formal methods, algorithms, and tools to assure the presence of critical properties. Excludes efforts directed toward: non-software-related aspects of human computer interaction, which are included in Human-System Interfaces; and application-specific software which is included in the related technology area.

	Modeling and Simulation Technology includes the specific and enabling technologies that allow the application of models and simulations both more broadly and with increased validity across the full spectrum of DoD enterprise activities. The areas of enabling technologies include high speed computing; hardware/software architecture and standards; advanced communications and security; human systems interfaces; authoritative representations of systems, environments, and behaviors; data/database standardization; and interoperability. The goals of DoD Modeling and Simulation Technology efforts are focused toward the seamless linkage of the various classes of simulations (live, constructive, and virtual) to support operational readiness of forces through enhanced training, improved acquisition practices, interoperability, and technology transfer possibilities.
Weapons	Includes efforts directed specifically toward: non-nuclear munitions, their components and launching systems—guns, bombs, guided missiles, projectiles, special warfare munitions, EOD devices, mortars, mines, countermine systems, and torpedoes and underwater weapons. Efforts include those in warheads and explosives, fuzing/safe and arm, guidance and control, gun propellants, launchers/dispensers, and missile propulsion systems, power systems and propellants. Integrating structures and materials are included in Materials, Processes and Structures. Generic efforts in electron devices and sensors not associated with specific weapon system applications are included in Electronic Devices and Sensors, respectively. Includes efforts directed specifically toward directed energy beams to destroy targets. These efforts include those associated with high-power microwaves, lasers, neutral particle beams, and closely related technology effort that uses elements found in directed energy systems such as high-resolution imaging systems and ultra-wideband radars. Excludes generic efforts in electronic devices and sensors, which are included in their own technology areas. Missile propulsion and control systems and their components.
Electronic Devices and Sensors	Includes efforts directed specifically toward: microelectronics; radio-frequency components; and electro-optical devices; these efforts are generic in nature, and include those associated with design and manufacture of radiation hardened microprocessor and memory chips, analog/digital converters, microwave and millimeter wave integrated circuits, transmit/receive modules, antennas, lasers, displays, and infrared focal plane arrays. Excludes efforts directed toward: specific weapon system applications, which are included in the related technology areas; and moderate-to-large-scale manufacturing process development, which are included in Manufacturing Science and Technology. Includes efforts directed specifically toward: radar; electro-optic sensors, including infrared and visible sensing and displays; acoustic sensors; multi-sensor integration; target identification; automatic target recognition; CNI; avionics; and vetronics. Excludes efforts directed toward: specific applications to precision guided munitions and electronic warfare, which are included in Conventional Weapons and Electronic Warfare/Directed Energy Weapons, respectively; and moderate-to-large-scale manufacturing process development and demonstration, which are included in Manufacturing Science and Technology.

Evironmental Sciences, Quality and Civil Engineering	The environmental sciences program encompasses the study, modeling, and simulation of the atmospheric, oceanic, terrestrial and space environments for the purpose of understanding and predicting the impact of those environments on personnel, platforms, sensors and weapons systems. The program includes the disciplines of meteorology, oceanography, solar and terrestrial physics, astrometry, seismology and mapping, charting and geodesy. Specific thrusts of the program include global, regional and local scale weather forecasting, ocean structure and forecasting, terrain analysis and extraction, space environment effects on spacecraft and communications, and environmental effects upon weapons and sensors. The environmental quality program includes the technologies that will permit environmentally safe operations as well as rapid and cost effective clean-up and restoration of existing conditions. The Strategic Environmental Research and Development Program (SERDP), by Congressional direction, is managed by an interagency Council chaired by the Director, Defense Research and Engineering, addresses environmental concerns of DoE, EPA and DoD, and includes global environmental change and clean energy, in addition to environmental quality technology. Environmental Quality Thrust Areas include installation restoration, noise abatement, pollution prevention, base support, atmospheric compliance, global marine compliance, and terrestrial and aquatic assessment. The Civil Engineering program is to maximize the efficiency of construction, maintenance and repair of military facilities, both fixed and deployed, and includes conventional facilities, fixed airfields and pavements, survivability and protective structures, firefighting, ocean and waterfront facilities/operations, sustainment engineering, and expedient airbase facilities/rapid repair and recovery.
Human Systems	The major goal of the clothing, textiles, and food program is to maximize the combatant's survivability, performance, and mission effectiveness by providing high quality protection and sustainment. For clothing and textiles, emphasis is placed on material systems and design concepts for advanced body armor, signature reduction, percutaneous chemical/biological protection, and integrated climatic/flame/thermal protection. In the area of food, emphasis is placed on food preservation, stabilization, processing, packaging, and equipment technologies. Human systems interfaces incudes efforts directed specifically toward aircraft cockpits and stations, ship and land vehicle stations, and operator personal equipment; these include efforts associated with crew stations, life support, protection, simulation and flight test evaluation, performance aiding, information management and display, and performance assessment and design methodologies. Excludes efforts directed toward: human-computer interaction software, which are included in Software; medical; manpower, personnel, and training; and chemical-biological defense—the latter three are included in their own technology areas. The DoD Manpower, Personnel and Training program seeks to improve the classification and assignment of people to military jobs, reduce attrition of high quality personnel, and help those who manage the operating forces to predict and measure the consequences of their decisions, improve the effectiveness of classroom and unit instruction, improve the efficiency of student flow through the training pipeline, enhance military training systems, provide opportunities for skill practice and mission rehearsal, and lower life-cycle costs.

	Defense medical sciences programs are focused on the protection and treatment of deployed forces, and address battlefield injury, endemic diseases, protection against chemical and biological agents, and the optimization of human capabilities to function safely and effectively in the military systems environment. Medical Thrust areas include military combat dentistry, infectious disease hazards of military importance, medical chemical defense, medical biological defense, human systems technologies, combat casualty care, ionizing radiation hazards, and medical free electron lasers.
Materials, Processes, Manufacturing, and Structures	Includes efforts directed specifically toward: structural materials; electronic and optical materials; low observable materials; armor materials; materials protection systems; non-vehicular power sources; and structural concepts and design methods for aircraft, spacecraft, ships, submarines, and land combat vehicles. These efforts are generic in nature, and include those associated with metal alloys, ceramics, polymers, composites of all types, and coatings. Excludes efforts directed toward: semiconductor chips; specific device, component, subsystem, or system technology development (except for the structures indicated), which are included in the related technology areas; and moderate-to-large-scale manufacturing process development and demonstration, which are included in Manufacturing Science and Technology. Includes technologies that provide scalable, flexible manufacturing capabilities for electronics and advanced materials; exploits information technologies for manufacturing applications; develops advanced design and manufacturing systems and demonstrates them in pilot factory settings for the next generation of affordable sensors and electronics components. The Technology Reinvestment Project (TRP) is a cost-shared, merit-based program. TRP areas will enhance dual-use manufacturing and support late stage product development. Manufacturing Technology (ManTech) develops the advanced manufacturing technology which will permit DoD materiel to be produced faster, better, and at less cost.

SCHEDULE

PHASE I:	
Service Organizational Meeting	May 20
First Government Panel Meetings	May 25-26
Non-Government Panel Group Meetings	June 21-23
Preliminary Government Panel Briefings	June 21
Non-Government Panel Briefings	July 19
Phase I Draft Report Completed	August 1
PHASE II:	
Begin Meetings	August
Briefings	mid-October
Phase II Draft Report	October
PHASE III:	
Begin Meetings	November
Final Report to OSD	January, 1995

DEFINITIONS

1. Goals and Objectives of Science, Technology, and Engineering Functions

- Infuse the art of the possible into military planning.
- Avoid technological surprise and ensure technological innovation.
- Provide special-purpose facilities.
- Have available a fast-reaction capability to solve critical, immediate technical problems that arise when unexpected operational situations are encountered.
- Stimulate the use of demonstrations and prototypes to mature and exploit U.S. and Allied technologies.
- Carry out activities having high technological risk or requiring intensive resource investment.
- Translate user needs into technology requirements.
- Be a constructive adviser for Department directions and programs based on technical expertise.
- Support the user in the application of emerging technology and introduction of new systems.

2. DOD Laboratory

DOD activities that perform one or more of the following functions: science and technology, engineering development, engineering support of deployed materiel and its modernization. Each Service organizes differently for such functions, but the term embraces the Army's laboratories, research institutes, and research, development and engineering centers; Navy laboratories, research institutes and centers, and warfare centers; and Air Force laboratories, and engineering and technical support activities. (Attachment A of the TOR provides a list of the DoD laboratories to be considered in this study.)

3. Mission of DoD Laboratories

The mission of the defense laboratories is to provide the technical expertise to enable the Services to be smart buyers and users of new and improved weapons systems and support capabilities. Dedicated organizations free from commercial pressure are required to provide this mission.

4. Other Government Laboratories

The laboratories of other government agencies such as the Department of Energy, Department of Commerce, or NASA; laboratories operated by Federally Funded Research and Development Centers; and government-owned, contractor-operated (GOCO) laboratories.

5. Functions

The functions provided by the DoD Laboratories and their outsourced performers are: (a) to create new knowledge through scientific investigations, (b) to advance technology through exploratory developments and advanced concept technology demonstrations, (c) to provide engineering support to program- and product-managed systems in development, and (d) to provide engineering support to operational weapon systems.

6. Performer

A performer is an organization that has the current capability to perform at least one function of a DoD laboratory. The ability to design, construct and test complex weapon system prototypes is an example of a performer.

7. Organic Performer

An organic entity is a DoD laboratory. The work in an organic entity is primarily conducted by civil servants and military personnel, with on-site contract support provided as necessary.

8. Out-sourced Performer

An element of a well defined work package may be outsourced from an organic element of a DoD laboratory to any qualified performer. These performers may be other government laboratories, contractors, universities or other not-for-profit organizations.

9. Inherently Governmental

Inherently governmental functions are those that require technical and/or financial decisions on behalf of the government. Additionally, inherently governmental activities include those actions required to prepare for and conduct source selections, the conduct of technological assessment involving proprietary intellectual property, the decision process leading to the development of government programs and budgets, the protection of advanced technology from premature export, those activities considered not economically justifiable by external suppliers, and those activities needed to provide a catalyst for industry investment and maturity.

LABORATORY INFRASTRUCTURE CAPABILITIES STUDY:

APPENDIX B:
PANEL PARTICIPANTS

Non-Government Panelists

Weapons

Mr. James Tedeschi	Hercules Aerospace Electronic System
Mr. Amis Alexander	Custom Analytical Engineering Systems, Inc.
Professor Philip Anderson (Chairman)	Princeton University
Mr. David Broden	Alliant Techsystems
Dr. James M. Walton	BDM International
Dr. William Boykin-President	Am Dyne Corporation
Robert W. McMillan	Georgia Institute of Technology
Professor Theodore Postol	MIT
Raj Aggarwal-Senior Engineering Fellow	Alliant Technology
Lucien Daouphras-Chief Scientist for SMP	Hughes Missile System Company

Space Platforms

Mr. Jessy Moore	Ball Corporation
Mr. Dick James	Boeing
Mr. Steven M. Robins-Mgr Lancaster Off	Thiokol Corporation
Mr. Mac Chapman	TRW
Dr. Art Morrissey	TRW

Human Systems

Mr. Christopher Jehn (Chairman)	Institute for Defense Analyses
Mr. Peter N. Butenhoff-President	Textile/Clothing Technology Corp.
Professor Gail H. Cassell	University of Alabama
Dr. David A. Goslin-President	American Institutes for Research
Mr. Irv Greenberg	Logistics Management Institute
Dr. Stephen J. Lukasik	
Dr. Robert O. Nesheim	
Dr. Garrison Rapmund	
Dr. Joseph Soukup	SAIC
Professor Henry L. Taylor	University of Illinois
Dr. Gershon Weltman	Perceptronics, Inc.
Dr. Don L. Zink-Director, Food Safety	Nestle USA, Inc.
Dr. Chris Jarvis	Clemson Apparel Research

Environmental Sciences

Dr. Roger Hart (Chairman)	Fluor-Daniel, Inc.
Mr. Dwayne Lee-Dep Exec Dir of Dev	Oak Ridge National Lab
Dr. Alan J. Witten	
Dr. William H. Patrick	Wetlands Biogeochemistry Institute
Dr. I.J. Won	
Dr. Robert Skrivanek	Visidyne, Inc.
Dr. J. Scott Thornton-President	Texas Research Institute
Mr. Douglas Barno	Composite Institute

Ships and Watercraft

Professor Stanley Dunn (Chairman)	Florida Atlantic University
Mr. William L. Marsh-Manager	Westinghouse Electric Corporation
Mr. Charles E. Aldrich, Jr.	General Dynamics
Mr. Michael L. Powell	Newport News Shipbuilding

Mr. Stanley Owen	Ingalls Shipbuilding, Inc.
Professor Richard Moore	University of Michigan

Ground Vehicles

Mr. Willian Agnew	General Motors Research Laboratories
Mr. Kevin Burns-President	Nevada Automation Test Center
Dr. Robert Lentz	General Dynamics Land Systems
Mr. Martin Goland (Chairman)	Southwest Research Institute
Mr. David Archer	Oshkosh Truck Corp.
Mr. Leroy Johnson	Oshkosh Truck Corp.
Mr. Raj Rajagopal	United Defense LP
Dr. John H. Johnson	Michigan Technological University
Prof. Gary L. Borman	University of Wisconsin
Mr. Thomas A. Kowalczyk	Martin Marietta Defense Systems
Mr. Tony Kirn	Caterpillar, Inc.
Mr. Lawrence R. Clark	United Defense LP

Electronics & Sensors

Dr. William M. Brown-Former President	ERIM
Mr. John Dehne (Chairman)-President	Loral
Dr. Bradford A. Becken	Raytheon Corp.
Dr. T.B. Ramachardran	Microwave Device Technology Corp.
Mr. Jack Kilby	
Mr. Reginald D. Varga-Manager WSI	McDonnell Douglas Aerospace Corp.
Dr. David F. Barbe-Executive Director	University of Maryland
Mr. Scott Moody-Vice President	Semiconductor Corp.
Mr. Richard A. Reed-Executive VP	Lockheed Sanders, Inc.
Dr. Neal Gallagher-Chairman, Dept of EE	University of Delaware
Dr. Stephen G. Bishop	University of Illinois

WMD Counterproliferation

Mr. Gregory L. Frank (Chairman)	Battelle
Dr. Robert C. Forney	I.E. du Pont de Nemours & Co.
Mr. Stephen Sergio	Booz, Allen & Hamilton
Dr. Ardash Deepak-President	Science and Technology Corporation
Mr. Robert Lang-MICAD Program Director	Loral
Dr. Andrew T. Zander	Varian Research Center
Dr. Peter J. Gerone	Tulane University
Dr. John Carrico	SRI International
Dr. Dale Keairns	Westinghouse S&T Center
Mr. Cosmo Dimaggio III	System Planning Corp.

C3/EW

Dr. Charles G. Brown	Macaulay-Brown, Inc.
Dr. John Paul Hyde	BDM International, Inc.
Mr. Ray L. Leadabrand (Chairman)	Leadabrand and Associates
Mr. Walter G. Carlson	Westinghouse Electric Company
Professor Walter E. Morrow-Director	MIT Lincoln Laboratory
Mr. George Tonn	Hughes Aircraft
Mr. Brian T. Wright-VP Engineering	Rockwell International

NON-GOVERNMENT PANELISTS

Materials, Processes and Structure, and Manufacturing

Mr. Charles W. Carlson	DuPont Advanced Material Systems
Dr. Dan Lee-Director DMI	RPI
Mr. Juluis J. Harwood (Chairman)	
Mr. Dave Hicks	NCMS
Mr. Warren Young	Bell Helicopter
Mr. Dick Engwall-Manager AMI	Westinghouse Office Services
Dr. Max Williams	

Computers, Software, Simulation & Modeling

Mr. Lou Auslander (Chairman)	CUNY
Mr. Eugene Brooks	Lawerence Livermore National Lab.
Mr. Robert B. Buchanan-Corp VP for Sim	SAIC
Mr. Ed Burke-Dir Advanced Processing Lab	AT&T Federal Systems Technologies
Mr. Bill Buzbee-Dir, Scientific Computing	National Center for Atmospheric Research
Mr. Ed Haug-Director	Center for Computer Aided Design
Mr. Eliot Moss	University of Massachusetts
Mr. Bob Tanner	BBN Simulation & Training Systems

Air Vehicles

Dr. Richard Thomas (Chairman)	Texas A&M
Mr. Bastian Hello	Rockwell International
Mr. Edwin Birtwell	GE Aircraft Engines
Mr. Woodlee Sconyers	Lockheed Fort Worth
Mr. Jeff Schweitzer	Pratt & Whitney Aircraft
Mr. Al Winn	McDonnell Douglas Helicopter Co.
Mr. John E. Krings	Test Pilot
Dr. Gerald Gregorek	Ohio State University
Mr. Kayon Stanzione	
Mr. Robert Kreiger	McDonnell Douglas Aeronautical
Mr. Ray Hemann	Advanced Systems Research, Inc

GOVERNMENT PANEL MEMBERS

Ships, Submarines, and Watercraft

Capt. J. Baskerville	Naval Sea Systems Command
Mr. R.E. Metrey	Naval Surface Warfare Center
Mr. A. Spero	Advanced Submarine R&D Office
Mr. V. Falchetta	Army Material Command
Mr. C. Curtis	Naval Undersea Warfare Center
Dr. W. Middleton	Naval Surface Warfare Center

Nuclear, Chemical, and Biological Defense and Counterproliferation

Dr. Brendan Godfrey	Armstrong Laboratory
Dr. Robert J. Reyes	U.S. Army Chemical and Biological Defense Command
Mr. Joseph J. Vervier	U.S. Army Edgewood Research Development
Mr. William C. Klein	U.S. Army Edgewood Research Development
Dr. Harold E. Guard	Office of Naval Research
Mr. Seymour Edelberg	MIT-LL
Mr. E. John Ainsworth	AFRRI
Ltc. Gregory B. Knudson	AFRRI
Maj. Billy W. Mullins	SAF/AQQS
Mr. Paul Castleberry	DNA
Mr. Michael Long	DoE
Mr. Stan Enatsky	NAVSEA
Mr. William S. Furshak	NAVSWCDD
Mr. Joe Brumfield	NSMC DD

Environmental Science and Quality and Civil Engineering

Mr. William Marcuson	Waterways Experiment Station
Mr. Andy DelCollo	Naval Facility Command
Mr. Donald Leverenz	U.S. Army Corps of Engineers
Mr. C. J. Kirby	Waterways Experiment Station
Mr. Don Snider	AMSRL-MO-TB
Dr. Herbert Carlson	PL/CAG
Dr. Mike Katona	AL/EQ-CA
LTC. T. Deloney	Ballistic Missile Defense Organization

Electronics and Sensors

Mr. Les McFawn	WL/AAR Bldg. 22
Dr. Rudolph G. Buser	NVESD
Dr. G. M. Borsuk	Naval Research Laboratory
Mr. Roger Sudbury	
Mr. Stan Hearron	Department of Energy
Mr. Giglio Varsi	NASA Headquarters
Mr. Howard Rast	NCCOSC
Mr. Kenneth Sleger	NRL
Mr. Thomas T. Steck	NVESD/AMSEL-RD-NV-D
Mr. Clare Thrunton	ARL/EPSD
Mr. Michael Tompsett	ARL
Mr. Paul Manz	ARL/EPSD
Mr. Dan McMorrow	BMDO/TRS

GOVERNMENT PANEL MEMBERS

Mr. Tom Pendergraft	NSWC
Mr. Ed Burke	ARL/S31
Mr. Tom Castaldi	NAWC
Mr. Lew Cohen	DNA/RAES
Mr. Vito Demonte	ARL/S31

Space Platforms

Col H. J. Mitchell	Space & Missile Systems Center/XR
Dr. Joseph Janni	Phillips Laboratory/CA
Mr. Fred Hellrich	NRL/NCST
Dr. Darrell Collier	USA/SSDC
Mr. William Stephenson	NASA HQ
Mr. Lyle Rutger	DOE/NE-52
Mr. Stanley Brown	DOE/NE-52
Mr. John Hussey	DOC/NOAA
Dr. Antonio Pensa	MIT/LL
Dr. Hugh Rugge	Aerospace Corp.
LtCol. Gilbert Perry	SMC/CE
Mr. Edward Salem	SMC/XR
LtCol. Howard Meyer	Phillips Laboratory/CA
Lt. Steed Lobotzke	SMC/XR

Materials, Processes and Structures, and Manufacturing

Mr. Ralph I. Adler	Watertown Arsenal
L. D. Johnson	Watertown Arsenal
Mr. Robert L. Rice	Wright-Patterson Air Force Base
Mr. Dan McDermott	Wright-Patterson Air Force Base
Dr. Don Paul	Wright-Patterson Air Force Base
D. U. Gubser	Naval Research Laboratory
D. J. Michel	Naval Research Laboratory
Dr. Bill Kessler	Wright-Patterson Air Force Base
Dr. Vince Russo	Wright-Patterson Air Force Base

Computer, Software, Modeling & Simulation

Mr. Randy Shumaker	Naval Research Laboratory
Col. Jim Blake	Army Research Laboratory
Mr. Harold Breaux	Army Research Laboratory
Dr. Andrew Mark	Army Research Laboratory
Dr. Ron Hofer	ARMY STRICOM
Mr. Glenn Racine	ARL
Mr. Bill Craig	US Army Missile Command
Mr. Mike Saboe	US Army Materiel Command
Dr. Martin Wolfe	U.S. Army CECOM RDEC
Dr. Jagdish Chandra	USARO
Dr. Dave Hislop	USARO
Dr. Susan Numrich	Naval Research Laboratory
Dr. Andre VanTilborg	
Dr. Elizabeth Wald	Office of Naval Research
Dr. Paul Reeves	NCCOSC
Mr. Dan Tarrant	Naval Air Warfare Center

GOVERNMENT PANEL MEMBERS

Col. John E. O'Pray	USAF ESC/XRP
Dr. George C. Mohr	AL/CA, Brooks Air Force Base
Dr. Raymond Liuzzi	USAF/RL/C3CA
Mr. Richard Simard	RL/IRRE, Griffiss Air Force Base
Mr. Mike Dieckhoff	PL/XPF, Kirtland Air Force Base
Capt. Gary L. Hall	PL/XPF, Kirtland Air Force Base
Dr. Marc Jacobs	HQ AFOSR/NM, Bolling Air Force Base

Human Systems

Dr. Robert Lewis	Commander US Army NATICK
Ms. Colleen J. Cathcart	U.S. Army Natick Research Dev. & Eng. Center
Col. Frazier Glenn	U.S. Army Medical Research Dev. Acq. & Log. Cmd.
Capt. Douglas A. Ehrhardt	U.S. Army Medical Research & Materiel Command
Mr. Wendell Banks	AL/CFP, Wright-Patterson AFB
Dr. Ken Boff	Al/CFH, Wright-Patterson AFB
Dr. Henk Ruck	AL/HR, Brooks Air Force Base
Ms. Debra R. Anderson	U.S. Army Natick Research, Dev. & Eng. Ctr.
Dr. David N. Erwin	AL/CD

Ground Vehicles

Dr. Richard McClelland	U.S. Army Tank-Automotive & Armaments Command
Mr. Charles Shoemaker	U.S. Army Research Laboratory
Mr. Doug Davis	MARCORSYSCOM
Mr. Steve Thibadoux	US Army MICOM
Dr. Rao Yalamanchili	US Army Research Lab

Weapons

Mr. William R. Barlow	WR-ALC/LKGE, Robbins Air Force Base
Mr. Jim Burda	ASC/VX, Eglin Air Force Base
Dr. Mike Caluda	Eglin Air Force Base
Mr. Paul Credle	Naval Surface Warfare Center
LCOL Jim Felty	US Department of Energy
Mr. Paul Homer	China Lake
Dr. Paul Jacobs	U.S. Army Missile Commad
Mr. Bob Kavetsky	Officer-in-Charge Indian Head Division
Mr. Jim Kelly	Naval Undersea Warfare Center Division
Col. Lanny J. Larson	Phillips Laboratory
Mr. Lew Lundberg	Naval Air System Command
Mr. David S. Malyevac	Naval Surface Warfare Center
Mr. Rick Morrison	US Army Research Laboratory
Juergen L. W. Pohlmann	Department of Defense, BMDO/TRD
Ms. Renata Price	U.S. Army Armament Research
Mr. Gerald E. Scheiman	U.S. Army Missile Command
Mr. Doug A. Sunchine	Defense Nuclear Agency

GOVERNMENT PANEL MEMBERS

Air Vehicles

Dr. G. Keith Richey	Wright-Patterson Air Force Base
Mr. Ray Hemann	Consultant
Mr. Terry Neighbor	Wright-Patterson Air Force Base
Capt. Don Wallace	NAVAIR System Command
Mr. John McKeown	NAVAIR System Command
Dr. Richard Carlson	US Army/AVSCOM (AMES Research Center)
Mr. Terry Putnam	NASA HQ, Code R
Mr. William Imfeld	Wright-Patterson Air Force Base
Mr. Andrew Kerr	US Army Aero Flight Dynamics Directorate
Mr. Jack Flaherty	Wright-Patterson Air Force Base

C3EW

Dr. Victor Monteleon	NRAD, San Diego
Mr. Daniel Prince	ESC/XRT
Mr. Don Eddington	NRAD, San Diego
Mr. Ray Irwin	NVESD, Ft. Monmouth
Mr. Paul J. Westcott	WL/AAWD, Wright-Patterson Air Force Base
Mr. John A. Montgomery	NRL
Mr. Don MacLellan	MIT-LL
Mr. Joe Pucilowski	CECOM, Ft. Monmouth
Mr. Roger Wiest	CECOM, Ft. Monmouth
Mr. Herbert E. Groener	CECOM, Ft. Monmouth
Mr. Walter Schoppe	NRAD, Warminster, PA
Mr. John Graniero	NRL
Mr. Michael Mudurian	NRAD, San Diego
Dr. Balram Prasad	DNA
Dr. Leslie J. Pierre	BMDO

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	November 1994	March 1994-August 1994

4. TITLE AND SUBTITLE
Laboratory Infrastructure Capabilities Study: Phase I Report
Part I: Introduction and Summary

5. FUNDING NUMBERS
DASW01-94-C-0054, T-AI6-655

6. AUTHOR(s) David R. Graham, Paul H. Richanbach, Edwin S. Townsley, Richard J. Bergemann, Harold E. Bertrand, H. Jerome Bracken, Al E. Brenner, Robert J. Bontz, Joan F. Cartier, L. Kirk Lewis, Karl H. Lowe, John Metzko, Karen J. Richter, David A. Sparrow, Robert D. Turner

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Institute for Defense Analyses
1801 N. Beauregard Street
Alexandria, VA 22311

8. PERFORMING ORGANIZATION REPORT NUMBER
P-3038

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Director for Laboratory Management
Office of Director of Defense Research and Engineering
The Pentagon, Room 3D129
Washington, D.C. 20301

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The Laboratory Infrastructure Capabilities Study brought together parallel panels of experts from inside and outside the government to examine the roles of DoD's laboratories, the extent to which DoD relies upon industry and academia in collaboration with the laboratories, and the potential for shifting more work from the laboratories to these "outsource" performers. The panels proposed that DoD consider structural changes in nine of the twelve product and technology areas examined. The panels also proposed action on a number of long-standing laboratory management issues, and offered proposals to address issues raised by the changing security and budget environments.

14. SUBJECT TERMS
Defense laboratories, infrastructure

15. NUMBER OF PAGES
70

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR