THE ARMY RESEARCH LABORATORY

Alternative Organizational and Management Options

Committee on Alternative Futures for the Army Research Laboratory
Board on Army Science and Technology
Commission on Engineering and Technical Systems
National Research Council

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Preface

Reflecting major changes in mission, personnel, and funding, the Department of Defense has questioned whether the military service laboratories are effectively organized to fulfill their changing responsibilities.

To help answer this question, the Assistant Secretary of the Army (Research, Development and Acquisition) and the Commander, Army Materiel Command (AMC), requested that the National Research Council (NRC) study the organizational and management alternatives for the Army Research Laboratory (ARL). Accordingly, the NRC formed the Committee on Alternative Futures for the Army Research Laboratory, under the leadership of the Board on Army Science and Technology. The committee, composed of experts in the management of research and development, cost analysis, personnel practices, and procurement regulations, held its first meeting on May 24–26, 1993, in Washington, D.C. It held a total of three full committee meetings and two executive panel meetings during the spring and summer of 1993. Committee members made extensive visits to research and development facilities of the Army and other agencies, both inside and outside the Department of Defense, and consulted with experts in research and development in industry, academic institutions, and government. It also commissioned a detailed study of the costs of research and development in various organizational settings, corresponding to the alternatives available to ARL.

On the basis of this research and its own expert judgment, the committee reviewed the ARL's program and activities, and evaluated the organization's ability to meet the long-term needs of the Army for research and technology development. It then assessed explicitly a range of organizational options for ARL, from management improvements in the current organization to the contracting out of all management and operations functions aside from oversight. It presents the advantages and disadvantages of these options to the Army in this report, and recommends that the Army select one of the three strongest options described. The selection should be based on the Army's priorities for internal capabilities and conversion costs.

The committee's report includes an executive summary, which briefly presents the committee's main findings, conclusions, and recommendations

and the reasoning that leads to them. While the summary faithfully reflects the contents of the report, it does not fully document or substantiate the results of the committee's study. For a full treatment of the topic, the reader is referred to the body of the report.

The committee received enthusiastic assistance and excellent advice from Army research and development officials in ARL, the AMC Headquarters, and the Army Research, Development and Engineering Centers. It wishes to thank in particular John Holmes and Kevin Kirby of ARL, and Edmund Westcott and Wayne Studebaker of AMC Headquarters, who served as liaisons to the committee with grace and alacrity, answering questions and offering insights.

The committee also wishes to express its gratitude to the NRC study staff for their time and devotion to this project. Albert Sciarretta, Duncan Brown, and Allison Knight deserve special thanks and recognition for their essential roles in this study.

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6.5	Mission support
6.7	Operational systems development
AMC	Army Materiel Command
ARL	Army Research Laboratory
ARO	Army Research Office
ASA(RDA)	Assistant Secretary of the Army (Research, Development and Acquisition)
CRADA	Cooperative Research and Development Agreement
DOD	Department of Defense
DOE	Department of Energy
FFRDC	Federally Funded Research and Development Center
FTE	Full-time equivalent
FY	Fiscal year
GOCO	Government-owned, contractor-operated
GS	General service
Lab Demo	Laboratory Demonstration
NAWC	Naval Air Weapons Center
NIST	National Institute of Standards and Technology
NRC	National Research Council
OFPP	Office of Federal Procurement Policy
OPM	Office of Personnel Management
R&D	Research and development
RDEC	Research, Development and Engineering Center
RDT&E	Research, development, test and evaluation
RIF	Reduction in force
S&E	Scientist and engineer
SES	Senior Executive Service
TRADOC	Training and Doctrine Command

THE ARMY RESEARCH LABORATORY

Alternative Organizational and Management Options

Executive Summary

With the end of the Cold War, the Army's budget for research, development, and acquisition is being slashed, from about $28 billion in fiscal year 1985 to a projected $9 billion or less in 1999. The Army plans to meet these cuts by reducing funding for the acquisition of major new systems while maintaining stable funding of $1.2 billion per year for the technology base (the basic research, exploratory development, and nonsystem-specific advanced development that can lead to future systems and provide continuous upgrades of existing systems)[1]. The goal is *horizontal technology integration,* the simultaneous integration of technology into different systems that fight together as units or task forces, providing exponential improvements in capabilities.

The U.S. Army Materiel Command's (AMC's) new Army Research Laboratory (ARL) is intended to be a major developer of the technology base. It therefore deserves priority in funding and personnel decisions, and it must have the administrative support necessary to pursue excellence in its own laboratories and through access to technology sources outside the Army.

This report assesses a range of organizational and management options for ARL in seeking those goals. It focuses on four distinct options in addition to the status quo (that is, ARL as planned for 1997, when it completes its process of formation):

1. *The ARL Enhanced option,* involving reforms of ARL's administrative procedures within the current legislative and regulatory setting (the baseline case for comparison of options);
2. *The National Institute of Standards and Technology (NIST) option,* which builds on the ARL Enhanced reforms by further strengthening laboratory managers' discretion in personnel decisions and in forming cooperative partnerships with industry and other government agencies, based

[1] Technology base funding will remain stable around $1.2 billion from fiscal year 1994 to fiscal year 1999, with $200 million for basic research, $600 million for exploratory development, and $400 million for nonsystem-specific advanced development.

on the model of NIST, the Commerce Department's main industrial research laboratory;

3. *The ARL Multicenter option,* in which most of ARL's research and development (R&D) are contracted out to several *centers of excellence,* overseen and guided by a strong permanent staff of government technical and management experts; and
4. *The Government-Owned, Contractor-Operated (GOCO) ARL option,* in which the entire program, including management, is contracted out to a single contractor.

To evaluate and compare these options and the status quo on a consistent basis, the committee used the following criteria, which represent the Army's varied requirements for ARL:

- linkage to Army strategies and objectives;
- potential to perform world-class land warfare research;
- diversity and quality of research sources;
- technology transfer to the Army;
- ability to leverage funds and programs of organizations outside ARL; and
- ability to improve productivity with respect to recurring costs.

Using these criteria, this report compares the options with the baseline ARL Enhanced option. It also compares the ARL Enhanced option with the status quo. It describes the conversion issues for each option, outlines potential responses, and estimates key conversion and operating costs. To put the issues for ARL in context, the report defines the characteristics of world-class research organizations, and examines the quality and relevance of research at the federally funded research and development centers of the military services, such as Lincoln Laboratory. The committee did not assess the scientific content of ARL's research program.

THE ARMY RESEARCH LABORATORY TODAY

ARL and other AMC laboratories have undergone frequent major realignments. In 1985, they were consolidated in the U.S. Army Laboratory Command, with the mission of doing basic research (6.1 funding), exploratory development (6.2 funding), and nonsystem-specific advanced development (6.3A funding), as well as coordinating AMC's 6.1, 6.2, and 6.3A funds. In 1992, most of the Laboratory Command and a few other research programs became ARL, a single laboratory concentrating on 6.1 and 6.2 work, without control over funding of others.

Primarily its efforts support long-range basic research and exploratory development. It has a civilian director, who reports to the Commander of AMC, the Army's research, development, acquisition, and logistics agency for nonmedical systems. ARL's mission is to:

> Provide America's soldiers the technology edge by conducting a broadly based multidisciplinary program of scientific research and advanced technology directed toward new and improved materials, components, subsystems, techniques and processes, and by performing objective analyses of combat system performance.

It carries out this mission in 10 broad areas which ARL calls "business areas," each in a separate ARL directorate: Advanced Computational and Information Sciences; Battlefield Environment; Electronics and Power Sources; Human Research and Engineering; Materials; Sensors, Signatures, Signal and Information Processing; Survivability/Lethality Analysis; Vehicle Propulsion; Vehicle Structures; and Weapons Technology. These activities fall in the Department of Defense (DOD) funding categories 6.1, 6.2, and 6.5.[2]

ARL employed about 3,600 people in fiscal year 1993, half of them scientists and engineers (about 400 of whom held Ph.D.s). By 1997, when formation of ARL is complete, the staff is expected to be about 3,100, including about 2,000 scientists and engineers (800 with Ph.D.s).

ARL's budget for fiscal year 1993 was about $500 million, including basic research, exploratory development, nonsystem-specific advanced development, mission support, and funding from other agencies. About $32 million was available for ARL's basic research program and about $170 million for exploratory development.

In funding terms, ARL cannot be said to hold a commanding position in the Army's technology base. Its $200 million of 6.1 and 6.2 funding in 1993 was only 22 percent of the Army's 6.1 and 6.2 total. Its $32 million in basic research funds were only 16 percent of the Army's 6.1 total, and its $170 million in exploratory development funds represent only 24 percent of the Army's 6.2 total. (In comparison, the Naval Research Laboratory has 34 percent of the Navy's 6.1 and 6.2 funding, but also receives advanced engineering, development, and procurement funds.)

Fifty percent of ARL's 6.1 and 6.2 program is approved by ARL's Board of Directors, half of whom are the technical directors of ARL's main *customers,* the eight research, development, and engineering centers (RDECs) of AMC. ARL directorates and specific RDECs formally agree on joint projects to cover this amount. The object is to ensure that ARL is responsive

[2] A small amount of 6.3A (non-system-specific advanced development) funding, remaining from Laboratory Command programs, will be phased out by fiscal year 1995.

to the RDECs and that technology transfer from ARL to the RDECs is effective.

The committee's assessment of ARL, with respect to the six criteria, shows that ARL has great strengths. But it also reveals that ARL is constrained by cumbersome procurement and personnel procedures and inappropriate limitations on contracting R&D. Furthermore, it has not received relief from recent resource reductions that would be expected on the basis of the Army's policy of emphasizing the technology base. Most important, its mission statement and business areas are too broad in scope for the resources allocated to ARL.

Linkage to Army Strategies and Objectives

ARL must focus both on the Army's long-term requirements for technology and on the shorter-term requirements of the RDECs—its principal customers—and of soldiers in the field. In general, it has stronger connections with the Army's short- and medium-term needs than with its long-term needs. It is closely attuned to current tactical and doctrine changes, which tend to be short range, and is influenced by the RDECs' requirements for technology in the short and medium range. Connections with the Army staff and the long-range doctrine and concept developers of the Army Training and Doctrine Command are very weak. ARL reports to AMC, which is more concerned with system development and production, immediate readiness, and logistics than with the technologies of the distant future.

World-Class Land Warfare Research

Because ARL is still in formation, its past performance as a consolidated laboratory is not available for examination. This committee relied heavily, therefore, on assessments of its inputs: management, personnel statistics, administrative practices, and funding. ARL is hampered by cumbersome federal and military administrative procedures. It lacks a focused R&D program (too many business areas and programs for the resources available). It is not receiving sufficient support at higher levels in funding and personnel decisions, particularly in recent hiring freezes and personnel cuts.

Personnel Procedures

Research and development has personnel needs that are different from those of other military functions, such as logistics. ARL needs unusually high

concentrations of highly skilled personnel, at high pay grades. It must have the flexibility to reassign and, when necessary, promote scientists and engineers to meet changing or more challenging opportunities. It needs personal accountability, so that individual performance, rather than seniority, determines pay and other rewards. Outstanding scientists and engineers should be able to advance more quickly than their less effective colleagues.

But these needs are being only partially met. In most of ARL's geographic locations, salaries are uncompetitive with the private sector. Managers have insufficient local authority to hire, fire, or reward. There are rigid limits on the numbers of high grades, and of total personnel. The hiring and termination approval process is cumbersome and slow. Promotions and merit-based pay raises are limited. These handicaps prevail despite clear directives in 1989 from DOD acquisition officials to implement the Defense Laboratory Demonstration (Lab Demo) program of reforms, which would go far toward relieving these obstacles. Despite ARL's persistent requests for permission to implement these reforms, they have been put into effect only on a limited basis.

Flexibility in reassigning ARL scientists and engineers is somewhat limited by the dispersed physical locations of its directorates although they are being consolidated to some extent in Adelphi and Aberdeen Proving Ground, Maryland. ARL's flexibility is also reduced by the current limits on high grade positions (GS-14 and higher), which make it difficult to promote a scientist or engineer from a low-grade to a high-grade position.

Personnel Cuts

The Army's *downsizing* has brought hiring and pay freezes and other personnel constraints. Surprisingly, ARL has not been given a high priority in this process. It continues to experience personnel cuts that equal or exceed the percentages cut in other Army organizations, particularly those supporting system acquisition. Current plans call for additional cuts in research, exploratory development, test and evaluation, and system development organizations, with the burden falling heavily on ARL. ARL may even be forced to use a *reduction in force.* These personnel constraints and reductions will significantly constrain ARL's efforts to recruit and maintain the quality engineers and scientists needed to enhance its workforce, and thus, its research.

Procurement Practices

In general, the further one moves away from government contracting and procurement practices and toward those of private industry, the more efficient are the processes. Sluggish procurement slows research and hurts morale. Research may be delayed by months for want of a seemingly simple item caught in the procurement process.

These problems would be substantially reduced by implementing the Lab Demo initiatives and simplifying procurement by generally increasing the decision-making authority of laboratory managers, shifting from rigid rules to guiding principles, and taking other steps to improve the responsiveness of the system. Again, as in the case of the Lab Demo personnel initiatives, ARL has not been granted permission for the most significant of these reforms. For example, at only a few ARL directorates are laboratory managers permitted to set their own levels of bench supplies. Some, but not all, use credit cards for purchases of up to $10,000 (the Lab Demo limit is $25,000). None have been granted permission for technical directors' discretionary funds of five percent of lab spending.

Funding

As in the case of their current personnel and procurement practices decisions, the Army, in funding ARL, has not adhered to Army policies calling for stable funding and focusing technology base resources to support upgrades of systems. Although the combination of 6.1 and 6.2 funds will remain relatively stable from fiscal year 1994 to fiscal year 1997, ARL will receive only 22 percent of the Army's total 6.1 and 6.2 funds. It will be difficult for ARL to be the *flagship* Army technology base laboratory it is chartered to be unless it is more generously treated.

At these funding levels, ARL must compete with the RDECs—its own customers—for funds from other services, the Advanced Research Projects Agency, program executive offices, and program managers.

With institutional funding of $200 million in R&D, ARL probably cannot support excellent research in its 10 broad business areas. Nor can it easily gain new competencies. The committee's collective experience suggests that at least $40 to $50 million per year is needed to support an adequate research program in a broad and Army-unique technology area, such as those ARL should be pursuing. As a comparison, the Advanced Research Projects Agency has spent about $100 million per year on its armor and antiarmor program (mostly with 6.2 funding and some advanced development [6.3] funding). It spends about $120 to $140 million per year in its advanced materials research

programs (6.1 and 6.2 funding). Based on fiscal year 1993 spending, the ARL Materials Directorate will receive only $13 million of the 6.1 and 6.2 funding.

ARL must focus its research on areas of unique importance to the Army's long-term technology needs and in which it has unique strengths. Any technology area in which outside organizations are more competent or cost-effective should be left to those organizations. ARL, for example, need not duplicate industrial or academic programs in areas such as electronics, materials, biotechnology, and the information sciences.

Diversity and Quality of Research Sources

ARL must be agile enough to exploit the best sources of research and technology, inside or outside the government. It needs diverse and flexible partnerships with industry, universities, and other government laboratories, rather than a monolithic internal capability. Today, its ability to form these relationships is limited. Some limitations are due to restrictions imposed by the Army in dividing ARL's mission from that of the other R&D organizations in AMC. Other limitations are due to the difficulties of DOD contracting mechanisms. Still others are related to ARL's overambitious program.

The Army requires all of ARL's basic research to be conducted internally. AMC's Army Research Office is responsible for buying basic research from universities. The RDECs may buy basic research from industry or from ARL. In exploratory development, ARL's sources are somewhat less limited, but it cannot contract out more than 30 percent of its work. Such restrictions were established to protect and maintain an internal capability to conduct basic research and exploratory development, a commendable objective. But such restrictions might hinder ARL's flexibility in providing its customers the best research and technology available internally or externally.

Additionally, DOD persists in using traditional procurement contracts—suitable for purchases of tanks, rations, or hand grenades—in buying R&D. These highly regulated contracts, which have inflexible terms and often require layers of approval, can slow progress, limit shifts in research direction, and discourage many potential sources from participating. DOD has had statutory authority for several years to use cooperative agreements—a more flexible form of contract widely used by other federal agencies to support R&D—but has not used that authority except in the Advanced Research Projects Agency. At the time of writing this report, the Director of Defense Research and Engineering was developing guidance urging the services to start exercising cooperative agreement authority.

The wide range of ARL's program, with its 10 broad business areas, may be partly a reaction to these contracting handicaps. The limits on contracting

encourage ARL to provide the maximum scope possible internally. Relief would let ARL focus on the Army's greatest needs with ARL's areas of greatest advantage both internally and externally.

Technology Transfer to the Army

ARL transfers technology to operational users indirectly, by way of the RDECs. The central transfer mechanisms are Technology Program Annexes, formal agreements defining specific joint ARL-RDEC research projects, with specified *transition points* from ARL to the RDEC. These agreements use the half of ARL's 6.1 and 6.2 program that is approved by the ARL Board of Directors, as explained earlier.

While Technology Program Annexes are a step in the right direction, they do not go far enough. Industry and many government agencies have found the sequential approach to technology transfer used in DOD—6.1 to 6.2 to 6.3A to 6.3B, and so on—too slow and uncertain to meet the needs of users. It is similar to a relay race in which technology is passed like a baton through different agencies separated by function, time, and location. Instead, many organizations have substituted a *nonlinear* or *systems* approach, in which each stage from concept to production and marketing is guided by the needs of all the other stages. Research is conducted in parallel with development, production, and fielding, requiring researchers to be more knowledgeable of systems integration, manufacturing, and user requirements. At NIST, for example, R&D teams follow a project beyond research, through development, and possibly all the way to production, and are not circumscribed in scope as is ARL (to 6.1 and 6.2 work).

ARL lacks the flexibility to be effective at technology transfer of this kind. In this context, it is difficult to see ARL, however well managed, as a successful *world-class* laboratory even though some world-class research might be conducted in it.

Ability to Leverage Funds and Programs

By strategic spending on external sources of technology, ARL could share costs with commercial firms and other government agencies, thus “leveraging” its funds through joint ventures and cooperative research and development. ARL's success has been limited, however, by the R&D contracting processes of the Defense Department, noted earlier, which discourage healthy interaction between government and contractor. As partial compensation, the recently authorized cooperative research and development agreements (CRADAs) have offered a means by which ARL may form more

flexible relations with the private sector (although they are no substitute for adequate contracting procedures).

A related form of leverage is the sharing of costs with other government laboratories. The Tri-Service Science and Technology Reliance program is intended to help reduce redundancy by defining the divisions of labor among the various DOD research and development agencies in different areas of technology. Too new to have demonstrated its success, the program offers a high-level forum for discussions that is bound to grow in practical importance as the Department of Defense accommodates lower defense budgets.

Improving Productivity

Reductions in defense funding mean that the quality and productivity of ARL's work requires continuous improvement. The Army has devised a total quality management program, to which ARL is committed. But the total quality management approach must be adapted to organizations doing R&D. ARL's inputs and outputs—mainly knowledge—are difficult to measure quantitatively; its quality is assessed most accurately by expert opinion, through peer reviews and management judgment. ARL should continue to use those measurements that are best suited to R&D, such as customer satisfaction, numbers of patents and papers, and percentages of Ph.D.s among scientists and engineers.

In any case, the current ARL's ability to implement total quality management is limited. ARL's administrative procedures are too rigid to permit the accountability and authority that are vital to continuous quality improvement. Decisions on detailed budgets, personnel numbers, promotion, and pay are made by higher headquarters. Incentives for performance are few. If ARL, in pursuit of total quality management, is to please its customers and build quality into every system and process in an organization, such restrictions must be loosened or removed.

These problems are not insurmountable. As this report shows, there are a range of options for the Army, each of which offers important relief from these handicaps.

GENERAL RECOMMENDATIONS

The committee's assessment of ARL as now constituted has revealed deficiencies in ARL's program and its management. Many of these problems are due to unduly restrictive federal and DOD administrative procedures, which fail to give managers the necessary authority and accountability. Others

appear to reflect a confusion about ARL's priorities and its relations with its customers and its sponsor.

To address these failings, the committee developed five general recommendations that apply in various ways to all four of the organizational options (indeed, to any productive future for Army R&D). Accordingly, these recommendations can be considered common assumptions of all the options (although their applicability may vary from option to option). They must be implemented if any of the recommended options are to be successful.

The committee believes that implementation of the first four recommendations are possible within AMC. However, an AMC commander would find it difficult to single out ARL for *elite status* as long as it is closely intermeshed with the rest of his command, both organizationally and physically. Few commanders who have the responsibility of optimizing value of the entire AMC command would find it tenable to establish a differentiated, organizational entity with a separate culture and set of operating policies that is required.

Streamlined Procurement Practices

Procurement practices should be streamlined, based on the Defense Laboratory Demonstration initiatives. The initiatives could ride on the coat tails of the Under Secretary of Defense for Acquisition and Technology report issued on January 12, 1993, by the Acquisition Law Advisory Panel, entitled Streamlining Defense Acquisition Law. The Lab Demo procurement initiatives should be implemented. The decision-making authority of laboratory managers should be increased, and other steps taken to improve the responsiveness of the system. Generally, all procurement constraints imposed by the Army should be selectively eliminated, to free laboratories to the limits of federal law and Defense Acquisition Regulations. (This recommendation does not apply to the GOCO ARL option, which—depending on the contract—may not be subject to federal procurement practices in the same way.)

Personnel Reforms

A thorough reform of personnel practices for science and technology personnel at ARL should be instituted. This reform should begin with the Defense Laboratory Demonstration initiatives (which can be undertaken quickly, within existing statutes and regulations). Among the Lab Demo personnel reforms are (a) giving laboratory managers the power to classify positions, (b) establishing a separate career ladder for scientists and engineers,

(c) offering short-term appointments for senior retirees from universities and industry, (d) locating key support functions such as personnel management and purchasing at laboratories, and (e) other measures to increase the authority and accountability of managers and workers. ARL should go as far as possible beyond these reforms, and should consider personnel programs demonstrated in other agencies, such as NIST. Such reforms will also attract outstanding leaders. Approval by Congress, the Office of Personnel Management, DOD, and the Army may be needed. (These reforms, like the Lab Demo procurement measures, would not apply to the GOCO ARL option, which has no government employees.)

A More Focused Program and a Well-Defined Mission

To maintain quality in the ARL research program as budgets decline, ARL should focus its mission and program over the next three years to include only those areas of technology that promise the greatest contributions to meeting the Army's long-range, land-warfare requirements and will not be adequately supported elsewhere. ARL should make more direct use of civilian research in areas of strong civilian support and interest (e.g., electronics, materials, biotechnology, information sciences), while focusing on its own core competencies and their evolution over time. This approach should also be taken with ARL's analytical support efforts.

To direct this more focused approach, the Army must rewrite ARL's mission statement, stressing the pursuit of the best research, technology development and analytical support inside or outside the Army, to meet needs broader than the specific system technologies developed by the RDECs. The current programs seem to be too internally oriented. In developing such a statement, the challenge will be not to offer ARL sufficient scope, but rather to give it a unique and stable role among Army R&D organizations.

As the program and mission are defined, the Tri-Service Science and Technology Reliance program will grow increasingly attractive as a way of sharing resources.

Partnerships for Technology Transfer

To facilitate technology transfer, ARL should initiate and broaden exchanges with civilian industry and universities through cost-sharing partnerships and guest researchers, and it should establish an improved process for development and technology transfer with its customers and operational users. Most important, ARL must work closely with the RDECs, avoiding duplication and competition for research funds. It should be

permitted to go beyond 6.1 and 6.2 work, to make cooperation with the RDECs, battle labs, and others, inside and outside the government, more fruitful.

A New Reporting Channel

It is the committee's judgement that ARL's reporting channel should be changed from the Commanding General of AMC to the Assistant Secretary of the Army (Research, Development and Acquisition). The committee believes that this change would better support a mission of Army-wide horizontal technology integration, make it easier for ARL to practice a nonlinear (nonsequential) approach to technology transfer, provide full-time research and technology leadership, provide more direct links to Army policy, operational, and program officials, and place ARL in a position that would reduce command concerns of giving ARL an elite status in terms of personnel, procurement, and other administrative reforms. The committee also believes that this move would enhance ARL's external status as the Army's flagship laboratory (putting it on a similar organizational level with the Naval Research Laboratory and NIST), promoting better relations with users, civilian industry and other government agencies.[3]

The ARL Board of Directors should be replaced by a new Army Science and Technology Advisory Board, an external board of independent experts to review and oversee the technical quality and relevance of ARL's work and ensure strong linkages exist.

COMPARING THE FOUR OPTIONS

The four organizational and management options can be seen as points along a spectrum, from rather modest administrative reforms within the current setting (the ARL Enhanced option) to the radical alternative of

[3] The committee recognizes the difficulty of considering a change in the reporting relationship for ARL without similar questions arising in respect to the Army Research Office (ARO), a similar basic research organization that manages university basic research efforts. A close, seamless working relationship between ARL and ARO would enhance ARL's diversity and quality of research sources. A common management structure would enhance this relationship. Such a working relationship has long existed between the Naval Research Laboratory and the Office of Naval Research (ARO's equivalent) under the Chief of Naval Research of the Navy, who reports to the Assistant Secretary of the Navy for Research, Development and Acquisition. However, it is beyond the charter of this study to address ARO's reporting channel. The Army should consider studying this reporting channel, ARO's relationship with ARL and the RDECs, and the Army's overall 6.1 program.

contracting out all of ARL's management and operations (the GOCO ARL option).

It is important to note that the average salaries for scientists and engineers vary from option to option. Engineers and scientists employed by private contractors are assumed to earn $70,000 per year on average, based on the committee's surveys of contract research organizations. Government-employed scientists and engineers in the ARL Enhanced and ARL Multicenter options would earn $52,700; in the NIST option, because of the various pay incentives, they would average $61,200. The average cost per scientist and engineer for each option depends on the relative proportions of contract and government employees.

For the purposes of comparison, the total operating budgets of all options are assumed to be equal ($323 million, in 1993 dollars, by fiscal year 1997). The number of scientists and engineers are scaled accordingly. Thus, the GOCO ARL option, 100 percent contracted, is calculated to have only 1,357 scientists and engineers in fiscal year 1997, substantially less than the 2,021 planned by ARL (and assumed in the baseline ARL Enhanced option); the NIST option would have 1,779, and the ARL Multicenter option would have 1,604.

The likely accompanying increases in productivity associated with these options—which determine whether the reduced staffs would achieve research output high enough to carry out ARL's mission with sufficient quality to warrant the conversion—are matters of judgment. This committee believes that all three of the higher cost per person options would pay for themselves, because they are most open to the efficiencies and incentives of the private sector. The Department of Energy sponsored-laboratories in universities and industry, the Jet Propulsion Laboratory sponsored by the National Aeronautics and Space Administration, and the Massachusetts Institute of Technology Lincoln Laboratory sponsored by DOD all have outstanding reputations for quality and productivity. Similarly, industrial laboratories such as Bell Laboratories, the Xerox Palo Alto Laboratories, the General Electric Laboratories, and many others also enjoy excellent reputations. Based on this experience, the committee believes that private-sector laboratories can deliver overall higher productivity for their higher per person costs.

No proven quantifiable measures of research productivity are available, which might indicate that 1,357 higher paid scientists and engineers (or 1,779, or 1,604) could be as productive as 2,021 government scientists and engineers. This comparison is complicated further by federal scientists and engineers who often accept lower pay in exchange for research opportunities available only in government laboratories or to fulfill a sense of *service to the nation.* In general, higher salaries, if linked with updated facilities, state-of-the-art equipment, professional working environment, and good leadership, can

attract higher quality people, who in turn are likely to produce disproportionately more valuable research.

ARL ENHANCED OPTION

The ARL Enhanced option (the baseline for comparison) involves frequently recommended changes in personnel, purchasing, and contracting arrangements, while keeping ARL a government organization. The option is based on the Lab Demo program of purchasing and personnel reforms, already mentioned, and DOD's proposed Laboratory Quality Initiatives, which build on the Lab Demo initiatives, including additional contracting reforms.

Contracting activity is assumed to account for 20 percent[4] of ARL's R&D (compared with the 30 percent figure found in the Army's current plans for ARL by fiscal year 1997). One-time conversion costs are estimated at $11 million (mainly severance pay for those made redundant as a result of the recommended focusing of ARL's program).[5] This option would offer a quick and substantial improvement in effectiveness, without the need for radical change or upheaval, and without the need for congressional authorization.

The contracting reforms assumed in this option—including the use of cooperative agreements for R&D—would improve ARL's ability to exploit diverse sources of research and technology and to leverage funds and programs. But ARL would be limited in these respects by the assumed 20 percent ceiling on contracting R&D. In none of these areas would it have advantages over the other options.

Technology transfer to the Army would improve marginally, through the focusing of ARL's program and formation of the technology transfer partnerships, both general recommendations (and both assumed for all of the committee's options). All other things being equal, one would expect an internal operation to have better technology transfer to other parts of the

[4] ARL's planned fiscal year 1997 budget and internal personnel strengths cannot support more than 20 percent of its budget contracted out.

[5] The committee believes that some of ARL's laboratories may need to be upgraded, regardless of the option chosen, to enhance the quality of the research environment. However, the committee could find no reason to believe that facilitation costs would differ among options. Thus, such costs would not be discriminators for choosing from among the options. Additionally, the committee adhered to the guidelines for this study that no additional capital costs be considered for any option. The committee believes, though, that such increases might improve the chances of attracting better research personnel. The Army should study the needs, if any, for laboratory improvements or changes to its current plans, and appropriately adjust the conversion costs.

Army, because there are fewer barriers; in this respect, this option would be favored over the GOCO ARL option.

Fully and properly implemented and supported, with the recommended new reporting channel and narrowed program, this option could give the Army a source of world-class science and technology. But implementation would be challenging, since the Army's past record for implementing Lab 21 initiatives has not been good. This option may not be a bold enough move to get senior leadership support for full implementation nor bold enough for meeting the Army's changing needs.

NIST OPTION

The NIST option, another option that retains most of the program within the Army (with an assumed 20 percent of R&D contracted), builds on the ARL Enhanced option by instituting more radical personnel practices, modeled on the well-known personnel demonstration program of NIST. Its other key feature is a two-tier system of independent external advisory boards, which review the quality and relevance of research programs. These advisory bodies are modeled on those of NIST.

This option has a substantial advantage over the ARL Enhanced baseline in its personnel procedures. Revised procedures would give laboratory managers the ability to hire and reward technical workers to meet managers' needs in a timely way. The resulting improvements in research quality and cost-effectiveness would be important. The one-time conversion costs would be more than those of the previous option (about $17 million), representing mostly the cost of severance for employees replaced in the reformulation and focusing of the program.

In all other respects, this option is identical to the ARL Enhanced baseline. It would have the same enhancements in linkage to Army strategies and objectives, the diversity and quality of research sources, technology transfer, and ability to leverage funds and programs. However, the actual NIST has an extensive program of partnerships and guest researchers from industry and universities that provides it with great leveraging capability. This program, if duplicated in ARL, would leverage its funds greatly. Thus, the committee has made the program a general recommendation.

The committee views this option as the best option that still retains the bulk of ARL's work within the Army. Bold and rapid implementation by the Army and Office of the Secretary of Defense would be needed to develop and implement the demonstration personnel system. Approvals might also be needed from Congress and the Office of Personnel Management.

ARL MULTICENTER OPTION

The ARL Multicenter option involves the same administrative reforms as the ARL Enhanced option, but would contract out most of the research and development to several *centers of excellence,* under the supervision of a strong permanent staff. For the purposes of this assessment, it is assumed that 30 percent of ARL research would be retained in internal laboratories of excellence, and the other 70 percent would be contracted out on multiyear contracts to centers organized around specific technology areas; the internal 30 percent would include the permanent staff of about 100 technical experts and managers. The one-time conversion costs would be higher than those of the ARL Enhanced or NIST option (about $56–$70 million,[6] mostly for severance pay for the 40 percent of ARL research personnel who would be displaced).

This option has the potential for dramatic improvements in the quality of ARL's R&D, its ability to leverage funds and programs, and its ability to improve its productivity and cost-effectiveness. Its use of a combination of contract and internal centers for ARL's research—government-owned and government-operated, government-owned and contractor-operated, and contractor-owned and contractor-operated—would enable it to seek the very best available sources of technology, and give it the network of contacts and partnerships through which to leverage its funds and programs. It would be well prepared to meet the changing needs of the future, by changing its research sources as needed.

Its links with the RDECs (which help determine the ease of technology transfer) would not be as strong as those of the ARL Enhanced or NIST options. However, its government staff would include RDEC personnel on rotating assignments, which would improve communication. Even more interesting is the possibility of wholesale technology transfer; responsibility for centers whose technology had matured beyond ARL's interests could be transferred as wholes to the appropriate RDECs.

This option would be stronger by nearly every criterion than the ARL Enhanced baseline, and the equal of every other option (except possibly in technology transfer, where it might be arguably inferior to the internal options).

Implementation would be contractually complex, because of the variety of sources, and would require effective planning and coordination by the permanent staff. The cost to obtain contractors (estimated at $7.5 to $21.5 million) would increase with the number of center contracts. Thus the cost to

[6] This cost will depend on the number of independent centers of excellence which are contracted out.

obtain contractors for this option could be more expensive than with a single GOCO contractor (estimated at $7.5 million).

There could be a gradual transition from either the ARL Enhanced or NIST options to the ARL Multicenter option through a systematic increase in the contracted out/internal ratio of funding over time.

GOCO ARL OPTION

The GOCO ARL option would break dramatically with the past, by contracting out all research and development, and its management, to a single organization. A small government staff (no more than a dozen members) would provide oversight for the Army. The one-time conversion costs of this option are estimated at $85 million, mostly severance costs for people.

The GOCO option would offer perhaps the best chance of all the options for ARL to do world-class technical work. Using the administrative procedures of the private sector, ARL could hire and promote, purchase, and contract more efficiently than any government organization. (In this option, the recommended government personnel and procurement reforms are irrelevant.) It could attract outstanding leaders and staff, attracted by the vital mission and the minimal administrative burdens of the laboratory. It could select its research sources with the utmost freedom and diversity. With its rich networks of contacts and its ability to exchange personnel easily with outside organizations, it would be able to form close relationships with outside entities through which to leverage ARL funds. Through incentive clauses in its management and operations contract with the Army, a GOCO ARL could have strong incentives to improve the quality and relevance of its work.

This option, however, could weaken ARL's linkages to Army strategies and objectives, by placing it outside the direct control of the Army. The GOCO ARL option because it is outside the government, might also be less able than the ARL Enhanced baseline (or other internal options) to transfer technology to the Army, provide technical support to operating forces, or carry out system assessments for the Army. Nevertheless, the Department of Energy GOCOs have done effective technology transfer and assessments for the Department of Energy, for example. While none of these problems is insurmountable—many existing GOCO laboratories manage them successfully—they must be counted as potential shortcomings when compared to the internal options. These areas would require management attention at both the GOCO ARL and its Army oversight organization to ensure effective coupling to other Army laboratories, engineering centers, and operating forces. Conversion would require notification of Congress (although not legislative authorization), and might be politically contentious.

To capture the benefits of the GOCO option, the Army would need to resist overly restrictive management through excessive government approvals of operations. The past decade has seen a clear trend toward increased oversight at the Department of Energy's GOCO laboratories and DOD's federally funded research and development centers. The greater the degree of detailed supervision from the Army, the less attractive the GOCO ARL option is, both to the Army and to potential contractors. The Army would need to give the lab the operational freedom and flexibility of an outside organization, and at the same time the trust and access of an internal lab with regard to substantive matters.

SELECTING AN OPTION

The determinate issue for the Army in selecting an option, all other factors being essentially equal, is whether a significant internal capability to do research is absolutely necessary. If the judgment is strongly affirmative, then the best internal option would be selected, assuming that it meets requirements for leadership, quality of research, and technology transfer. On the other hand, many experts on research management regard contract organizations as more likely than internal DOD laboratories to achieve these goals. Thus, the choice of an ARL option is a matter of judgment about the factors most important to the Army in the particular case.

The committee believes that the ARL Enhanced option may not be bold enough to meet the Army's changing needs nor to obtain strong support from senior leaders, judging from ARL's inability thus far to implement the Lab Demo initiatives that are at the option's heart. The NIST, ARL Multicenter, and GOCO ARL options would all be major improvements over the current situation, *and all three have the potential to produce a world-class laboratory.* The NIST option in particular is an excellent internal option. The main uncertainty about a NIST ARL is whether it could receive the necessary approvals by DOD and Congress and be accepted by the existing bureaucracies so as to be implemented successfully. The ARL Multicenter and GOCO ARL options have varying advantages and disadvantages, but the advantages far outweigh the disadvantages in terms of quality and productivity. These latter two options could be implemented by the Army without statutory changes, although they would be politically contentious. However, they face acceptance problems similar to those of the NIST option.

Properly implemented, each would be an improvement over the status quo, not only in the efficiency and flexibility of ARL's personnel and purchasing systems, but also in terms of more fundamental reforms, such as a more focused program; more flexibility in conducting research across the spectrum of the 6.1, 6.2, and 6.3A funding categories; better leadership; better

responsiveness to the Army's goals; and more fruitful relations with customers and other partners.

The committee strongly recommends that the Army implement either the NIST, ARL Multicenter, or GOCO ARL option. The choice among these three depends largely on the importance to the Army of an internal research capability, and on the Army's judgment of the practical and economic obstacles to implementing particular options. Above all, the Army should incorporate all five general recommendations in any choice it makes.

The Army must have the support and the commitment of its top leadership, and the patience to evolve and stabilize ARL into an organization that can have a major impact on the Army of the future. Without this, the Army will waste critical resources and not reap the benefits described in this report for its chosen option.

1

Introduction

With the end of the Cold War, the Army's budget for new equipment is being slashed by billions of dollars, from about $28 billion in research, development, and acquisition in fiscal year 1985 to a projected $9 billion in 1999. With $1.2 billion reserved for research and development (R&D), higher productivity is needed more than ever to maintain the operational capabilities of reduced force structures and lower costs of future systems. Laboratories must have the flexibility to exploit advances in civilian technologies, and to provide continual upgrades of existing systems. The Army will be challenged to meet these new needs.

The policy of the Army is to accommodate declining budgets by cutting acquisition of major new systems, while maintaining stable funding[1] for the technology base (the basic research, exploratory development, and nonsystem-specific advanced development that can lead to future systems and provide continuous improvement and upgrades of existing systems) (Department of the Army, 1994). The Army Materiel Command's (AMC's) new Army Research Laboratory (ARL) is intended to be a central component of the Army's technology base. As such, ARL is seeking a role as the Army's *flagship* laboratory for basic research and exploratory development (Army Research Laboratory, 1993).

As the flagship laboratory for multidisciplinary research and technology development in support of the Army's technology base, ARL must shape its program according to the Army's needs for technology 5 to 15 years into the future (Army Research Laboratory, 1993). At the same time, it has customers to serve who may have short-range needs not only for advanced technologies but also for system performance assessments and field assistance. The proper balance between its long- and short-range perspectives must be maintained. ARL will also need to strike an even more difficult balance: between building excellence in its own research in the areas of unique and crucial interest to

[1] Technology base funding will remain stable around $1.2 billion from fiscal year 1994 to fiscal year 1999, with $200 million for basic research, $600 million for exploratory development, and $400 million for nonsystem-specific advanced development.

the Army on the one hand, and building partnership relationships with the best and most appropriate research and technology sources outside the Army on the other. If it is to be the flagship laboratory, ARL must have the funding, personnel, and administrative support necessary to pursue excellence, not only in its own laboratories, but also through access to technology sources outside the Army.

Army laboratories and engineering centers have done excellent work in the past, as is manifest in the Army's superb capabilities worldwide. The science and technology activities of AMC, including ARL, the Army Research Office, and the Research, Development and Engineering Centers (RDECs) have greatly benefited soldiers and other users. The Tri-Service Science and Technology Reliance Program, codirected by AMC personnel, has reduced duplication by introducing Department of Defense (DOD)-wide R&D planning and cooperative research.

But changing conditions have prompted reassessment of ARL's organization, its mission, and its personnel, procurement, and funding practices. This study assesses organizational and management options for ARL, focusing on four distinct options in addition to the status quo, ranging from an enhancement of ARL's administrative procedures within the current setting to the contracting out of the entire program, including management. It evaluates these options in terms of the following criteria:

- linkage to Army strategies and objectives;
- potential to perform world-class land warfare research;
- diversity and quality of research sources;
- technology transfer to the Army;
- ability to leverage funds and programs of organizations outside ARL; and
- ability to improve productivity with respect to recurring costs.

This report distinguishes each option from the status quo, describes the conversion issues for each option and recommends potential responses, and estimates conversion costs. To put the issues for ARL in context, it defines the characteristics of world-class research operations, and it examines the quality and relevance of research at government labs, government-owned, contractor-operated (GOCO) labs, and federally funded research and development centers of the military services, such as Lincoln Laboratory. The committee did not assess the scientific content of the ARL research program itself. (The committee's full statement of task is in Appendix A.)

This assessment, by necessity, depends heavily on expert judgement. First of all, ARL is in a state of transition, and in its current form it has little past record to judge. More fundamentally, research management can rarely rely on quantitative data on outcomes and relationships. When necessary, the

committee has compensated for the lack of quantitative data with expert judgement from within and external to the committee.

THE ARMY RESEARCH LABORATORY

ARL is a multidisciplinary applied research laboratory conducting weapons and weapons-related basic research, exploratory development, and performance analyses. Formed in late 1992, it was conceived to be the Army's demonstration laboratory in support of DOD's Laboratory Demonstration (Lab Demo) Program (see Chapter 3; Atwood, 1989). The intent of the laboratory demonstration was best summarized by the Federal Advisory Commission on Consolidation and Conversion of Defense Research and Development Laboratories in 1992:

> The goal of the Lab Demo Program is to increase local management authority and flexibility to approach that of a GOCO laboratory while retaining the advantages of closer customer ties enjoyed by DOD laboratories.

ARL is intended to be the Army's flagship laboratory under the authority of a single civilian director, performing long-range research not linked directly to Army systems. ARL provides the broad technology base to support the wide variety of Army missions in the future. The Director of ARL reports to the Commander of AMC, the Army's research, development, acquisition, and logistics agency for nonmedical systems. The current mission and program emphases of ARL were developed from the Army's Lab 21 study (Department of the Army, 1991) and the Defense Base Closure and Realignment Commission (1991) decisions, and were influenced in great measure by the organizational elements assigned to ARL, which for the most part were derived from AMC's U.S. Army Laboratory Command.

At the time of the Lab 21 study, the Army had no single laboratory organization with a widely recognized identity, like the Naval Research Laboratory. Thus, one of the more important things that came from the study was the insistence that ARL be a single entity.

> ARL's stated mission is to:
>
> Provide America's soldiers the technology edge by conducting a broadly based multidisciplinary program of scientific research and advanced technology directed toward new and improved materials, components, subsystems, techniques and processes, and by performing objective analyses of combat system performance.
>
> (Vitali, 1993)

It carries out this mission in 10 broad areas which ARL calls “business areas”:

- Advanced Computational and Information Sciences;
- Battlefield Environment;
- Electronics and Power Sources;
- Human Research and Engineering;
- Materials;
- Sensors, Signatures, Signal and Information Processing;
- Survivability/Lethality Analysis;
- Vehicle Propulsion;
- Vehicle Structures; and
- Weapons Technology.

These business areas are primarily supported with DOD funding categories 6.1 (basic research), 6.2 (exploratory development), and 6.5 (mission support), as well as some customer funds (Vitali, 1993).

Table 1-1 provides a breakout of fiscal year 1993 funding. The 6.3A funding will be mostly phased out by fiscal year 1994. Mission support (6.5) is used by ARL for analysis and assessment of systems, as well as conducting occasional external studies. By fiscal year 1997, ARL's total operating revenue will drop from $484 to $323 million (both in fiscal year 1993 dollars). No more than 30 percent of ARL's funding may be contracted out in fiscal year 1997. However, the committee has determined that planned budgets and personnel strengths will allow for only 20 percent to be contracted out in fiscal year 1997 (see Appendix D).

TABLE 1-1 ARL Program Data (Fiscal Year 1993, $ Millions)

Operating Revenue	($ millions)
6.1 (basic research)	37
6.2 (exploratory development)	172
6.3A (nonsystem-specific advanced development)	40
6.5 (mission support)	117
6.7 (engineering development)	2
Other appropriations*	59
Reimbursable customer program*	110
Revenues not available for ARL operations	(53)
Total:	484

* See Table D-5 for detailed listing.

It is important to recognize that AMC's laboratories have already undergone two major realignments since 1985. In that year, it was consolidated in the U.S. Army Laboratory Command and given the mission of conducting basic research, exploratory development, and nonsystem-specific advanced development. It was also responsible for coordinating all of AMC's 6.1, 6.2, and 6.3A funding, including that of the RDECs. The intent was to reduce overlap, redundancy, and lack of focus. In 1992, most of the U.S. Army Laboratory Command and its seven "corporate laboratories," along with a few other Army research organizations, were formed into a single laboratory, ARL, with efforts concentrated in basic research and exploratory development, and with no control over funding to AMC's RDECs.

Organization

ARL headquarters is in Adelphi, Maryland. There are 10 "directorates," corresponding to the 10 business areas, as well as an Operations Directorate and an Advanced Concepts and Plans Directorate. ARL is still undergoing realignments and consolidation, and is scheduled to complete its formation in fiscal year 1997. Figure 1-1 is ARL's organizational chart.

ARL directorates are currently located at eight sites in the United States:

- Adelphi Laboratory Center, Maryland (Headquarters; Operations; Advanced Concepts and Plans; Sensors, Signatures, Signal and Information Processing);
- Aberdeen Proving Ground, Maryland (Advanced Computational and Information Sciences; Human Research and Engineering; Weapons Technology; Survivability/Lethality Analysis);
- National Aeronautics and Space Administration Lewis Research Center, Ohio (Vehicle Propulsion);
- National Aeronautics and Space Administration Langley Research Center, Virginia (Vehicle Structures);
- White Sands Missile Range, New Mexico (Battlefield Environment; Survivability/Lethality Analysis);
- Watertown, Massachusetts (Materials);
- Ft. Monmouth, New Jersey (Electronics and Power Sources); and
- Woodbridge, Virginia (Electromagnetic Effects).

Continuing consolidation will bring a further concentration of these facilities, through the closure of the Watertown, Woodbridge, and Ft. Monmouth installations, and the transfer of their activities to other sites. Adelphi and Aberdeen will be the main ARL installations.

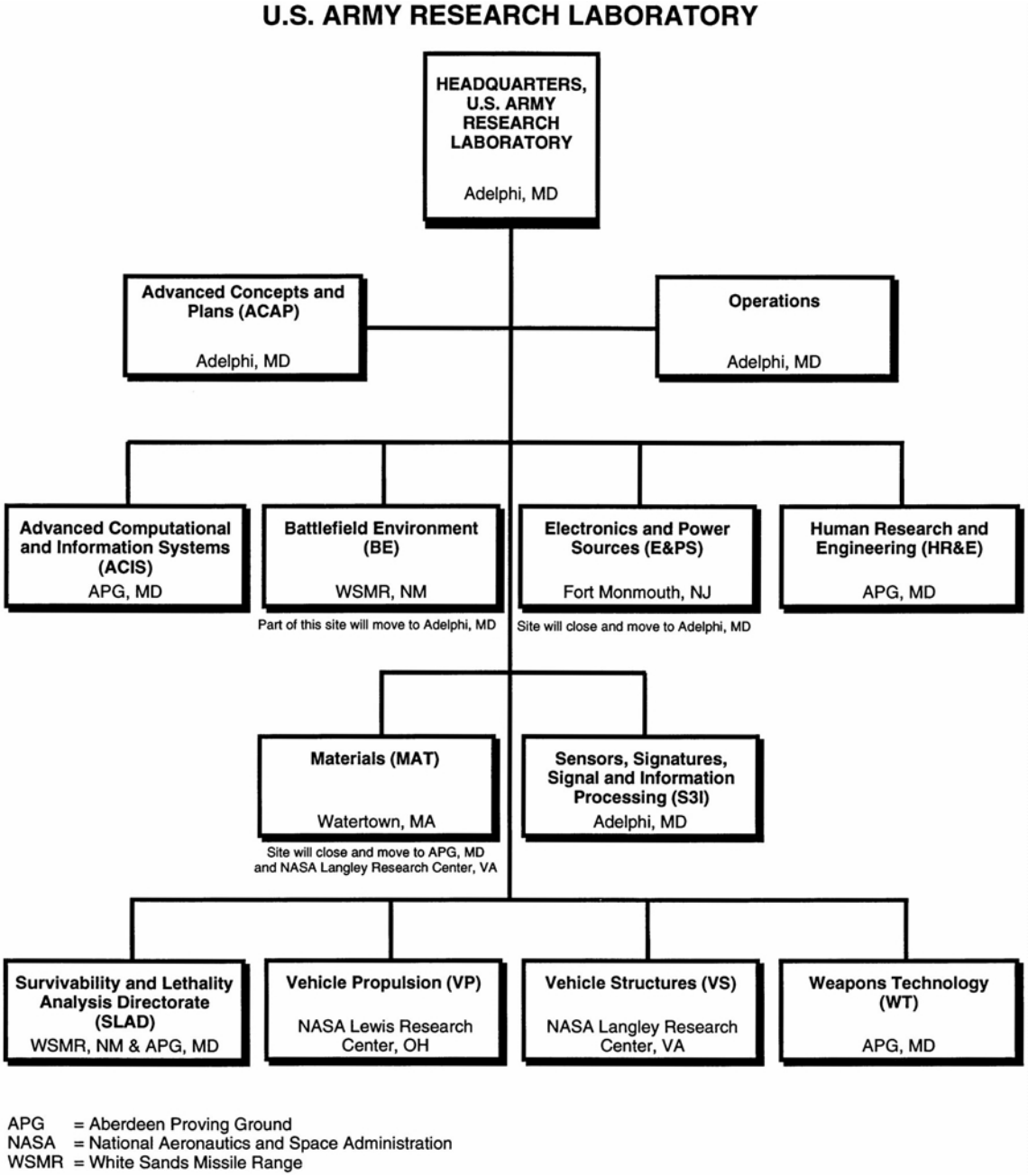


FIGURE 1-1 ARL organizational chart.

THE ARMY TECHNOLOGY BASE INFRASTRUCTURE

ARL is a vital part of the Army's research, development, test, and evaluation infrastructure. A view of how ARL fits into the science and technology organizational structure is illustrated in Figure 1-2. AMC's major subordinate commands which have organizational RDECs are the:

- Armament, Munitions and Chemical Command (soon to become part of the Industrial Operations Command)

  — Armament RDEC (gun tubes, fire controls, munitions, mines, and warheads);

- Aviation and Troop Command

  — Aviation RDEC (aviation structures, propulsion, electronics, and weapons);
  — Belvoir RDEC (mobility, countermobility, bridging, fuels, and environmental controls); and
  — Natick RDEC (food, clothing, shelters, airdrop, and individual equipment);

- Chemical and Biological Defense Command

  — Edgewood RDEC (chemical and biological defense; nuclear, biological, and chemical reconnaissance and decontamination; and obscurants);

- Communications-Electronics Command

  — Communications-Electronics RDEC (command, control, communications, and intelligence; electronic warfare; night vision; electro-optics; and surveillance);

- Missile Command

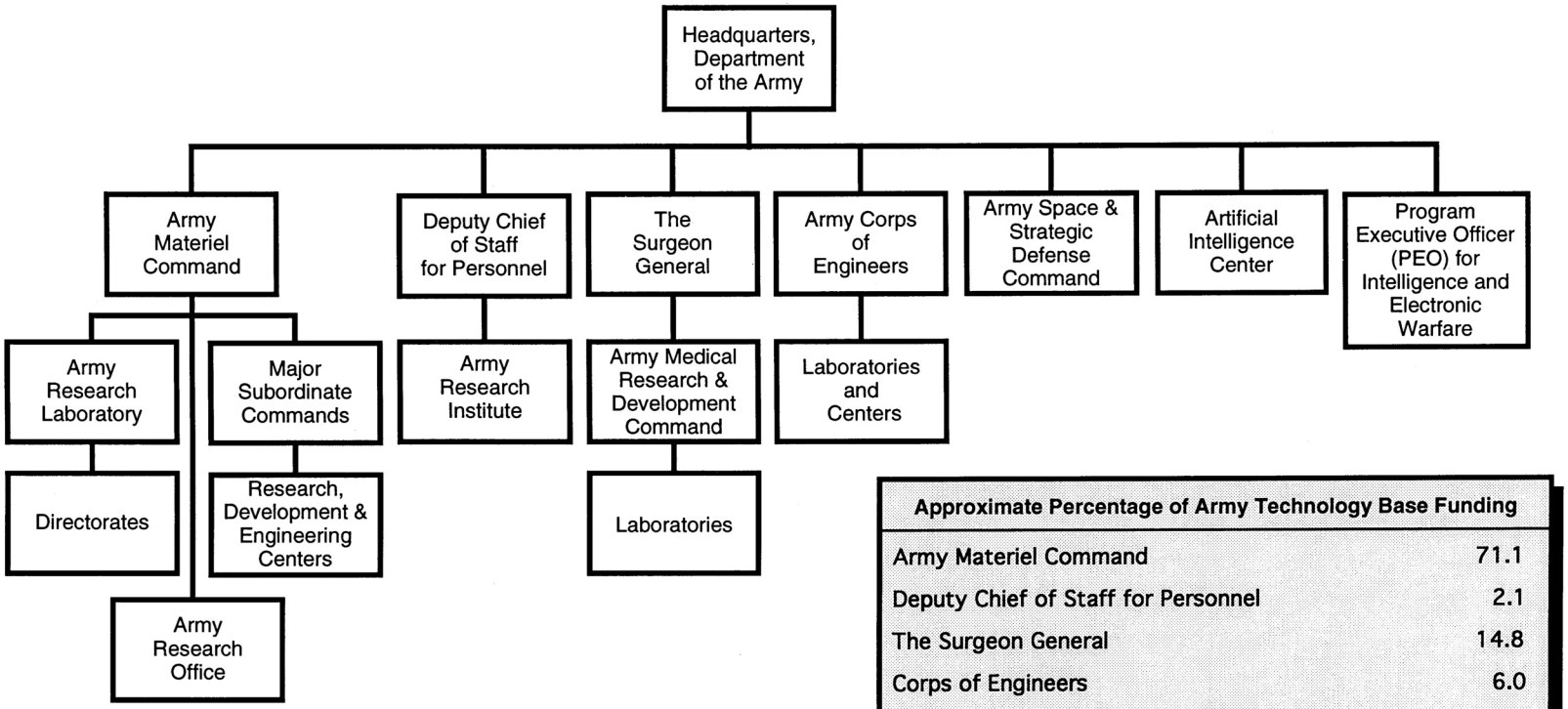
  — Missile RDEC (missile/rocket systems and high-energy lasers); and

- Tank-Automotive Command

  — Tank-Automotive RDEC (wheeled vehicles, tracked vehicles, and engineering support for fielded systems).

The Research and Technology Process

Figure 1-3 is a simple depiction of ARL's research and technology development process in support of higher level strategy, guidance and plans. The ARL process includes identifying science and technology needs it can satisfy, developing a research and technology program, executing funded basic research and exploratory development, and transitioning the scientific knowledge or technology to customers. Transitioning technology to a Program



Approximate Percentage of Army Technology Base Funding	
Army Materiel Command	71.1
Deputy Chief of Staff for Personnel	2.1
The Surgeon General	14.8
Corps of Engineers	6.0
Space and Strategic Defense Command	0.2
Artificial Intelligence Center	0.2
PEO for Intelligence and Electronic Warfare	5.6

FIGURE 1-2 The Army technology base

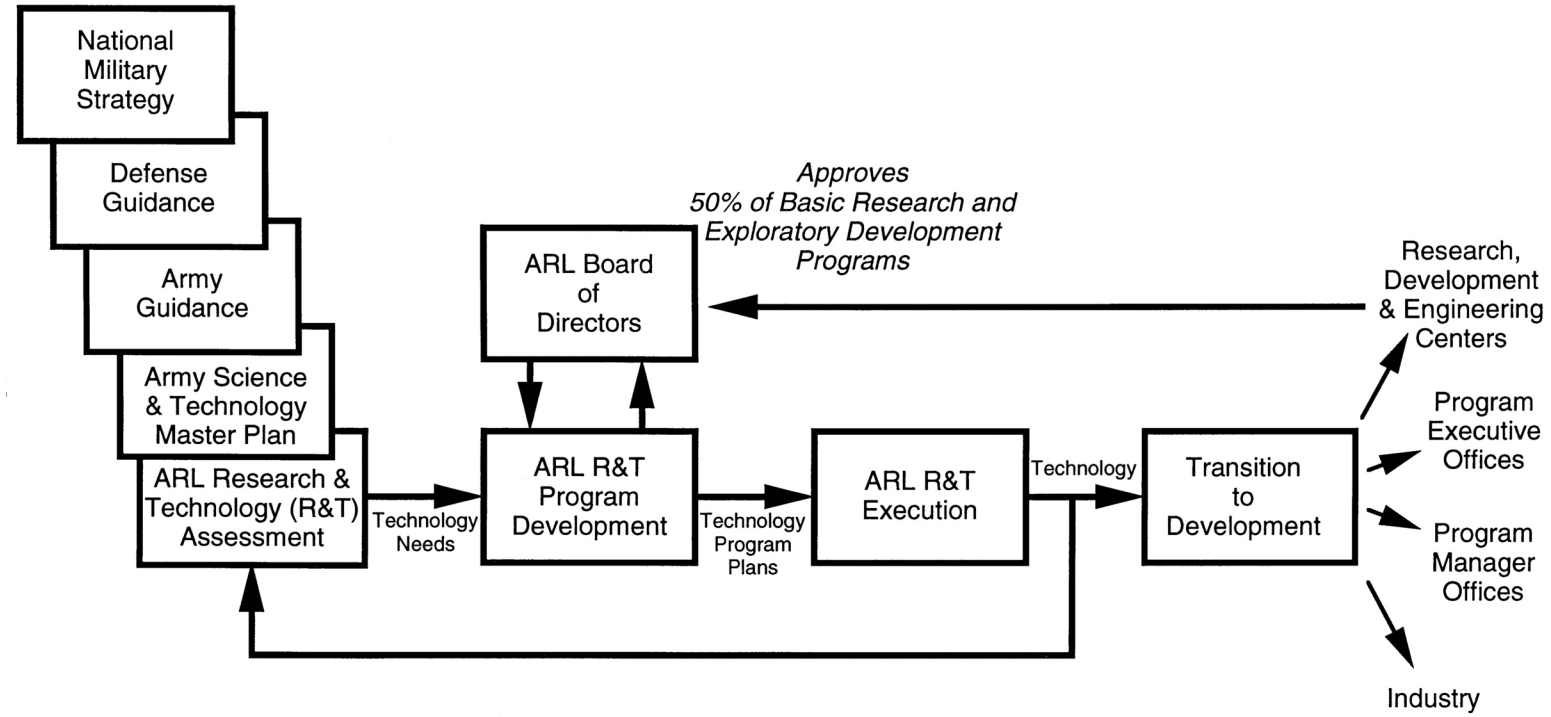


FIGURE 1-3 The ARL research and technology process.

Executive Officer or Program Manager must be coordinated with the appropriate RDEC.

Not shown in Figure 1-3 is ARL's mission requirement for performing an analysis of weapons and weapons-related systems. Numerous areas are analyzed, including:

- directed energy effects;
- ballistic vulnerability;
- nuclear survivability/vulnerability;
- human perceptual, cognitive, and psychomotor performance;
- soldier performance measurements;
- control, display, and workstation design; and
- structural analysis and dynamics.

ORGANIZATIONAL OPTIONS

To assess ARL's opportunities for the future, the committee defined four organizational and management options, in addition to the status quo. These options can be seen as points along a spectrum, from improvements within the current structure, through more radical changes in mission and governance, and finally to contracting out the management and performance of ARL's R&D. Properly implemented, each would be an improvement over the status quo, not only in the efficiency and flexibility of ARL's personnel and purchasing systems, but also in more fundamental reforms, such as a more focused program, more flexibility in conducting research across the spectrum of the 6.1, 6.2, and 6.3A funding categories, better responsiveness to the Army's goals, and more fruitful relations with customers and other partners.

Each of the options will likely be implemented by fiscal year 1997. For purposes of comparison, they are all assumed to have the same operating budget—that planned for ARL in 1997 ($323 million, in 1993 dollars). Implementation of any options will generate turmoil—some more than others. The options are discussed and compared more fully in Chapter 3, Chapter 4, Chapter 5, and Chapter 6. Briefly, they are:

- *The ARL Enhanced option,* involving reforms of ARL's administrative procedures within the current legislative and regulatory setting (the baseline case for comparison of options);
- *The National Institute of Standards and Technology (NIST) option,* which builds on the ARL Enhanced reforms by further strengthening laboratory managers' discretion in personnel decisions and in forming cooperative partnerships with industry and other government agencies, based

on the model of NIST, the Commerce Department's main industrial research laboratory;

- *The ARL Multicenter option, in* which most of ARL's research and development are contracted out to several *centers of excellence,* overseen and guided by a strong permanent staff of government technical and management experts; and
- *The Government-Owned, Contractor-Operated (GOCO) ARL option,* in which the entire program, including management, is contracted out to a single contractor.

VISION OF FUTURE ARMY RESEARCH AND DEVELOPMENT AND ARL'S ROLE

This study is a timely one. ARL, inescapably, faces a period of dramatic change in its mission. The technology base is, arguably, more crucial to the nation's defense than ever before. At the same time, the assumptions underlying our defense are under intense scrutiny inside and outside the military establishment.

Despite declining research, development, and acquisition budgets, the Army will continue to modernize. Modernization will be necessary to maintain a technological edge over potential enemies and to replace aging equipment. In the past, much of the Army's modernization was primarily accomplished through the development and procurement of new systems (known as “new starts”). However, future budgets will not support this approach. Future modernization will probably include a small portion (approximately 10 to 20 percent) of new starts, commercial buys (about 20 percent), and perhaps 60 to 70 percent using technology insertion (enhancing a fielded system by adding on or upgrading it with a new technology). To maximize the benefit of technology insertion, technologies would need to affect as many systems as possible; the emphasis is on broadly enhancing an entire force, rather than single systems. This process is known as *horizontal technology integration* (Garner and Hite, 1993). To manage this new modernization thrust, Army acquisition program managers would have to be oriented more toward technologies rather than systems.

As the principal R&D laboratory in the Army, ARL would be best positioned to support horizontal technology integration. To accomplish this goal, ARL must have the flexibility and capability to focus its core competencies on technologies that cut across numerous systems and promise significant breakthroughs in performance. The future ARL will need to work directly with Army acquisition program managers to attain horizontal technology integration and with the AMC's RDECs on system-specific

technologies. This report will emphasize the importance of ARL in supporting horizontal technology integration.

The Committee's Approach

In assessing ARL and comparing the four organizational and management options, the committee has sought to sweep away old preconceptions about what is or is not possible in improving military acquisition. That fresh perspective has revealed extraordinary opportunities. This report can only identify those opportunities. The Army must grasp them.

REFERENCES

Army Research Laboratory. 1993. Business Plan, Fiscal Years 1994–2004. 1(January). Adelphi, Maryland: Army Research Laboratory.

Atwood, D.J. 1989. Laboratory demonstration program: Actions for improvement of the quality, productivity, and efficiency of DOD laboratories. November 20. Memorandum.

Defense Base Closure and Realignment Commission. 1991. Report to the President. Washington, D.C. July 1.

Department of the Army. 1991. LAB 21. Report prepared for the Secretary of the Army. Draft.

Department of the Army. 1994. Army Science and Technology Master Plan. 1 (November).

Garner, J.M., and R.V. Hite. 1993. Horizontal technology integration. Concept Paper. Headquarters, Department of the Army. November 8.

Vitali, R. 1993. Briefing by Richard Vitali, Acting Director, Army Research Laboratory to the Committee on Alternative Futures for the Army Research Laboratory, Washington, D.C., May 24, 1993.

2

Review of the Army Research Laboratory Today

An organizational and management change alone does not guarantee that ARL will be effective as a source of high-quality research and technology. ARL's mission and ability to conduct world-class research must be supportive of any organizational change if it is to be the Army's flagship laboratory and support horizontal technology integration.

The committee reviewed the current ARL to better understand its strengths and weaknesses in the funding, personnel, and administrative support necessary to pursue excellence in its own laboratories and in technology sources outside the Army. With this understanding, the committee was better prepared to address the advantages and disadvantages of the four organizational and management options, as well as make general recommendations for improvement.

ASSESSMENT CRITERIA

The committee chose six criteria which reflect the Army's desires for ARL's performance. These criteria were used to review the current ARL and to compare the four organizational and management options considered in this study. The six criteria are:

- *Linkage to Army strategies and objectives*: Responsiveness to the needs of the Army's leadership, tacticians, and soldiers in the field.
- *World-class land warfare research*: The ability to conduct world-class research in areas of unique interest to the Army. The committee defines a world-class Army laboratory as one that provides *value* to both its immediate customers (other research, development, and acquisition organizations) and to its ultimate customer, the soldier. In addition, it has nationally recognized leaders and researchers working with state-of-the-art equipment in appropriate facilities; efficiently manages internal programs and takes advantage of external efforts; has an imaginative, innovative, and productive research program; and has a record of successful and timely transfer of research knowledge and technology to useful applications.

- *Diversity and quality of research sources*: The ability to obtain research and technology development knowledge from diverse sources in universities and industry to support changing Army needs.
- *Technology transfer to the Army*: The capacity for effective technology transfer to Army systems, either directly or through ARL's customer organizations (mainly the RDECs).
- *Ability to leverage funds and programs*: The ability to exploit research and technology development efforts outside ARL, through contracts, cooperative ventures, and multiservice projects. As much effort as possible should be exploited with minimum cost to ARL.
- *Ability to improve productivity with respect to recurring costs*: Cost-effectiveness and the ability to improve quality and organizational efficiency.

As stated earlier, these criteria reflect the Army's desires in the Statement of Task (Appendix A). However, after reviewing ARL and assessing each of the options, the committee concluded that there may be other assessment criteria that the Army should consider in its decision process. The criteria could include: the impacts of proposed organizational changes on the Joint Directors of Laboratories and cross service coordination, and necessary facilitation costs (or cancellation of planned facilities) for enhancing each ARL option.[1] A review of the current ARL according to each of the criteria follows.

Linkage to Army Strategies and Objectives

The committee believes that ARL's primary and most challenging task is to conduct long-range (5- to 15-year) Army basic research and exploratory development. Also, ARL must continue its additional tasks of conducting some short-range R&D (in support of RDECs and program managers), system assessments, and field assistance. To remain focused on these tasks, ARL maintains a variety of links with the Army's staff, with tactics and doctrine developers, and with soldiers in the field, in addition to its principal customers, AMC's RDECs.

Short- and Long-Range Perspectives

Liaison with Tactics and Doctrine Developers. Four ARL directorates—Advanced Concepts and Plans, Weapons Technology,

[1] See additional discussion of facilitation costs in the listing of assumptions in Chapter 7.

Survivability and Lethality Analysis, and Human Research and Engineering—continuously evaluate Army personnel, materiel, and information systems in terms of technical and operational requirements. For operational requirements, these directorates must work closely with the trainers, tacticians, and doctrine developers at the Army's Training and Doctrine Command (TRADOC). These directorates inform the other ARL directorates of the latest Army requirements, so that they may maintain the necessary technical capabilities and seek technical solutions for deficiencies.

TRADOC has six battle labs. The battle labs simulate and experiment with warfighting concepts and materiel capabilities that will be available in the next two to three years (Porter, 1993). The time horizons of RDECs are more consistent with those of the battle labs, and therefore, AMC has appropriately assigned the RDECs as the primary liaisons to each battle lab. However, ARL has also established liaisons at some of the battle labs. ARL regards these arrangements—which include interactions with the RDEC liaisons—as partnerships, in which its liaison personnel assess technology for TRADOC and discuss research programs with the RDECs in return for insight into Army needs identified in battle lab experiments (Army Research Laboratory, 1993b). This short-range view supports ARL's efforts to satisfy the immediate needs of the RDECs and soldiers in the field. However, it does not provide a long-range perspective in support of future Army needs.

ARL does not have strong links with the advanced concepts directorates of the TRADOC schools. These directorates' evaluations of future tactics and doctrine could provide a long-range perspective for ARL. These advanced concept directorates work closely with the battle labs to develop smooth transitions from short-range to long-range doctrine. Likewise, a similar transition for technology could be established between the RDECs and ARL.

Field Assistance Teams. ARL provides field assistance teams to satisfy soldiers' immediate needs for technical help. Scientists and engineers on these teams may be stationed at major Army commands for periods ranging from a few weeks to one- or two-year assignments. The Human Research and Engineering Directorate also maintains permanent field teams at Army branch (e.g., Armor, Infantry, etc.) schools.

ARL has about 60 scientists and engineers working in long-term field assistance and TRADOC liaison positions. By fiscal year 1997, that number should drop to at the most 50. Although small in number, these field activities provide excellent linkages to short-range Army strategies, objectives, and needs. Work is normally funded by TRADOC battle labs and schools. Customers interviewed by the committee were highly supportive of the efforts of these people.

Military Personnel in ARL. Military personnel in ARL provide a direct link to the user. ARL currently has about 120 military officers and enlisted soldiers, who bring experience in wartime and peacetime execution of current Army doctrine and tactics, as well as an interpretation of Army short-range requirements.

ARL has approximately 25 additional positions that require officers with doctoral degrees. Such officers can speak the languages of both the users and the developers. They are important sources of information for ARL's civilian scientists and engineers as well as soldier-scientist ambassadors to the military community. Their academic experience brings to ARL glimpses of academia's state-of-the-art research. Frequently, however, these highly educated officers do not have much experience in the planning and execution of Army doctrine and tactics.

Linkage to Short-Range Needs through the ARL Board of Directors. The principal function of the ARL Board of Directors is to review the laboratory's basic research and exploratory development programs to ensure their relevance to the programs of ARL's direct customers, the RDECs. At least half of the programs must support the RDECs' efforts. This support is documented in memoranda of agreement developed by ARL and RDEC scientists and engineers. Each agreement defines the needed joint technical work and the specific arrangements for transfer of responsibility from ARL to the specific RDEC involved. These agreements are known as Technology Program Annexes. ARL directorate executives are responsible for implementing the Technical Program Annexes (Army Materiel Command, 1992b).

The ARL Board of Directors has 16 permanent members: the 2 Principal Deputies for Acquisition and Technology at AMC headquarters (who serve as co-chairs), a Department of the Army human factors engineering representative, a technical director from the Information Systems Command, 8 RDEC technical directors, the technical directors of AMC's simulation command and testing command, the director of AMC's systems analysis activity, and the director of ARL. Its four associate members include two senior staff members of the Materiel Command's headquarters and the directors of the Army Research Office (ARO) and the Battle Lab Integration and Technology Directorate of TRADOC. Other than the directors of ARL and ARO, the members come from organizations with primarily short- or mid-range needs for technologies and systems. The board does not conduct technical assessments or peer reviews for determining quality of research at ARL.

Linkage to Long-Range Needs through the AMC Board of Directors. In addition to the ARL Board of Directors, there is an AMC Board of Directors which reviews AMC's technology plans and provides ARL's primary long-range perspective. The AMC Board of Directors provides corporate oversight and approval of strategic planning, policies, and processes for the management of all research, development, engineering, testing, and evaluation activities of AMC (Army Materiel Command, 1992a). It helps the Department of the Army develop long-range research, development, and acquisition plans and approves policies and procedures to link the programs of AMC, the Army, and the Office of the Secretary of Defense.

The AMC Board of Director's membership is similar to that of the ARL Board of Directors. The board is chaired by AMC's Deputy Commanding General (a three-star general). Its 21 other senior members include the members of the ARL Board of Directors plus the Deputy Assistant Secretary of the Army for Research and Technology, the Deputy Assistant Secretary of the Army for Programs and Policy, a deputy chief of staff from the U.S. Army Training and Doctrine Command, and 2 additional senior staff members from the AMC headquarters (Rosenkrantz, 1994).

Financial Links with RDECs. At least half of ARL's 6.1 (basic research) and 6.2 (exploratory development) programs must support the direct needs of AMC's RDECs, ARL's primary customers (Army Materiel Command, 1992b). The RDECs typically demonstrate short-range perspectives to support the needs of its main customers, the program executive officers and program managers, who are primarily concerned with the acquisition phases of demonstration and validation, engineering and manufacturing development, and production of hardware and software systems. Appropriately, each RDECs' basic research through engineering development institutional funding[2] is oriented toward satisfying near-term hardware and software needs.

The Other Half of ARL's 6.1 and 6.2 Mission Funds. ARL focuses the other half of its 6.1 and 6.2 programs on long-range research, in support of future Army requirements or for developing new doctrine. As such, the customer for this half of ARL's 6.1 and 6.2 appropriated mission program is the Assistant Secretary of the Army (Research, Development and Acquisition) (ASA[RDA]). The ARL Director and the ASA(RDA) agree on programs in support of the Army Science and Technology Master Plan. The ASA(RDA),

[2] This institutional funding, specifically appropriated by the Department of the Army, is intended to be sufficient to carry out core research and development, without the need for additional funds from outside.

AMC, and ARL must ensure that this half of ARL's 6.1 and 6.2 mission funds continues to support long-range Army needs.

In terms of balancing its R&D programs, the committee believes that ARL does not have enough control to shape its own research program in support of long-range Army requirements.

Governance by AMC. ARL is governed by AMC which is primarily responsible for system development and production, system support, and readiness, as well as basic research and exploratory development. System development and production, support, and readiness require a short-range view of R&D.

The Commander of AMC reports to the Chief of Staff of the Army, who does not have primary responsibility for research, development, and acquisition in the Army. This responsibility is in the charge of the ASA(RDA). As a comparison, the Naval Research Laboratory reports to the Chief of Naval Research, who in turn reports to the Assistant Secretary of the Navy for Research, Development and Acquisition.

Linkage to ASA (RDA). The program guidance and institutional funding of ARL are determined by the civilian ASA(RDA) and passed on to AMC. The ASA(RDA) has Army-wide responsibility for the following:

- establishing policies, procedures, priorities, and funding for science, technology, research, development, and acquisition;
- setting procurement policy, procedures, and practices;
- overseeing the acquisition managers of all Army major weapon systems from initiation to fielding, including product improvements;
- ensuring that future battlefield operational needs are addressed in the Army's R&D planning (in cooperation with the Deputy Chief of Staff for Operations);
- ensuring that the Army explores multiple sources of science, technology, research, and development in academia and industry; and
- developing the Army's Science and Technology Master Plan.

Of particular importance to ARL is the fact that the ASA(RDA) controls all of the Army's 6.1 and 6.2 funds, allocating them among ARL, the RDECs, ARO (the Army's conduit for university research grants), the Surgeon General, the Army Research Institute, and the Army Corps of Engineers. Also, the ASA(RDA) is charged with assessing the long-range view of Army technology needs, and managing a technology program that spans the boundaries of all of the Army's laboratories and engineering centers.

As a flagship laboratory responsible for long-range research and development programs, ARL must maintain a close working relationship with the ASA(RDA). This is especially necessary if ARL is to support Army-wide technology insertions as a means of gaining total force enhancements. With the Army-wide outlook, long-range plans, and Army staff links, the ASA(RDA) provides the conduit for developing, coordinating, and implementing ARL's long-range programs and its horizontal technology insertion efforts.

Seminar Wargames. The ARL-sponsored, annual seminar wargames[3] often include representatives of ARL directorates, the RDECs, TRADOC, and other defense laboratories and engineering centers. The wargames allow materiel developers and doctrine developers to build consensus about technology needs and new doctrinal and tactical concepts. Each seminar lasts only a few days and receives relatively little funding. This technology *push and pull* exchange helps develop a two-way linkage between ARL and Army strategies and objectives.

Army Strategic Planning for Science and Technology. ARL participates with other Army laboratories and engineering centers in writing planning documents such as the Army's Science and Technology Master Plan, which is the strategic plan for the Army's science and technology program. It is based on the leadership's vision of the future Army, as constrained by realistic funding limits.

World-Class Land Warfare Research

The primary function of ARL should be to conduct world-class research and technology development in support of the Army's long-range land warfare needs. However, as true to all laboratories in general, the quality and relevance of research are difficult to measure quantitatively and accurately. A recent National Research Council study of Air Force laboratories reached the same conclusion (National Research Council, 1993). Like the Air Force, ARL measures R&D through peer reviews and performance indicators (Gendason and Brown, 1993). Output measures, such as the numbers of refereed papers or patents per scientist, are easily determined, but may not properly reflect all the efforts and accomplishments of the laboratory's

[3] The purpose of these wargames is more to discuss materiel and doctrinal options, rather than move simulated combat forces on maps, computers, or physical terrain.

scientists and engineers (e.g., the scientist who would rather conduct research than write, or the software engineer who may find it impossible to get a patent). In addition, although less of a problem for the bulk of basic research, measures of recognition (i.e., honors, peer recognitions, and awards from professional and learned societies) can be distorted by the classified nature of military research. Another possible output measure is the transition of given technologies to further development or application, yet, this again can be a deceiving metric as the origin of the technology that finally makes up a weapon system may be obscure. Input measures, such as the numbers of Ph.D.s from highly regarded graduate programs and the state of equipment and facilities, are more convincing, albeit less reliable, measures. To date, the Army laboratories are only beginning to measure the quality of their work, and have not developed enough data to validate their measurements against nationally recognized world-class laboratories (Department of the Army, 1992). Thus, in reviewing ARL's ability to conduct world-class research, this committee relied heavily on judgments of input criteria: management, personnel statistics, administrative practices, and funding.

ARL has some broad areas of excellence. Some elements of its directorates have the ability to conduct world-class research in areas that are uniquely tied to the Army. Many ARL scientists and engineers, for example, presented outstanding summaries of their research projects at the 18th Army Science Conference in June 1992 (Kamely et al., 1993). ARL excels in the use of simulation and modeling that can predict the performance of new components and systems. Using high-performance computing, ARL pursues radical new concepts in projectile design, gun propulsion, armor technology, and novel weapons. Its evaluations of man-machine interfaces in proposed equipment designs are also excellent. It uses simulation to conduct comprehensive and accurate analyses of developmental systems without costly large-scale experimentation such as live-fire testing (Taulbee, 1993). It has been responsible for the basic research underlying night vision systems and has made major contributions through this research to the Army's night warfare capabilities. Much other excellent R&D goes unrecognized because it is classified.

But ARL still does not have the reputation enjoyed by some government laboratories like the Naval Research Laboratory and the National Institute of Standards and Technology. The committee believes that the conditions for maintaining consistent excellence have not yet been fully established. As experienced by many government laboratories and engineering centers, ARL suffers undue constraints on management, restrictions on hiring and promotion, unresponsive procurement systems, and reductions in personnel and funding. Unless corrected directly with administrative changes or indirectly with an organizational or management structure change (e.g., a

GOCO laboratory), these and other conditions will prevent ARL from achieving, let alone maintaining, world-class status.

The Director, Senior Leadership, and Staff

The quality of research in ARL depends primarily both on capable managers and supervisors and on talented and experienced senior scientists and engineers, who stand outside the management chain but guide and inspire younger colleagues. Yet, in personnel management, ARL is highly constrained. Salaries are uncompetitive.[4] Managers have little local authority to hire, reward, and fire personnel. There are rigid limits on the numbers of high grades and total personnel. The process of approval for hiring scientists and engineers and senior managers is cumbersome and slow, and requires many months and layers of approvals. Promotions, merit-based pay raises, and firings are limited (see Chapter 7 and Appendix D). Many personnel reforms permitted by the Federal Employee Pay Comparability Act of 1990 and the Civil Service Reform Act of 1978 have not yet been implemented (Army Laboratory Command, 1991). In order to assert its world-class status, ARL needs the administrative flexibility to hire and reward the best possible technical personnel, from the director to the bench level.

The Director. As an implementation of the Lab 21 study, the directorship of ARL changed from a two-star general officer to a civilian Senior Executive Service (SES) position with a protocol rank of a two-star general. The decision to have a civilian director was wise. Since military commanders typically rotate in and out of their assignments within two years, a civilian director brings stability. A civilian also has the potential to have much more technical experience, at the bench and in directing research, than the typical Army general officer.

Senior Technical Leadership. ARL has 26 other general officer equivalent civilian positions—19 SES and 7 Scientist-Technologist positions.[5] These

[4] The average salary per ARL scientist and engineer was found to be $52,700 as opposed to the average GOCO scientist and engineer salary of $70,000 (see Chapter 7 and Appendix D). In addition to differences in averages, the GOCOs also have a much wider pay band available at equivalent grade levels.

[5] An SES is a senior manager, while a Scientist-Technologist is an SES equivalent, nonsupervisory, technical person (senior researcher).

positions are difficult to fill with qualified research and development personnel. Approval by AMC, Department of the Army, Office of the Secretary of Defense, and Office of Personnel Management takes at least nine months. (At the time of this report, there were 6 SES positions unfilled [3 since October 1, 1992]. Concern over downsizing the Army and anticipation of a larger than usual number of SES retirements in 1994 has drastically slowed down the system [Kirby, 1994].)[6]

The next level of supervisors and senior researchers are also difficult to recruit or promote because of hiring freezes and imposed limits on the numbers of GS-13s, 14s, and 15s allowed in ARL. All Army organizations have similar limitations which can be attributed to downsizing and reduced funds. However, an organization primarily oriented toward R&D needs a high proportion of experienced Ph.D. and M.S. scientists and engineers in grades GS-13 and above. This ideal condition is not the case in ARL, as it is within the Naval Research Laboratory (see Figure 2-1). ARL is thereby prevented from recruiting experienced scientists and engineers, and from promoting capable scientists and engineers from within. These current restrictions have the further negative impact of encouraging talented young scientists and engineers in ARL who realize that promotion above GS-12 is unlikely to seek employment elsewhere.

Scientists and Engineers. ARL employs about 3,600 people, half of them scientists and engineers; about 400 of the scientists and engineers hold Ph.D.s. By fiscal year 1997, employment is projected to drop to about 3,100 people. At that time, ARL hopes to increase its number of Ph.D. scientists and engineers to 800 (40 percent of the total scientists and engineers). The current distribution of Ph.D.s in ARL's directorates is described in Figure 2-2.

ARL is not as well endowed with Ph.D.s as some well regarded federal laboratories. Even if it can double its current number of Ph.D. scientists and engineers by fiscal year 1997, it still will not match the current 47 percent at both NIST and the Naval Research Laboratory. With the current freeze, the most recent proposed reductions in Table 2-1, and other restrictive personnel policies, it is not clear how, by 1997, ARL will fulfill its goal of increasing the number of Ph.D. scientists and engineers to 800.

The Naval Research Laboratory credits its high levels of Ph.D.s to its innovative personnel office (which is highly sensitive to the special needs of

[6] The large SES pay raise in 1991 encouraged SESs to stay in service until 1994 in order to maximize retirement pay, since it is based on a percentage of the average of the last three years of salaries. The committee could see no apparent reason for this to slow down the system unless the elimination of positions will be somewhat dependent on which SES positions are vacated from retirements.

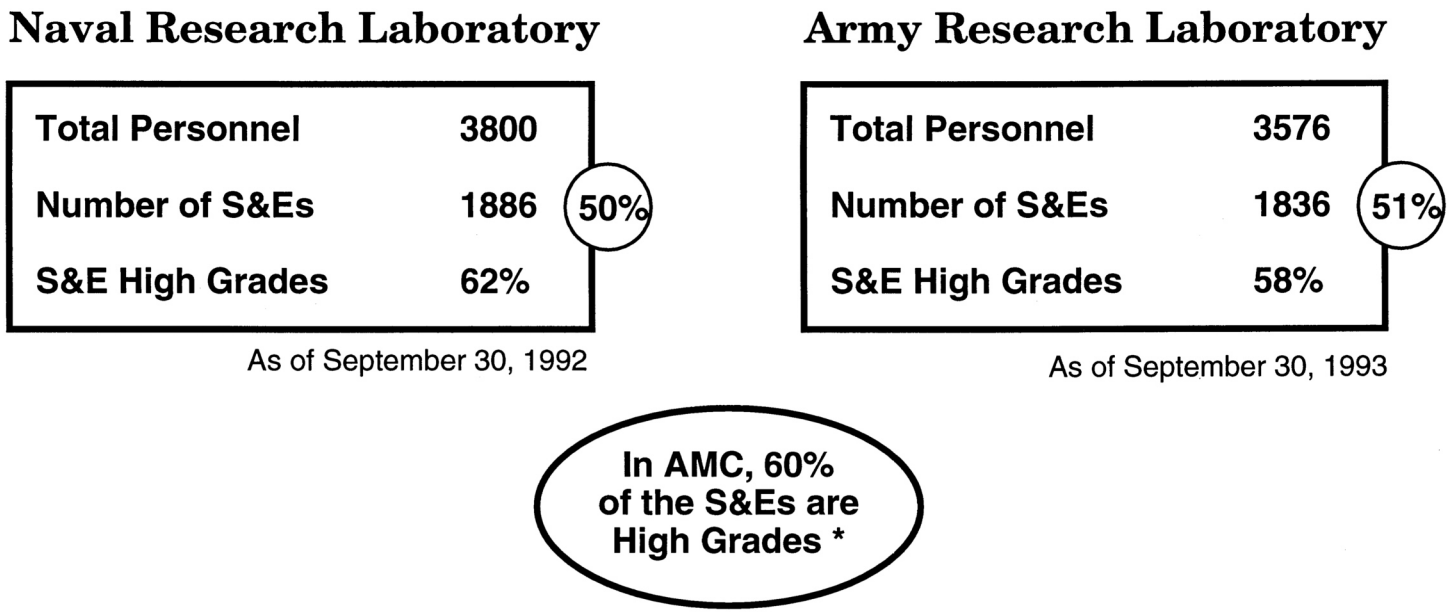


FIGURE 2-1 Personnel: the Naval Research Laboratory versus the Army Research Laboratory.
Source: Data from the Army Research Laboratory.

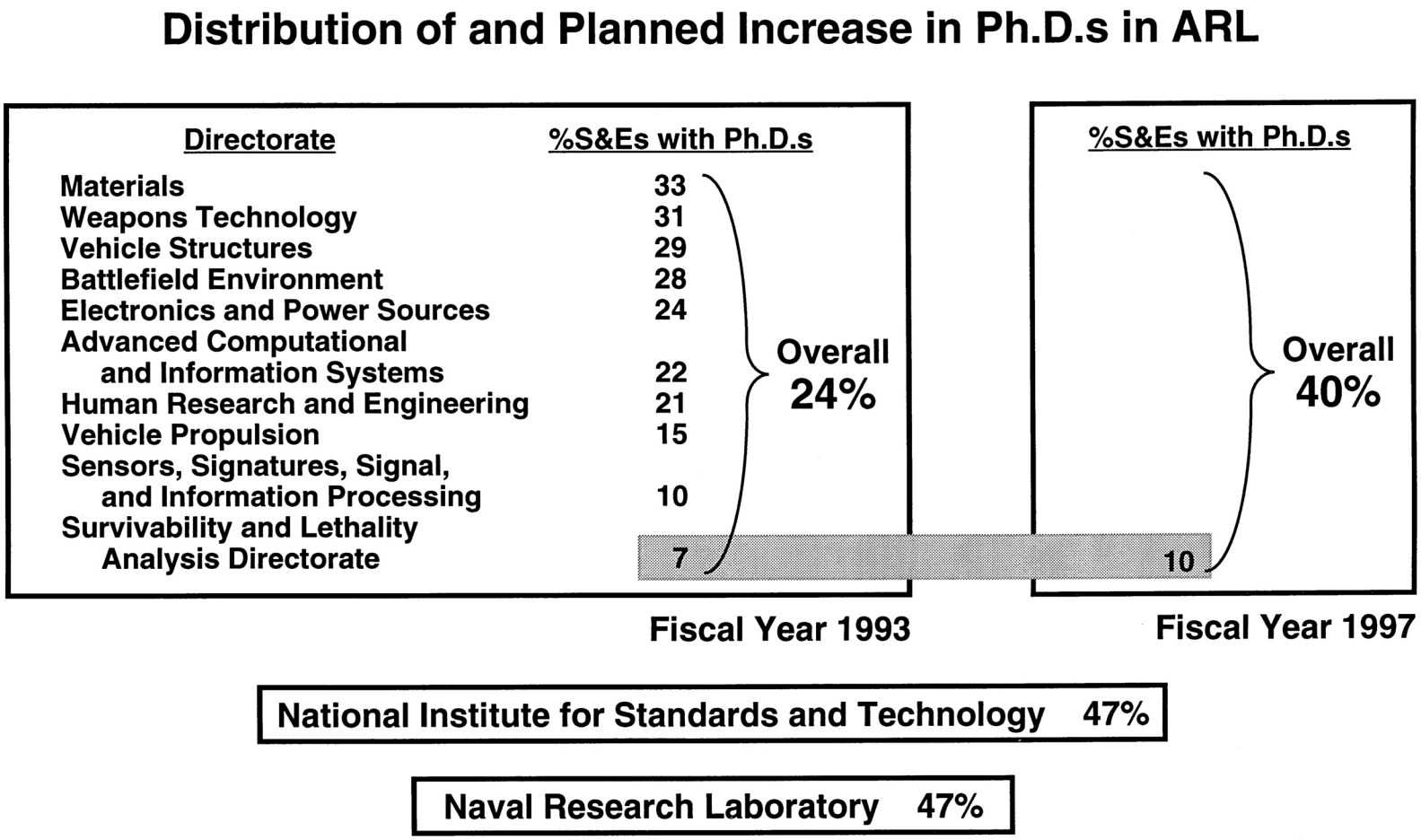


FIGURE 2-2 Distribution of Ph.D.s in ARL's directorates,
Source: Army Research Laboratory.

TABLE 2-1 Army and AMC Proposal for Distributing Research, Development, Test and Evaluation Personnel Reductions, By Agency. Source: Prather, 1993.

Proposed New AMC Program Budgetary Guidance (Research, Development, Test & Evaluation Spaces)	Fiscal Year 1994	Fiscal Year 1995	Fiscal Year 1996	Fiscal Year 1997	Fiscal Year 1998	Fiscal Year 1999	Percent Loss Fiscal Years 1994–1999
AMCCOM	3,709	3,299	3,299	3,299	2,969	2,756	25.7
ATCOM	1,826	1,619	1,619	1,619	1,513	1,445	20.9
CBDCOM	1,223	1,083	1,083	1,083	1,012	966	21.0
CECOM	1,429	1,366	1,366	1,366	1,351	1,267	11.3
MICOM	1,603	1,406	1,406	1,406	1,390	1,304	18.7
STRICOM	250	250	250	250	250	250	0.0
TACOM	403	403	403	403	399	385	4.5
TECOM	6,691	6,638	6,522	6,445	6,181	5,996	10.4
ARL	3,496	2,961	2,932	2,847	2,819	2,678	23.4
AMSAA	328	280	276	276	275	275	16.2

NOTE: U.S. Army Agency in AMC
AMCCOM Armament, Munitions, and Chemical Command
ATCOM Aviation and Troop Command
CBDCOM Chemical and Biological Defense Command
CECOM Communications-Electronics Command
MICOM Missile Command
STRICOM Simulation, training and Instrumentation Command
TACOM Tank-Automotive Command
TECOM Test and Evaluation Command
AMSAA Army Materiel Systems Analysis Agency

the Naval Research Laboratory and has implemented many of the Defense Laboratory Demonstration [Lab Demo] initiatives), to its concern for the professional morale of its scientists and engineers (e.g., permitting them to control their own programs as they progress from basic research on through engineering development), and to its long-term reputation of excellence. Additionally, the Naval Research Laboratory augments its pool of government Ph.D.s through the use of the Inter-government Personnel Act which authorizes salary payments to universities and industry for visiting researchers, whose appointments are not to exceed one year (Tolles, 1994).

Acquiring Highly Qualified Scientists and Engineers. One approach for ARL to upgrade current education levels in its workforce is to enroll its scientists and engineers in advanced degree programs. The Army provides its civilian employees a variety of opportunities for relatively short-term training (ranging from several weeks to a year), which lend themselves to the pursuit of master's degrees. But it has been forbidden by law (Public Law 101-510) to support full-time study leading to degrees, and therefore cannot generally support doctoral studies. However, exceptions have been provided since May 1992, with the issue of the Office of Personnel Management Bulletin 410-132. If a shortage of qualified personnel can be shown to exist, an agency may support full-time doctoral or other studies. AMC is exploring this option for ARL and the RDECs.

Another approach is recruitment, however, the Army must take into account the quality of scientists and engineers being recruited. The most qualified candidates available to ARL, considering limitations in hiring, paying, and rewarding technical personnel, may not be of world-class quality. AMC recognizes this problem and has taken actions to attract highly qualified scientists and engineers, but AMC's hiring freeze and the Army's mandated personnel and budget cuts have limited the success of innovative recruitment efforts.

An AMC-wide hiring freeze over the past two years has prevented ARL from hiring the young scientists and engineers that might bring the knowledge and the quality that ARL needs. ARL (and its predecessors in the Laboratory Command) hired only 45 people in fiscal year 1992 (9 of them scientists and engineers) and 7 people in 1993 (none of whom were scientists or engineers).

There is merit in the saying that quality begets quality. The reputation of ARL's R&D efforts (and of Army laboratories in general) is not considered comparable with that of the Naval Research Laboratory, NIST, or of many of the world-class laboratories in industry or academia. The committee believes that this less favorable reputation also hinders ARL's ability to attract promising young researchers from excellent graduate programs. The current ARL efforts to publicize research accomplishments, sponsor seminars and

workshops, participate in science conferences, and promote a public relations program should help build its reputation.

Personnel Management. Despite the overwhelming need to improve the technical makeup of its workforce, ARL is highly restricted in its current management of personnel. Limitations on competitive salaries and promotions and shortcomings in the current hiring and firing policies persist in ARL, despite initiatives from DOD acquisition officials to implement the Defense Lab Demo program of reforms,[7] that would streamline personnel and procurement procedures and generally give managers greater discretion and accountability (Atwood, 1989; U.S. Congress, Office of Technology Assessment, 1989). The Lab Demo initiatives could be carried out by administrative fiat, within the letter of the regulations of the Office of Personnel Management and the Federal Acquisition Regulation. The reasons why the Lab Demo initiatives have not been fully implemented at ARL could not be determined by the committee.

In addition, the committee believes that some of the personnel management decisions of the Defense Management Review Decisions will make a bad situation worse. Defense Management Review Decisions are a current DOD initiative to regionally consolidate support functions such as maintenance, finance, and personnel. For R&D organizations, some of these moves may degrade the local decision authority necessary to exploit opportunities and respond rapidly to new needs. Intended to improve efficiency, they have the perverse effect of robbing ARL of flexibility in assigning personnel. For example, the proposed Defense Management Review Decision 974 for consolidating personnel administration, authorized by AMC in the draft Civilian Personnel Consolidation Mandate 93-01 (dated July 19, 1993), will hamper ARL's recruiting by preventing timely offers to qualified scientists and engineers and by reducing the influence of the Director in personnel decisions. In general, it might reduce ARL's ability to establish innovative personnel policies suited to its own needs; for example, ARL might want to enhance or tailor the performance reviews of its scientists and engineers, but the regional personnel office might want standard performance review evaluations.

Impacts of Personnel Cuts. Personnel reductions, caused by downsizing, significantly constrain ARL's efforts to improve the quality of its workforce. ARL cannot set its own personnel levels to meet its budget and work

[7] These initiatives are described more fully in Chapter 3, as part of the description of the ARL Enhanced option.

requirements. Like most other federal organizations, its personnel numbers are set by higher headquarters, in this case by the Army and AMC.

Current plans call for additional cuts, with the burden falling heavily on ARL. Table 2-1 shows the Army's and AMC's most recent proposal for distributing Army-mandated job cuts among ARL and other research, development, test, and evaluation organizations. ARL may be forced to use a *reduction in force* to reach the fiscal year 1995 allocation of 2,961.

The committee believes that ARL's cuts are based on Army program guidance and recently proposed budgets. ARL's proposed budget available to this committee more closely supports the new 1997 figure of 2,847 (assuming the Army intends to implement its plan to contract out 30 percent of the ARL budget).[8] A rationale could not be determined for the wide variance in percentages of cuts in AMC commands.

Additionally, President Clinton's Executive Order 12839, dated February 10, 1993, required each agency to reduce its workforce by 4 percent, with at least 10 percent of those cut at grade 14 or higher. ARL has not received any relief from bearing its *proportional share* of these cuts, along with acquisition and logistics organizations.

Procurement Practices

The committee believes that, in general, as one moves away from government practices and toward those of private industry, contracting and procurement become more efficient. Sluggish procurement practices, for even a seemingly simple item, slow down research progress and hurt staff morale. In some cases a less than desirable item is delivered, as a result of adherence to regulations governing bidder selection. The Competition in Contracting Act is frequently applied in ways that result in time-consuming competitions for procurements over certain threshold values. According to policy, the Director of ARL, as Head Contracting Authority, may approve *sole source* contracts for up to $10 million. However, in practice, the Director must justify such decisions to both Army contracting officials and Congress, sometimes causing the process to become as tedious as full and open competition (Holmes, 1993). At the Branch Chief level, sole source procurement is allowed only for items under $25,000, insufficient when compared to the cost of high-tech laboratory equipment (Holmes, 1993). Purchases of greater than $25,000 normally take more than three months to complete (National Performance

[8] The committee was initially briefed with a 1997 personnel strength of 3,100 for ARL. Based on proposed budgets, personnel salaries, and overhead, this figure would restrict ARL to contracting out only about 20 percent of its budget. Thus, the committee used 20 percent in its calculations (see Chapter 7 and Appendix D).

Review, 1993). The General Services Administration's supply schedule limits managers in what they can buy and how much they must pay. The entire system is not designed to support one-of-a-kind and rapidly changing research projects.

Many of these problems would be substantially reduced by implementing the Lab Demo initiatives, thus simplifying procurement and generally increasing the decision-making authority of laboratory managers (see Chapter 3). This is evidenced by some of the Lab Demo procurement reforms that ARL has managed to implement. For example, the procurement of low-value items has been streamlined in some laboratories by using commercial credit cards with spending limits of $2,500 up to, in some cases, $10,000. A few laboratory managers are permitted to set their own level of bench supplies. These practices represent a formative start, but they should be exploited fully.

Funding

Indicative of the defense budget as a whole, ARL's funding for research, development, test and evaluation has declined from about $368 million in fiscal year 1993 to about $316 million in fiscal year 1994.[9] However, the budget is expected to stabilize at about this level through fiscal year 1997, despite further reductions expected in the Army's research, development, and acquisition budgets. These figures reflect the tension between the declining budgets and the Army's policy of trying to protect the technology base.

The Army's Flagship Technology Base Laboratory. The mission and program emphases of the Army Research Laboratory were largely developed in the Army's Lab 21 study (Department of the Army, 1991). To establish ARL as the flagship technology base laboratory for Army materiel, Lab 21 established institutional funds for ARL's core research mission. The customers for the output of this institutionally funded research were to be primarily the RDECs (Army Research Laboratory, 1993a).

However, the funding in support of the flagship laboratory did not materialize as it was envisioned. Figure 2-3 shows a graph (top) used to illustrate the Lab 21 *vision* for ARL in 1991 (Department of the Army, 1991).

[9] The reduction includes about $13 million for basic research (6.1) and exploratory development (6.2), almost all ($38 million of $40 million) of nonsystem-specific advanced development (6.3A) funding, and about $7 million for mission (analytical) support (6.5). The decline in 6.3A was expected as part of ARL's reorganization. Along with these reductions there is an increase of about $5 million for operational systems development (6.7) in support of technology insertions into existing systems. Table D-5 provides more details on funding data.

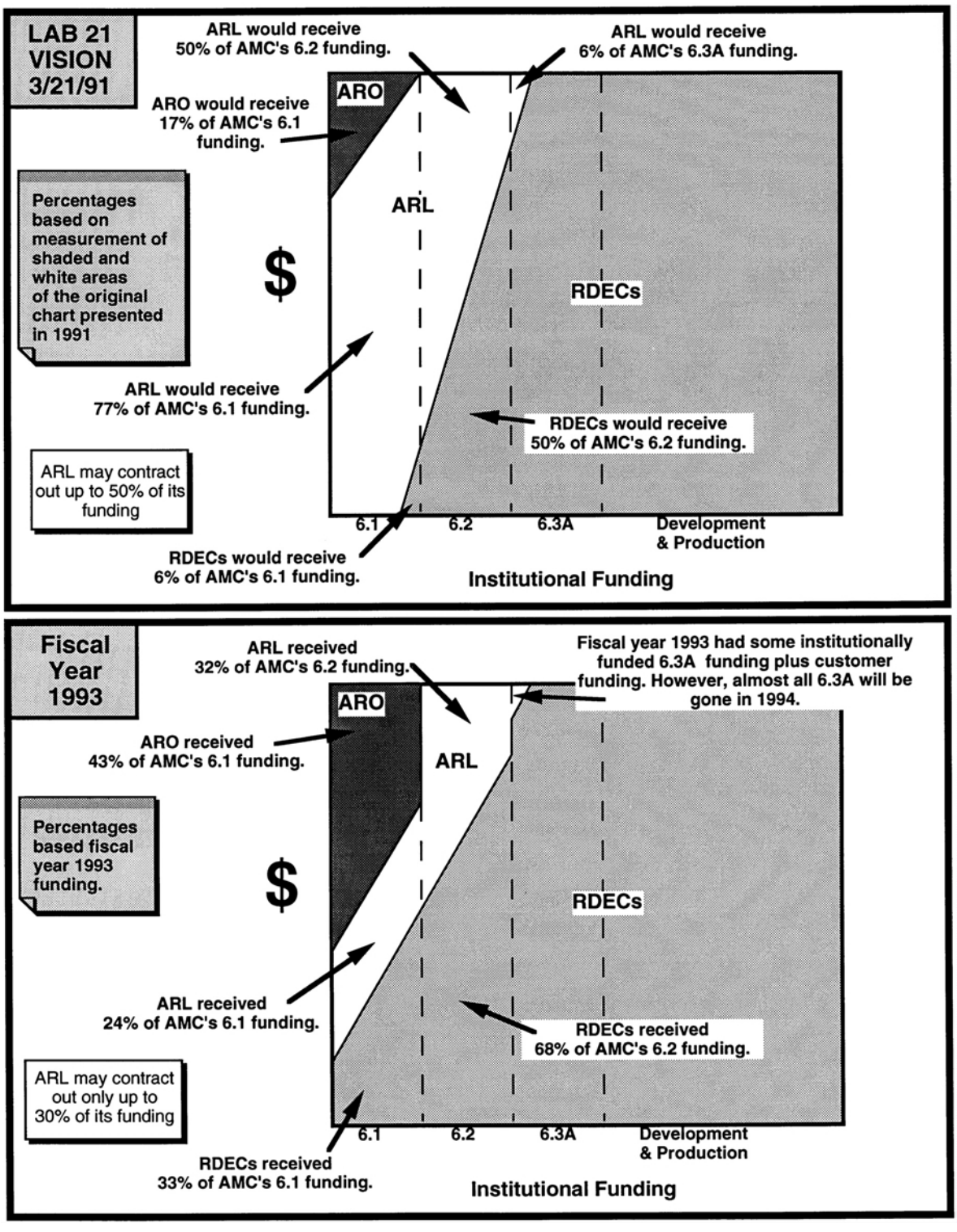


FIGURE 2-3 ARL funding: fiscal year 1991 vision versus fiscal year 1993 reality. Sources: Data from the ASA(RDA) Lab 21 Vision Briefing, 1991, and Table 2-2.

While this graph was only notional and was not intended to convey precise funding quantities, it can be considered a reflection of ARL's intended role.

The corresponding graph in the bottom half of the figure shows the actual distribution of funds in fiscal year 1993. ARL's actual percentage (white area) of 6.1 and 6.2 funding in AMC is much smaller in fiscal year 1993 than the Lab 21 vision. ARL today receives only 16 percent of the Army's 6.1 funding total, and 24 percent of its 6.2 funds (Table 2-2) for a total of 22 percent of the Army's science and technology funds. (The Naval Research Laboratory operates with 34 percent of similar funds in the Navy, but also receives advanced engineering, development, and procurement funds [Singley, 1993].) ARL does not dominate either category of funds in the Army, and its limits for contracting out research have been reduced from 50 to 30 percent. This pattern raises committee concerns that the Army may have failed to provide ARL with the resources and flexibility needed to carry out its intended mission of promoting the development of the technology base for future systems. Additionally, this change in funding does not support the Army's science and technology strategy to improve efficiency by stabilizing science and technology funding (Department of the Army, 1992).

TABLE 2-2 Technology Base (6.1 and 6.2) Funding (Fiscal Year 1993)

	6.1 (millions)	AMC/Army (percent)	6.2 (millions)	AMC/Army (percent)
Army Research Office	56.8	43/29	0	0
Army Research Laboratory	32.3	24/16	170.2	32/24
AMC Research, Development and Engineering Centers	43.1	33/22	354.3	68/49
AMC Total	**132.2**	/67	**524.5**	/73
Army Research Institute for Behavioral Sciences	3.7	/02	13.6	/02
The Surgeon General	49.7	/25	91.2	/13
The Corps of Engineers	10.9	/06	78.2	/11
Program Executive Office for Intelligence and Electronic Warfare		0	9.4	/01
Total Army	**196.5**		**716.9**	

At current funding levels, ARL must compete with the RDECs—its own customers—for funds from other services, the Advanced Research Projects Agency, program executive offices, and program managers to make up for institutional funding shortfalls. In fiscal year 1993, ARL received $50 million from program executive officers and program managers and $32 million from other Army and DOD agencies, as well as only $28.1 million direct from the RDECs.

Too Broad a Research Program. With a $200 million institutionally funded R&D budget, can ARL support world-class research in 10 broad business areas? Most likely not. The committee's collective experience suggests that at least $40 to $50 million per year is needed to support an adequate R&D program in each technology area (i.e., business area). As a comparison, the Advanced Research Projects Agency has spent about $100 million per year on its Armor/Anti-Armor program (mostly with 6.2 funding and some advanced development [6.3] funding). In comparable technology areas, the Advanced Research Projects Agency averages about $120 to $140 million per year in its advanced materials research programs (6.1 and 6.2 funding) (Richardson, 1993). While based on 1993 expenses, ARL's Materials Directorate will probably receive about $13 million (6.5 percent) of ARL's institutional 6.1 and 6.2 funds.

ARL's broad research program is a result of its broadly-stated ARL mission statement with its associated business areas and core competencies derived from historical areas of emphasis. Although ARL's mission statement can be used to justify nearly any conceivable technical effort undertaken, it doesn't have the funding to support such efforts (Army Research Laboratory, 1993a). In addition, its mission does not separate ARL responsibilities from those of the RDECs, and allows for possible unnecessary overlap and duplication. Some may agree that overlap and duplication may increase the probability of finding a breakthrough in research. However, at a time when funding shortfalls necessitate the use of cooperative agreements and other cost-saving research efforts, overlap and duplication are an unnecessary drain on funds.

Quality of Research Facilities

The Defense Base Closure and Realignment Commission (1991) directed that parts of ARL be physically moved to consolidate its operations (see Chapter 1). This decision required funding for new facilities in Maryland, at Aberdeen Proving Ground and Adelphi. The Commission allocated about $400 million in fiscal years 1991–1997 for the construction of materials and

electronics laboratory facilities and the relocation of personnel and equipment into these facilities. The new facilities will provide the modern infrastructure required of world-class laboratories.

However, funds for repair, maintenance, and operation of existing and new facilities are insufficient. For example, $25.6 million have been programmed for fiscal year 1997, which is $20.2 million less than what ARL estimates is required (ARL Fiscal Year 1996-10 Long Range Research, Development and Acquisition Plan for Base Operations). The committee has no way of judging the accuracy of ARL's maintenance estimates, but such a discrepancy suggests that ARL in the future may be hindered from making significant changes to facilities to support new research thrusts or changes in emerging technologies.

Reporting Channel and Status

The committee believes that to some degree, the status of an organization influences the perception of its ability to conduct world-class research. A laboratory's status may be enhanced by external agencies' views of how important that laboratory and its efforts are to its parent organization. That perception can be influenced by its governance mechanisms, including its reporting channel. As a nationally recognized laboratory, the Naval Research Laboratory's importance to the Navy's research program is reinforced by its reporting channel to the Chief of Naval Research, who in turn reports directly to the Assistant Secretary of the Navy for Research, Development and Acquisition. NIST enjoys similar importance in the Department of Commerce and within the government. It reports to the Under Secretary of Commerce for Technology, an arrangement that ensures high-level support. The perception of ARL by industry, academia, and other government research and development organizations may not be equivalent, since its reporting channel is not directly to the Army's research and technology leadership, the ASA(RDA).

In the discussion of this criterion, the committee has identified several problems in ARL in personnel management, contracting, procurement, and funding (research, development, and facility maintenance). The committee also concludes that ARL has too broad a research program for available resources. In this context, it is difficult to see ARL, however well managed, as a successful world-class laboratory even though some world-class research may be conducted in it. Additionally, the committee believes that its current reporting channel does not hold the same status as other government world-class laboratories.

Diversity and Quality of Research Sources

The Army's technology base is a moving target. ARL must be agile enough to exploit the best sources of research and technology, inside or outside the government, at any given time. ARL should cultivate a diverse and flexible network of contacts and partnerships with industry, academic researchers, and other government laboratories, rather than attempting to cover all of the Army's technology needs itself. It should concentrate its internal resources in areas of technology where it has unique strengths, or where it alone can meet an emerging Army need.

Restrictions Imposed by the Army. The Army has required that all of ARL's basic research (6.1) be conducted internally. In comparison, ARO is responsible for buying basic research from universities. The RDECs may buy basic research from industry or from ARL. For exploratory development (6.2), ARL is somewhat less limited, but it cannot contract out more than 30 percent of its work. Such restrictions were established to maintain an internal capability to conduct basic research and exploratory development, but do not provide ARL the flexibility to provide its customers the best research and technology available internally or externally.

Restrictions Due to DOD Contracting Mechanisms. Responsive contracting mechanisms are essential to effective R&D. Yet, DOD persists in using traditional procurement contracts—suitable for purchases of aircraft, rations, or hand grenades—in buying research and development. These highly regulated contracts, which often require layers of approval and have inflexible contract terms, degrade ARL's ability to buy from a diversity of sources, especially commercial ones, in a timely way. The tedious process for establishing and implementing such contracts not only slows progress, but also limits diversity and quality by discouraging many potential sources from participating. Once a contract is signed, changes in its deliverables are slow, cumbersome, and expensive to obtain which prohibits ARL from quickly altering the focus of the research to meet changing needs.

ARL, for these reasons, must depend on internal expertise for quick responses or for projects that require changes in research focus. This dependence may be a reason for ARL's broad and overambitious program of 10 business areas. By relieving these contracting limits, the Army could allow ARL to focus its program on its own areas of greatest expertise, while contracting for, or otherwise acquiring, the best research and technology from the outside for other areas.

DOD has had full statutory authority for several years to establish cooperative agreements—a form of contract widely used by other federal agencies to support research and development—and has not used that authority except in the Advanced Research Projects Agency. Successful purchases of research and development often involve interactions between the government and the contractor that are unavailable in the standard DOD procurement contract, but to which cooperative agreements lend themselves.

Technology Transfer to the Army

ARL must be able to identify potentially useful technologies, develop them, and transfer the results through the various stages to ultimate practical use. These are key considerations in evaluating ARL and the plans for its management and governance.

Normally, ARL does not transfer technology directly to users, but instead transfers its technologies to the RDECs, who complete the transfer to the Program Managers and Program Executive Officers (the managers for the development and acquisition of hardware and software systems). Technology transfer is promoted in a number of ways:

- As explained earlier in this chapter, ARL and the RDECs establish Technology Program Annexes, which define the responsibilities of an ARL directorate and an RDEC in a specific joint research project and provides a specified *transition point* of project leadership.
- ARL is responsible for 38 of the Army's 200 Science and Technology Objectives: agreements to make defined major technology advances within a given time schedule (Department of the Army, 1992). Science and technology objectives are developed by both the materiel and combat development communities. Fixed transition points from ARL to an RDEC are set on time lines, and funding is programmed to support the transferred effort.
- ARL held an ARL Technology Opportunities Conference in October 1992, which brought together 600 bench-level ARL scientists and engineers, RDEC personnel, and representatives of TRADOC's battle labs for discussions of technologies and user needs.

ARL's linkages and ability to transfer technology directly to the RDECs are made easier by its reporting channel to AMC. A change in ARL's reporting channel outside of AMC could inhibit direct linkages to the RDECs. Technology transfer to the RDECs would become a greater challenge, but with care and attention, this challenge could be met. The committee also believes, however, that the anticipated enhancements in the quality of ARL's

research and development efforts will partially compensate for the weakened ties between ARL and the RDECs.

The Importance of an Integrated Approach to Technology Development

With research, development, and acquisition resources decreasing in the Army, there is a steadily increasing need to integrate the process of technology development to assure that particular technologies are supported from cradle to grave. ARL cannot do this alone, since it is limited to basic research (6.1) and exploratory development (6.2), and does not have direct contact with program managers who apply technologies in systems and report through program executive officers to the ASA(RDA).

The RDECs, on the other hand, are able to conduct basic research, exploratory development, nonsystem-specific and system-specific advanced development (6.3A and 6.3B), and engineering development (6.4). Technology transfer thus should occur more easily within the RDECs than from ARL to the RDECs. An interactive relationship with the RDECs is therefore critical for ARL if it is to see its technologies applied to systems. The experience of the committee has shown that the best way to transfer technology is through personal interactions—in fact, by transferring people from one organization to another.

While the Technology Program Annexes are the key means of forming these partnerships, they account for only half of ARL's program. Other than the AMC Board of Directors and the guidance of the ASA(RDA)'s Science and Technology Master Plan, there is no continuous overall management of the R&D activities of ARL, ARO, and the RDECs. While it is beyond the charter of this study to recommend the initiation of a program of overall management, the Army should consider this possibility, perhaps in the form of a single Army research and development laboratory integrating all of the R&D organizations currently under the supervision of AMC. This would certainly ease the technology transfer among the current three AMC organizations—ARO, ARL, and the RDECs—and to system program managers, as well as avoid duplication and unnecessary competitions for funds.

A New Model of Technology Transfer

The Defense Department's longstanding policy of funding research sequentially, from basic research (6.1) up to engineering development (6.4), and finally to production and use, with different agencies involved at different points along the way, leads to a large number of technology transfers. These

transfers are difficult when they take place among separate entities such as ARL, the RDECs, and system program managers.

Industry and many government agencies have found this sequential approach to technology transfer too slow, too uncertain, and too unlikely to meet the real needs of users. They have substituted a *nonlinear* or *systems* approach to guide the work and facilitate technology transfer. Each stage from concept to production and marketing is guided by the needs of all the other stages and is highly interactive (rather than sequential). Figure 2-4, adapted from a presentation by the Xerox Corporation, provides one way of visualizing this process. This figure basically shows a matrix-type organization that requires the teamwork of all parties (including teams or individuals who stay with particular projects through at least several stages), highly increased interaction, considerable flexibility, and outstanding corporate management for its successful implementation.

The best illustrations of this approach among the federal laboratories are probably the nuclear weapons programs of the U.S. Department of Energy, as well as the R&D teams at NIST, the China Lake facility of the Naval Air Warfare Center, and the Naval Research Laboratory. At these laboratories, projects are followed beyond the research phase, through development, and sometimes all the way to production; they are not constrained in scope as is ARL (to 6.1 and 6.2 work). In addition, such an approach was possible at one of ARL's predecessor organizations, Harry Diamond Laboratories. The team that developed the fuse for the Patriot air defense missile's new antitheater ballistic missile capability, in the buildup to Operation Desert Storm, was able to continue its involvement through the war, perfect the fuse, and get it to production for use in limited numbers against Iraqi Scud missiles. The team was able to do this only because in war the bureaucratic lines break down.

Such issues arise more clearly in considering joint ventures or other types of projects with outside entities, whether with industrial companies or other DOD or federal activities. The “transfer point” as determined by ARL's current scope may be impractical, because it lacks the essential element of flexibility and concurrency. Should industrial joint ventures be with ARL and an RDEC, with one or the other having the overall responsibility? Such arrangements would seem unwieldy, but could be a consequence of the present organizational responsibilities.

This difference in approach and the limitations on ARL's scope have significantly influenced ARL's management, governance, and integration with military and industrial R&D. In considering ARL's current governance, the Commander of AMC may be reluctant to allow ARL to venture into technology areas beyond the 6.2 (exploratory development) funding level and possibly infringe on the mission and efforts of one of his RDECs.

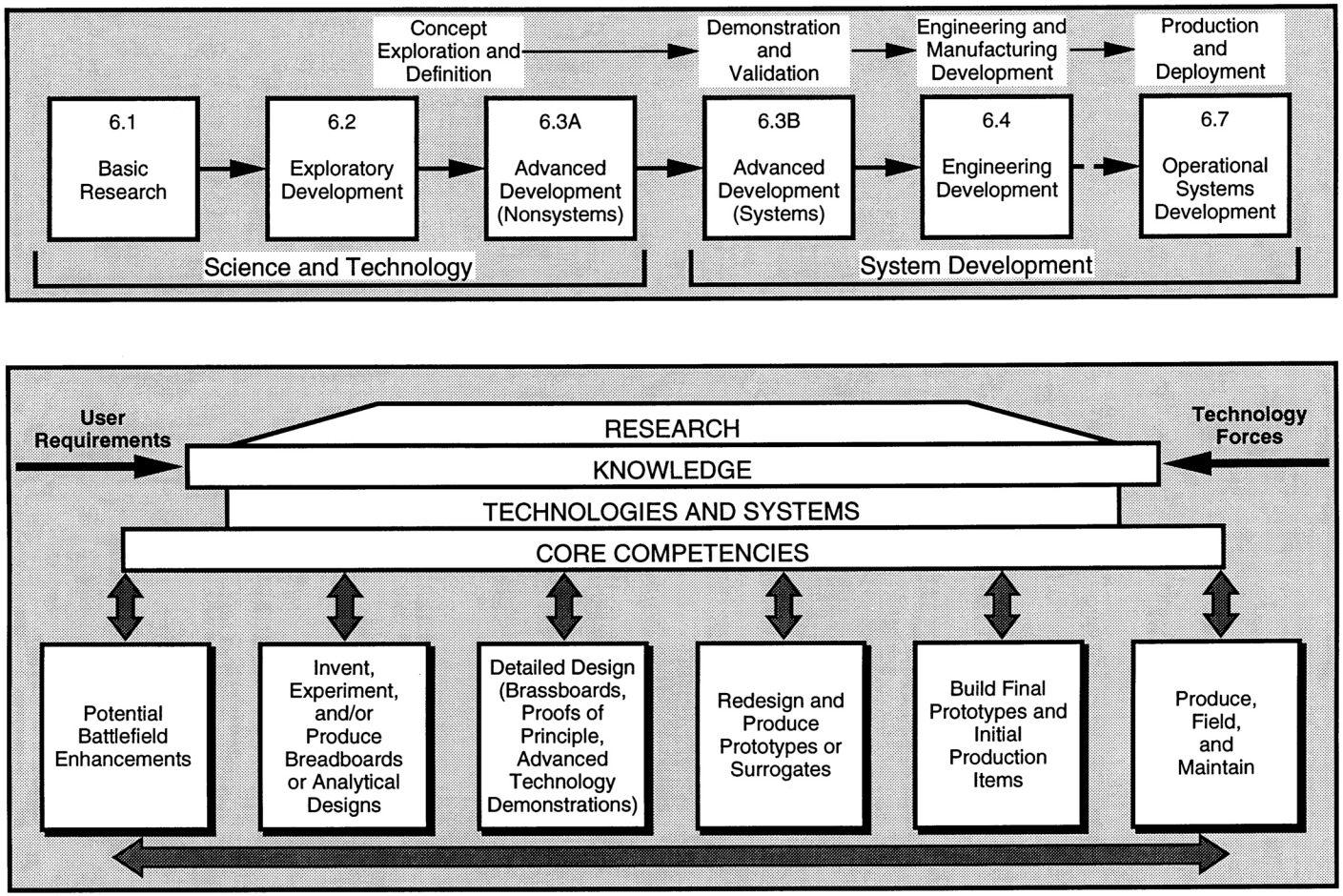


FIGURE 2-4 Comparison of the linear research and development model used in the Department of Defense acquisition process (top) with the interactive model now commonplace in industry and gaining acceptance in some government agencies (bottom). The illustration of the interactive model is adapted from a presentation on the Xerox Corporation's *Total Process Innovation* system, which includes much more interaction and teamwork throughout.

Ability to Leverage Funds and Programs

The Army is not self-sufficient with regard to technology. The Army's technology base investment is about $12 billion. The nation as a whole spends about $150 billion on research and development. ARL must capitalize on these external sources of technology. By strategic spending on these sources of technology, military laboratories can share the costs of technology with commercial firms and other government agencies, thus *leveraging* its funds through joint ventures and cooperative research and development. ARL's success in this area so far has been limited.

Technology from the Private Sector

In many vital fields, such as electronics, commercial firms have produced technology that is more advanced and more cost-effective than its counterparts in government laboratories. It is necessary to exploit these sources of so-called “dual-use” technology to the extent possible, through small research contracts and other interactions that increase the payoff to the Army from relatively small investments. The term “spin-on,” a play on the familiar expression “spin-off,” is used to describe this process.

ARL is always seeking partnerships of this kind. However, any leverage the government may have is limited by the DOD's insistence on using procurement contracts for research and development, rather than the more flexible cooperative agreement form, which permits real partnership in discussing aims and products. Neither party to a typical R&D contract is likely to be satisfied, and the administrative burdens are great.

As a means to resolve this issue, the Federal Technology Transfer Act of 1986 allowed for the establishment of the cooperative research and development agreement (CRADA), a contractual form created to foster technology transfer from the federal domain to the private sector. The cooperating organization (which may be a firm, a university, a nonprofit R&D organization, another federal laboratory, or a state agency) provides personnel, equipment, or financing for R&D activities that complement a federal laboratory's mission. The federal laboratory can grant these collaborating parties patent licenses or assignments in inventions made by federal employees under the agreements; and permit federal employees or former employees to participate in commercializing any resulting inventions. The federal partner receives a royalty-free, nonexclusive license to any copyrights or inventions. CRADAs are no substitute for adequate research contracting procedures. They are required to be of no net cost to the government, and thus cannot be used to transfer funds to contractors.

ARL has been a very active participant in this effort, with 54 active CRADAs as of late 1993. ARL plans to increase its CRADA activity by 15 percent per year from fiscal year 1994 to fiscal year 1999 (Army Research Laboratory, 1993c). The rich opportunities for collaboration presented by CRADAs have therefore been a great opportunity for ARL.

Technology from Other Government Agencies

Another form of leverage, too little exploited in the world of defense technology, is the sharing of costs and effort with other government laboratories. Traditionally, each service has been responsible for its own technology, from basic research to engineering design. The recent establishment of the Tri-Service Science and Technology Reliance program is intended to help the Armed Services and other organizations in the Defense Department share the burdens of and reduce redundancy in research and development efforts, by defining the division of labor in more than 200 specific areas of technology. In each area, one of the participating organizations takes the lead responsibility. The program is too new to have demonstrated its success, but does offer a high-level forum for discussions aimed at increasing research productivity. It will surely grow in practical importance as defense budgets decline.

Technology Program Annexes also serve as a leveraging function for both parties, through the formation of ARL-RDEC teams (see Technology Transfer to the Army in this chapter). ARL gains additional science and technology knowledge, which is most likely to be used for supporting near-term research and development.

Improving Productivity

Cost-effectiveness for ARL, as for every other organization in DOD, has a new urgency, owing to today's lower defense funding. A program of continuous improvement will be needed. The Army has therefore embraced the methods of total quality management, and has begun development of its own program, called Total Army Quality. This program is beginning to identify measurable standards for gauging progress (Army Research Laboratory, 1993b). ARL intends to take the following steps to improve quality in the next five years:

- improve customer feedback mechanisms;
- increase training opportunities;

- make benchmarking (comparison of ARL methods with those of other organizations) *an expected activity* throughout ARL;
- examine the potential of business process engineering;
- train at least two people as experts in the methods of Total Army Quality; and
- expand employee quality survey participation to at least half of ARL employees.

However, the total quality management approach of emphasizing quantitative measurement of multiple tangible inputs and outputs is not always suited to R&D organizations. ARL's inputs and outputs—mainly knowledge—are extremely difficult to measure in these terms. Industry and government laboratories are struggling with this problem. The consensus is that the quality of research and development can be assessed most accurately by expert opinion, through peer reviews and management judgment and a history of known successes. The committee feels that the ARL Board of Directors cannot provide this assessment as well or as independently as a group of nongovernment, nationally-recognized science and technology experts.

Besides this difficulty, ARL, as now constituted, is also limited in its ability to implement other aspects of total quality management. Its personnel and procurement administrative procedures, as explained earlier in this chapter, are too rigid and unresponsive to permit the management and worker accountability and authority that are vital to continuous improvement.

None of these problems is insurmountable, of course. As this report shows, there is a range of options for the Army, each of which offers important relief from these obstacles. ARL, if it is to thrive, must seek this relief.

GENERAL RECOMMENDATIONS

The committee's review of ARL has revealed deficiencies in its program and its management. Many of these problems stem from unduly restrictive federal and Defense Department administrative procedures, which fail to give managers the authority and accountability that provides for excellent research and development needs. Other problems appear to reflect a confusion about ARL's mission, priorities, role in conducting research, and relations with its customers and its sponsor.

After reviewing ARL, the committee believes even more strongly that an organizational and management change alone does not guarantee that ARL will be a source of high-quality research and technology. Deficiencies

exist that must be resolved with actions beyond the transition to a new organizational structure (if appropriate for the option).

Many reforms can be made in ARL to resolve personnel, procurement, and funding issues while it is under the governance of AMC. However, the committee believes that implementation within the AMC could also be a problem. An AMC commander would find it difficult to single out ARL for elite status as long as it is closely intermeshed with the rest of his command, both organizationally and physically. No commander who has the responsibility of optimizing value of the entire AMC command would find it tenable to establish a differentiated, organizational entity with a separate culture and set of operating policies.

The committee's general recommendations include:

- streamlining ARL's procurement practices;
- improving its personnel practices;
- focusing ARL's own mission and research program to bring it into line with budgetary realities and unique Army needs;
- improving the formation of partnerships with customers, users, and industry to broaden the technology base and to improve technology transfer out of and into ARL; and
- changing its reporting channel from the Commanding General of AMC to the ASA(RDA). It is the committee's judgement that this change would better support a mission of Army-wide horizontal technology integration, make it easier for ARL to practice a nonlinear (nonsequential) approach to technology transfer, provide full-time research and technology leadership, and place ARL in a position which would reduce command concerns for giving it an elite status in terms of personnel, procurement, and other administrative reforms. The committee also believes that this move would enhance ARL's external status as the Army's flagship laboratory (putting it on a similar level with the Naval Research Laboratory and NIST). This recommendation also includes replacing the ARL Board of Directors with an independent science and technology advisory board.

A detailed discussion of each of these recommendations is found in Chapter 8 (Conclusions and Recommendations).

THE ARMY'S CHOICES

The four organizational and management options considered by the committee, described and assessed in Chapter 3, Chapter 4, Chapter 5 through Chapter 6, are all significant steps toward a more effective and responsive Army Research Laboratory. They offer a range of solutions to the deficiencies the committee has found in its review of the current ARL.

All of the options have as their fundamental assumptions the implementation of the five general recommendations, to the extent that they are applicable. (The procurement and personnel reforms, obviously, would inherently be implemented by the contractors who play important roles in the ARL Multicenter and GOCO ARL options.) Regardless of the option chosen, carrying out these recommendations fully and quickly would give the Army Research Laboratory a more secure and unique mission, as the premier Army materiel laboratory.

REFERENCES

Army Laboratory Command. 1991. CMRL Baseline Study.

Army Materiel Command. 1992a. Charter for Army Materiel Command Board of Directors. Alexandria, Virginia. August 21.

Army Materiel Command. 1992b. Minutes of the AMC Board of Directors Meeting. Alexandria, Virginia. November 23.

Army Materiel Command. 1993. Briefing to the ARL option panel, Committee on Alternative Futures for the Army Research Laboratory, Alexandria, Virginia. June 14, 1993.

Army Research Laboratory. 1993a. Business Plan, Fiscal Years 1994–2004. Global Strategy. 1(January). Adelphi, Maryland.

Army Research Laboratory. 1993b. Business Plan, Fiscal Years 1994–2004. Long Range Plan. 2(August). Adelphi, Maryland.

Army Research Laboratory. 1993c. Business Plan, Fiscal Years 1994–1999. Responsive to Owners and Customers. 2. Adelphi, Maryland

Atwood, D.J. 1989. Laboratory demonstration program: Actions for improvement of the quality, productivity, and efficiency of DOD laboratories. November 20. Memorandum.

Defense Base Closure and Realignment Commission. 1991. Report to the President. Washington, D.C. July 1.

Department of the Army. 1991. LAB 21. Report prepared for Secretary of the Army. Draft.

Department of the Army. 1992. Army Science and Technology Master Plan. November.

Department of the Army. 1993. U.S. Army Research Laboratory (ARL) Board of Directors (BOD). February 19. Memorandum from Army Materiel Command Headquarters, Alexandria, Virginia.

Gendason, P., and E.A. Brown. 1993. Measure of R&D effectiveness: A performance evaluation construct. 1993 Management for Quality in Research and Development Symposium. Juran Institute, Inc., Chicago, Illinois.

Holmes, J. 1993. Personal communication from John Holmes, Office of the Director, Army Research Laboratory, Adelphi, Maryland, to Albert A. Sciarretta, Study Director, November 17, 1993.

Kamely, D., K.A. Bannister, and R.M. Sasmor, eds. 1993. Army Science: The New Frontiers, Military and Civilian Applications. Saratoga, New York: Borg Biomedical Books.

Kirby, K. 1994. Personal communication from Kevin Kirby, Personnel, Army Research Laboratory, Adelphi, Maryland to Albert A. Sciarretta, Study Director, March 11, 1993.

National Performance Review. 1993. Creating a Government that Works Better and Costs Less. Washington, D.C.: U.S. Government Printing Office. September 7.

National Research Council. 1993. Managing Air Force Basic Research. Committee on Air Force Research Management, National Research Council. Washington, D.C.: National Academy Press.

Porter, D. 1993. Briefing by D. Porter, Director, Mounted Battlespace Battle Lab, U.S. Army Armor Center, to the ARL option panel, Committee on Alternative Futures for the Army Research Laboratory, at Ft. Knox, Kentucky, June 16, 1993.

Prather, Maj. Gen. T.L., Jr. 1993. Proposal for new staffing levels for U.S. Army Materiel Command (AMC) research, development, test and engineering (RDT&E) activities. November 15. Memorandum to Army Materiel Command subsidiary commanders.

Richardson, J. 1993. Personal communication by James Richardson, Special Assistant, Advanced Research Projects Agency, Arlington, Virginia to Albert A. Sciarretta, Study Director, December 6, 1993.

Rosenkrantz, B. 1994. Personal communication by B. Rosenkrantz, AMC Headquarters, Alexandria, Virginia, to Albert A. Sciarretta, Study Director, March 11, 1994.

Singley, G. 1993. Briefing by George Singley III, Director of Research and Technology, Office of the Assistant Secretary of the Army (Research, Development and Acquisition), to selected members of the Committee on Alternative Futures for the Army Research Laboratory, Pentagon. May 11, 1993.

Taulbee, S., ed. 1993. ARL predictive technology. Adelphi, Maryland: Army Research Laboratory. Pamphlet.

1994. Personal communication by W. Tolles, Assistant Director for Strategic Planning, Naval Research Laboratory, with Albert A. Sciarretta, Study Director, January 28, 1994.

U.S. Congress, Office of Technology Assessment. 1989. Holding the Edge: Maintaining the Defense Technology Base. OTA-ISC-420. Washington, D.C.: U.S. Government Printing Office. April.

3

ARL Enhanced Option

The ARL Enhanced option is the baseline for the committee's comparison of options. This option involves the implementation of several well attested measures that could be taken, within the limits of current administrative statutes and regulations, to give ARL more authority over its personnel and procurement decisions, and more effective relations with its research and development contractors. These measures have all been fully assessed by the military acquisition system over the past several years, but have not been thoroughly implemented. They would require only administrative directives by the Department of the Army, without congressional action, and could be implemented by fiscal year 1997, when ARL is scheduled to complete its process of formation. This option is therefore a reasonable baseline for the assessment. Two broad changes are assumed for this option:

- implementation of the Defense Laboratory Demonstration program of personnel and purchasing reforms, mandated by the Deputy Secretary of Defense in 1989 (Atwood, 1989); and
- implementation of the Department of Defense's Laboratory Quality Initiatives, proposed in 1993 as a contribution to the Defense Task Force of the Vice President's National Performance Review (Bachkosky, 1993). (One notable aspect of these initiatives is the use of cooperative agreements for procuring R&D, rather than the procurement contracts now used for this purpose by the Army.)

An independent external science and technology board of independent technical experts would replace ARL's current Board of Directors. This board, reporting to the ASA(RDA), would review ARL R&D programs for technical quality, orientation, and relevance, and advise on broad research directions.

Contracting activity would account for 20 percent of ARL's research and development (corresponding to the committee's evaluation of budget and personnel plans for ARL).

ENHANCEMENTS

Defense Laboratory Demonstration Initiatives

The Lab Demo initiatives were directed by Donald Atwood, Deputy Secretary of Defense, in a memorandum in late 1989. These initiatives, to be taken at several military laboratories, including the U.S. Army Laboratory Command elements that have since become ARL, have several main points:

- *Simplify contracting and procurement* by removing service-imposed constraints that go beyond statutory requirements. In particular: (a) maintain laboratory bench stocks based on manager's assessments rather than demand data; (b) streamline procurement reviews by matching their complexity to that of the business situation, not simply the dollar amount; (c) make wider use of Broad Agency Announcements (in which the government solicits ideas in a broad area, rather than tightly specifying the contents of proposals); (d) make wider use of legitimate exception provisions of the Competition in Contracting Act (which requires full competitions based on cost, even for small procurements); (e) limit final negotiations to suppliers having a reasonable chance of award; and (f) issue commercial credit cards to labs for purchases of up to $25,000.
- *Simplify personnel procedures* by removing service-imposed constraints that go beyond the requirements of law. In particular: (a) let line managers classify positions (with automated position classification system); (b) install a dual career ladder, with science and technology *supergrade* staff positions (GS-16 through GS-18) equivalent to 3 percent of the scientist and engineer positions, to offer incentives for nonmanagerial advancement; (c) offer short-term appointments to attract distinguished senior retirees from industry or universities; and (d) appoint laboratory technical directors to four-year terms, with annual renewal thereafter.
- *Increase local decision authority* by (a) placing support functions (e.g., personnel, procurement, counsel, etc.) under the direct supervision of lab directors and (b) giving technical directors discretionary funds of 5 percent of their laboratories' gross project costs.

Each of the Lab Demo initiatives has been presented often to high officials of DOD and the Department of the Army. Implementation has not been successful. Despite the energetic efforts of proponents, only a few initiatives have received enough support in the Army, DOD, or the Office of Management and Budget to be implemented (Heeb, 1993). The committee also discovered an excessive number of briefings were required for each initiative, increasing its chances for disapproval (Army Lab Demo Team,

1991). Figure 3-1 represents the committee's assessment of the progress made thus far in implementing each initiative at ARL, despite its best efforts.

To implement just one of the many Lab Demo initiatives, a laboratory must receive changes or waivers in regulations at the local command, the Army Materiel Command, the Department of the Army, often the Department of Defense, and sometimes other agencies, such as the Office of Personnel Management; at each level, a pyramid of subsidiary approvals must be obtained, from all functionaries with interests in the change. The Tri-Service Lab Demo Executive Panel (1993) recognized 75 separate sub-initiatives required to implement the 15 primary initiatives (Army Lab Demo Team, 1991). One action officer on Lab Demo estimated that getting approval for one subinitiative required more than 100 briefings.

Laboratory Quality Initiatives

The Laboratory Quality Initiatives (Department of Defense, 1993) build on the Lab Demo program of reforms, and have been largely adopted as goals by the Vice President's National Performance Review (Leonard, 1993). They include the following changes:

- Manage workforce size according to budget (rather than by detailed instructions from the Army).
- Review the Defense Management Review Decisions for impacts on laboratory quality.
- Obtain authority for direct hiring of scientists and engineers, without prior approval. (Direct hiring authority is granted by the Office of Personnel Management in cases in which personnel are deemed not to be in *sufficient supply.* Some laboratories have direct hiring authority for clerical workers, but not for technical personnel.)
- Obtain DOD authorization for services to enter into cooperative agreements in procuring R&D. Only the Advanced Research Projects Agency, of all DOD organizations, has this authority today (see Cooperative Agreements below).
- Obtain approval under Defense Acquisition Regulations for a test of a streamlined R&D contract process.
- Establish a senior laboratory management champion at the Director of Defense Research and Engineering to review DOD and service actions for undue constraints on research and development.

A memorandum on these initiatives, forwarded to the Director of the Defense Performance Review Task Force (Bachkosky, 1993; Lab Demo Executive Panel, 1993), reported that these initiatives would reduce

Laboratory Demonstration Initiatives	Percent Complete	Comments
AMC and Department of the Army cannot impose policies that go beyond statutory dictates.	○	
Director appointed to four-year tenure, with annual renewal thereafter.	○	
Support functions (personnel, procurement, counsel, etc.) co-located at the lab, under the direct supervision of the Director.	◔	Partial. DMRD * actions, if successful, will negate implementation.
Technical Director is authorized a discretionary fund of 5 percent of the gross project costs of the laboratory.	○	
Line managers classify positions.	◕	Subject to stovepipe review and approval.
Automated position classification system to support managers.	○	
Scientific-Technologist (S-T) staff positions up to 3 percent of the scientist and engineer positions.	◔	About one-tenth of this.
Term appointments to attract distinguished senior retirees from industry or universities.	◔	
Use of Army supply system at the option of the Director.	◔	Being implemented.
Laboratory bench stock based on manager's assessment rather than demand data.	◔	Being implemented.
Remove service imposed procurement constraints.	○	
Base procurement review on business situation, not dollar amount.	○	
More extensive use of "Broad Area Announcements."	●	
More extensive use of legitimate exception provisions of the Competition in Contracting Act.	○	
Limit final negotiations to suppliers having a reasonable chance of award.	○	
Government-wide commercial credit card for purchases of $25,000.	◔	$2,500, some allowance of $10,000.

* DMRD = Defense Management Review Decision

○ = Not implemented. ◔ ◑ ◕ = Partially implemented. ● = Fully implemented.

FIGURE 3-1 Implementation of Lab Demo initiatives at ARL.
Source: Committee on Alternative Futures for the Army Research Laboratory.

procurement lead times by 50 to 70 percent; cut R&D contracting time by 30 to 50 percent; reduce overhead and administrative personnel (and overhead rates); improve the responsiveness of facility construction and maintenance; increase the number of personnel with advanced degrees; reduce attrition; cut recruiting time; increase numbers of patents, publications, and cooperative agreements with industry and academia; and increase technology transfer.

The Laboratory Quality Initiatives are reflected in many of the initiatives of the National Performance Review (1993), as shown in Table 3-1 (Department of Defense, 1993).

Cooperative Agreements

Responsive contracting mechanisms are essential to ARL's effectiveness. DOD has had statutory authority for cooperative agreements—a form of agreement widely used by other federal agencies to support R&D partnerships with outside organizations—for some years; 10 U.S.C. 2358 was amended in 1981 to include grants, and 10 U.S.C. 2371 authorized cooperative agreements and other transactions in 1989. But it has not exploited that authority except in the Advanced Research Projects Agency. At the time of writing this report, the Director of Defense Research and Engineering was developing guidance for urging the services to start exercising cooperative agreement authority (Dunn, 1993).

R&D often involves flexibility in research approaches, innovation, support, stimulation, and cooperation, which are unavailable in the standard federal procurement contract that has a rigidly defined product and discourages any deviations from prescribed deliverables by the customer. The ARL Enhanced option would involve the use of cooperative agreements to the maximum extent feasible.[1]

A cooperative agreement is much like a grant in its basic purpose, but allows for a more active role by the agency. Grants are normally used for transferring funds to a recipient to support or stimulate the performance of a public purpose, such as university research, without substantial involvement by the granting agency. A cooperative agreement is appropriate when the purpose is the same as for a grant, but substantial involvement is expected by the agency and any technical collaboration anticipated is defined and specified in advance.

[1] Cooperative agreements under 10 U.S.C. 2371 should be distinguished from a Cooperative Research and Development Agreements (CRADAs) authorized under the Federal Technology Transfer Act of 1986 (Public Law 99-102) to foster technology transfer from federal laboratories to the commercial sector through cooperative work R&D. With CRADAs no transfer of funds is permitted to accompany the technology exchange.

TABLE 3-1 Crosswalk Between Initiatives

Lab Quality	National Performance Review
Manage to Budget	BGT 03 Empower managers to perform BGT 04 Eliminate employment ceilings DOD 02 Establish a unified budget for DOD DOD 06 Establish and promote a productivity enhancing capital investment fund FM 07 Create innovation funds
Resolve DMRD Conflict	REG 03 Encourage consensus-based rule making
Direct hire authority	HRM 01 Create a flexible and responsive hiring system
Cooperative agreements	PROC 04 Establish new simplified acquisition threshold and procedures
Expedite Streamlined R&D Contracts	DOD 03 Purchase best value common supplies and services PROC 03 Encourage more procurement innovation
Other pertinent reforms	HRM 02 Reform the General Schedule Classification and Basic Pay System HRM 03 Authorize agencies to develop programs for improvement of individual and organizational performance HRM 04 Authorize agencies to develop incentive awards and bonus systems to improve individual and organizational performance HRM 05 Strengthen systems to support management in dealing with poor performance HRM 12 Eliminate excessive red tape and automate functions and information for classifying positions

NOTE: BGT = Budgeting
DMRD = Defense Management Review Decisions
FM = Financial Management
HRM = Human Resource Management
PROC = Federal Procurement
REG = Regulatory Systems

Both grams and cooperative agreements must be supported by valid proposals. These proposals would normally come in response to Broad Agency Announcements, and must (a) demonstrate innovative and unique methods, approaches, or concepts and (b) not closely resemble any pending competitive acquisition requirements.

Under 10 U.S.C. 2371, cost sharing in cooperative agreements is the norm, but not an absolute standard; contributions can include the fair market value of equipment, facilities, services, materials, and other assets. Intellectual property provisions are negotiable, giving the private sector party an additional incentive to enter into the cooperative agreement.

COMPARATIVE ASSESSMENT

The ARL Enhanced option is the baseline, to which the other options are compared. It offers the Army a quick improvement in ARL's effectiveness, without the need for radical change or upheaval, and without the need for congressional authorization. The following assessments, with respect to the committee's assessment criteria, highlight the effects of the changes assumed for this option, and compare the option with the others considered by the committee.

Linkage to Army Strategy and Objectives

Implementing this option, in itself, would have little effect on ARL's sensitivity and responsiveness to the Army's long-range strategy objectives. Some of the assumed personnel and purchasing reforms, as noted earlier in this chapter, would improve ARL's ability to respond to changes in Army needs in the shorter term.

World-Class Land Warfare Research

The initiatives assumed for this option would produce measurable improvements in ARL's R&D inputs. The committee believes that these improvements would soon lead to improved outputs. The personnel reforms would let ARL more quickly increase the proportion of its staff scientists and engineers who hold Ph.D.s, add needed expertise to its staff, and reward exceptional efforts. The procurement reforms would speed purchases of needed supplies and equipment and cut administrative overhead sharply. The use of cooperative agreements for research and development contracting would expose both ARL and its private sector partners to stimulating

exchanges of ideas and techniques that will enrich the intellectual climate and broaden the scientific and technological options available to the Army.

The result would be a laboratory with performance superior to that of ARL without these enhancements. Fully and properly implemented and supported, with the recommended new reporting channel and more focused mission (see Chapter 2), this option could give the Army a world-class source of science and technology.

Diversity and Quality of Research Sources

The ARL Enhanced option, by virtue of its improved internal quality and its use of cooperative agreements, would better exploit outside sources of research and technology. The range of sources available would increase, and ARL's activities with its partners would be richer, more flexible, and more interactive.

However, the option—like ARL may be in 1997—is restricted to contracting no more than 20 percent of its R&D (and that 20 percent is limited to work in funding category 6.2). (This percentage corresponds to ARL's available funding and personnel plans for fiscal year 1997.) An organization weighted heavily toward internal research and development, with severe budget constraints and the current overmanning (may be corrected through force reduction), cannot compete with the other options considered in optimizing diversity. The Army would have to increase ARL's research and development budget as well as be more flexible in ARL's percentage of contracted research and development.

Technology Transfer to the Army

The ARL Enhanced option would not have a substantial effect on ARL's success in transferring technology to users through the RDECs, the field assistance programs, and other means discussed in Chapter 2. One might argue that the general improvement of ARL's R&D would enhance its technology transfer, but such an effect would be marginal.

ARL could be improved in this area by the focusing of its mission and the formation of the technology transfer partnerships, both recommended in Chapter 2 (and both assumed for all of the committee's options). If ARL were not competing with its own customers (the RDECs) and were doing research and development its customers considered critical, technology would flow more easily.

All other things being equal, one would expect an internal operation to have better transfer to other parts of the Army, as there are fewer barriers.

Ability to Leverage Funds and Programs

Military plans rely increasingly on exploiting technologies developed outside the Army, in areas where outside work is more advanced or more cost-effective. New links are needed with commercial and academic laboratories, and the laboratories of other government agencies. A wide variety of mechanisms are available, including the use of off-the-shelf commercial products, collaborative working arrangements in which costs and results are shared, and "spin-on" and "spin-off" programs that aim at exploiting "dual-use" technologies. This option would better prepare ARL to achieve this goal, by virtue of its more flexible management practices, and in particular its use of cooperative agreements, which would free ARL to do truly cooperative R&D with its contractors.

The ARL Enhanced option, because of its limited contracting, would not have the rich networks of interactions with outside organizations that are built into options using contractors.

Recurring Costs and Productivity

The ARL Enhanced option involves substantial increases in ARL's ability to improve its cost-effectiveness and productivity. The Lab Demo program and Laboratory Quality Initiatives alone would reduce ARL's administrative overhead dramatically (Department of Defense, 1993). Contracting would take less effort and get research underway with less delay, making it possible for ARL to look for the best research sources rather than seeking ways of *piggybacking* on present sources. Highly qualified personnel would be easier to hire. In addition, the overall quality of ARL's work would increase because of the improved administrative procedures and the more effective cooperation with R&D contractors.

On the cost side, the ARL Enhanced option has the advantage of relying on government-employed scientists and engineers, who are paid less on average than contractors ($52,700 per year, in 1993 dollars, compared with $70,000). Under the constant operating budget assumed for all options in the committee's comparison, ARL would be able to afford a larger technical staff through this options. Other options would rely more on contractors and, in the case of the NIST option, pay their government employees on average more than ARL does today. (Chapter 7 reviews the cost comparisons of the options; Appendix D contains details of the committee's cost study.)

IMPLEMENTATION ISSUES

It is assumed that ARL (like all other options considered by the committee) could be reorganized with the features of the ARL Enhanced by fiscal year 1997. One might expect some turbulence and morale problems at first, thus the full benefits would appear over a period of years.

The cost of conversion would be small, about $11 million, in severance pay and other personnel costs, to account for the personnel displaced by the recommended narrowing of ARL's program (see Chapter 2 and Chapter 7).

As noted earlier, implementation of the administrative reforms of this option will require serious attention at the highest possible levels. Despite ARL's best efforts to fully implement the Lab Demo initiatives, implementation of reforms were retarded by the lack of such support and the need to obtain a pyramid of separate approvals for each initiative. This option may not be bold enough to gain full support within DOD.

Needless to say, without the administrative reforms, this option is meaningless.

Some caution is warranted in changing the status quo at ARL. Any impact on the decisions of the Base Closure and Realignment Commission would require notification of the commission. The latest (1991) commission has dissolved and the next (1993) commission will not present its findings until 1995. The commission would have to review decisions which substantially affect facilities, base closures, or other commission issues.

OVERALL EVALUATION

If done properly, with the full implementation of the Laboratory Demonstration Program initiatives and the Laboratory Quality Initiatives, this option could provide the conditions for an better laboratory. It would not be as likely to achieve world-class status or as high a reputation as the other options, which go further in taking advantage of the private sector and modern techniques of laboratory management.

The real challenge, as suggested above, would be implementing these rather modest reforms in the face of the vacillation and friction of the DOD decision-making system, which requires approval from the bottom up of even minor changes. The failed implementation of the Defense Lab Demo program, described earlier in this chapter, shows that modest reform may not be worth the effort of attaining it. More radical change, with support from high officials such as the Chief of Staff of the Army and the Secretary of the Army, could stand a better chance of taking place.

REFERENCES

Army Lab Demo Team. 1991. DMR Lab Demonstration Program Summary. June 24.

Atwood, D.J. 1989. Laboratory demonstration program: Actions for improvement of the quality, productivity, and efficiency of DOD laboratories. November 20. Memorandum.

Bachkosky, J. 1993. Reinvention laboratories. July 30. Memorandum from the Deputy Director, Defense Research and Engineering, to the Director, Defense Performance Review Task Force.

Department of Defense. 1993. Laboratory Quality Initiatives.

Dunn, R.L. 1993. Personal communication from Richard L. Dunn, General Counsel, Advanced Research Projects Agency, Arlington, Virginia, to Albert A. Sciarretta, Study Director. December 7, 1993.

Heeb, M. 1993. Personal communication from Michael Heeb, U.S. Department of Energy, Washington, D.C.

Leonard, W. 1993. Crosswalk between NPR and LQI. Briefing charts presented by W. Leonard, U.S. Army Missile Command Lab Demo Office. October.

National Performance Review. 1993. Creating a Government that Works Better and Costs Less. Washington, D.C.: U.S. Government Printing Office. September 7.

Tri-Service Lab Demo Executive Panel. 1993. DoD Laboratory Quality Initiatives. Draft memorandum for the Secretaries of the Military Departments; Comptroller; Director, Defense Research and Engineering; Assistant Secretary of Defense (Force Management and Personnel); Deputy Undersecretary of Defense (Acquisition Reform); Director of Defense Procurement.

4

NIST Option

The National Institute of Standards and Technology (NIST) is the principal laboratory of the Department of Commerce, charged with helping U.S. industry through standards development and research. NIST has expanded its responsibilities to industry significantly under the Technology Competitiveness Act of 1988.

The NIST option is shorthand for a conversion plan that copies the NIST model. It is not an option that combines ARL with NIST.

The NIST option involves maintaining the Army Research Laboratory as a government-operated laboratory in the Department of the Army, while adopting certain relationships, policies, and practices of NIST to improve ARL's performance. Specifically, this option would replicate a Personnel Demonstration Program established under the NIST Authorization Act for fiscal year 1987 (Public Law 99-574), which gives NIST greater control over its personnel procedures, including a simplified pay grade system, more local authority over hiring, and more effective rewards for extraordinary individual performance. The option would also replicate healthy features of NIST's governance, including its external review and oversight bodies. In other respects, such as its personnel and contracting procedures, it would be equivalent to the ARL Enhanced option.

In the NIST option, the percentage of internal research is assumed to remain the same as that planned for ARL in fiscal year 1997, with 20 percent contracted out. (This percentage is the same as in the ARL Enhanced option, which is the baseline for comparison.)

THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

NIST was founded in 1901 as the National Bureau of Standards, responsible for both aiding industry and " . . . developing, maintaining, and retaining custody of the national standards of measurement." In 1988, under the Omnibus Trade and Competitiveness Act, the agency was renamed and its responsibilities broadened " . . . to assist industry in the development of technology . . . needed to improve quality, to modernize manufacturing

processes, to ensure product reliability . . . and to facilitate rapid commercialization . . . of products based on new scientific discoveries." The Institute reports to the Under Secretary of Commerce for Technology, an arrangement that ensures high-level support (National Institute of Standards and Technology, 1992).

NIST has built a tradition of vigorous interaction with customers and clients from industry, government, universities, and foreign countries. The industry-focused R&D is conducted by about 3,200 regular employees and 1,200 guest researchers at major sites in Gaithersburg, Maryland, and Boulder, Colorado. The regular employees include 1,580 full-time scientists and engineers, of whom 47 percent hold Ph.D.s. (Kramer, 1993).

In fiscal year 1993, NIST had an operating budget of about $500 million plus more than $100 million for construction of research facilities. Consistent with its *partnership* philosophy, NIST's operating budget includes $218 million of funding from customer and client organizations—namely, $111 million in other-agency research funding (58 percent of it from DOD) $68 million in in-kind transfers, and $39 million in fees (Kammer, 1993).

The Institute spans a wide range of technical fields, including physics, chemistry, lightwave electronics, semiconductor devices, biotechnologies, advanced materials, high-performance computing and information technologies, and automated manufacturing. The guest research involves customers and clientele closely, providing important channels of technology transfer. Ties with industry are also fostered by Cooperative Research and Development Agreements, authorized by the Technology Transfer Act of 1986, through which government and private sector entities can share the costs and results of R&D projects carried out in partnership. In fiscal year 1993, NIST worked with 181 research partners on 209 Cooperative Research and Development Agreements in 128 areas of research (Kammer, 1993). The need for better manufacturing methods gives a distinctive character to NIST's R&D programs and involves the Institute in partnerships with government agencies as well as industry. For example, NIST operates the Navy's Center of Excellence for precision automated manufacturing as part of the Institute's automation program.

Since 1988, NIST has established seven regional Manufacturing Technology Centers, budgeted in fiscal year 1993 at a total of $17 million (Kammer, 1993). The concept includes technical outreach activities to help smaller manufacturers improve their productivity and competitiveness by learning from larger manufacturers, from academia, and from NIST itself.

NIST recently undertook the Advanced Technology Program of grants to U.S. industry for high-risk, precompetitive research on commercially promising technologies, budgeted in fiscal year 1993 at $68 million (with a roughly equal amount provided by recipients). The priorities are set by industry, fostering market pull rather than technology push, but grantees are

selected for technical and business merit by outside experts. The Advanced Technology Program grants are expected to grow dramatically over the next several years, as proposed by the Clinton Administration. Such growth would significantly expand NIST resources and greatly increase its technological influence.

NIST has two sources of external program oversight and stewardship: the Visiting Committee on Advanced Technology, and the Board of Assessment of NIST Programs. The Visiting Committee on Advanced Technology, written into the NIST enabling act, oversees NIST's budget and operations at the policy level. It functions much like a corporate Board of Directors, providing general guidance.

The Board of Assessment has existed at the will of the Commerce Department since 1959. Each of NIST's 8 major laboratories has an assessment panel of about 20 technical experts, mainly from industry and academia, who meet annually to critique the laboratories' technical programs. Each panel issues an annual report; these reports are published by the National Research Council (NRC), to provide overall feedback to the lab directors, the NIST director, and Office of Management and Budget, and congressional decision makers. The Board of Assessment is made up of about ten technical experts, largely drawn from past chairs of the assessment panel.

ENHANCEMENTS

The NIST option offers several important enhancements over the baseline ARL Enhanced option, described in Chapter 3. The NIST Personnel Demonstration Program goes substantially beyond the personnel measures of DOD's proposed Laboratory Demonstration program—the basis for the ARL Enhanced option—in giving managers discretion over the hiring, firing, and pay of research and development personnel; in fact, an act of Congress would be required to implement these policies. The option's external oversight boards would also be a break with ARL's current governance structure, which is dominated by the RDECs that are ARL's main customers (see Chapter 1 and Chapter 2).

Flexible Personnel Policies and Procedures

ARL currently operates under the civil service personnel system. The result, as explained in Chapter 2, is difficulty in attracting and retaining high quality scientists and engineers. The hiring process is slow, salaries are uncompetitive, and it is difficult to compensate high performers as well as weed out misfits and nonperformers. NIST, in contrast, has devised flexible

personnel policies and procedures that reinforce the NIST commitment to achieving excellent personnel. They are embodied in the NIST Personnel Demonstration Program (Cassady, 1991).

The NIST Authorization Act for fiscal year 1987 (Public Law 99-574) established a five-year project to demonstrate an alternative personnel management system (National Institute of Standards and Technology, 1987). The goals are to improve hiring of high-quality personnel and to compensate and retain high performers. Implemented in January 1988, the project and its innovations are proving successful. The demonstration project has significantly changed NIST management of human resources. Evaluations and feedback from managers and employees show that these changes have significantly improved NIST's ability to recruit and retain quality staff.

Personnel demonstration projects were a creation of the Civil Service Reform Act of 1978 (Public Law 95-454). Within specified limits, these projects may be undertaken "notwithstanding any lack of specific authority and notwithstanding any other provision of law relating to personnel" (U.S. House of Representatives, Committee on Post Office and Civil Service, 1978). A demonstration project allows an agency, through its own innovations, to design and implement improvements "to determine whether a specified change in personnel management policies or procedures would result in improved Federal personnel management" (5 U.S.C. 4701[a][4]).

Demonstration projects are expected to provide ideas to the Office of Personnel Management (OPM) and to Congress in solving civil service problems, such as those addressed by *Civil Service 2000,* a Hudson Institute study that OPM forwarded to Congress in June 1988. *Civil Service 2000* spoke of "the coming crisis" in the civil service and recommended giving Federal agencies "more flexibility and freedom in personnel matters" and undertaking "extensive additional experiments with delegated personnel authority" (Johnston, 1988).

The NIST project differs from other agency projects in two important respects. First, while other demonstration projects were created by approval of OPM, Congress created the NIST project and specified many of its features. Second, while under the Reform Act, OPM *conducts* demonstration projects (5 U.S.C. 4703[a]), however, the NIST legislation specified that the NIST project "be conducted by the Director of the National Bureau of Standards" (now NIST) after being jointly designed by NIST and OPM (Public Law 99-574).

A recent report prepared for NIST's Visiting Committee on Advanced Technology reviews the design and implementation of the demonstration project, how it is intended to improve on the General Schedule system, and how it is working (Cassady, 1991). The report also shows why the project was not made obsolete by the recent pay reform legislation, and why it continues to be useful in informing Congress and OPM on civil service reform. Although

the Federal Employees Pay Comparability Act of 1990 (Public Law 101-509, 1990) resolved many important pay issues, there are lingering problems in position classification, staffing, performance management, and pay and performance linkage that have been recognized by *Civil Service 2000* (Johnston, 1988) and other studies and that are being successfully addressed by the NIST project.

Objectives

The NIST project covers pay, position classification, recruitment, qualifications examination, retention, performance management, employee development, and employee relations. The objectives are as follows:

- *Enable NIST to compete more effectively in the labor market* through agency-based hiring (using NIST-created candidate registers rather than OPM registers), expanded direct hiring (selection of qualified candidates for hard-to-fill positions without posting vacancies and rating and ranking applicants), greater management involvement in recruiting and hiring, flexible entry salaries, recruiting allowances, and more flexible paid advertising.
- *Allow NIST to compensate and retain good performers* through pay-for-performance, the higher pay potential of pay banding, supervisory differentials, and retention allowances.
- *Improve personnel administration* through pay banding, simplified classification, and automation of personnel processes.
- *Strengthen managers' roles in personnel management* through delegation of authority and accountability to line managers.
- *Compare compensation with similar private sector positions annually,* based on total compensation (basic pay, bonuses, allowances, retirement, health insurance, life insurance, and leave benefits).
- *Maintain compensation costs* within the limits of the former system.

Basic Features

The key elements of the NIST demonstration program follow:

- *Restructured pay grade and step system.* NIST has devised a simplified pay band system for its employees that gives NIST flexibility to pay its best employees well (see Chapter 7 and Appendix D).
- *Decentralized hiring authority.* Line managers have hiring authority within limits. A line manager may extend an offer to a new graduate almost

immediately, rather than undergoing the months-long process the civil service practices entail.

- *Restructured position descriptions under local control.* Position descriptions are very specific, reducing the requirement to search other government agencies for potential transfers before hiring new employees (and limiting *bumping* by personnel who have lost their jobs during reductions in force).
- *Management assignment pay differential.* This additional salary is given to line managers only during their tenure as managers.
- *Rank order evaluation procedures.* Professional employees are ranked from best to worst, as well as rated by the normal federal system.
- *Extra tenure credit for high rank.* Extra years of employment are credited each year to those employees who are highly ranked relative to their peers. This serves to protect them during reductions in force.
- *Large taper in raise distributions.* The rating and ranking system supports management's discretion in the allocation and variation of pay raises. Highly rated personnel may receive higher pay raises than those with lower ratings.

The personnel system at NIST is in its second five-year demonstration period. It has had one major revision after its initial implementation. Presumably at the end of the current demonstration, NIST will apply for and receive approval for permanent status.

Evaluations of the NIST Personnel Demonstration Project

OPM conducts an annual evaluation of the project through a contractor, as required by the project legislation. The University Research Corporation conducted annual evaluations in the first two years of the project (University Research Corporation, 1989; University Research Corporation, 1990). Although the General Accounting Office report (General Accounting Office, 1991) faulted the University Research Corporation evaluation, OPM stands behind the evaluation and this report cites evaluation findings discussed below. For the evaluation of the third year of the project, OPM contracted with the Human Resources Research Organization (Human Resources Research Organization, 1992).

According to the University Research Corporation reports, the Personnel Demonstration Project brought faster classification and hiring; the ability to make hires that could not be made under the former system; greater pay flexibility, particularly at the entry level; and higher rewards for, and more effective retention of, good performers. Managers, supervisors, and employees

reported that the demonstration project was a success, but needed improvement in some areas. In response, the performance appraisal and pay-for-performance systems were extensively revised, and the automated classification system was expanded and made more user-friendly (National Institute of Standards and Technology, 1990; Office of Personnel Management, 1990).

The 1989 University Research Corporation report said:

> Overall, NIST staff and management believe the Demonstration Project addresses previous problems in staffing and hiring and has the potential to make NIST a better place to work. Many of the staff feel that positive results have already been attained. In particular, they feel that decentralization and streamlining of the hiring procedures has enabled NIST to attract individuals who might have been lost under the old cumbersome processing procedures. The most useful interventions are the agency-based hiring, the delegation of classification and hiring to the line managers, and the flexibility in entry salary offered by pay bands and delegated authority.

Employees were surveyed in the summer of 1989 (University Research Corporation, 1990). Most responses were positive. Supervisors were much more satisfied with the new personnel system than with its predecessor. The most negative responses to the demonstration project personnel system have been in performance appraisal and, by extension, pay for performance. Both supervisory and nonsupervisory employees provided ideas for improving the system, through focus groups and other forums. NIST responded to this feedback by developing a revised performance appraisal and payout system, which was approved by the OPM and implemented for the 1991 performance cycle (Office of Personnel Management, 1990).

NIST also uses a post-doctoral program, administered in part by the NRC, for recruiting and evaluating new Ph.D. recipients. About 50 two-year appointments are made each year. About half of the program participants stay on to become regular NIST employees. (ARL also participates in this NRC program, and has about 24 NRC post-doctoral fellows.) This mechanism gives the organization a chance to evaluate new candidates in the workplace without making permanent commitments.

External Review and Oversight for ARL

The NIST option includes a two-tiered system of external advisory boards modeled on those of NIST. An ARL analog of NIST's Visiting

Committee on Advanced Technology, made up of senior executives from defense-related U.S. industry and RDECs (the ARL customer base), would review and recommend ARL's policy structure and budget. Another board, comparable to NIST's Board of Assessment, would provide separate scientific and technical reviews of each of ARL's directorates (subsidiary laboratories), its technology sources, and the overall ARL. This board's membership would include nationally recognized technology experts.

COMPARATIVE ASSESSMENT

The committee assessed the NIST option with respect to six key criteria, which together encompass the Army's requirements for its technology base laboratories. On the basis of these criteria, the option presents both advantages and disadvantages when compared with the other options considered.

Linkage to Army Strategies and Objectives

This option would not substantially improve ARL's sensitivity or responsiveness to the needs of the Army, compared with the ARL Enhanced baseline. Secondary improvements would be expected, however, as a result of the improved performance and reputation of the laboratory, owing to the more flexible personnel policies.

Because ARL would remain a government organization, staffed and managed by government personnel, this option would provide simpler links to the Army's policy makers than either of the contracted options (ARL Multicenter and GOCO ARL). Communications would be clear and direct, without the need to build in protections against conflict of interest. The relationship between the Army and ARL could be one of partnership, rather than oversight. (To obtain the full benefit of this change, the Army would have to guard against applying overbearing management and program controls.)

World-Class Land Warfare Research

The ability of ARL to conduct world-class research in support of Army requirements would be enhanced by the improvement in scientific and technical staff that the flexible personnel practices and the new external oversight bodies would produce. It would take some time for these improvements to take full effect (see Implementation Issues below).

However, the quality of the R&D work might be somewhat lower than it would with either of the contracted options, owing to the various personnel incentives, recruitment flexibility, and other advantages of those options. The relevance of the work, on the other hand, may be higher, because of the more direct channels of communication to users in the Army. The work would still be hampered by government administrative regulations. (The measures assumed for this option would bring substantial improvements, but would offer less management flexibility in personnel and procurement practices than the contracted options.)

Diversity and Quality of Research Sources

Adopting this option would not directly affect the diversity and quality of research sources as compared with the baseline, the ARL Enhanced option. To the extent that the new external oversight bodies (modeled on NIST's Visiting Committee on Advanced Technology and the Board of Assessment) provide useful critiques of research sources, this aspect of ARL's operations would improve, however.

This option—even if ARL could contract out its maximum of 30 percent of its program—would be inferior in this respect to either the ARL Multicenter option (70 percent contracted) or the GOCO ARL option (100 percent contracted).

Technology Transfer to the Army

This option would not be substantially different from the baseline, the ARL Enhanced option, in its ability to transfer technology to users. It could be argued that the higher-quality staff that would result from the personnel reforms and the advice of the Visiting Committee and the Board of Assessment would be more effective in their relations with outside organizations. This effect, however, would likely be marginal.

The relations with the RDECs, ARL's main channel of technology transfer, would be relatively simple. (These simple relationships in themselves would not negate the current conflicts that exist between ARL and the RDECs.) The personal contacts on which successful technology transfer depends would not be hampered by conflicts between government and contractor priorities, or by procedures designed to curb conflict of interest. The difference in organizational culture between ARL and RDECs would be minimal.

Ability to Leverage Funds and Programs

This option would neither substantially improve nor substantially diminish ARL's ability to leverage funds and programs of outside organizations, compared with the ARL Enhanced baseline. The assumed personnel reforms and the new oversight bodies, however, might improve somewhat the staff's willingness and ability to make the necessary contacts with the best commercial and academic R&D organizations to enhance the flow of dual-use technologies between ARL and commercial or academic laboratories.

This option, on the other hand, would be significantly weaker in this respect than the more outward-oriented options, ARL Multicenter and GOCO ARL. Those options, with their rich links to the private sector, and their ability to easily exchange personnel with contractors, would find it far easier to maintain the shifting research and development partnerships that are needed to take advantage of dual-use opportunities.

Recurring Costs and Productivity

The NIST option would be a substantial improvement over the ARL Enhanced baseline in enabling ARL to improve its productivity and quality. The personnel demonstration would give management and personnel the accountability and flexibility that continuous quality improvement programs require.

Increased productivity would be required of this option, because it entails increases in recurring costs, owing to its higher pay scales. The average scientist's or engineer's salary would rise to an estimated $61,200, compared with $52,700 for the ARL Enhanced option. (These estimates are based on cost surveys of ARL and NIST commissioned by the committee; see Chapter 7 and Appendix D.) The committee assumes, in comparing options, that the overall budget would remain the same ($323 million 1993 dollars in fiscal year 1997); as a result, the number of scientists and engineers, including contractors, would be 1,779, compared with 2,021 in the ARL Enhanced option.

IMPLEMENTATION ISSUES

The NIST option, with one major exception, is a matter of continuous improvement rather than sudden transition. New procurement practices could be in place within a year. The new demonstration personnel system, which would need immediate approval, would take two years to design and

implement (and would require an act of Congress). Its effect on the quality of the professional staff would become significant over five years.

The improved oversight arrangements could be instituted more rapidly. Terms of reference could be drawn up and approved within six months, and the Visiting Committee and Board of Assessors could be conducting their first reviews within a year of the initial decision.

The one-time cost of conversion for the option would be about $17 million (see Chapter 7 and Appendix D). This cost is mainly due to severance pay for employees replaced in the recommended narrowing of ARL's program. The implementation of the new personnel system would entail a minor cost (less than $2 million).

OVERALL EVALUATION

The NIST option offers the Army a substantial improvement in both external oversight and internal management, at a relatively small cost in either dollars or organizational disruption. The revised personnel system would result in a superior cadre of scientific and engineering talent, although the full effect would take years to achieve.

The new Visiting Committee, modeled on NIST's Visiting Committee on Advanced Technology, would provide continuity through changes in Presidential administrations. It would function as the source of policy advice to the Army. The external Board of Assessment would serve a similar function for the Director of ARL, with periodic performance reviews that would gradually improve the quality and relevance of ARL's research and development.

Together, these changes would bring ARL a gradually improving reputation, making it possible to attract and retain better quality scientific managers at all levels of ARL.

REFERENCES

Cassady, A. 1991. NIST Personnel Management Demonstration Project—Design, Implementation, and Accomplishments. NISTIR 4640. Gaithersburg, Maryland: National Institute of Standards and Technology.

General Accounting Office. 1991. Review of Evaluation of Personnel Demonstration Project at Commerce. GAO/GGD-91-93. Washington, D.C. May.

Human Resources Research Organization. 1992. National Institute of Standards and Technology Personnel Management Demonstration Project, Fourth Annual Evaluation Report. Vol. 1. Washington, D.C.December.

Johnston, W.B. 1988. Civil Service 2000. Report prepared by the Hudson Institute for the Office of Personnel Management. Washington, D.C.: U.S. Office of Personnel Management. June.

Kammer, R. 1993. Briefing by Raymond Kammer, Deputy Director, National Institute of Standards and Technology to the Committee on Alternative Futures for the Army Research Laboratory, Washington, D.C., May 24—26, 1993.

Kramer, S. 1993. An overview of NIST. Briefing by S. Kramer, Associate Director, National Institute of Standards and Technology, at the National Institute of Standards and Technology, Gaithersburg, Maryland, May 13, 1993.

National Institute of Standards and Technology. 1987. Federal register. October 2. Amended May 17, 1989, and May 10, 1990.

National Institute of Standards and Technology. 1990. Position classification manual. Gaithersburg, Maryland: National Institute of Standards and Technology. December.

National Institute of Standards and Technology. 1992. Research, services, facilities. Gaithersburg, Maryland: National Institute of Standards and Technology.

Office of Personnel Management. 1990. Personnel Management Demonstration Project; Alternative personnel management system at the National Institute of Standards and Technology: Notice of proposed amendment. Federal Register, May 10. pp. 19688–19692.

University Research Corporation. 1989. Implementation Report: National Institute of Standards and Technology Personnel Management Demonstration Project. Washington D.C.: U.S. Office of Personnel Management. August.

University Research Corporation. 1990. Second Annual Evaluation Report: National Institute of Standards and Technology. Appendice D and Appendice E. Washington, D.C.: U.S. Office of Personnel Management.

U.S. House of Representatives, Committee on Post Office and Civil Service. 1978. H.R. 11280 to Reform the Civil Service Laws. Report. Washington, D.C.: U.S. Government Printing Office. May 31.

5

ARL Multicenter Option

The Army Research Laboratory Multicenter option involves contracting out most of ARL's work to several centers of excellence, under the oversight of a permanent staff of government technical experts, planners, and managers from the RDECs, the Training and Doctrine Command, Army staff, and other agencies. The object is to buy research and development from the best source, no matter what that source might be. This option, in a sense, would be a hybrid of current ARL assets and the GOCO option. The permanent staff of about 100 technical experts would be analogous to that of the Advanced Research Projects Agency.

In general, the option may be compared to the Air Force Wright Laboratory. The Wright Laboratory currently has a significant number of contractor personnel, industrial interns, and Air Force Ph.D. fellows working side-by-side with both military and civil service researchers. The out-of-house/in-house ratio of research comes close to that the committee recommends for the Multicenter option. Furthermore, the Wright Laboratory contracts with outside GOCO-like centers, such as the University of Dayton Research Institute (Bement, 1994).

This option abandons the concept of a central *corporate* laboratory. While there are many arguments in favor of such a laboratory, many leading commercial institutions are moving away from central laboratories, establishing more flexible arrangements to better ensure buying the best in any given field, and to gain the advantages of richer and more concurrent interactions among researchers, product and system developers, and customers (Dimmock, 1993).

ENHANCEMENTS

The ARL Multicenter option builds on the ARL Enhanced option (Chapter 3). It includes the same procurement, contracting, and personnel reforms; a narrowed program, with fewer business areas; new partnerships for technology transfer; and the recommended change in reporting channel, from

the Commander, Army Materiel Command, to the Assistant Secretary of the Army (Research, Development and Acquisition).

In its organization and management, however, it would depart radically from the ARL Enhanced baseline. The planning and analysis functions of ARL, now performed mainly by the Operations and Advanced Concepts and Plans directorates, would remain government responsibilities, preserving strong links with the Army staff and with users. The R&D program would be divided by business area among several (perhaps four to six) centers, chosen competitively to involve the very best performers to be found in the private or public sector. The centers of excellence could be government-owned and government-operated, government-owned and contractor-operated, or contractor-owned and contractor-operated. Some current ARL directorates might be among the centers.

An external board of independent technical experts would replace ARL's current Board of Directors. This board would review ARL's R&D programs for technical quality and relevance, and advise on broad research directions.

For purposes of analysis, it is assumed that 70 percent of the operating budget of ARL would be contracted out. That figure would be variable, depending on the Army's requirements and the availability of expertise inside and outside the Army at any given time. There could be a gradual transition for the ARL Enhanced or NIST options to the ARL Multicenter option through a systematic increase in the contracted out/internal ratio of funding over time.

Permanent Staff

The permanent staff would include about 50 to 100 senior scientists and engineers, planners, and managers whose central mission would be identifying the Army's technology needs, translating them into R&D programs at the centers of excellence, and overseeing and evaluating the implementation of the programs. It would include both civilian scientists and engineers and active-duty Army officers with advanced degrees. It would offer short-term rotating assignments, of one to two years, to personnel of the Army's RDECs and user agencies. Senior retirees from industry and academic institutions would also be offered short-term appointments, as provided for in the Defense Laboratory Demonstration initiatives that are the basis of the ARL Enhanced option (Atwood, 1989).

The permanent staff would provide strong links to the users, communicate with requirements generators, and provide corporate memory. As government employees, its members would enjoy broad access to developments both at the centers of excellence and in the government. One or more small teams would be charged with identifying opportunities for

leveraging Army funds through small cooperative projects with outside organizations in related fields.

In addition, the permanent staff would require the prestige to attract the best technical talent and industrial partners; the ability to bring in sufficient short-term expertise while maintaining corporate memory; a well developed strategy for identifying and acquiring the best technology, wherever it resides; the ability to quickly implement research decisions; and a tolerance of failure (Richardson, 1993). To maintain these qualities, ARL would need high-level Army support. It would also need the time to build its staff and reputation through high-quality research and development with tangible impacts on the Army.

It should also be noted that if the key science and engineering centers in ARL are contracted out, it will be difficult to *grow* a government technical manager within ARL for the permanent staff. Technically-oriented managers would have to come from industry, academia, or from the RDECs.

Centers of Excellence

ARL's R&D development would be carried out by several centers of excellence, each concentrating on a single business area of the new, more focused ARL program. Centers could be owned and operated by the federal government (either current ARL directorates or the laboratories of other federal agencies) or run by industrial, academic, or nonprofit contractors, using government or contractor facilities. The mix of centers and the ratio of internal to contracted effort would evolve with time, depending on Army needs.

The contracted centers would have broad, long-term missions similar to those of the GOCO laboratories of the U.S Department of Energy. Each would be responsible for carrying out research and development in a technology area equivalent in scope to those of today's ARL directorates (see Chapter 1).

Contracts for the centers could be 5 to 10 years in length, with periodic performance and mission reviews. As new technologies became important to the Army, this version of ARL could quickly create new centers, while phasing out centers in maturing or otherwise unneeded technologies. If a maturing technology had proven its worth, the contractor could compete to work for the appropriate RDEC, which could continue to exploit the technology in system applications.

At least two of the centers, it is assumed, would be derived from current ARL components, and would remain government-owned and operated. The analytical functions that support decision making in acquisition could form one or two such centers for the Survivability and Lethality Analysis

Directorate and the Human Research and Engineering Directorate. Another likely candidate is the ARL Weapons Technology Directorate because of the uniqueness of its facilities, equipment, and personnel, which would be hard to replicate elsewhere.

COMPARATIVE ASSESSMENT

This option has major advantages over the other options considered by this committee, as well as a couple of disadvantages. The option was developed by the committee as a hybrid of the best of the ARL Enhanced, NIST, and GOCO options. It is therefore designed to yield the most favorable possible assessments, according to the committee's assessment criteria. The option is also designed to take optimal advantage of the strengths of each of the other options: the flexibility and business practices of the private sector, as in the GOCO option, allied with the ARL Enhanced and NIST options' access to Army strategies and objectives. As shown in this report, the Multicenter option scores very high in comparison with the other options.

One disadvantage is that there is no standing example to give credence to the assessment. A paper system can always look better than a real one. The Air Force Wright Laboratory is close in its operations.

Another disadvantage will be the management of each center which is contracted out. Unlike the GOCO option, which will only have one contract, this option will have a few.

Linkage to Army Strategy and Objectives

The ARL Multicenter option is designed to optimize the linkage to the Army's strategy and objectives. The permanent staff would be devoted to that function, and would have the specific responsibility of linking world-class R&D with Army needs. The rotational appointments of personnel from RDECs and user organizations would complete the linkage. These strong connections with Army policy makers, the RDECs, and users would give ARL a clear focus on the needs and intentions of the Army, which would not be as easily accessible to the GOCO ARL option (Chapter 6). The ARL Enhanced and NIST options would have strong links, although they would lack the variety of this option. This option would therefore be superior to all of the others with respect to this criterion.

World-Class Land Warfare Research

The Multicenter option is designed specifically to buy science and technology from the best available sources, thereby attempting to achieve the highest quality. The permanent staff could thus achieve the world-class cachet of the Advanced Research Projects Agency.

On the other hand, the centers of excellence would have neither the single clear reward system nor the rich variety to be expected of a single major contract laboratory, like that represented by the GOCO ARL option. Nor would they have the scale. By standards of pure research excellence, the GOCO ARL option might surpass it.

The question of perception rears its head in this assessment. It is likely that implementing the ARL Enhanced option, for example, could greatly improve the lab, yet not counter perceptions about the quality or research and development in Army laboratories. The NIST option could be even better, but would have to be implemented with a burst of publicity to receive the respect from which NIST itself benefits. The ARL Multicenter option, like the GOCO ARL option, would involve radical change, and could therefore lead to immediate radical improvements in perception.

Diversity and Quality of Research Sources

Its combination of responsiveness and flexibility would make this option better than any other by this criterion. The option is designed for the highest possible diversity and quality of research sources. Its permanent staff would be charged with selecting technologies critical to the Army, and seeking the best available sources for those technologies, inside or outside the government. In order to do this, part of its permanent staff would have to come from industry or academia so as to bring in a knowledge of external sources.

Technology Transfer to the Army

This option would face a challenge in transferring technology to users, by way of the RDECs. All other things being equal, technology transfer should be best from internal staff, who have access to government information and cannot be suspected of commercial conflict of interest. There should be no proprietary barriers either in learning what industry has to offer, or in letting the user know what is available. The two internal options (ARL Enhanced and NIST) have advantages in that respect, because technology need not flow across the barriers between the private and public sectors. The ARL

Multicenter option would, by this reasoning, be somewhat superior to the GOCO ARL option, but not to the others.

But this option holds important potential for extremely effective technology transfer in particular cases. It would facilitate ARL's moves out of maturing areas of technology, no longer of interest from ARL's standpoint, and into new areas, by phasing out existing centers and opening new ones. Support for the mature technologies could be assumed by the appropriate RDECs, simply by assuming responsibility for the center involved. The personnel working on the mature technology would continue to work on that technology after the transfer.

Such transfers would test the Army's commitment to change, however. It would be difficult to bring a successful center to an end, for the sake of establishing a new and untested one. (In other guises, of course, this reluctance is felt by every R&D organization.) The test of management and oversight would be ARL's rate of turnover of centers over the years. (With 5-to 10-year contracts, this test would take more than a decade to produce meaningful results.)

Short of these wholesale transitions, the permanent staff would ensure effective technology transfer to the Army by attracting rotational appointments from RDECs, doctrine developers, and users and by ensuring that ARL's R&D were aimed at Army needs.

Ability to Leverage Funds and Programs

This option would give ARL a strong ability to leverage Army funds and programs. Its emphasis on external sources of technology and rotating personnel assignments would give it a rich network of contacts with organizations in relevant areas of technology, which could not be equaled by an in-house option. At the same time, its permanent staff would be aware of Army needs and technology programs. Properly implemented, it would surpass all other options with respect to this criterion.

It is quite possible that some of the contract centers of excellence would be in institutions doing broader work in the same areas. The synergy with other professionals in the same field could leverage funds and programs.

The permanent staff would have a vital role in this respect. While most of the staff of the nucleus would be concerned with the major technologies of the centers, several small teams would be assigned to monitor, understand, and leverage particular technologies being developed elsewhere, through cooperative research agreements (see Chapter 3), cooperative research and development agreements, and otherwise, and translate it into Army terms and Army needs. The handicap these teams would have is that it is harder to perform this function without having large amounts of funds to disburse.

Recurring Costs and Productivity

The ARL Multicenter option has an inherent impetus for quality and productivity improvement, in the continuing competition among centers, which would be rewarded for improvements and phased out if they did not perform or became irrelevant. For this reason, the option would at least equal the GOCO ARL option in its ability to generate improvement and practice total quality management (within the contracted centers). Unless the permanent staff and the government centers of excellence have at least NIST-like personnel and procurement freedoms, it will be challenging for them to practice total quality management. It would surpass the ARL Enhanced or NIST options, which would remain subject to federal administrative constraints, albeit reduced ones because of the recommended personnel and procurement reforms (Chapter 3 and Chapter 4).

In fact, this competition could become a management challenge. ARL would have to find some meaningful and objective common accounting measures for the recurring costs and output of its disparate centers. (It is unlikely that any center would allow others to benefit from unfair accounting.) Productivity is extremely hard to define and measure in this way, even in the context of a single organization, with a single accounting system. Still, this difficult task would be well worth attempting if it let ARL management reward improvements in productivity. Additionally, if a center failed to provide a technology that the Army needed, management could allow that center to lapse.

Increased productivity would be a necessity owing to its higher pay scales. The average government scientist's or engineer's salary would be $52,700 (1993 dollars), the same as in the ARL Enhanced baseline. But 70 percent of the work would be done by contractors, at an average salary of $70,000. (These estimates are based on cost surveys of ARL and NIST commissioned by the committee; see Chapter 7 and Appendix D.) Based on a budget of $323 million, the total number of scientists and engineers, including contractors, would be 1,604, compared with 2,021 in the ARL Enhanced option.

IMPLEMENTATION ISSUES

The one-time cost of implementing this option is estimated to be substantially more than that of implementing either of the in-house options (i.e., ARL Enhanced and NIST). It would be less than that of the GOCO ARL option, because some people, facilities, and systems would stay in place. The one-time conversion cost would be between $56 and $70 million, including personnel costs and the costs of obtaining contractors. Most of this

cost ($48.5 million) is for severance and other personnel costs for the nearly 1,500 personnel who would be terminated, owing to the recommended narrowing of ARL's program and the higher salaries to contractors, under the committee's assumption that the operating budget for each option is equal. An additional $7.5 to $21.5 million is estimated to be needed for the contracting process, each time the contracts were put up for competition. (The amount depends on the number of centers contracted out to independent contractors.)

Implementation of the Multicenter option would not be accomplished without considerable turmoil. Some government facilities might be closed. Many current employees would probably not find jobs in the new centers.

One concern with this option (and with the GOCO ARL option, as well) is that if the work is performed in other than current or projected facilities it might conflict with findings of the Defense Base Closure and Realignment Commission (1991), which must consider all changes in military facilities. At the very least, such a change would require review by the Commission.

OVERALL EVALUATION

This option provides the conditions for a good balance of incentives for high-quality research, on the one hand, and responsiveness to Army needs on the other. However, it has its drawbacks. It would be contractually complex, in the first place. Overseeing a shifting collection of centers, each with its own administrative processes and traditions, would be challenging, to say the least.

In addition, as mentioned earlier, implementation of this option would disrupt ARL quite thoroughly, dislocating personnel and interrupting some programs. Some government facilities might be closed. Many current employees would be displaced. In this committee's view, such disruption would be an acceptable price to pay for a laboratory that has a secure role for the future, and a deserved reputation for both excellence and responsiveness.

REFERENCES

Atwood, D.J. 1989. Laboratory demonstration program: Actions for improvement of the quality, productivity, and efficiency of DOD laboratories. November 20. Memorandum.

Bement, Jr., A. L. 1994. Communication to the Committee on Alternative Futures for the Army Research Laboratory. March 4. Memorandum.

Defense Base Closure and Realignment Commission. 1991. Report to the President. Washington, D.C. July 1.

Dimmock, J. 1993. Personal communication by J. Dimmock, former Vice President for Research, McDonnell Douglas Aircraft Corporation.

Richardson, J. 1993. Personal communication by James Richardson, Special Assistant, Advanced Research Projects Agency, Arlington, Virginia, August 31, 1993.

6

GOCO ARL Option

One organizational form frequently mentioned in discussions of the options for military laboratories is the government-owned, contractor-operated (GOCO) laboratory, on the model of the U.S. Department of Energy's (DOE's) national laboratories or the federally funded research and development centers (FFRDCs) that support the Department of Defense (Defense Science Board, 1987). The key characteristic of this option is that management and operation of the laboratory are taken out of the government sector and placed under contract with the private sector. ARL personnel would be removed from the federal payroll, and the contractor would be responsible for forming and directing the staff of the new organization. The contractor would also carry out research and development in the areas of interest to the Army, according to the broad policy directives of the Army and the terms of the contract. Salary and other personnel decisions, purchasing practices, and other aspects of management would be the responsibility of the contractor, subject to oversight by the Army. Facilities and equipment can be owned by the government, the contractor, or both.

The ARL GOCO would have broad authority for management and operations contracting, and sufficient flexibility and discretion to operate like a modern corporate laboratory (Roussel et al., 1991). Only a small senior Army staff (i.e., less than 10) would be needed to oversee the laboratory, assess its performance, and facilitate technology transfer within the Army; a small procurement and contract staff would also be needed.

The formal features of a GOCO organization are set out by the Office of Federal Procurement Policy (OFPP) in Policy Letter 84-1 (Office of Federal Procurement Policy, 1984). The contractor may be a university or university consortium, a for-profit corporation, or a not-for-profit corporation. Selection of the contractor could take place in an open competition, with all bidders welcome; in a restricted competition with a list of prequalified bidders; or through direct conversion of ARL to a not-for-profit corporation with no competition. The type of contract typically used is known as a management and operations contract (Office of Federal Procurement Policy, 1984).

The choice of any particular combination of these alternatives would affect the organizational form, culture, governance, and management, which in turn would determine the laboratory's potential for excellence. But the initial major decision is whether to convert to a nongovernment entity. The decision has a broad set of advantages and disadvantages, as well as implementation issues. Once such a decision is made, the desired organizational form, contract vehicle and requirements, and conversion process can be chosen. The committee has addressed the major advantages and disadvantages of this broad option, without regard to the various alternatives discussed above.

The federal government has a long history of contracting for the management and operation of government-owned R&D facilities. The U.S. Department of Energy and its predecessor agencies have relied on GOCO organizations for more than 40 years for nearly all research, development, and demonstration work and for management and operation of nuclear weapons production facilities (see Appendix E). DOD—and particularly the Air Force—has used various contract organizations, known as Federal Contract Research Centers, for vital R&D and engineering support, including critical technology assessment and procurement assistance. In 1984, OFPP Policy Letter 84-1 set out a formal federal definition and governing regulation for FFRDCs, taking in both the Department of Energy's GOCO laboratories and the Defense Department's Federal Contract Research Centers (Office of Federal Procurement Policy, 1984). Although a decade has passed since this redesignation, the older terms remain common. This report uses the term *GOCO*, under the assumption that the government would continue to own at least some of ARL's facilities. The conversion process itself must follow the requirements laid out for FFRDCs in general.

In this option, 100 percent of ARL's R&D is assumed to be contracted out, compared with 20 percent for the ARL Enhanced and NIST options. The average annual salary of contract scientists and engineers is $70,000, compared with $52,700 for government-employed scientists and engineers, according to a cost study commissioned by the committee (see Chapter 7 and Appendix D).

ENHANCEMENTS

The flexibility, management efficiency, and technical leadership of a successful GOCO organization are potentially highly attractive. Such an arrangement can have, in a sense, the best of government and private worlds. A contractor can have the access to Army planning and security information of an *insider.* At the same time, it can have the management freedom of an *outsider*, especially with respect to the federal personnel and procurement

systems, which are not well suited to the changing needs of research organizations (National Research Council, 1993).

In this respect, the GOCO ARL option is superior to the ARL Enhanced baseline (and to any of the in-house options discussed in this report). A GOCO organization can use the management methods of the best commercial organizations, without hindrance by the many well-intentioned but nonetheless constraining requirements of government operations. It need not set aside contracts for small or disadvantaged business. Limited only by its total budget, it may hire, fire, and reassign employees as necessary to improve quality or meet new opportunities and changing demands. It can recruit exceptionally qualified personnel with high pay, without delay for approval from above, reward exceptional individual and group performance with higher pay and other incentives (such as the latest research equipment), and delegate its budgetary and hiring authority as necessary. Above all, it need not struggle with the cumbersome and sluggish government procurement system, which can tie up even minor purchases in months of paperwork.

In reality, today's GOCO laboratories and military FFRDCs, notably those of the U.S. Department of Energy, are increasingly burdened with federal management controls as a result of both legislative and executive oversight. The ideal of the GOCO laboratory, with its freedom to focus on research, guided only by the broad directives of its government sponsor, has been eroded in recent decades by the accretion of well-intentioned financial audits, personnel controls (including direct salary caps), and environmental mandates from above (U.S. Congress, Office of Technology Assessment, 1989).

In evaluating the GOCO ARL option, the advantages and disadvantages of existing GOCO organizations are used as a model. In converting ARL to a GOCO laboratory, the Army would need to take extreme care in creating the contract vehicle, the form of governance and organization, and the oversight measures to achieve desirable characteristics and mitigate potential problems.

COMPARATIVE ASSESSMENT

The committee assessed the GOCO ARL option according to six key criteria, which together encompass the Army's requirements for its technology base laboratories. The GOCO ARL option, when compared to the other options, shows strong advantages and disadvantages.

Linkage to Army Strategies and Objectives

By placing the laboratory outside the direct control of the Army, this option could make it more challenging to provide direct technical support to operating forces, to transfer technology to Army systems programs, and to carry out technology assessment on behalf of the Army. While none of these problems is insurmountable—many existing DOD FFRDCs and DOE GOCO laboratories manage them successfully—they will require extraordinary efforts on both sides. This fact must be regarded as a disadvantage of this option compared to any of the others considered by the committee.

To encourage the relevance and quality of the research program and avoid conflict of interest, the Army and GOCO contractor would need to cultivate a relationship that encouraged objectivity and frankness on both sides. It would be important to specify properly who in the Army is the sponsor, and to whom technology products are delivered (the Army's RDECs, Program Managers, and Program Executive Officers, etc.). The laboratory would need a clear and unique mission, and the broad guidance and high-level access to Army planning that a long-range research organization needs. Its customers, to whom technology products must be transferred, would require confidence that their links to the new contractor laboratory were reliable and free of conflict of interest (Laslic, 1993; Meisel and Jacobs, 1979).

World-Class Land Warfare Research

Of all the options considered by the committee the GOCO ARL option offers the best chance for ARL to conduct, and be recognized for, superior technical work.

One of the foremost potential advantages of a GOCO laboratory over a government laboratory is the ability to attract outstanding leadership at all levels of the staff. The laboratory's mission, the stimulating nature of the work, and the ability to contribute to national goals are attractive. In addition, pay and other incentives can be set competitively to attract and reward excellence in R&D personnel.

A very important characteristic for R&D organizations aspiring to world-class status is the ability to maintain technical competency throughout the staff. An assessment by the U.S. Congress, Office of Technology Assessment (U.S. Congress, Office of Technology Assessment, 1989) noted that,

> Recruiting and retaining qualified scientists and engineers is a major problem for DOD laboratories. In the current sellers' market, government salaries and benefits for technically trained

personnel are not generally competitive with either industry or universities. Many DOD labs have given up trying to recruit the best and the brightest. Loosening up the rigid civil service salary structure is a principal component of ideas to reform lab management, and being able to pay competitively—above civil service ceilings—is a major incentive for converting labs to GOCO status.

The gap in average pay between government and private sector scientists and engineers has narrowed in recent years (see Chapter 7 and Appendix D). But the issue is not average pay; it is the availability of rewards for exceptional performance and leadership. Effective commercial R&D organizations tend to pay some R&D people highly, because success in developing a new technology depends on the extraordinary abilities and motivation of a few people. These people may not have excellent management and communications skills, but they may be paid more than some of the management personnel. In commercial organizations few feel that this is unjust. Additionally, many other motivational measures are used (e.g., opportunities to have more flexibility in directing their work, access to independent R&D funds to investigate their ideas, attendance at symposiums, etc.). Historically, GOCO laboratories have depended on such motivational measures with considerable success (National Research Council, 1993). In federal agencies, scope for such measures remains severely limited despite repeated initiatives to change this.

The administrative burden on managers is also important. Well managed R&D organizations give their leaders enough administrative support and freedom from undue administrative detail to permit them to remain technically involved in laboratory projects. This involvement gives staff daily guidance and insight into the views of the leadership, enhancing the quality of the technical work accomplished. The need to administer federal personnel and procurement regulations tends to prevent senior ARL managers from participating in this way (Army Research Laboratory, 1993). Contract organizations are not bound by these regulations, and therefore tend to adopt management controls more like those of the private sector. (As already pointed out, government oversight—however desirable on other grounds—can weaken this advantage, thus it should be minimized.)

Additional important features are the abilities to recruit high quality graduate students, to administer salary adjustments coupled to an effective R&D-oriented performance review system, and to have a mechanism for eliminating lower performance staff from the workforce. Many GOCO laboratories have excellent post-doctoral internship programs in which only a percentage are subsequently formally recruited into the staff. A number have practices of eliminating a fixed percentage of staff annually from their

lower (not necessarily unsatisfactory) performers. This practice keeps performance expectations high, enhances productivity, and allows continuous hiring of new staff with fresh ideas, enthusiasm, and state-of-the-art skills and knowledge (Informal discussions with executives of various laboratories, 1993).

In addition to the general governance issue of to whom ARL reports, other governance issues enhance their performance over typical governmental entities. Governance mechanisms vary widely among GOCO laboratories and FFRDCs, but they all take significant steps to augment the laboratory management. They generally have boards consisting largely of outsiders, who bring a broad and balanced view to policy formulation and management issues, as well as external evaluation of scientific and management performance. The Brookhaven National Laboratory, Argonne National Laboratory, and Sandia National Laboratories are examples of laboratories with such directly involved boards. Another pattern is seen in the three laboratories managed by the University of California, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Lawrence Berkeley Laboratory; they are overseen by the regents of the University of California, a body that is rather remote from the main issues of the laboratory and has many other issues on its agenda. DOE is seeking to have each laboratory develop a high-level advisory committee patterned after those long used by several of these laboratories. A number of the DOD FFRDCs are independent corporations and have corporate boards heavily populated with senior executives with in-depth R&D and government policy experience (Aerospace Corporation, 1993; MITRE Corporation, 1993; RAND Corporation, 1993).

Diversity and Quality of Research Sources

A GOCO operation has the greatest flexibility of all the options considered in choosing its research sources. The GOCO ARL option could be monolithic and attempt to provide all skill and effort from within its own organization. On the other hand, it could contract for any amount of effort from as wide a variety of sources as it and the government agreed was best. An extreme example of the latter approach is the well regarded Electric Power Research Institute, which contracts out virtually all of its research.

The key issue here is for the Army to provide the flexibility for this to occur within the contract vehicle, and to provide appropriate guidance to the GOCO contractor as to what it wants. Some GOCO laboratories have a wide spectrum of technical competency and others are quite narrow in scope. ARL is quite diverse. If better focused, it would become narrower technically but still quite broad. Also the mandate to focus on “leap-ahead” capabilities would require it to continually change its mix of technical competencies. A properly

guided GOCO with a flexible contract vehicle could adjust its mix of university and industrial sources, and internal and external efforts over the life-cycle of any particular technology—much as the government does now. The primary distinction would be that once the Army decided it wanted ARL to develop a new competency or divest itself of one, this would be accomplished through a process lying outside the government. This should be more flexible and timely than governmental action in the other options. If the Army wanted to maintain some particular source of expertise—it could direct the GOCO to do so, just as it now directs ARL or the Army Research Office to do so.

Technology Transfer to the Army

The GOCO ARL option would have an inherent handicap in transferring technology to its customer organizations, RDECs, and thence to the program managers and program executive officers. As an organization outside the Army—indeed, one that owes its strengths to its outsider status—it would run the risk of isolation from the needs of the RDECs for technology. The personal contact on which technology transfer depends might be hampered by the difference in organizational culture between the two organizations. Modern concurrent engineering practices occur through the creation of project teams, which travel along the development path with the project, thus facilitating technology transfer. An initial impression might be that a GOCO ARL could be seen as irrelevant by its customers, who, it should be remembered, have the capacity and the funding to do 6.1 and 6.2 work themselves. However, an organization that practices total quality management would strive to rectify this problem.

To counter this tendency, strong links would need to be built between the GOCO ARL and the RDECs to ease technology transfer. Personnel exchanges (including temporary assignments for government personnel at the GOCO ARL) would be one means of forming these links. Clarification of the two parties' roles and responsibilities would be essential.

One vital function of ARL as presently constituted is procurement assistance (i.e., the analytical support function). A GOCO ARL could be either better or worse than a government laboratory at this function, depending on the entity selected as the contractor and on the mechanisms for protecting against conflicts of interest (mainly owing to the commercial interests of profit-making contractors). This issue would have to be considered carefully in selecting a contractor and in devising contract terms. There is good precedent for using the DOD FFRDCs to assist in military procurements; for example, personnel of the MITRE Corporation, an Air Force FFRDC, routinely participate in government source selection evaluation boards. However, most DOD FFRDCs are independent corporations with no

other business than supporting the government. Similar assurance could theoretically be achieved with a profit-making company as contractor if the GOCO's work were properly segmented from the rest of the company (e.g., by establishing a separate corporate division with its own board reporting only to the overall corporate board, forbidding employees to exchange information across corporate divisions, and prohibiting the parent company from competing in technology procurements by the GOCO laboratory).

The GOCO laboratories of the Department of Energy, several of which are managed and operated by divisions of for-profit companies, show that conflict of interest can be controlled. Nonetheless, today's public and congressional concerns with fairness and perception of fairness in contracting must be taken into account when considering the GOCO ARL option.

ARL today provides a significant amount of support to field forces, through quick response to technical problems in the field. While a GOCO laboratory could provide similar direct technology transfer to the ultimate users, it is likely again, that government personnel could provide this service more easily. Still, some GOCOs and FFRDCs perform such tasks quite well. For example, the Center for Naval Analysis routinely provides personnel for shipboard evaluations at sea; MITRE Corporation personnel flew on each flight of the prototype Joint Surveillance and Tactical Airborne Radar System during Operation Desert Storm; and the DOE GOCO laboratories have provided personnel for on-site inspection in Russia.

Ability to Leverage Funds and Programs

Reductions in budgets have raised interest in how ARL might take advantage of R&D done outside the Army, in commercial and academic laboratories, and in the laboratories of other government agencies. A wide variety of mechanisms are available, ranging from using commercial products directly to collaborative working arrangements. In short, the Army is interested in spin-on technologies for defense use, as well as spin-off from defense research to commercial applications.

The GOCO ARL option, with its rich networks of contacts and its ability to exchange personnel easily with outside organizations, would be the most effective of all the options in forming the close relationships with outside entities on which spin-on and spin-off depend. As in all technology transfer, personal contact is essential. The best working partnerships offer channels for transfer in both directions. By sharing costs and information with external organizations, all parties win (Arrison et al., 1992; Ward, 1993).

There continue to be major problems regarding intellectual property rights, differing goals, and objectives that affect willingness to share and cooperate. The reality is that many initiatives are confusing and often

superficial. Nonetheless, it is clear that the Army, and hence ARL, must focus more on these issues and develop broader, more effective mechanisms involving more diverse sources.

Many improvements that could be made in this arena can be taken with any of the options considered by the committee. There are two major issue areas that may provide some differentiation between options. Unfortunately neither is clear-cut, and they probably affect each option in opposite ways. These two areas are willingness and ability to share ideas and cultural willingness and ability to use and exploit the work of others.

Some argue, for example, that industry is more willing to provide proprietary material to government entities than to contractors, even if they are FFRDCs. On the other hand, FFRDCs like MITRE have, and control access to, tens of thousands of industry proprietary documents. Also, there have been repeated complaints from industry that the government does not adequately protect their proprietary material and therefore they do not include them in responses to government agency Broad Area Announcements which seek innovative ideas, or submit them as unsolicited proposals. Thus, it seems that there are difficulties in this area for both government entities and GOCOs, but they may be somewhat more tractable for options that keep ARL within the government.

The other problem area is one of creating a cultural attitude that keeps a broad external perspective, rapidly exploits external advances when applicable, and builds on what others are doing. In the past, government laboratories have tended to prefer in-house efforts heavily and even some private sector companies exhibit this behavior. This is antithetical to the cultural attitudes necessary to be successful in leveraging other's work. Currently, industry is putting much emphasis on improving in this regard, and many potential GOCO contractors have existing cultures that emphasize outward relationships and exploiting anything that gives them a competitive advantage. Thus, a judicious choice of contractor entity to manage the GOCO could provide the cultural environment and set of existing relationships with industry and academia needed for ARL to better leverage external funds and programs.

One area of technology transfer in which GOCO laboratories have not excelled is in the development of CRADAs. The national laboratories have attracted much criticism for their slowness to conclude CRADAs, owing to their two-stage approval process (not only the laboratory, but the sponsor, must approve each CRADA [General Accounting Office, 1991]). DOE has taken steps to streamline the approval process; the Army could benefit from that experience.

Recurring Costs and Productivity

GOCO laboratories have direct incentives to satisfy their government clients. Their contracts can place a premium on getting the job done on schedule and keeping costs under control. If well-designed, the contract can provide for responsiveness to changing needs and circumstances.

A GOCO laboratory has the potential to manage personnel and internal operations to the best commercial standards, including support functions such as personnel, finance, accounting, procurement, security, and facilities. With a GOCO organization, these activities could be tailored to the needs of the laboratory, far more easily and efficiently than attempting the same tailoring within the federal government.

Also, there are greater opportunities for personal incentives to manage well and to be effective in executing the organization's mission. This includes not only financial rewards but also incentives such as scientific training, peer recognition, stimulating personnel exchanges with government organizations, and the recognition associated with being a member of a high-quality organization. In many instances, there might be opportunities for advancement in the parent organization.

To capture these benefits, however, the Army must not overly restrict management through the contract vehicle, by requiring excessive government approvals of operations. The past decade, for example, has seen a clear trend toward increased technical control and oversight over both the DOE GOCO laboratories and the DOD FFRDCs; many senior managers at these laboratories believe that these well-intentioned measures have reduced research productivity. Today there is one DOE field employee for every 28 laboratory employees, not counting the oversight personnel at DOE headquarters (see Appendix C). A DOE task force is currently developing methods to enhance its GOCO partnership, but their draft report is not yet available. The key for the Army is to create effective government oversight of business practices without imposing the government's own management methods.

There would be substantial pressure for productivity increases, because this option would entail substantial increases in recurring costs, owing to the higher pay scales of contract engineers. The GOCO ARL option would have only 1,357 scientists and engineers, compared with 2,021 for the ARL Enhanced and 1,779 for the NIST option, and 1,604 for the ARL Multicenter option.

It is difficult to judge the import of this difference in staff. It would obviously be better to have more professional staff than fewer, all other things being equal. But all other things are not equal. In the GOCO ARL option, for example, projects could be staffed more flexibly than in a government laboratory, so that skills could be used more efficiently. It is also

possible—although hard to prove—that well-motivated staff working outside the government system would be more productive. The cost can be assessed quantitatively in this case, but the potential offsetting benefits are generally subjective. The net effect can thus only be predicted by judgement.

IMPLEMENTATION PROCESS AND ISSUES

The regulatory processes that would have to be followed in converting ARL to a GOCO laboratory are well specified, but are subject to some uncertainties of interpretation. In addition to these hurdles, the Army could face a variety of other, nonregulatory implementation issues, such as dealing with the status of the federal employees.

Establishing a GOCO Laboratory as an FFRDC

To give a GOCO organization the "degree of access, beyond that normally characteristic of the contractual relationship, to government and/or supplier data, employees, and facilities needed to discharge its responsibilities efficiently and effectively, whether the data is sensitive/proprietary or not" (Office of Federal Procurement Policy, 1984), it is necessary to follow procedures set out by the Office of Management and Budget for forming an FFRDC. Thus, the transition of ARL to a GOCO would follow not only the procedures of establishing a GOCO, but also the procedures for establishing an FFRDC. The transition for the GOCO and the FFRDC would involve two major areas of concern for—complying with existing laws and regulations, and resolving political, personnel, facility, and contracting issues.

The procedures for creating an FFRDC are set out in OFPP Policy Letter 84-1 (Office of Federal Procurement Policy, 1984). The head of a department (such as the Secretary of the Army) has the authority to create an FFRDC, if he or she determines that it is appropriate within the scope and specific criteria of Policy Letter 84-1. The department head is also required to notify Congress formally, to permit comment. Public notice and comment through the *Commerce Business Daily* and *Federal Register* are also required. The process could be politically contentious, but the Secretary of the Army has full authority to create a GOCO ARL.

Establishing an FFRDC

As prescribed in OFPP Policy Letter 84-1, the Army must ensure the following:

- Existing alternative sources for satisfying the Army's requirements cannot effectively meet the special R&D needs.
- At least three notices describing the scope and nature of the effort are placed over a 90-day period in the *Commerce Business Daily* and the *Federal Register* indicating the Army's intention to convert ARL to a FFRDC.
- There is sufficient government expertise available to adequately and objectively evaluate the work to be performed by the FFRDC.
- Controls are established to ensure that the costs of the services being provided to the Army are reasonable.
- The responsibility for capitalization of the FFRDC has been defined in such a manner that ownership of assets may be readily and equitably determined upon its termination,
- The purpose, mission, and general scope of effort of the FFRDC is stated clearly enough to enable differentiation between work which should be performed by it and that which should be performed by a non-FFRDC.

Additionally, the Federal Acquisition Regulation, Part 35 (Federal Acquisition Regulation, 1990) directs that:

- The executive office of the President, Office of Science and Technology Policy, is notified.
- A reasonable continuity in the level of support to the FFRDC is maintained, consistent with the Army's need for the FFRDC and the terms of the sponsoring agreement.
- Office of Management and Budget Circular A-120 is complied with when applicable, and quantity production or manufacturing is not performed unless authorized by legislation.
- Approval must be received from the Secretary of the Army.
- The FFRDC must meet a special long-term R&D need that cannot be met as effectively by existing in-house or contractor resources.
- The FFRDC will generally have access beyond that which is common to the normal contracting relationship, to government and supplier data, including sensitive and proprietary data, and to employees and facilities.
- The FFRDC is required to operate in the public interest, and to be free from organizational conflicts of interest, and to have full disclosure of its affairs to its sponsoring agency.
- The FFRDC should not compete with the private sector. (In other words, it may not respond to competitive requests for proposals.)

Requirements for Cost Comparisons

There is no requirement in the Office of Federal Procurement Policy Circular 84-1 for cost comparisons. The focus in this circular is on whether alternate sources can more effectively provide support as compared to a GOCO. However, other legislation focuses on cost comparisons. According to Section 2462 of U.S. Code Title 10, DOD can procure supplies and services from sources in the private sector if those sources can provide the supplies and services at a lower cost than a government source. This policy is also described in regulations that deal with the Commercial Activities Program: Office of Management and Budget Circular A-76, DOD Directive 4100.15, DOD Instruction 4100.33, and AR 5-20. These require cost studies to establish the relative costs of internal performance and contract performance of existing or proposed commercial activities. AR 5-20, paragraph 4-1.b.(1), requires that an agency perform a cost study when proposing the conversion of an existing internal activity to a commercial activity (Gamboa, 1993).

If applicable, these requirements could create an issue for the conversion of ARL, because conversion to the GOCO ARL option (or the ARL Multicenter option) would hopefully raise quality, but not lower the costs of laboratory operations. This study has assumed that the Army would convert ARL to a GOCO in a *constant budget* approach, reducing staff to meet the confines of a fixed budget. The required cost comparisons do not account for differences in quality of work. AR 5-20, paragraph 1-6.i, seems to provide relief from these requirements, because it exempts research, development, test and evaluation functions from the cost study requirements of the Commercial Activities Program.

However, the exemption in AR 5-20 may not eliminate the issue. Section 2461 of U.S. Code Title 10 imposes certain requirements before a commercial or industrial type function of DOD being performed by DOD civilian employees as of October 1, 1980, can be converted to contract performance. Before such a conversion can be accomplished, Congress must be provided:

- notice of any decision to study such function for possible contract performance;
- a detailed summary of the cost comparison demonstrating that contract performance will result in certain savings and a certification that the entire cost comparison is available;
- certification that the government cost is based on the most efficient and cost effective organization; and
- a report containing information specified in the statute.

Thus, if the Army found it desirable to convert ARL to a GOCO laboratory, it would need to make a determination as to the applicability of

this statute. If it were determined to be applicable, an exemption would need to be sought on the basis of extraordinary action being necessary due to current downsizing and reorientation of defense R&D activities.

Inherently Governmental Functions

By statute, the government may not contract out "inherently governmental functions." The OFPP issued Policy Letter 92-1 in an attempt to clarify this issue and seeks to spell out what are inherently governmental functions (Office of Federal Procurement Policy, 1992). The policy letter does not deal specifically with R&D, and is careful to say that its opinions may not be legally valid. If interpreted broadly and literally the statute would foreclose an enormous fraction of the work that the government already contracts out. Thus, a broad interpretation does not seem to be in the intent of Congress or the Executive branch.

A GOCO ARL could not by itself take any official government actions. Therefore, any activity in which ARL today directs governmental action would have to be restructured so that the GOCO organization provided advice, while the appropriate government office determined whether the recommended action was appropriate and, if so, directed implementation.

Such a two-stage process can be difficult in some circumstances (for example, it is the cause of the relative slowness in DOE laboratories creating CRADAs). The principal concern over this matter may be the system assessment work done by ARL (which some ARL leaders assume is an inherently governmental function, according to statements made during a June 1993 visit by committee members). Many DOE GOCO laboratories and DOD FFRDCs have long done technology assessments (although implementation of the results must be approved by the sponsors). The OFPP policy letter appears generally consistent with existing GOCO practices, which include both research and development and considerable highly classified intelligence evaluation, planning, and support. Nevertheless, a GOCO ARL would likely find it more difficult than a government laboratory to establish the necessary communications between organizations.

While not technically a statutory issue, there is also an issue over whether the Army should contract out functions which are central to its future and mission accomplishment. The industry approach is not to outsource activities regarded as core competencies. The Army currently has its R&D activities split between the Army Research Office, ARL, and the RDECs. If it created a GOCO, it could do so in a way that it could be treated as an "organic" capability.

Potential Problems of Implementation

The implementation issues discussed thus far refer to regulations and public laws. Other issues and potential disadvantages are a result of attitudes and organizational culture, although they often take the form of procedural and contractual actions that could dilute the effectiveness of the GOCO ARL. Many pressures of this kind come from non-Army entities that would be involved in oversight functions affecting both the conversion to, and the operation of, the GOCO.

Perceptions of Unfair Competition with the Private Sector

Conversion of ARL to a GOCO laboratory could be perceived as unfair to the private sector (taken to include universities, not-for-profit institutions, and industry), which might thereby lose the opportunity to compete for some of the work themselves. However, private firms can compete to run the GOCO. Some in the private sector might object also to the specific features of the conversion process, such as the selection of the contractor. Such protests could slow conversion and make it more costly. The committee recognizes that the current Congressional mood seems to disfavor FFRDC funding.

Such objection could be limited by the potential subcontracting activities of the new laboratory. ARL currently contracts out some work (20 percent possible, with a maximum limit of 30 percent), and could continue to do so as a GOCO organization. Left to its own judgment, the GOCO management might contract out even more, a move that would make the implementation of this option more attractive to the private sector. In any case, the contract should allow the GOCO contractor to seek the best source of research work. (In fact, an ARL GOCO could be modeled after the Electrical Power Research Institute, in which almost all of the work is done by contractors with only some highly specialized analytical activities carried out internally; this, in fact, is substantially the ARL Multicenter option discussed in Chapter 5.)

Personnel Issues

One major issue area would be the resolution of personnel issues—the termination of personnel from the civil service system, and whether and how they would be offered private employment in the new organization. Under contracting out procedures, in-house employees are given right of first consideration. Current regulations require that severance pay be granted to all employees, even those immediately hired by the new GOCO laboratory.

Questions have also been raised about the transferability of, and potential losses from leaving, the civil service retirement and benefits systems (such as pensions, insurance, medical insurance, and leave). Many of these questions are contentious, and might add weight to objections from the civil service unions. ARL has only minimal union representation, but the unions might dislike the precedent set by the conversion. There is no way to judge in advance the union reaction, but the issue is not a legal obstacle.

Choosing a Conversion Method and Creating a Contract

As mentioned earlier, the Army has various alternatives in creating a GOCO ARL, like creating a new FFRDC as a private contracted corporation uniquely formed to manage ARL or to having an open competition to create and manage the laboratory strictly as a GOCO. Each of these alternatives raises its own issues. Fundamentally the Secretary of the Army can create a GOCO (or FFRDC) if he or she chooses, subject to notification of Congress and the Office of Management and Budget. He or she would also have to notify industry through the *Commerce Business Daily* and *Federal Register*, and respond to industry comments. It is also possible to go to an existing FFRDC (or small subset of FFRDCs) and invite them to submit a proposal to create a GOCO, circumventing some of the process of creating a new entity. However, FFRDCs are limited by their charters. There may be an option to transfer work from ARL to an existing FFRDC if it is within its charter. But this may raise cost comparison issues per 10 USC§2462. This approach would presumably generate protests from those excluded, but if the protests were managed successfully, could be the fastest and least costly. Most likely a new FFRDC would have to be created to run ARL.

It is important that the Army take a broad approach to creating contract requirements so that the mission of the GOCO is properly focused on selected, important technology areas as well as specifying other work the GOCO would do.

Also, careful deliberations must go into deciding in advance what organizational culture is desirable for an ARL GOCO, what key skills its management must have, and what type of governance it should have (such as an outside board of trustees). These determinations must be made before choosing a specific form of GOCO and conversion process, because they will have great influence on the choice.

While the management and operation contracts for the DOE GOCOs are good models for the Army, they will need to be tailored significantly because a GOCO ARL would have a different customer relationship with the Army than DOE's GOCOs have with DOE.

Time Required for Implementation

Another important implementation issue is the time it would take. Any estimate must be highly uncertain, because it must include effects of possible resistance on the part of some members of Congress, the workers and worker's unions, and possibly parts of industry. However, such a conversion might generate support from the Office of the Secretary of Defense, which would facilitate the conversion. Considering these ambiguities and the necessary approval process, it seems reasonable to estimate that once the Army decides to convert ARL into a GOCO organization, it would take at least six months to gain the necessary approvals (first as a GOCO and then as an FFRDC under OFPP Policy Letter 84-1). If competition were desired, a request for proposals could be prepared in parallel and be ready for release. If at least 90 days were allowed for industry response and at least 90 days for contract award, a GOCO could begin operations in less than two years.

If the Army created an FFRDC especially to operate an ARL directly, without competition, it might take 9 to 12 months to obtain the Office of Management and Budget approval, incorporate, create a board of trustees, have the board choose key executives, and negotiate a contract. It is quite likely, however, that a full competition would be required, to satisfy demands for equity and fairness; in that case, the schedule might be extended by an additional 6 months.

Allowing an additional six months to develop staff assignments, and six months for personnel to become reasonably focused on their work, an ARL could be functioning reasonably well in two to two and one-half years of a decision to pursue this option. While some loss of productivity could be expected during this period, it might be tolerable, given the internal turmoil of the Army over the next several years, the reductions already contemplated, and the lack of an overwhelming external threat.

These timelines are optimistic and faster than an average request for proposal process, but are feasible with total Army and the Office of the Secretary of Defense support. It would seem that if the executive leadership of the Army chooses the GOCO option and focuses on implementing it, these time estimates could be met.

Costs

Cost estimates must be accepted with caution. Government accounting systems are quite different from those of the private sector, making valid comparisons difficult. The committee commissioned the most comprehensive study yet attempted, which, despite its uncertainties, for the first time places

the various options on a consistent basis for analysis (see Chapter 7 and Appendix D).

A one-time conversion cost would also be incurred. This cost, estimated at $85 million, accounts for severance pay and other personnel costs, as well as contracting costs. As noted in Chapter 7, all government employees, even if offered jobs in the new GOCO ARL, would receive severance payments unless they find jobs elsewhere in the civil service. (The committee assumes, in making its cost estimates, that few would succeed, owing to general declines in government employment, but that some would retire; this assumption is thus a conservative estimate of these costs. See Chapter 7 for details.) The cost of severance pay is the major cost differential between the GOCO ARL option and others considered by the committee (see Chapter 7 and Appendix D).

The question is whether the higher pay and other personnel incentives increase the value of individual research enough to offset these costs. The answer is a matter of judgment. Many have concluded that for similar work of comparable quality the cost comparison of contractor versus government research will show only marginal differences (Defense Science Board, 1987). Current metrics for measuring quality and output for R&D work are inadequate for the purpose of making a quantitative value comparison. Thus, a value comparison must be judgmental and made by informed persons.

In any case, it is likely that there will always be perceptions that it is more expensive to contract for a GOCO ARL then to do the same work in the government. Perennial criticism of the GOCO on these grounds could be expected, complicating the Army's management problem.

OVERALL EVALUATION

The history of GOCO organizations and the broader class of FFRDCs shows that, if the Army decides that a nongovernmental entity is desirable, a combination of organizational form, contract features, and degree of competition can be developed and implemented to provide the Army with the results it seeks. There are difficulties in creating and managing a GOCO laboratory, however, that could result in a less than optimal outcome.

The contract vehicle must provide broad authority for the contractor to exercise management judgment and flexibility (including in subcontracting), while allowing effective government oversight, auditing, and inspection. Otherwise, many of the benefits of a GOCO organization can be lost. The GOCO ARL option should be treated by the Army much as a corporate laboratory is treated by its industrial parent organization, with joint development of objectives, responsibility for performance in the hands of the

managers and staff, and evaluation of results in terms of products (Roussel et al., 1991).

The key ingredients for a GOCO contractor are to bring a blend of R&D innovativeness, technical managerial competency, operational understanding, and business skills to the table. This must be done in a way that no important conflicts of interest exist with any other business the parent may be in. One solution would be to organize the new GOCO ARL as an independent FFRDC, which did no other business, and recruit the necessary talent from a variety of outside corporate and university sources. It will also be necessary to continuously monitor and ensure that linkages to Army strategy and science and technology objectives, as well as mechanisms for technology transfer, exist and are effective.

The major issues associated with achieving a GOCO ARL are possibly political controversy and the one-time cost of severance pay. The revenue-neutral assumption of this option underscores the need for the GOCO ARL to be more productive and better focused than today's ARL. The one-time severance pay cost may seem high to some, but compared with the overall research, development, and acquisition budget of the Army and the current costs of downsizing, it is not large. It would also be small compared with the advantage to the Army of having a highly respected GOCO laboratory.

REFERENCES

Aerospace Corporation. 1993. Annual report.

Army Research Laboratory. 1993. Meeting with the GOCO ARL option panel, Committee on Alternative Futures for the Army Research Laboratory. Adelphi, Maryland. June 29, 1993.

Arrison, T.S., C.F. Bergsten, E.M. Graham, and M. Caldwell Harris, eds. 1992. Japan's Growing Technological Capability: Implications for the U.S. Economy. National Research Council. Washington, D.C.: National Academy Press.

Defense Science Board. 1987. Report to the Secretary of Defense of the Summer Study on Technology Base Management. Washington, D.C. December.

Gamboa, A. 1993. Briefing by Anthony Gamboa, Office of the General Counsel, to the GOCO ARL option panel, Committee on Alternative Futures for the Army Research Laboratory, Washington, D.C., June 28–30, 1993.

General Accounting Office. 1991. Diffusing Innovations: Implementing the Technology Transfer Act of 1986. Washington, D.C.: Program Evaluation and Methodology Division.

Federal Acquisition Regulation. 1990. Title 48 - Federal Acquisition Regulations Systems Chapter 1. Part 35. Volume I.

Informal discussions with executives of various laboratories. 1993. Communication from executives from Sandia National Laboratories, Lawrence Livermore National Laboratory, Brookhaven National Laboratory, the MITRE Corporation, the Aerospace Corporation, and Lincoln Laboratories to the GOCO option panel, Committee on Alternative Futures for the Army Research Laboratory.

Laslic, S.W. 1993. The Cold War and American Science: The Military-Industrial Academic Complex at MIT and Stanford. New York: Columbia University Press.

Meisel, R.C., and J.F. Jacobs. 1979. MITRE, the First Twenty Years: A History of the MITRE Corporation, 1958–1978. Bedford, Massachusetts.

MITRE Corporation. 1993. Annual report.
National Research Council. 1993. Improving the Recruitment, Retention, and Utilization of Federal Scientists and Engineers. National Research Council. Washington, D.C.: National Academy Press.
Office of Federal Procurement Policy. 1984. OFPP Policy Letter 84-1, Federally Funded Research and Development Centers. Washington, D.C.: Executive Office of the President, Office of Management and Budget. April 4.
Office of Federal Procurement Policy. 1992. OFPP Policy Letter 92-1, Inherently Governmental Functions. Washington, D.C.: Executive Office of the President, Office of Management and Budget.
RAND Corporation. 1993. Annual report.
Roussel, P.A., K.N. Sand, and T.J. Erickson. 1991. Third Generation R&D Managing the Link to Corporate Strategy. Boston: Harvard Business School Press.
U.S. Congress, Office of Technology Assessment. 1989. Holding the Edge: Maintaining the Defense Technology Base. OTA-ISC-420. Washington, D.C.: U.S. Government Printing Office. April.
Ward, B.L. October 24, 1993. From weapons to widgets: it's Martin Marietta's turn to produce a peace dividend at the Sandia Labs. (Sandia National Laboratories to be managed by Martin Marietta, includes related articles). New York Times. F5.

7

Cost, Personnel, and Procurement Comparisons of Options

This chapter summarizes the committee's cost estimates for the four Army Research Laboratory organizational and management options, and discusses the major personnel and contracting issues raised by each option. Appendix D contains the detailed background, data collected, comparative analyses made, and findings in the areas of cost, personnel, and procurement.

The baseline for cost analysis, with which each of the four options was compared, was the projected ARL personnel structure for fiscal year 1997 (the year when ARL's formation will be complete), as provided by ARL. This baseline, labeled “ARL-97,” represents a significant reduction in support staff, compared with the current ARL staffing, in accordance with the Army Science and Technology Master Plan (Department of the Army, 1992a) and the directives of the Defense Base Closure and Realignment Commission (1991). Because several actions to achieve the ARL-97 structure have already been initiated, the committee found the planned fiscal year 1997 structure better for comparison purposes than the current (fiscal 1993) ARL structure.

ASSUMPTIONS

The major assumptions used for cost comparisons follow.

- All options would operate with the same budget as is planned for ARL in fiscal year 1997 ($323 million in fiscal year 1993 dollars); this *revenue-neutral* assumption means that recurring costs would remain constant and that the major differences in the estimated quantifiable costs of the options would be their one-time conversion costs.
- The revenue-neutral assumption implies that, in all the options but the ARL Enhanced, fewer personnel could be afforded, because personnel would receive higher salaries or benefits; it further implies that, for those options, there would be a necessary reduction in the total number of personnel to remain within the fixed budget.
- The committee believes that some of ARL's laboratories may need to be upgraded, regardless of the option chose, to enhance the quality of the

research environment. However, the committee could find no reason to believe that facilitation costs would differ among options. Thus, such costs would not be discriminators for choosing from among the options. Additionally, the committee adhered to the guidelines for this study that no additional capital costs be considered for any option. The committee believes, though, that such increases might improve the chances of attracting better research personnel.

- The focusing of the laboratory's work in fewer business areas would result in the displacement of a number of scientists and engineers (S&Es) who would not be qualified to perform research in the areas of concentration.
- The in-house/contracted ratio for the fiscal year 1997 ARL is assumed to be 80/20 as opposed to the 70/30 provided by ARL (see Appendix D).

Another general assumption for this study is that, if the Army were to emulate the structure, management, personnel practices, and facilities of research laboratories generally considered in the scientific community to be world-class, the value of the resulting research effort would be enhanced compared to that of the existing ARL. Under such circumstances, even if a conversion were to take place with no increase in operating cost (not counting the one-time conversion costs), the long-term value would increase even though the number of personnel decreased. Achieving the Army's vision of becoming a world-class laboratory requires the ability to attract and retain exceptional scientists and engineers, whose increased productivity would make up for the lower number of personnel afforded under the options in which pay for these exceptional personnel was higher.

PREVIOUS STUDIES

A number of previous studies were reviewed to gain insight into what past analyses concluded about the costs of converting government research laboratories to either NIST-like or GOCO operations. These studies were conducted by ARL's predecessor, the U.S. Army Laboratory Command (1990); by the Air Force, the Navy, and the Office of the Secretary of Defense (Office of the Secretary of Defense, 1991a, 1991b; Heeb, 1991). The studies are discussed in more detail in Appendix D.

All previous studies assumed that scientists and engineers in a GOCO operation would be paid substantially more than in the current structure. Consequently, on an equal operating cost basis, significantly fewer S&Es, as well as fewer total staff, would be affordable.

These studies found one-time conversion costs to be very large. For example, the Army study concluded that the conversion costs for the U.S.

Army Laboratory Command would be $525 million, without including the costs for severance pay and other reduction-in-force (RIF)-related costs. The bulk of this conversion cost was for retirement pay buyouts, which, according to DOD instructions, is not a proper cost of conversion, since those costs will be paid at some time regardless of whether the conversion occurs. It is understood that, during the conversion process, disposition of retirement pay entitlements would have to be determined; for example, in conversion to a GOCO organization, such pay could fund the contractor's retirement fund for government employees hired by the contractor, or be held by the government for later payment to the individual.

None of the studies provided evidence that the same missions as required from the baseline laboratories (government-owned and -operated) could be carried out satisfactorily by substantially fewer personnel, or that greater productivity or overall value would be added by changing to the new structures. However, the committee believes that private sector laboratories can deliver higher productivity per person. This belief is supported by the excellent reputations of the Department of Energy laboratories sponsored in universities and industry, the Jet Propulsion Laboratory sponsored by the National Aeronautics and Space Administration, and the Massachusetts Institute of Technology Lincoln Laboratory sponsored by the Department of Defense.

COSTING APPROACH

The committee took the following steps in costing the options:

- select the appropriate cost metrics on which to base the comparisons;
- collect available actual data for each metric;
- analyze the data to obtain usable metric values, where possible on a per capita basis, for use in the comparisons;
- calculate the cost impact on personnel of fixed operating budgets (i.e., how many fewer personnel could be afforded); and
- calculate the total cost of the conversion to each of the options.

The general results of these steps are described below, and the results are summarized in the next two subsections.

To provide valid comparisons, the committee chose cost metrics carefully. A number of metrics were considered in the course of the study; those used were selected on the basis of (a) availability of data; (b) meaningfulness of the parameter for comparison purposes; and (c) the

committee's belief that the metric represents a true discriminator of the options. The wide variation in accounting procedures from facility to facility meant that cost comparisons only at a very high level of aggregation were considered appropriate. The committee selected the following metrics:

- total operating costs (adjusted to exclude the cost of contracting out research);
- total operating cost (adjusted) per S&E;
- average salary;
- cost of designing and training for new personnel system;
- severance pay and other RIF costs; and
- contracting (for a research contractor or a GOCO management firm) process.

Other conversion costs (not easily calculated or measured, but considered important to document) include:

- pay differential for converted personnel;
- facilities upgrade;
- processing costs of legislative and regulatory changes;
- costs of obtaining understanding and approval of labor unions (if necessary);
- disruption costs; and
- government monitoring and oversight costs.

The total estimated fiscal year 1997 budget (excluding pass-through funding to outside contractors for research) of $323 million (in fiscal year 1993 dollars) was provided by ARL and is assumed in this study to be the operating budget for all options (i.e., the recurring operating costs are to be the same before and after conversion). Consequently, the number of S&Es and the number of support staff affordable under each option were determined based on the average salaries of contractor and government personnel. All costs in this study, except where otherwise noted, are in constant fiscal year 1993 dollars. If the actual fiscal year 1997 funding is less, the number of affordable manpower positions will be proportionately fewer.

It was assumed, as stated earlier, that ARL would focus on fewer, and possibly a different set, of business areas, requiring different skills than are currently available. For costing purposes, it was assumed that half of ARL's 10 business areas would be eliminated, and that, as a result, half of ARL's S&Es would be either RIFed or reassigned. It was further assumed that half of the affected personnel could be reassigned to the new or refocused business areas, while the remaining half (or 25 percent of the total) would be replaced by S&Es with new skills.

In the NIST option, not all government S&Es leaving could be replaced by other government S&Es, because the total number of S&Es affordable within the fixed budget amount is less than in the baseline.

In the ARL Multicenter and GOCO ARL options, the terminated S&Es would be replaced by contractor personnel and be entitled to severance and other pay. Current Office of Personnel Management and DOD regulations require that any government employee who is terminated due to conversion to a commercial enterprise, and who is not retiring, is eligible for severance and other benefits, whether or not he or she is hired by the commercial firm involved in the conversion (Office of Personnel Management, 1989; Department of Defense, 1993). Because the costs for a pure contractor-owned and contractor-operated commercial venture were not estimated, the GOCO ARL costs were used in the estimate for the ARL Multicenter option. The costs to obtain contractors in the ARL Multicenter vary according to the number of contractors being sought.

The following calculation procedures and per capita costs were used for the conversion cost comparisons:

- The number of scientists and engineers affordable under each option was determined by dividing the operating budget by the fully loaded cost per S&E; the fully loaded cost is the average salary multiplied by a loading factor to account for all costs for the laboratory (including support staff and facilities). The loading factor was 3.4, representing an average load for salaries at an ARL-like laboratory, as explained in Appendix D.
- The average S&E salary rate of $70,000 per year, determined for the GOCO ARL option, was used for all contract personnel in all the options to keep the comparisons consistent and valid.
- The ratio of S&Es to total staff was held constant for all options (even though contractors may choose to operate differently), and the ratio was based on the ARL-97 plan to have 1,744 S&Es as part of a total staff of 3,131; thus to calculate the total staff for each option, the number is multiplied by 1.8 (3,131/1,744).
- The cost of severance was calculated by ARL, based on the actual population of personnel expected at ARL in fiscal year 1997; per capita severance pay ($21,000) was calculated by dividing the total severance cost by the number of people being RIFed. Based on the ARL-supplied information, all options that would require RIFs used 23.8 percent to calculate the number of people who could be RIFed but would be eligible for retirement or would find other government jobs, leaving only 76.2 percent of the total to receive severance pay and other RIF-related payments. Other RIF-related payments and associated costs for individuals leaving the government was estimated using Army-wide estimated costs (Department of the Army, 1992b) of $11,500 per person RIFed.

- Per capita costs for personnel system design and training (for the NIST option) were based on recent experience at the China Lake, California, installation of the Naval Air Warfare Center, which recently converted its Point Mugu facility to the *demonstration project* personnel system.
- Costs to obtain a contractor to perform and/or manage research activities for the ARL Multicenter and GOCO ARL options were based on the $7.5 million average of a range ($5 to $10 million) for competing to obtain a single contractor. This range was based on historical government-to-contractor conversions through the Office of Management and Budget-specified process (Office of Management and Budget Circular A-76, dated August 4, 1983). Costs to obtain more than one contractor for the ARL Multicenter would increase with the number of contractors.

These calculations and costs are discussed in greater detail, including their sources, in Appendix D. These costs, and any other conversion costs which may be identified in a more detailed estimate of conversion costs, could, in some instances, be spread over more than one year for budgeting purposes.

COST ANALYSIS

This subsection summarizes the cost analysis and results conversion cost calculations for each of the four options (Table 7-1).

ARL Enhanced Option

The ARL Enhanced option maintains the fiscal year 1997 ARL number of in-house S&Es (1,744) and total government staff (3,131) and maintains the same in-house/contracted ratio (80/20) as in the fiscal year 1997 baseline. This option differs from the baseline only in the reduction and/or focusing of the business areas and the resulting change in S&E personnel numbers. The termination of 25 percent of the ARL's S&Es (436 of 1,744), to be replaced by S&Es with different skills, causes the only conversion cost. Of the 436 S&Es who are displaced by the reduction in the number of business areas, 23.8 percent of them (104) would either be eligible for retirement or find other government employment, leaving 332 to be RIFed, and would receive termination pay (severance pay and other allowances) resulting in a conversion cost of $10.8 million for this option. The 23.8 percent is consistent with the severance pay calculations made for the committee by ARL, as explained in Appendix D. Providing the director discretionary funding, already in the budget, or reassigning ARL to Department of Army headquarters is not

TABLE 7-1 Cost Comparison (Fiscal Year 1993 $)

	Baseline Cases		Options			
	ARL FY 1993	ARL FY 1997	ARL Enhanced	NIST	ARL Multicenter	GOCO
Operational Budget (millions)	484	323	323	323	323	323
In-House Dollars	317	257	257	257	97	0
Contracted Out Dollars	167	66	66	66	226	323
In-House Percentage	65	80	80	80	30	0
Contracted Out Percentage	35	20	20	20	70	100
Average Salary per S&E (thousands)						
In-House	52.7	52.7	52.7	61.2	52.7	NA
Contracted Out	70.0	70.0	70.0	70.0	70.0	70.0
Total Staff (S&Es and Other)	5,095	3,629	3,629	3,194	2,880	2,436
Total Staff in House	3,835	3,131	3,131	2,696	1,174	0
Total Contracted Staff	1,260	498	498	498	1,706	2,436
In-House S&Es	1,769	1,744	1,744	1,502	654	0
Contracted Out S&Es	702	277	277	277	950	1,357
Total Number of S&Es	2,471	2,021	2,021	1,779	1,604	1,357

Business Areas	10	10	5	5	5	5
Impact of Fewer Business Areas (fewer S&Es)	0	0	436	436	0	0
People Displaced (including S&Es)	0	0	436	629	1,957	3,131
S&Es Hired with Replacement Skills	0	0	436	194	0	0
People Retiring/Transferring/Attriting (24 percent)	0	0	104	149	465	744
People to be RIFed	0	0	332	480	1,492	2,387
Conversion Costs (millions):						
Severance Pay (21,000 each)	NA	NA	7.0	10.1	31.3	50.1
"Other" Costs (11,500 each)	NA	NA	3.8	5.5	17.2	27.5
System Design Cost ($348/S&E)	NA	NA	NA	0.5	NA	NA
Training Cost ($546/S&E)	NA	NA	NA	0.8	NA	NA
Cost to Obtain Contractor(s)	NA	NA	NA	NA	7.5–21.5*	7.5
Total Conversion Cost (millions)	NA	NA	10.8	16.9	56.0–70.0	85.1

* The cost will depend on the number of independent centers of excellence which are contracted out.

expected to add any additional costs, but may result in a shift of responsibilities and personnel, and may have a positive impact on productivity.

NIST Option

Under the NIST option, salaries would be permitted to rise under a pay-for-performance system, approaching the salary practices of industry (National Institute of Standards and Technology, 1993). For the purpose of this analysis an instant rise in salaries was assumed. The higher average S&E salary ($61,200 per year compared with $52,700 for ARL) would cause the total number of S&Es affordable under the budget (1,502) and the total number of staff personnel (3,194) to be less than that for the baseline. The cost of contracting out would remain constant. Reducing the number of business areas would cause 436 (25 percent) of ARL's S&Es, and 193 other staff personnel to be terminated, for a total of 629 displaced personnel. Only 194 government S&Es, with new skills, could be hired in order to stay within the affordable total of 1,502 S&Es. This reduction in the number of business areas would cause the actual RIF of 480 people at a cost of $15.6 million in severance and other allowances. Another $1.3 million would be required to design or adapt a NIST-like personnel system to ARL and to train the government employees in the use of that system, making the total conversion cost of this option $16.9 million.

Of no cost consequence, but of interest, is the fact that NIST was the only government laboratory visited that had a revolving investment account. Laboratory directors can draw on the fund to procure equipment and replenish the fund by amortization over a number of years.

ARL Multicenter Option

The ARL Multicenter option differs from the baseline by changing the in-house/contracted ratio from 80/20 in the baseline to 30/70 in this option. Using the same rationale as was used for the other options, this change results in a reduction to 654 government S&Es and 1,174 total government employees. The total government (654) and contracted (950) S&Es in the final structure are estimated to be 1,604, compared with a total of 2,021 in the baseline case, for a 21 percent reduction in S&E staff. Because 950 S&Es are being contracted, it is expected that the contractor would have enough margin to select new employees with the newly required skills. The one-time severance pay and other allowances would be $48.5 million, due to the 1,492 personnel that would be terminated (76.2 percent of the 1,957 people lower than the baseline number of 3,131). Somewhere between $7.5 and $21.5

million is estimated to be required for the contracting process (based on the number of contracts). Thus, the total conversion cost would be between $56.0 and $70.0 million.

GOCO ARL Option

Analysis of the costs of the GOCO ARL option is based on a number of diverse data sources. Considerable data were obtained from the U.S. Department of Energy (1992a, 1992b), and further information was collected from Sandia National Laboratories and Brookhaven National Laboratory. Summary information was obtained from federally funded research and development center sources, discussed in more detail in Appendix D. Sandia personnel stated that the average S&E salary there is $70,000, and that this salary is comparable with industrial salaries. Since ARL-97 is distributed in three geographical areas, no regional adjustment was made to these data. It was further assumed that the GOCO firm would operate in a method more analogous to ARL than to Sandia, where high security and safety concerns, as well as high equipment maintenance costs, cause the overhead costs to be very high (as is true at all DOE multipurpose laboratories). Since all government employees who are not eligible for retirement or reassignment would be eligible for termination pay (76.2 percent of the 3,131 people, or 2,387 employees), the one-time severance pay and other allowances would amount to $77.6 million, in addition to the initial contracting process costs of $7.5 million. This cost to acquire a contract would apply each time the contract is recompeted.

COST FINDINGS

The most significant findings, as highlighted above and discussed in more detail in Appendix D, are the following:

- All conversions to different management structures involve some one-time conversion costs. Those options shifting more of the research effort to contracted sources require larger one-time conversion costs.
- The recurring annual operating budgets for all options were assumed to be the same as the current budget; therefore, the one-time conversion costs are not recoverable over time except through potential improvements in operating efficiency or research productivity.
- Table 7-1 is a summary of the estimated staffing levels and conversion costs for the four options. As shown in the table, when the total annual operating budget is held constant for all options, the conversion costs

will be greater the farther the option is from having all government personnel at ARL. For all except the ARL Enhanced option, the number of S&E personnel and the number of overall staff will decrease.

- The benefit or value side of the equation is extremely difficult to assess. ARL has announced its vision of becoming a world-class laboratory. There is general agreement that a pay structure, for instance, that would help attract and retain world-class scientists and engineers would bring the laboratories closer to this vision. It is less clear what the additional costs implied by a richer and more flexible pay plan would yield, quantitatively, in research output. It is also likely that additional capital investment will be required to maintain world-class scientists. These costs cannot be estimated without a clearer definition of the laboratory's mission in the new environment.
- The government management and oversight of contract operations could result in significant recurring costs, which were not calculated in this study. A current DOE study is reviewing how to reduce these costs. The Secretary of Energy, in her Congressional testimony, stated that DOE oversight experience indicates a requirement of 1 field officer for each 28 contract personnel, not including the DOE headquarters personnel that perform oversight and policy functions. DOE in recent years has come to consider the national laboratory employees to be quasi-government employees, and now keeps tight control over them. DOE is currently studying its relationships with these laboratories. On the other hand a number of federally funded research and development centers are monitored with much fewer personnel. The number of personnel performing this function depends directly on the details of the negotiated contract(s). The Army should manage this oversight function so that it does not result in such a large number of overseers and so that it does not become a major additional cost.

COSTING LIMITATIONS

A number of limitations apply to the results shown in this analysis. Among the most significant limitations are the following:

- Because there is no evidence of a defense R&D organization having been converted from government operation to contract operation, the analysis has significant uncertainties.
- There is no quantitative evidence that the alternative management structures for ARL would be able to complete ARL's mission, or whether they would represent better values to the Army. (Judgments of research value are beyond the scope of the cost study.)

- It is possible that a new, aggressive management team, either government or contractor, could operate more efficiently (e.g., reduce the ratio of indirect to direct personnel) and thereby operate either at less cost or with more S&Es than the numbers shown.
- Any change in governance (e.g., ARL reporting to the Assistant Secretary of the Army [Research, Development and Acquisition], rather than to the Army Materiel Command), is not assumed to significantly affect cost but could affect value.
- It was not possible within the time available to compare above base pay benefits because of large definitional and accounting differences; however, we believe the cost comparisons presented form a reasonable basis on which to draw conclusions about the magnitude of costs required to achieve each option.
- The time it takes to prepare for and perform a transition and the time lost during disruption could not be estimated with a high degree of accuracy.
- Costs may be affected by local conditions. ARL-97 will operate in three dispersed geographical areas, but no attempt was made to refine the data collected to take this geographical factor into account. A GOCO can pay prevailing salaries for an area—sometimes more and sometimes less than a government employee in the same area.
- The one-time conversion costs do not include the cost of buying out retirements, which the Navy and the Air Force estimated to be about $43,000 to $50,000 per person, although the referenced Army study did not consider this cost relevant (Office of the Secretary of Defense, 1991b). These costs are not properly costs of conversion, because they would have to be paid at some time, with or without conversion.
- The cost of additional government personnel to provide policy, manage and oversee the contract, which could result in a significant amount if based on DOE experience and congressional requirements, is not included in the estimates. Acquisition return could reduce this cost. As mentioned earlier, the Army should strive to avoid the burden of large numbers of oversight personnel no matter which of the options is selected.

PERSONNEL

The chapters on each of the four options (Chapter 3, Chapter 4, Chapter 5, through Chapter 6) discussed the personnel implications of each option. This subsection provides an overview of the issues and a summary of the personnel improvements which are likely under each of the four options.

Key personnel issues that the committee examined under each of the four options (ARL Enhanced, NIST, ARL Multicenter, and GOCO ARL)

include the ability to hire, the ability to pay for performance, and the ability to fire. Each of these issues was examined for each option and the results are provided in the following paragraphs.

- Within existing laws and regulations, much can be improved in the personnel management area. For example, permitting line managers to classify positions and establishing an automated position classification system, with an associated S&E database, to support the line managers in their job classification process would shorten the time it takes to establish and fill a critical S&E position. This measure can be taken within AMC's current statutory and regulatory authority. It is among the Defense Laboratory Demonstration Initiatives (see Chapter 3) and has been partially implemented. Changes in the position classification process would have to be coordinated with and approved by the Office of Personnel Management. The use of term appointments to attract senior retired research experts is another example of an improved procedure which has been tried only in a limited way at ARL.
- More personnel management flexibility (e.g., hiring, firing, pay for performance, etc.) could be achieved under the NIST option (see Chapter 4). The existing personnel demonstration projects at NIST and the Naval Air Warfare Center at China Lake have proven that the ability to hire rapidly, assess periodically, and encourage improvements in performance or fire for lack of satisfactory performance (within a set period of time after hiring) are all working well and should result in better performance by all employees under these revised civil service rules.
- Of the four options being considered, the GOCO ARL option offers the greatest opportunity for achieving excellence in the personnel arena, as was discussed in Chapter 6, but this excellence could be at a greater overall cost, as is demonstrated by the conversion cost comparisons shown in the previous subsections. The reasons for this excellence would be that the GOCO contractor could operate ARL as a business and not be bound by any of the constraints of the current civil service personnel system. The ARL Multicenter option (Chapter 5) would also achieve this excellence in the 80 percent that would be contracted out under that option.
- All of the options considered would involve labor/management relations issues that would have to be addressed at conversion time.

For more details on the personnel issues addressed for each of the options, see Chapter 3, Chapter 4, Chapter 5 through Chapter 6.

CONTRACTING

The chapters on each of the four options (Chapter 3, Chapter 4, Chapter 5 through Chapter 6) discussed the procurement and contracting implications of each option. This subsection provides an overview of the issues and a summary of the contracting improvements which are likely under each of the four options.

The further one moves in contracting and procurement practices away from government standards (the Federal Acquisition Regulation) and toward those of private industry, the faster and more efficient should be the processes. However, the government has instituted some innovative practices (e.g., for low-value items utilizing credit cards distributed to certain centers) to attempt to speed up the procurement process time. As discussed in Chapter 3 (ARL Enhanced option), and as recommended by the Laboratory Demonstration Initiatives, more extensive use of Competition in Contracting Act exceptions should be promoted (e.g., sole-source awards when justified, prequalified bidders lists so that awards are made on a price basis only). The Army should make use of all contracting practices, allowable within the Federal Acquisition Regulation, to improve the procurement process.

Specific contracting implications of each ARL option are summarized below:

- Under either of ARL (Enhanced or Multicenter) and the NIST options, there are to be no changes in the Federal Acquisition Regulation, and the only efficiency possible is to follow procurement practices that have proven successful at other places.
- The GOCO ARL option should provide the most flexible contracting procedures and the fastest completion time on all contracting actions, since when true relaxation of, or creative deviations from, the procurement process rules is permitted, the process will move more smoothly and the end result will be more rapid completion of all contracting actions.

For more details on the contracting issues addressed for each of the options, see Chapter 3, Chapter 4, Chapter 5 through Chapter 6 and Appendix D.

REFERENCES

Army Laboratory Command. 1990. GOCO's vs. Army Labs. Internal report. March 23.

Defense Base Closure and Realignment Commission. 1991. Report to the President. Washington, D.C. July 1.

Department of the Army. 1992a. Army Science and Technology Master Plan. November.

Department of the Army. 1992b. Estimating costs of reduction in force (RIF). DAPE-CPE. June 29. Information Paper.

Department of Defense. 1993. DOD program for stability of civilian employment; DOD displaced employees information and entitlement pamphlet. DOD Manual 1400.20-1-M. September.

Department of Energy. 1992a. Capsule review of DOE research and development laboratories and field facilities. Office of the Technical Advisor. Washington, D.C. September.

Department of Energy. 1992b. The National Laboratories of the U.S. Department of Energy. Washington, D.C.

Heeb. M.1991. GOCO or status quo for defense R&D labs. Department of Defense. Briefing for the Advisory Commission on the Consolidation and Conversion of Defense Research and Development Laboratories. July 17–18, 1991.

National Institute of Standards and Technology. 1993. NIST evaluation of a Hay Management Consultants report on Total Compensation Comparability (January 10, 1992). Informal communication to the Committee on Alternative Futures for the Army Research Laboratory, June 2, 1993.

Office of Management and Budget. 1983. Circular A-76. August 4.

Office of Personnel Management. 1989. Notice of proposed changes to Title 5 of the code of federal regulations, attachments 1 and 2 to FPM Bulletin 550-68.

Office of the Secretary of Defense. 1991a. GOCO or status quo for defense R&D labs? Briefing by Michael Heeb for the Advisory Commission on the Consolidation and Conversion of Defense Research and Development Laboratories, July 17–18, 1991.
Office of the Secretary of Defense. 1991b. Background material on GOCOs. DOD Laboratory Demonstration Program Panel. June.

8

Conclusions and Recommendations

While the Army's decisions about the future of the Army Research Laboratory will hinge on some matters that are beyond the scope of this committee, the primary issues are discussed in this report. The committee has made a number of important findings about the problems facing ARL in the next decade, and the sources of those problems. To help solve those problems, it offers five broad recommendations, whose implementation would improve ARL's utility to the Army regardless of the organizational option chosen. This report compares the options on a consistent basis, using a straightforward set of management criteria that reflect the Army's desires for ARL's performance. The Army itself will have to select an option on the basis of its resources and strategies. The committee can only stress that the time for substantive change has come.

REVIEW OF THE ARMY RESEARCH LABORATORY

In its review of ARL, this committee relied heavily on judgments of its *inputs*: management, personnel statistics, administrative practices, and funding. ARL is hindered by cumbersome personnel, contracting, and procurement administrative procedures, by a lack of focus in its program, and by a lack of support in funding and personnel decisions. The conclusions with respect to the assessment criteria follow.

Linkage to Army Strategies and Objectives

ARL is intended to be a flagship laboratory for multidisciplinary research and technology development in support of the Army's technology base. It must shape its program according to the Army's needs for technology 5 to 15 years in the future. At the same time, it has customers to serve, primarily AMC's RDECs with their short- and mid-range needs. ARL has very strong linkages to short- and mid-range Army strategies and objectives. In reporting to AMC, ARL is governed by an agency that is oriented more

toward the short-range view of readiness and system support than with the long-range benefits of basic research and exploratory development. ARL's primary oversight body, the ARL Board of Directors, mostly has members who are primarily concerned with short- and mid-range science and technology issues. ARL has some direct links and many indirect links (through the RDECs) to the Training and Doctrine Command (TRADOC) battle labs, but these doctrine-oriented labs are mostly concerned with short-range technology issues. ARL's field assistance teams are primarily involved with resolving short-range problems. ARL has weak links to the long-range planners of the Army staff and the advanced concepts directorates of TRADOC, which could give a long-range perspective on the Army's needs. Its long-range perspective is currently supported with its seminar wargames, its participation in writing planning documents such as the Army Science and Technology Master Plan, and the direction provided by the AMC Board of Directors.

World-Class Land Warfare Research

To do world-class research and development, ARL needs the administrative flexibility to hire and reward the best possible technical personnel, and to buy equipment and supplies according to its needs. In today's defense environment, it must be recognized that ARL and other technology base organizations represent core competencies for the national defense, and must be protected to some extent from personnel reductions, as demanded by Army policy. In both respects, ARL's status as a world-class source of research and technology is threatened.

Inappropriate Personnel Procedures. Research and development has personnel needs that are different from those of other military functions, such as logistics. ARL needs higher concentrations of highly qualified personnel, at high pay grades. It must have the flexibility to hire and reassign scientists and engineers to meet changing needs and new opportunities, and to reward outstanding personnel with pay and promotions.

These needs are not being taken into account. Salaries are uncompetitive. Managers have little local authority. There are rigid limits on the numbers of high grades, and of total personnel. Promotions and merit pay raises are limited. The Defense Laboratory Demonstration program of reforms, which would correct many of these problems, has not been fully implemented. The Army's downsizing has brought hiring restrictions, personnel reductions, limits on numbers of high pay grade personnel, and other personnel constraints. These management constraints have prevented

ARL and AMC from recruiting highly qualified personnel, and will most likely prevent ARL from achieving its goal of having 800 Ph.D. scientists and engineers by fiscal year 1997.

Inefficient Procurement. Sluggish federal and Department of Defense procurement practices hinder research progress and hurt staff morale. Scientists and engineers may be delayed by months for want of a seemingly simple item caught in the highly bureaucratic procurement system. In some cases a less than desirable item is delivered, as a result of regulations governing bidder selection. Lab Demo initiatives could have resolved many problems but were never fully implemented.

Inadequate Funding. The Army has not given ARL a high enough priority in funding decisions. As the Army's funding has declined, ARL has not fared well in defending its share of basic research and exploratory development funds. Increasingly, it must compete with other AMC and DOD organizations for funding in both categories.

With institutional funding for $200 million in basic research and exploratory development, ARL probably cannot support excellent research in each of its 10 broad business areas. Nor can it easily gain new competencies. The committee's collective experience suggests that at least $40 to $50 million per year is needed to support an adequate research program in a broad and Army-unique technology area, such as those ARL should be pursuing. As a comparison, the Advanced Research Projects Agency has spent about $100 million per year on its armor and antiarmor program (mostly with 6.2 funding and some advanced development [6.3] funding). It spends about $120 to $140 million per year in its advanced materials research programs (6.1 and 6.2 funding). While based on fiscal year 1993 spending, ARL's Materials Directorate will receive about $13 million of ARL's institutional 6.1 and 6.2 funding.

Lack of Focus. ARL's attempt to support 10 broad business areas, with inadequate resources and continuing cuts in personnel and funding, makes it impossible to conduct world-class research in a few important areas. It is becoming more and more a *Jack of all trades.*

Quality of Research Facilities. Base closure decisions are benefitting ARL by providing construction funds for new research facilities. However, funds for maintenance and facility upgrades appear to be inadequate, especially if

needed to make significant changes to facilities in support of new research thrusts or changes in emerging technologies.

Perceived Quality. The committee believes that status of an organization influences the perception of its ability to conduct world-class research. A laboratory's status may be enhanced by its governance, including its reporting channel. Nationally recognized government laboratories like the Naval Research Laboratory and the National Institute of Standards and Technology enjoy a reporting channel directly to senior research and technology leadership within their appropriate organizations.

The committee's discussion of ARL's world-class research capabilities centers mostly on many input problems that are indicators of problems in producing high-quality research. In this context, it is difficult to see ARL, however well managed, as a successful world-class laboratory even though some world-class research might be conducted in it.

Diversity and Quality of Research Sources

ARL must take advantage of the best sources of research and technology, no matter where they are found. It is constrained in several ways from doing so:

- The Army, in establishing ARL, limited it to contracting no more than 30 percent of its exploratory development, and none of its basic research. The Lab 21 study envisioned more flexibility by setting the limit at no more than 50 percent of its exploratory development.
- DOD R&D contracting mechanisms—notably the failure to authorize the use of cooperative agreements—are a serious obstacle to forming the truly cooperative research partnerships that are needed.

The wide range of ARL's program, with its 10 broad business areas, may be partly a reaction to these handicaps or to other limitations on exploiting outside research. The contracting limits make it reasonable to provide the maximum scope possible internally. Relief would let ARL focus on its areas of greatest advantage while acquiring the best research and technology from outside.

Technology Transfer to the Army

ARL transfers technology to users via the RDECs, who in turn transfer it to program managers and program executive officers, who apply the technology in systems. ARL's main vehicles for technology transfer to the RDECs are Technology Program Annexes, formal agreements that define joint ARL-RDEC research projects.

However, Technology Program Annexes alone do not produce the rich interactions of researchers, developers, systems integrators, and users that the best R&D organizations have evolved. The Defense Department's sequential approach to technology transfer is too slow, too uncertain, and too unlikely to meet the real needs of users. ARL, limited to 6.1 (basic research) and 6.2 (exploratory development) work, is particularly handicapped unnecessarily in forming the varied partnerships that are needed for success. A nonlinear or systems approach now found in industry and many government agencies promises to be more efficient and supportive of technology transfer.

Ability to Leverage Funds and Programs

ARL's ability to capitalize on external sources of technology by cost sharing in joint ventures and cooperative research and development is limited. The R&D contracting processes used in DOD are more suited to procurement and unduly restrict interaction between government and contractor. Cooperative research and development agreements, a contractual form authorized under the Technology Transfer Act of 1986, permit healthy collaboration, of which ARL has taken strong advantage. But they are not sufficient in themselves, because they are required to be of no cost to the Army, and are therefore unsuitable for major R&D programs.

The recently established Tri-Service Science and Technology Reliance program is intended to help the Armed Services and other organizations in the Defense Department share the burdens of R&D, but the program is too new to have demonstrated its success.

The Technology Program Annexes agreed between ARL and the RDECs serve a leveraging function for both parties, through the formation of ARL-RDEC teams.

Improving Productivity

The Army has embraced the methods of total quality management, through its Total Army Quality program, in which ARL participates. But the total quality management approach, which emphasizes repetitive quantitative

measurements of numerous tangible inputs and outputs, is poorly suited to measuring one of a kind, mostly intangible basic research and exploratory development. Industry and government experts generally agree that the quality of research and development can be assessed most accurately by expert opinion, through peer reviews and management judgment.

Regardless of this difficulty, ARL as now constituted does not present a promising field for total quality management. Its administrative procedures, as explained earlier in this chapter, are too rigid and unresponsive to permit the management and worker accountability and authority that are vital to continuous quality improvement. Budgets and personnel numbers are set in detail by higher headquarters. The promotion and pay system makes it difficult to reward exceptional effort. Hiring is slow, and requires multiple approvals. Purchasing and contracting are unresponsive.

GENERAL RECOMMENDATIONS

The committee's assessment of ARL as now constituted has revealed deficiencies in its program and management, due to unduly restrictive administrative procedures and apparent confusion about ARL's priorities and its relations with its customers and its sponsor.

To address these failings, the committee developed five broad recommendations that apply to any of the four options for ARL (indeed, to any productive future for Army R&D). Accordingly, all of the organizational and management options considered by the committee include these measures, except where the particular features of an option precludes it. (For example, recommendations for improving government administration do not apply to the GOCO ARL option.)

Streamlined Procurement Practices. Procurement practices should be streamlined and implemented, based on at least the Defense Laboratory Demonstration initiatives.[1] The decision-making authority of laboratory managers should be increased, and other steps taken to improve the responsiveness of the system. Generally, all procurement constraints imposed by the Army should be selectively eliminated, to free laboratories to the limits of federal law and Defense Acquisition Regulations.

Since this recommendation closely resembles the procurement practices within private organizations, it would be inherently implemented in the

[1] The initiatives could ride on the coattails of the Under Secretary of Defense for Acquisition and Technology report issued on January 12, 1993, by the Acquisition Law Advisory Panel, entitled Streamlining Defense Acquisition Law.

GOCO ARL option and the contracted centers of the ARL Multicenter option. However, if the language of a contract makes the contractor subject to federal procurement practices, then the language should also reflect the implementation of this recommendation.

Personnel Reforms. A thorough reform of personnel practices for science and technology personnel at ARL should be instituted. This reform should begin with the Lab Demo initiatives (which can be undertaken quickly, within existing statutes and regulations). Among the Lab Demo personnel reforms are (a) giving laboratory managers the power to classify positions, (b) establishing a separate career ladder for scientists and engineers, (c) offering short-term appointments for senior retirees from universities and industry, (d) locating key support functions such as personnel management and purchasing at laboratories, and (e) other measures to increase the authority and accountability of managers and workers.

ARL should go as far as possible beyond even the Lab Demo reforms. Such reforms will also help attract outstanding leaders. Approval by Congress, the Office of Personnel Management, and the Department of Defense may be needed.

As a government-operated laboratory, the goal for ARL should be to create a personnel demonstration project like that established for NIST by an act of Congress in 1988, with such features as a more flexible pay system, decentralized hiring authority, no limits on the number of higher grade positions, rank order evaluation of staff, extra tenure credit for high performance, and three-year probation periods for new hires (see Chapter 4).

This demonstration will have benefits and costs. The benefit or value side of the equation is extremely difficult to assess. ARL has announced its vision of becoming a world-class laboratory. There is general agreement that a pay structure, for instance, that would help attract and retain world-class scientists and engineers would bring the laboratories closer to this vision. It is less clear what the additional costs implied by a richer and more flexible pay plan would yield, quantitatively, in research output. It is also likely that additional capital investment will be required to maintain world-class scientists. These costs cannot be estimated without a clearer definition of the laboratory's mission in the new environment.

Innovative recruiting and training programs are also needed. ARL should be enabled to hire outside the government (using a simple waiver of the restrictions due to the current hiring freeze). It is necessary to increase the academic qualifications of the ARL staff, and thereby approach its goal of having 800 Ph.D.s on its staff by fiscal year 1997. Some mechanisms have been used by ARL, but more can be utilized including the financing of on-campus graduate training for qualified government employees, cooperative research

with academic institutions that allows government employees to do degree-qualifying work at their own benches, and postdoctoral fellowships like those offered by the Applied Physics Laboratory at Johns Hopkins University (which is relatively close to ARL).

Since all personnel in the GOCO ARL option and the contracted centers of the ARL Multicenter option would be in the private sector, these reforms would be inherently implemented. However, if the language of a contract makes the contractor subject to federal personnel practices, then the language should also reflect the implementation of this recommendation.

A More Focused Program and a Well Defined Mission. To maintain quality in the ARL research and systems analysis program as budgets decline, the Army should focus the ARL program and mission over the next three years to include only those areas that are unique to Army land-warfare science and analytical support needs and are not adequately supported elsewhere. ARL should make more direct use of commercial research in areas of strong commercial interest and support (e.g., electronics, biotechnology, information sciences, etc.), while focusing on its own core competencies and their evolution over time.

Neither DOD nor the Army can afford to pursue all technologies. ARL must select specific high-priority areas appropriate to its core competencies, and manage the rest by contracts and cooperative agreements with industry, and by cost-sharing arrangements to encourage commercial industry to pursue technologies of interest to the Army. Any technology area in which an outside organization is more competent or more cost-effective as a source of technology should be left to that organization. These efforts should be made, wherever possible, in partnership with the RDECs and other laboratories, services, and agencies. ARL's program must be tailored to its budget and to the Army's unique needs.

The mission should be more focused towards the identification and exploitation of science and technology that offers potential leaps ahead in Army capabilities, rather than striving for excellence in areas in which ARL has no unique role. Many of these areas involve ARL in direct competition with RDECs and other government agencies. In others, industry or universities may be the strongest. ARL should identify perhaps four or five key areas, where it has or should develop unique strengths (i.e., core competencies), which should be funded to the fullest extent possible. The committee believes that one definition of a key area may be an area that will give the Army the greatest force enhancement (i.e., an enhancement of many different systems) through horizontal technology integration. As the program and mission are defined, the Tri-Service Science and Technology Reliance

program will grow increasingly attractive as a way of sharing resources with other DOD organizations.

The mission should also concisely state the analytical support efforts of ARL. The analyses efforts of the Survivability and Lethality Analyses Directorate and the Human Research and Engineering Directorate are clearly different from the research and exploitation of science and technology.

Inherent in the description of ARL's mission should be an understanding of its linkages to Army strategies and objectives. With this definition, ARL should be able to establish the proper balance of long-range links with TRADOC advanced concepts directorates, short-range links with field assistance teams, short- and mid-range links with TRADOC battle labs, and other links with Army staff and agencies.

This reexamination of the overall mission and program should be undertaken on an Army-wide basis, including the ASA(RDA), Deputy Chief of Staff for Operations, TRADOC, RDECs, and others. ARL must remain flexible enough to pass responsibility for mature technology areas to appropriate customers while focusing its own efforts on emerging technologies with military implications. This technology transfer will recognize more rapid implementation in the future.

To direct this more focused approach, ARL's mission statement must be rewritten to stress the pursuit of the best research, technology development, and analytical support inside or outside the Army, to meet needs broader than the specific system technologies developed by the RDECs. The current programs seem to be too internally oriented. In developing such a statement, the challenge will be not to offer ARL sufficient scope, but rather to give it a unique and stable role among Army R&D organizations.

Partnerships for Technology Transfer. To facilitate technology transfer, ARL should initiate and broaden exchanges with civilian industry and universities through cost-sharing partnerships and guest researchers, and it should establish an improved process for technology development and transfer with its customers and operational users. Most important, ARL must work closely with the RDECs, avoiding duplication and competition for research funds. ARL should be permitted to go beyond 6.1 and 6.2 work, to make cooperation with the RDECs, battle labs, program managers, and others, inside and outside the government, more fruitful by using modern industrial R&D practices. Going beyond 6.1 and 6.2 work will also support the rapid exploitation of technologies, which is the key to Army modernization in the future.

A New Reporting Channel. It is the committee's judgement that to provide a central focus for the Army's recently strengthened policy to encourage innovation and Army-wide horizontal technology integration, to accommodate a nonlinear approach in research and development, and to make it easier to establish ARL as an elite R&D organization, the Army should change ARL's reporting channel to the ASA(RDA). The ASA(RDA) can provide full-time research and technology leadership and direct links to the Army program officials.

The committee also believes that this move would enhance ARL's external status as the Army's flagship laboratory (putting it on a similar level with the Naval Research Laboratory and NIST); thus improving ARL's relations with users, civilian industry, and other government agencies. The recognition of ARL's new status by those inside and outside the Army should also help ARL recruit the best possible talent.

As a comparison, the Naval Research Laboratory reports directly to the Chief of Naval Research, who does not report to the Chief of Staff of the Navy, but rather to the Assistant Secretary of the Navy for Research, Development and Acquisition. It shares this reporting channel with the Office of Naval Research, which is responsible for all basic research (funding level 6.1). Similar to the reporting channels of the Naval Research Laboratory and NIST, ARL would have a unique status among all other Army laboratories and engineering centers, which are assigned at lower levels, to AMC, the Surgeon General, or the Army Corps of Engineers.

ARL, in this position, could act as an immediate advisor to the ASA(RDA) in the execution of his research and technology responsibilities. The Director of ARL and his staff could assist the ASA(RDA) in joint planning, dual-use, and commercialization activities. ARL could help the ASA(RDA) look across equipment mission areas and ensure horizontal integration of technologies in all Army materiel and information systems. The ARL Director could more easily advise the Deputy Chief of Staff for Operations and the Chief of Staff of the Army on technologies that might influence future doctrine or satisfy current and future needs.

This higher reporting authority would better facilitate implementation of needed changes in procurement, contracting, and personnel policies. Implementation within AMC is possible. However, an AMC commander would find it difficult to single out ARL for elite status as long as it is closely intermeshed with the rest of his command, both organizationally and physically. No commander who has the responsibility of optimizing value of the entire AMC command would find it tenable to establish a differentiated, organizational entity with a separate culture and set of operating policies.

Although it is also possible in the current reporting channel, the new reporting relationship could further reinforce ARL's role in developing technologies and providing system analyses that cross AMC commodity

(RDEC) boundaries, such as in areas of advanced materials, electronic components, lethality, vulnerability, and phenomenology. Coupling the reporting channel to the ASA(RDA) with a more focused ARL mission, that includes horizontal technology integration, could reduce the overlap between ARL and the RDECs. ARL and the RDECs should continue to have their programs reviewed, synchronized, and approved at the ASA(RDA) level, to maximize return on the science and technology and R&D investments. Greater stress could be placed on the use of a variety of technology sources in academia, industry, other government agencies, domestic and foreign.

The committee also recommends that this change in reporting channel should also remove ARL from the direct influence of the ARL Board of Directors. In place of the ARL Board of Directors, the Army should establish a new external board of independent experts to review and oversee the technical quality and relevance of ARL's work. It should continue to use agencies like the Army Science Board and the Board on Army Science and Technology to review its efforts, and it should continue to participate in all Army R&D reviews. To ensure a continuing focus on Army needs and maintain its supplier-customer relationship with the AMC RDECs, the Director of ARL should remain a member of the AMC Board of Directors.

The ASA(RDA), unlike AMC, would not be as reluctant to allow ARL, where feasible and practical, to take technologies that do not logically fall in the purview of any one RDEC beyond the 6.2 level and even to integrate them into systems, if that were the most economical and sensible course. There are occasions when it will be more logical, less expensive, and more timely to have ARL take the technology to maturity and integrate it in a multiplicity of systems. This would not be very likely within AMC, owing to the responsibility of the Commander to maintain the division of labor within his command and to pressures from the RDECs (ARL and AMC Boards of Directors).

Relations with customers other than the RDECs would improve. Industry, academia, and other agencies would quickly recognize ARL's increased status and importance. The Director of ARL could assume the role as the Army member of the Joint Directors of Laboratories, currently held by the Deputy Assistant Secretary of the Army for Research and Technology, making him the Army's focal point for the Tri-Service Reliance program. These relationships would be enhanced by ARL's new participation in strategic planning.

The new reporting channel would separate ARL from its current primary customers, the RDECs. As a result, technology transfer to the RDECs would become a greater challenge, but with care and attention, this challenge could be met. As the new reporting channel becomes better understood, and missions and programs better defined and aligned, ARL's relationship with the RDECs should improve. They would not compete within the same

command for the same resources. Participation of the Director of ARL within the AMC Board of Directors would also help maintain the linkage between ARL and the RDECs.

Based on current AMC headquarters administrative demands, the administrative burden on the ASA(RDA) would be minimal, and could be less if ARL was established as a self-supporting Field Operating Agency. The administrative demands at the AMC headquarters of managing policy and providing personnel and procurement support for ARL requires only four to five people. Most of the effort is in interpreting or implementing decisions made at the Department of Defense or Department of the Army level. The Army's recent plans to establish regional administrative support centers suggests that, in any case, AMC headquarters may have less administrative workload as time goes on anyway. Additionally, since ARL already controls so much of its personnel, budget, and procurement activities, it could easily become totally self-sufficient as a Field Operating Agency, similar to the Army Research Institute (for the Behavioral and Social Sciences) which reports to the Deputy Chief of Staff for Personnel, and others like the Army's Strategic Defense Command, the Concepts Analysis Agency, the Commercial Activities Management Agency, and the Health Professional Support Agency.

Such a realignment addresses most of the issues of status, stability, linkage to Army strategy and objectives, diversity and quality of research sources, leveraging of funds and programs, and customer relations. The realignment would place ARL in the forefront of the Army's science and technology planning, help concentrate its efforts on the most critical technologies needed for future systems, and help ensure these technologies are funded.

The committee recognizes the difficulty of considering a change in the reporting relationship for ARL without similar questions arising in respect to the Army Research Office (ARO), a similar basic research organization. The 6.1 program for ARL must take advantage of university research efforts to enhance ARL's diversity and quality of resource sources. Therefore, a close, seamless working relationship is necessary between ARL and the ARO. A common management structure would enhance this relationship. Such a working relationship has long existed between the Naval Research Laboratory and the Office of Naval Research (ARO's equivalent) under the Chief of Naval Research of the Navy. Additionally, similar arguments for changing the reporting channel for ARL could be used for moving ARO under the ASA(RDA). However, it is beyond the charter of this study to address ARO's reporting channel. The Army should consider studying this reporting channel, ARO's relationship with ARL and the RDECs, and the Army's overall 6.1 program.

COMPARING THE FOUR OPTIONS

In assessing the range of opportunities available to ARL, the committee defined four organizational and management options. All embody the changes in the five general recommendations above (except where the particular features of an option make one or another recommendation irrelevant). The options can be seen as points along a spectrum:

- *The ARL Enhanced option* (the baseline for comparison) involves conservative changes in personnel, purchasing, and contracting arrangements, while retaining government operation. For comparison's sake, 20 percent of ARL's R&D is assumed to be contracted out.
- *The NIST option,* another option internal to the Army (with contracting assumed to cover 20 percent of ARL's program) builds on the ARL Enhanced option by instituting more radical personnel practices, modeled on the successful personnel demonstration program of NIST. The option also includes a two-tier technical advisory system, with an external oversight board for ARL itself, and specialized boards for the ARL directorates.
- *The ARL Multicenter option* involves the same administrative reforms as the ARL Enhanced option, but would contract out most (perhaps 70 percent) of the research and development to several centers of excellence, under the supervision of a strong core staff. This option provides flexibility to the Army to vary ARL's operations from the current government-operated laboratory to a GOCO-like laboratory by adjusting the percentage of R&D contracted out.
- *The GOCO ARL option* would break dramatically with the past, by contracting out all research and development, with oversight by a small government staff. (The recommended administrative reforms would be generally irrelevant to this option.)

Table 8-1 provides a matrix comparison of the options. As seen in the matrix, the options are points along a spectrum, especially with respect to the amount of ARL contracted out, average salaries, the numbers of government scientists and engineers, and conversion costs.

The total operating budgets of all options are assumed to be equal ($323 million, in 1993 dollars, by fiscal year 1997). It is important to note that the average salaries for scientists and engineers vary from option to option. Contractors' scientists and engineers, on average, are assumed to make $70,000 per year, based on the committee's cost studies. Government employees in the ARL Enhanced and ARL Multicenter options would make $52,700; in the NIST option, because of the various pay incentives, they would average $61,200. The average personnel cost for each option depends on the

TABLE 8-1 Summary of Options Assessed by the Committee, with Comparative Data on ARL for Fiscal Year 1997

Characteristic	ARL, 1997*	ARL Enhanced Option**	NIST Option	ARL Multicenter Option	GOCO ARL Option
Main features	ARL as planned by Army for fiscal year 1997	Modest administrative reforms	Personnel procedures and technical oversight boards based on NIST practices	Several *centers of excellence,* contract and in-house (assumed 70 percent contract)	Single operation and management contract
Administrative reforms	Not applicable	Lab Demo, Lab Quality initiatives; New reporting channel to ASA(RDA)	Lab Demo and Lab Quality initiatives, personnel demonstration project modeled on NIST's; New reporting channel to ASA (RDA)	Lab Demo and Lab Quality initiatives; New reporting channel to ASA(RDA)	Administrative policies of industry; New reporting channel to ASA(RDA)
Oversight	ARL Board of Directors, dominated by RDECs, AMC Board of Directors	Science and Technology Advisory Board, AMC Board of Directors	Two-tier external technical oversight board, AMC Board of Directors	Science and Technology Advisory Board, AMC Board of Directors	External board of directors
Operation budget, millions	$323	$323	$323	$323	$323

Contracted percentage (assumed)	20 percent	20 percent	20 percent	70 percent	100 percent
Average salary, scientists and engineers (in-house and contract), thousands	$56.2	$56.2	$63.0	$64.8	$70.0
number of scientists and engineers:					
In-house	1,744	1,744	1,502	654	0
Contract	277	277	277	950	1,357
Total	2,021	2,021	1,779	1,604	1,357
One-time conversion cost, millions	Not applicable	$10.8	$16.9	$56.0-70.0	$85.1

* Committee's estimates, based on ARL plans.
** Baseline for comparison of options.

ratio between contract and government employees. Thus, the GOCO ARL option, 100 percent contracted, is calculated to have only 1,357 scientists and engineers in fiscal year 1997, substantially less than the 2,021 planned by ARL (and assumed in the baseline ARL Enhanced option); the NIST option would have 1,779, and the ARL Multicenter option would have 1,604.

The increases in productivity associated with these options—that is, whether the reduced staffs could achieve research output high enough to carry out ARL's mission—are matters of judgment. This committee believes that they could; the higher cost options are those most open to the efficiencies and incentives of the private sector. The Department of Energy laboratories sponsored in universities and industry, the Jet Propulsion Laboratory sponsored by the National Aeronautics and Space Administration, and the Massachusetts Institute of Technology Lincoln Laboratory sponsored by DOD all have outstanding reputations for quality and productivity. Similarly, industrial laboratories such as Bell Laboratories, the Xerox Palo Alto Laboratories, the General Electric Laboratories, and many others also enjoy excellent reputations. Based on this experience, the committee believes that private-sector laboratories can deliver higher productivity for their higher per person costs.

The committee also recognizes that there are no proven quantifiable measurements of research productivity available which would allow the committee to verify that 1,357 higher paid scientists and engineers (or 1,779 or 1,604) could be as productive as 2,021 government scientists and engineers. This comparison is complicated further by federal scientists and engineers who often accept lower pay in exchange for research opportunities available only in government laboratories to fulfill a sense of *service to the nation.* In general, however, higher salaries can attract higher quality people if linked with updated facilities, state-of-the-art equipment, professional working environment, and good leadership.

ARL Enhanced Option

This option would offer a quick and substantial improvement in effectiveness, without the need for radical change or upheaval, and without the need for congressional authorization. One-time conversion costs are estimated at $11 million (mainly severance pay for those made redundant as a result of the recommended narrowing of ARL's program).

The contracting reforms assumed in this option—including the use of cooperative agreements for research and development—would improve ARL's ability to exploit diverse sources of research and technology and to leverage funds and programs. But ARL would be limited in these respects by the

20-percent ceiling on contracting R&D. In none of these areas would it have advantages over the other options.

Technology transfer to the Army would improve marginally, by the narrowing of its program and the formation of the technology transfer partnerships, both general recommendations. All other things being equal, one would expect an internal operation to have better transfer to other parts of the Army, because there are fewer barriers; in this respect, this option would be favored over the GOCO ARL option.

Fully and properly implemented and supported, with the general recommendations, this option could give the Army a source of world-class science and technology. But the committee believes that implementation of this option could be very challenging, since the Army's past record for implementing Lab 21 initiatives is not very convincing. This option may not be a bold enough move to get the attention needed to fully implement a new management and organizational structure for ARL, nor meet the Army's changing needs.

NIST Option

This option has a substantial advantage over the ARL Enhanced baseline in its personnel procedures, which would give laboratory managers the ability to hire and reward technical workers to meet their needs in a timely way, rather than accepting detailed and time-consuming direction from above. It also would benefit from the advice of the two-tiered advisory system. The resulting improvements in research quality and cost-effectiveness would be important. The one-time conversion costs would be more than those of the previous option (about $17 million), representing mostly the cost of severance for employees replaced in the reformulation and narrowing of the program.

In all other respects, this option is identical to the ARL Enhanced baseline. It would have the same enhancements in linkage to Army strategies and objectives, the diversity and quality of research sources, technology transfer to the Army, or ability to leverage funds and programs. However, the actual NIST has an extensive program of partnerships and guest researchers from industry and universities that provides it with great leveraging capability. This program, if duplicated in ARL, would leverage its funds greatly. Thus, the committee made it a general recommendation.

The committee views this option as the best “internal” version of ARL and recommends it if the Army chooses not to contract out large portions of ARL's research. Strong support from the Army and the Office of the Secretary of Defense would be needed to obtain the necessary approvals from Congress and the Office of Personnel Management for the demonstration personnel system.

ARL Multicenter Option

This option has the potential for dramatic improvements in the quality of ARL's research and development, its ability to leverage funds and programs, and its ability to improve its productivity and cost-effectiveness. Its use of a combination of contract and internal centers of excellence for ARL's research—government-owned and government-operated, government-owned and contractor-operated, and contractor-owned and contractor-operated—would enable it to seek the very best available sources of technology, and give it the network of contacts and partnerships through which to leverage its funds and programs. It would be well prepared to meet the changing needs of the future, by changing its research sources as needed.

Contracted centers may not have the tight connections with the RDECs that would make for excellent technology transfer to the Army, compared with the government-operated ARL Enhanced or NIST options. However, ARL's government staff would include RDEC personnel on rotating assignments, which would improve communication. Even more interesting is the possibility of wholesale technology transfer; responsibility for centers whose technology had matured beyond ARL's interests could be transferred as wholes to RDECs.

The one-time conversion costs would be high (about $56 to $70 million,[2] mostly for severance pay for the 40 percent of ARL research personnel who would be displaced). But this option would be stronger by nearly every criterion than the ARL Enhanced baseline, and the equal of every other option (except possibly in technology transfer to the Army, where it might be arguably inferior to the internal options).

Implementation would be complex contractually, because of the variety of sources, and would require effective planning and coordination by the permanent staff.

GOCO ARL Option

The GOCO ARL option would offer perhaps the best chance of all the ARL conversion options to do world-class technical work. Using the administrative procedures of the private sector, ARL could hire and promote, purchase, and contract more efficiently than any government organization.

The recommended government personnel and procurement reforms would be an inherent part of the option. It could attract outstanding leaders and staff on the basis of competition, minimal administrative burden, and the

[2] This cost depends on the number of contracts that must be established for independent centers of excellence.

vital mission of the laboratory. It could select its research sources with the utmost freedom and diversity. With its rich networks of contacts and its ability to exchange personnel easily with outside organizations, it would be able to form the close relationships with outside entities through which to leverage ARL funds. Through its management and operation contract with the Army, a GOCO ARL could have strong incentives to improve the quality and relevance of its work.

This option, however, could weaken ARL's linkages to Army strategies and objectives, by placing it outside the direct control of the Army. The contractor's concern for its customer and future contracts could lessen this problem. The GOCO ARL option would also be less able than the ARL Enhanced baseline (or other internal options) to transfer technology to Army users, provide technical support to operating forces, or carry out technology assessments for the Army. While none of these problems is insurmountable—many existing GOCO laboratories manage them successfully—they must be counted as inherent deficiencies compared to internal options.

The one-time conversion costs of this option are estimated at $85 million, mostly severance costs for people. Conversion would require notification of Congress (although not legislative authorization), and might be politically contentious.

To capture the benefits of the GOCO option, the Army would need to resist overly restricting management caused by requiring excessive government approvals of operations. The past decade has seen a clear trend toward increased oversight at the Department of Energy's GOCO laboratories and the Defense Department's federally funded research and development centers. The Army would need to give the laboratory the operational freedom and flexibility of an outside organization, and at the same time the trust and access of an internal lab with regard to substantive matters.

Comparing the Options

Table 8-2 provides a comparison of each of the options with respect to each of the committee's evaluation criteria, as well as an overall committee evaluation (last row).

SELECTING AN OPTION

The determinate issue for the Army in selecting an option, all other factors being essentially equal, is whether a significant internal capability to do research is absolutely necessary. If the judgment is strongly affirmative,

TABLE 8-2 Summary Comparison of Options with Respect to the Committee's Evaluation Criteria

Evaluation Criteria	ARL Enhanced Option	NIST Option	ARL Multicenter Option	GOCO ARL Option
Linkage to Army strategies and objectives	Improved by change in reporting channel (common to all options).	Same as ARL Enhanced.	Possibly weaker than ARL Enhanced, because of heavy emphasis on contract research.	Possibly weaker than ARL Enhanced, because of heavy emphasis on contract research.
World-class land warfare research	Modest improvement, would require strong leadership to implement.	Substantial improvement, owing to NIST-style personnel policies, oversight by independent technology review boards.	Dramatic improvement, owing to emphasis on procuring the best available research and technology, inside and outside the Army.	Dramatic improvement, owing to freedom from govemment administrative restrictions, emphasis on high-quality personnel.
Diversity and quality of research sources	Improved by contracting improvement, but limited by 20 percent ceiling on contracting.	Same as ARL Enhanced.	Dramatic improvement, owing to use of multiple emphasis on contracting centers of excellence, of research.	Substantial improvements, but less than ARL Multicenter.
Ability to leverage funds and programs	Improved by contracting improvements, but limited by 20 percent ceiling on contracting.	Same as ARL Enhanced.	Dramatic improvement, owing to varied relations with contractors and military organizations.	Dramatic improvement, owing to freedom to contract for research.

Improving productivity	Modest improvement, owing to greater management accountability,	Substantial improvement, owing to NIST-style personnel policies.	Dramatic improvement, owing to contract incentives and competition among centers.	Dramatic improvement, with properly drawn incentive clause in contract.
Committee's evaluation	Not bold enough.	Best option that keeps bulk of program inside Army. May be difficult to obtain approval and implement.	The equal of any of the options in quality, except possibly for technology transfer and complexity of management by the Army.	Potential for excellent laboratory, but vulnerable to government micromanagement, and could be politically contentious.

then the best internal option would be selected, assuming that it meets requirements for leadership, quality of research, and technology transfer. On the other hand, members of this committee believe that contract organizations are more likely than internal DOD laboratories to achieve these goals. Thus, the choice of an ARL option is a matter of judgment about the factors most important to the Army in the particular case.

The committee believes that the ARL Enhanced option may not be a bold enough move to get the attention needed to fully implement a new management and organizational structure for ARL, nor meet the Army's changing needs. The ARL Enhanced option itself would require extraordinarily strong support, judging from ARL's inability thus far to implement the Lab Demo initiatives that are at the option's heart. The NIST ARL, ARL Multicenter, and GOCO ARL options would all be major improvements over the current situation, *and all three have the potential to produce a world-class laboratory.* The NIST option in particular is an excellent internal option; the other two have varying advantages and disadvantages, but the advantages far outweigh the disadvantages in terms of quality and productivity. The main uncertainty about a NIST-like ARL is whether it could be approved by DOD and the Congress and be accepted by the existing bureaucracies so as to be implemented successfully. The ARL Multicenter and GOCO ARL options could be implemented by the Army without statutory changes, although they would be politically contentious.

The committee strongly recommends that the Army implement either the NIST, ARL Multicenter, or GOCO ARL option. The choice among these three depends largely on the importance to the Army of an internal research capability, and on the Army's judgment of the practical and economic obstacles to implementing particular options.

The Army must have the support and the commitment of its top leadership, and the patience to evolve and stabilize ARL into an organization that can have a major impact on the Army of the future. Without this, the Army will waste critical resources and not reap the benefits described in this report for its chosen option.

Appendix A:

Statement of Task

The Board on Army Science and Technology (BAST) will establish a committee to examine approaches to and the implications of converting the Army Research Laboratory (ARL) to a government-owned, contractor operated (GOCO) operation or to a government operation modeled after the National Institute of Standards Technology (NIST). The study will be conducted over a nine-month period beginning April 1, 1993. Neither the study approach nor options will violate the provision of the 1991 Base Closure and Realignment (BRAC) report which established ARL.

The BAST will establish a 16-member committee of experts in the areas of contracting; personnel, compensation, and retirement; R&D management; measurement of R&D productivity; and cost effectiveness analysis. Experts will be sought who have experience with DOD laboratories, private sector laboratories, and other laboratories such as Department of Energy, NIST, and GOCO. It is anticipated that panels will be established to assess the laboratories and the alternatives. The committee and panel members will be subject to the usual bias procedures of the NRC.

The first task of the committee will be to define the three alternatives [(1) ARL as it currently exists and with improvements that are planned or that could reasonably be expected in the normal course of development; (2) NIST; and (3) GOCO]. Each alternative will then be evaluated using criteria such as the following:

a. Laboratories maintain relevance to the military user.
b. Laboratories deliver “world class” technology to the user.
c. Work does not compete, but rather complements, that of other academic and industrial research institutions.
d. Operations are efficient and effective.
e. Ability to leverage funds is not degraded.
f. “Smart buyer” capability is maintained by the Army.
g. Potential for technology transfer is enhanced not degraded.

In addition to the above three alternatives, consideration will be given to variations of these models, such as university-managed centers of excellence

and labs managed by university research consortia or foundations. Once the alternatives are defined the committee will:

- Identify the characteristics that distinguish ARL from a GOCO or a NIST.
- Examine and analyze the research quality and relevance of current military GOCOs, such as Lincoln Laboratory.
- Define the characteristics of a "world class" research operation.
- Specify the advantages and disadvantages of conversion to a GOCO or a NIST relative to ARL. Where the advantages or disadvantages are not immediately quantifiable, suggest how the Army might proceed with measuring or otherwise comparing them.
- Describe how the Army should proceed if it were to convert the laboratories to a "world class" operation on the GOCO or NIST model.

— Identify opportunities which exist or problems that would have to be overcome in the course of conversion, including the following:

- schedule for conversion.
- legislative changes or concerns.

- Describe approaches to solving these problems.
- Estimate the cost of conversion and subsequent operation.
- Provide definite recommendations on implementation, including how to arrange the transition of personnel and property, the relative advantages of a single contractor and a prime contractor-subcontractor arrangement, the criteria for choosing contractors and reviewing their performance, and the appropriate length and type of the initial contract.
- Prepare a report that will both identify and analyze problems and options associated with the conversions, and will develop a framework for planning the implementation of conversion.

The study's final report will help the Army determine the feasibility and practicality of converting ARL to GOCOs or to NISTs. The report will be subject to review in accordance with procedures established by the Report Review Committee of the NRC. It will be prepared in sufficient quantity to ensure adequate distribution to the Army, the public, and other interested parties in accordance with NRC policy. Funds have been budgeted for this purpose.

Appendix B:

The Federal Personnel System

The federal civil service system is a large and cumbersome assemblage of laws, regulations, and supplements which strive to achieve internal equity, but inadvertently hamper the government's abilities to compete for talented scientists and engineers and to reward an individual for exceptional performance. Unless bold changes and exceptions to policy are sought, it will always inhibit the Army Research Laboratory's recruitment and award programs. It will hamper the recruitment and retention of quality researchers; thus hindering its chances of achieving world-class recognition.

THE CIVIL SERVICE SYSTEM

The federal personnel system has been evolving for more than 100 years, growing bigger and bigger with time. Citing a 1988 Office of Personnel Management publication, the recent Gore report, *Creating a Government that Works Better and Costs Less,* stated: ". . . anecdotal mistakes prompted additional rules. When the rules led to new inequities, even more rules were added. Over time . . . a maze of regulations and requirements was created, hamstringing managers . . . often impeding federal managers and employees from achieving their missions and from giving the public a high quality of service" (National Performance Review, 1993).

The Classification Act of 1949 established the General Schedule (GS), a single, nationwide pay structure for federal employees that today consists of 15 grades, each with 10 pay steps. There are more than 400 GS occupations in the federal government. Each is classified on the basis of that position's complexity and degree of responsibility. Each grade includes scientific, engineering, accounting, medical, and other professions along with administrators, technicians, and clerical positions, that are deemed to be of equal rank, and they are paid within the same relatively narrow range. The system tends to look inward, in order to reduce internal inequity among similar federal agencies, and not be concerned with external or market competitiveness (Office of Personnel Management, 1989).

OTHER STUDIES

For years, study committees and task forces have identified the shortcomings of the federal personnel system. Many view that these shortcomings have to be strengthened since the lifeblood of an R&D laboratory—its scientific and engineering personnel—is an ever declining asset. Predictions made a decade ago are seeing their fruition today. To quote from the report of the White House Science Council Federal Laboratory Review Panel (1983):

> The inability of many Federal Laboratories—especially those under civil service constraints—to attract, retain, and motivate qualified scientists and engineers is alarming. The personnel problem is most serious at government-owned, government-operated laboratories (GOGO's) [and] . . . if not corrected will seriously threaten their vitality.

The system, however, has always seemed to be too large to overcome. Recently, however, Vice President Al Gore pushed this problem into the national limelight with his report on *Creating a Government that Works Better and Costs Less* (National Performance Review, 1993). Not surprisingly, his findings were no different that those in the National Research Council's study, *Improving the Recruitment, Retention, and Utilization of Federal Scientists and Engineers* (National Research Council, 1993); the U.S. Merit Systems Protection Board's special study, *Federal Personnel Offices: Time for Change?* (1993); and the Congress, Office of Technology Assessment study, *Holding the Edge, Maintaining the Defense Technology Base* (1989).

THE MAZE OF REGULATIONS AND REQUIREMENTS

The above studies discovered the same bureaucratic barriers that inhibit federal organizations like ARL from running a high-performance personnel system. The following information summarizes and quantifies the rules and regulations which govern the federal personnel system:

- Federal personnel law (Title 5 of the U.S. Code) consists of 850 pages, and there is related material in other titles of the statutes, such as Title 29, the Fair Labor Standards Act.
- There are over 1,300 pages in the regulations published by the Office of Personnel Management (Title 5 of the Code of Federal Regulations) to prescribe implementation of the statutes.

- There are about 7,000 pages in the Federal Personnel Manual published by the Office of Personnel Management. In addition to the basic manual, there are numerous supplements that provide additional detail. For example, the Federal Personnel Manual Supplement 289-33, whose 900 pages give instructions on completing Standard Form 50, "Notification of Personnel Action."
- There are nearly 12,000 pages in the white-collar position classification system.

Besides the federal system, the Department of Defense publishes an extensive amount of its own implementing policies and procedures. In 1992, DOD had collected 30,000 pages of printed material from the Departments of the Army, the Navy, and the Air Force, in an effort to consolidate and reduce defense civilian personnel policies and procedures (McAllister, 1992).

THE PROBLEM GROWS

Since 1992, even more personnel policies have been developed in response to the growing need to reduce the size of DOD. Some examples are:

- Executive Order 12839 of February 10, 1993, which requires federal agencies with more than 100 employees to eliminate not less than 4 percent of its civilian personnel positions over the next 3 fiscal years. At least 10 percent of the reductions are to come from the Senior Executive Service, GS-15, and GS-14 levels or equivalent.
- The recent Defense Management Review Directive 974 considers consolidating personnel administration in geographical regions. AMC, not waiting on a DOD decision, has drafted an implementation directive—Civilian Personnel Consolidation Mandate 93-01 (July 19, 1993).
- Defense Planning Guidance, dated September 13, 1993, mandated a 20 percent decrease in personnel at all research, development, test and evaluation activities by fiscal year 1999. This decrease is in addition to reductions directed by Program Budgetary Directive 755. AMC quickly responded and drafted a letter which will reduce the ARL's personnel levels to 2,678 by fiscal year 1999 (Prather, 1993).
- Many DOD and Army pamphlets are being revised and policies are being established to define programs that will attempt to "minimize the adverse effects on employees caused by actions required for the effective management of the Department of Defense, such as, but not limited to, reductions in force, base closures, consolidations, contracting out, position classification decisions, rotation from overseas, and transfers of functions" (DOD Manual 1400.20-1-M which implements the policies outlined in DOD

Directive 1400.20). These programs include decisions such as filling vacant Senior Executive Service positions with Senior Executive Service personnel whose positions have been eliminated.

ATTACKING THE PROBLEM

There have been efforts to cut through the bureaucratic red tape to assist managers of laboratories in recruiting and retaining quality scientists and engineers. For example, the Civil Service Reform Act of 1978 allowed for personnel management demonstrations which would address the problems of recruiting, retaining, and motivating scientists and engineers. These demonstrations were the basis for many of the pay-related flexibilities contained in the Federal Employees Pay Comparability Act of 1990 (National Research Council, 1993).

However, ARL has seen little benefit from these initiatives, primarily because the Army and AMC have failed to implement many of these demonstration initiatives (see Figure 3-1). ARL may have renewed hope with initiatives that will spawn from Vice President Gore's report. The personnel recommendations made in that report will create an environment that will support requests for bold personnel changes within the Army Research Laboratory. Some of Vice President Gore's recommendations are (National Performance Review, 1993):

- Create a flexible and responsive hiring system. Authorize agencies to establish their own recruitment and examining programs. Abolish centralized registers and standard application forms. Allow federal departments and agencies to determine that recruitment shortages exist and directly hire candidates without ranking. Reduce the types of competitive service appointments to three. Abolish the time-in-grade requirement.
- Reform the General Schedule classification and pay system. Remove all grade-level classification criteria from the law. Provide agencies with flexibility to establish broad banding systems built upon the General Schedule framework.
- Authorize agencies to develop programs for improvement of individual and organizational performance. Authorize agencies to design their own performance management programs which define and measure success based on each agency's unique needs.
- Authorize agencies to develop incentive award and bonus systems to improve individual and organizational performance. Authorize agencies to develop their own incentive award and bonus systems. Encouraging agencies to establish productivity gain sharing programs to support their reinvention and change efforts.

- Strengthen systems to support management in dealing with poor performers. Develop a culture of performance that provides supervisors with the skills, knowledge, and support they need to deal with poor performers, and holds supervisors accountable for effectively managing their human resources. Reduce by half the time needed to terminate federal employees for cause.

Considering these recommendations, now may be the *best* time for the Army to buy into a new personnel system for ARL.

REFERENCES

McAllister, B. August 10, 1992. Pentagon begins unifying civilian employee rules. Washington Post. A-17.

National Performance Review. 1993. Creating a Government that Works Better and Costs Less. Washington, D.C.: U.S. Government Printing Office. September 7.

National Research Council. 1993. Improving the Recruitment, Retention, and Utilization of Federal Scientists and Engineers. National Research Council. Washington, D.C.: National Academy Press.

Office of Personnel Management. 1989. Research Report I, Framework and Operation of the Governments White Collar Pay System, in Supplement, Federal White-Collar Pay System: Report on a Market-Sensitive Study, Research Reports I through IX. August.

Prather, Maj. Gen. T.L., Jr. 1993. Proposal for new staffing levels for U.S. Army Materiel Command (AMC) research, development, test and evaluation (RDT&E) activities. Memorandum to Army Materiel Command subsidiary commanders.

U.S. Congress, Office of Technology Assessment. 1989. Holding the Edge: Maintaining the Defense Technology Base. OTA-ISC-420. Washington, D.C.: U.S. Government Printing Office, April.

U.S. Merit Systems Protection Board. 1993. Federal Personnel Offices: Time for Change? August.

White House Science Council Federal Laboratory Review Panel. 1983. Report. May.

Appendix C:

The Federal Procurement and Contracting System

The Army Research Laboratory spends millions of dollars on procuring supplies and services and contracting out research. The problems associated with the procurement of supplies and services are as numerous and as bureaucratic as the federal personnel system described in Appendix B). Additionally, if the Army chooses either the GOCO or ARL Multicenter (with GOCO or federally funded research and development [FFRDC] centers) options, it will have to follow certain regulations and requirements associated with establishing FFRDCs. GOCOs are considered to be subsets of FFRDCs.

THE PROCUREMENT SYSTEM: MORE BUREAUCRACY THAN BUYING

The federal contracting and procurement system relies heavily on rigid rules and procedures, extensive paperwork, detailed design specifications, and multiple inspections and audits. Like the personnel system, it was originally designed with the best of intentions. However, numerous attempts to prevent profiteering and fraud through the creation of a centralized management system and the writing of additional rules and regulations, have produced an unwieldy system.

Contracting efforts in the government are governed by Executive Order 12352 and controlled by the Federal Acquisition Regulation which has about 1,600 pages, and about 2,900 more pages of agency-specific supplements. As Vice President Al Gore discussed in his report on *Creating a Government that Works Better and Costs Less,* these rules support an "overly centralized purchasing system which takes decisions away from managers who know what they need, and allows strangers—often thousands of miles away—to make purchasing decisions. The frequent result: Procurement officers, who make their own decisions about what to buy and how soon to buy it, purchase low-quality items, or even the wrong ones, that arrive too late" (National Performance Review, 1993a).

As with the federal personnel system, Vice President Al Gore has also pushed federal procurement problems into the national limelight with his report. The report reinforces what most federal workers and many taxpayers already know: the federal procurement system is an extraordinary example of bureaucratic red tape (National Performance Review, 1993a).

UNNECESSARY EXPENDITURES OF TIME AND MONEY

When discussing government procurement, horror stories are plentiful. Stories abound about $100 hammers, waiting more than a year to buy a personal computer, and requirements for numerous people, unaffiliated with the purchase, to sign-off on every procurement, large or small.

Stories like these were documented by the Office of Federal Procurement Policy (OFPP) and the U.S. Merit Systems Protection Board in January 1993. These two agencies collaborated in conducting a survey of more than 1,000 federal managers. The findings of the survey were that the federal procurement system is not giving its customer's what they want, it pays prices often higher than necessary, and it assumes that line managers cannot be trusted (National Performance Review, 1993a).

A study by the Center for Strategic and International Studies added several other conclusions. These conclusions are not a surprise to managers and researchers at ARL. The study concluded that the procurement system adds costs without adding value; it impedes government's access to state-of-the-art commercial technology; and added red tape forces businesses to alter standard procedures and raise prices when dealing with the government (National Performance Review, 1993a).

WHY ARE THERE PROBLEMS?

The Federal Acquisition Regulation contains too many rules. According to a Merit Systems Protection Board survey, rules are changed too often and are so process-oriented that they minimize discretion and stifle innovation (National Performance Review, 1993b). In addition to the Federal Acquisition Regulation, there are numerous other requirements that impact procurement. Here are just a few:

- The procurement of computers and software is stifled by Congress' Brooks Act of 1965 and Congress' expansion of the same Act in 1986. This act directed the General Services Administration to centrally purchase computers and software in order to save money for the

government. This approach made sense for the large flame computers of the 1960s and 1970s but not for the personal computers and software of the 1990s. This centrally controlled procurement system does not keep up with rapid advances in the personal computer world. Due to rapid advances in personal computer technology, the government often buys computers that are state-of-the-art when the purchase process begins and when prices are negotiated, but which are almost obsolete when the computers are delivered. Thus it looks like the government is paying the price of the most advanced personal computer for those which may be two generations old.

- ARL must buy test tubes and many other items through a system called the Multiple Award Schedule program. Under this program, the General Services Administration negotiates and awards contracts for multiple vendors of comparable products and services, at varying prices. In many cases, ARL is forced to buy through the General Services Administration while at the same time complying with the Federal Acquisition Regulation.
- Under current law, agencies are only allowed to make purchases of less than $25,000 on their own, using simple procurement procedures (National Performance Review, 1993a). As discussed in Chapter 3 , one method of exercising this freedom is through the use of *credit cards.* However, credit card limits in the Army are normally about $2,500, which are not enough when buying one-of-a-kind, state-of-the-art research and automation equipment.

These are just a few of the limitations which are placed on ARL when it attempts to procure supplies and services. These limitations cause delays in procurement of an item, and may cause the purchasing of a generic item which does not meet the exact specifications of a research project. Recent studies, such as Vice President Gore's Report, show that the savings that were originally envisioned in the government's centrally-managed, highly-controlled procurement system do not exist today. In fact, the system may create additional salary, facilities, and opportunity costs when a researcher has to wait days, weeks, or even months for an item needed to continue a research project.

CURRENT STREAMLINING EFFORTS

Section 800 of the fiscal year 1991 National Defense Authorization Act (Public Law 101-510) directed the establishment of an advisory panel to identify and simplify acquisition law. Subsequently, the Under Secretary of Defense for Acquisition and Technology appointed a panel of recognized public and private sector experts in acquisition law and

procurement policy to review the applicable laws and regulations and make recommendations for change.

On January 12, 1993, the Acquisition Law Advisory Panel issued an 1,800 page report entitled Streamlining Defense Acquisition Law. The report recommends significant changes to the defense procurement system, to include amending, deleting, consolidating, or rescinding 300 of the 600 statutes reviewed by the committee. It was delivered to Congress, and incorporated into Vice President Gore's National Performance Review. These recommendations could pave the way to an improved procurement system within DOD by streamlining statutes, improving access to commercial technologies, and simplifying the acquisition process. The Advisory Panel believes that, once implemented, significant savings will be made in lead time and acquisition costs.

For example, one of the recommended changes is a simplified acquisition threshold that also improves small purchases by exempting most socioeconomic requirements and corresponding contract clauses and raising the threshold from $25,000 to $100,000. This would streamline over 50 percent of the contract actions over $25,000 while only affecting 5 percent of all contract dollars (Sullivan, 1994).

CONTRACTING RESEARCH

If ARL is to contract out research or be totally contracted out as a GOCO organization, it must follow U.S. Code Title 10 and numerous other rules and procedures.

According to Section 2462, U.S. Code Title 10, the Department of Defense can procure supplies and services from sources in the private sector only if such sources can provide them at a lower cost than available within the government. This requirement is also described in the regulations concerning the Commercial Activities Program, which include Office of Management and Budget Circular A-76, DOD Directive 4100.15, DOD Instruction 4100.33, and Army Regulation 5-20. These authorities describe procedures to conduct cost studies to establish the relative costs of in-house performance versus contract performance for existing or proposed commercial activities. In particular, Paragraph 4-1.b.(1), Army Regulation 5-20, requires that a cost study be performed when considering the conversion of an in-house activity to a contractor activity.

However, for research and development, the requirements are not very clear. Paragraph 1-6.i, Army Regulation 5-20, exempts research, development, test and evaluation functions from the requirements of the Commercial Activities Program to inventory, review, and cost study commercial activities. At the same time, this exemption does not override

the statutory requirements of Section 2461, U.S. Code Title 10, which makes no exception for R&D. This statute requires that before a commercial function of DOD, being performed by Department of Defense civilians as of October 1, 1980, can be converted to a contractor operation, Congress must be provided:

- notice of any decision to study such function for possible contract performance;
- detailed summary of the cost comparison which demonstrates that going to a contractor will result in cost savings and a certification that the entire cost comparison is available;
- certification that the government cost is based on the most efficient and cost effective organization; and
- a report containing information specified in the statute.

These requirements should not be difficult to achieve (Gamboa, 1993).

ESTABLISHING A GOCO ORGANIZATION

Since, the Army would want ARL to have the special relationship with the government that is described in OFPP Policy Letter 84-1, the establishment of ARL as a GOCO organization, or as a center of excellence within the Multicenter option, must follow the rules for establishing a GOCO and the rules for establishing an FFRDC. The following regulations and procedures describe what the Army would have to do to establish an FFRDC (GOCO).

Background

FFRDCs are privately operated, but publicly funded under a long-term contract with a federal sponsoring agency. FFRDCs are operated, managed, or administered by either a university or consortium of universities, other not-for-profit or nonprofit organization, or an industrial firm, as an autonomous organization or as an identifiable separate operating unit of a parent organization (Federal Acquisition Regulation 35.017-2). They are intended by their sponsors to have an intimate, flexible, and relatively informal or *special* working relationship with them, which non-FFRDCs do not have. FFRDCs are organizations exclusively or substantially financed by the federal government on a relatively long-term basis. They are intended to conduct (1) basic and applied research; (2)

development; or (3) management of research or development at the request of the federal government.

Authority

- The establishment, continuation and dissolution of FFRDCs is governed by OFPP Policy Letter 84-1, dated April 4, 1984. This policy letter is implemented by Federal Acquisition Regulation Part 35, Title 48 of the Code of Federal Regulations 35.017.
- The use of FFRDCs is limited by Section 2367, U.S. Code Title 10.
- The management of DOD FFRDCs is regulated by the DOD FFRDC Management Plan issued August 14, 1992, by the Director of Defense Research and Engineering.

Establishment

As prescribed by OFPP Policy Letter 84-1, in order to establish an FFRDC, the sponsoring agency must ensure that the following guidelines are met.

- Existing alternative sources for satisfying agency requirements cannot effectively meet the special R&D needs.
- At least three notices are placed over a 90-day period in the *Commerce Business Daily* and the *Federal Register* indicating the agency's intention to sponsor an FFRDC and the scope and nature of the effort.
- There is sufficient government expertise available to adequately and objectively evaluate the work to be performed by the FFRDC.
- Controls are established to ensure that the costs of the services being provided the government are reasonable.
- The responsibility for capitalization of the FFRDC has been defined in such a manner that ownership of assets may be readily and equitably determined upon termination of the FFRDC relationship with its sponsor.
- The purpose, mission, and general scope of effort of the FFRDC is stated clearly enough to enable differentiation between work that should be performed by the FFRDC and that should be performed by a non-FFRDC.

Additional Requirements

Additionally, Federal Acquisition Regulation Part 35 directs that:

- The Executive Office of the President, Office of Science and Technology Policy is notified.
- A reasonable continuity in the level of support to the FFRDC is maintained, consistent with the agency's need for the FFRDC and the terms of the sponsoring agreement.
- Office of Management and Budget Circular A-120 is complied with when applicable, and quantity production or manufacturing is not performed unless authorized by legislation.
- Approval must be received from the head of the sponsoring agency.
- FFRDCs must meet a special long-term R&D need which cannot be met as effectively by existing in-house or contractor resources.
- They generally have access beyond that which is common to the normal contractual relationship, to government and supplier data, including sensitive and proprietary data, and to employees and facilities.
- They are required to operate in the public interest, and to be free from organizational conflicts of interest, and to have full disclosure of its affairs to its sponsoring agency.
- They should not compete with the private sector.
- They may perform work for other than the sponsoring agency under the economy act, or other applicable legislation, when the work is not otherwise available for the private sector.

CURRENT LIMITATIONS ON FFRDCS

U.S. Code Title 10, Section 2367, states, “the head of an agency may not obligate or expend amounts appropriated to DOD for the purposes of operating an FFRDC that was not in existence before June 2, 1986, until:

- the head of the agency submits to Congress a report with respect to such center that describes the purpose, mission, and general scope of effort of the center; and
- a period of 60 days beginning on the date such report is received by Congress has elapsed.

Congress has periodically expressed concern about the growth of FFRDCs and has set a ceiling on total defense FFRDC spending:

- Public Law 102-172, Section 8106, reduced FFRDC funding by $133,300,000 and mandated conflict of interest policies.
- Public Law 102-190, Section 256, limited the number of man-years for each FFRDC.
- Public Law 102-396, Section 9090, reduced funding by another $300,000,000 and disallowed the establishment of any new FFRDCs with fiscal year 1993 money.
- The DOD FFRDC management plan directed reduction of the total amount of funds available to pay costs to DOD FFRDCs by 12 percent for a three-year period beginning in fiscal year 1992.

REFERENCES

Gamboa, A. 1993. Briefing to the GOCO ARL option panel, Committee on Alternative Futures for the Army Research Laboratory, at its meeting, Washington, D.C., June 28–30.

National Performance Review. 1993a. Creating a Government that Works Better and Costs Less. Washington, D.C.: U.S. Government Printing Office. September 7.

National Performance Review. 1993b. Reinventing Federal Procurements, "PROC08: Reform Information Technology Procurements." Washington, D.C.: U.S. Government Printing Office, September.

Sullivan, B.E. 1994. The Section 800 Report . . . Streamlining Defense Acquisition Law. Army RD&A Bulletin. January–February.

Appendix D:

Cost, Personnel, and Contracting Considerations

This appendix provides the background, data, comparative analysis results, and statement of findings for each of the three areas (cost, personnel, and contracting) examined by the committee. Each of these three areas is discussed separately below, with the key issues and findings relative to each of the four options considered: (1) an ARL Enhanced option with no regulatory changes (Chapter 3); (2) a NIST option employing demonstration model personnel procedures (Chapter 4); (3) an ARL Multicenter option involving 70 percent of the research being performed outside of ARL under one or more contracts (Chapter 5); and (4) a GOCO ARL option in which all research and management are contracted out (Chapter 6).

COSTS

One of the objectives of this study was to determine the magnitude of the cost implications involved in changing ARL from its current management structure to alternative management structures. Each conversion option considered has both nonrecurring (i.e., one time) conversion-related cost and recurring operating cost implications. Data for this cost analysis was based on and derived from prior studies and operational cost data from organizations considered to be appropriate models—sources for the data are referenced throughout this appendix. It is difficult to make a direct cost comparison between the different conversion options. Cost estimates can never fully take into account the specific differences between one laboratory option and another, nor one particular (actual or hypothetical) conversion or transition and another. Each organization has a unique set of tasks, its own computing and travel needs, its own support staff requirements and its own facility and utility needs, and each is located in a particular part of the country with its own local area cost considerations. These differences tend to reduce the accuracy of detailed cost comparisons.

The assumption underlying this study is that if the Army were to emulate the structure, management, personnel practices, and facilities of research laboratories generally considered within the scientific community to be

world-class, the value of the resulting research effort would be enhanced compared to that of the existing ARL laboratories. Under such circumstances, even if a conversion were to take place within an equal total operating cost constraint (except for one-time conversion costs), the long-term value would increase.

To achieve the Army's vision of becoming a world-class laboratory ARL will have to attract and retain exceptional S&Es. This will probably require additional capital investments, which could not be considered here, within the scope of this analysis.

Previous Studies

A number of previous studies were reviewed to gain insight into what prior studies concluded about the costs of conversion of government research laboratories to either a NIST-type operation or a GOCO-type operation (these two operations would include the ARL Multicenter option since it is a mixture of in-house and contracted-out research). The summary below identifies those studies and indicates what the committee discovered from that information. The studies used are referenced by number and the numbered references are included at the end of this appendix.

Relative to the ARL Enhanced Option

A baseline study was conducted by U.S. Army Laboratory Command to provide guidance and direction to ARL in its formative (formation was in 1992) years. The costs and staffing envisioned for fiscal year 1997 generally follow the guidelines of this Laboratory Command study. The Combat Materiel Research Laboratory (now ARL) Baseline Study (Army Laboratory Command, 1991) was reviewed. The results shown in Table D-1 are close to the actual data received from ARL. The study does not appear to have considered any significant changes in personnel or laboratory management of the type envisioned in the ARL Enhanced option.

Relative to Demonstration Projects

The committee reviewed several studies that provide information on the attempts to estimate the impact on conversion to NIST-like operations. The most relevant of these studies were those conducted by the National Research Council (National Research Council, 1993), several Office of Personnel Management (OPM) analyses and reviews of the ongoing demonstration

TABLE D-1 ARL Baseline Study Comparison ($ Millions)

	Current (Fiscal Year 1993)	Baseline Study (Fiscal Year 1990)
Direct Costs		
Direct Labor (Fringe, Benefits, Supplies)	170.0	123.9
Support Contracts	167.1	40.4
Equipment	above	18.3
Military Reimbursement	N/A	5.0
Subtotal	**337.1**	**187.6**
Indirect Costs		
Indirect Labor (loaded)	32.0	15.5
Support Contracts	15.5	10.0
Equipment		2.5
Subtotal	**47.5**	**28.0**
General and Administrative		
Laboratory General and Administrative		31.3
Base Operations/Maintenance		41.3
Laboratory Command/ARL Headquarters		20.2
Subtotal	**99.5**	**92.8**
Non-reimbursable Interservice Support Agreement		15.0
Non-reimbursable Military		3.0
Subtotal	**0.0**	**18.0**
Grand Total	**484.1**	**326.4**
Workyears	3929	3144
Cost/Workyear	123.2K	103.8K
Escalated (fiscal year 19993)		114.1K

projects the Naval Air Weapon Center (NAWC) at China Lake and NIST, and internal reviews of the ongoing demonstration projects. The fact that the demonstration project at China Lake has been extended twice from its original five-year life is evidence that the project has become accepted by the various agencies in the government as viable and worthwhile. The visit made by the panel to China Lake resulted in an impression that the personnel at China Lake are benefitting from relaxed personnel regulations and their payfor-performance evaluation system is enabling constructive actions to be taken when poor or borderline performance is identified.

No studies were found that would provide information on conversions to an ARL Multicenter option; however, this option is basically a hybrid between the ARL Enhanced and the GOCO ARL option (a mix of in-house research and contracted-out research), so the information provided for those two options is pertinent to the ARL Multicenter option.

Relative to Conversion to a GOCO

The committee found no evidence of an entire defense research laboratory having ever been converted to a GOCO operation. Only selected services within laboratories have been converted under Office of Management and Budget A-76 rules to commercial contracts and the available examples are not directly applicable. Consequently no data are available to ascertain implications on resources or value from such a conversion. However, a number of studies are available which conjecture the implications of such conversions.

An internal study conducted by ARL (Army Laboratory Command, 1990) examined the conversion of the Laboratory Command, the predecessor of today's ARL, to a GOCO operation. The following key assumptions were made in that study:

- The average scientist's and engineer's salary was increased by 60 percent and other salaries were increased by lesser amounts.
- The S&E-to-support-staff ratio was raised from 1:1.1 to 1:1.6.
- Annual facilities replacement costs are 5 percent of facilities value.
- New construction (one-time) was estimated at $18 million (in fiscal year 1989 dollars).
- A GOCO fee of 1 percent was assumed and the total cost for government oversight was 1 percent.
- Annual maintenance costs were not estimated.
- Included were 155 percent of payroll to buy-out retirement and 45 percent for early retirement (one-time).

- Sizable one-time costs to improve facilities, maintenance, and equipment were included.

Using these values and assumptions the Army generated two management and staffing structures. One structure assumes the total budget is held constant, including the capital investment costs (Table D-2). The other structure keeps the salary budget fixed, but pays for capital investment as additions to the budget (Table D-3). In both cases the one-time conversion costs would have been funded off-line.

The one-time conversion costs documented in the Army study totaled $525 million, with $282 million for personnel-related costs and $243 million for facility-related costs. The personnel-related costs include $218 million to buy out retirement and $64 million of early retirement benefits. These costs are not applicable according to DOD Pamphlet 1400.20-1-P (Department of Defense, 1993) since these costs are normal deferred costs. On the other hand, severance pay and other reduction-in-force (RIF)-related expenses, in accordance with the Department of the Army information paper (Department of the Army, 1992a) should be included in conversion costs, but were not part of the Army study conversion costs.

Drawing on the Army study, as well as comparable studies performed by the other Services, the Office of Secretary of Defense conducted an in-house review (Heeb, 1991; Department of Defense, 1991) which resulted in a third structure (Table D-4) for the Laboratory Command/ARL on an almost *equal* recurring operating cost basis. Other cost impact conclusions stated in the Office of Secretary of Defense study, based on the individual Service studies, were:

- Facilities upgrading will require a one-time cost of 30 percent of the total current budget.
- One-time personnel conversion costs will be higher than the current annual total salary budget, possibly twice as large.
- Salary increases for a GOCO option should be about 26 percent to 34 percent.
- Annual operating costs for the GOCO option would run at least 20 percent over the current costs for a similar laboratory staff. The study further concluded that since no Service estimate included all of the potential cost increases, all of these estimates may be low.

The point of including the results summarized above is that, in prior studies, the cost of converting ARL to a GOCO operation was considered to be a very expensive option in terms of reduced staff structure and one-time conversion costs. In neither of the above studies was it demonstrated that any

TABLE D-2 Staffing Structure Holding Total Budget Constant (ARL Study)

	Current ARL ($ millions)	GOCO ($ millions)	Percentage of Personnel in GOCO
Total Budget	780	780	—
Total Staff	3035	1736	45
S&E	1766	668	38
Technical	504	420	83
Administrative	754	334	44
Clerical	568	214	38
Maintenance	243	100	41

TABLE D-3 Staffing Structure Holding Salary Budget Constant (ARL Study)

	Current ARL ($ millions)	GOCO ($ millions)	Percentage of Personnel in GOCO
Salary Budget	141	141	—
Total Staff	3835	2761	72
S&E	1766	1062	60
Technical	504	669	132
Administrative	754	531	70
Clerical	568	340	60
Maintenance	243	159	65

TABLE D-4 Holding Recurring Operating Costs Constant (Study of the Office of the Secretary of Defense)

Conversion Estimate

	Current			Example GOCOs				
Employee/Type	Full Time Employees	Average Salary (K)	Total Salary (M)	Full Time Employees	Increase Salary (percent)	Average Salary (K)	Total Salary (M)	Percent Full Time Employees
Scientists/Engineers	1,766	38.3	68.5	1,413	60	62	88	80
Technicians	504	32.3	16.3	1,165	30	42	49	230
Admininstrative	754	31.6	23.8	377	20	38	14	50
Clerical	568	18.3	10.4	284	15	21	6	50
Maintenance	243	29.0	7.0	243	10	32	8	100
Total	3,835	—	141*	3,482	44 avg	—	184*	—
Scientist and Engineer: Support	1.2	—	—	1.5	—	—	—	—
Contracting		$532M				$488M		

* Includes 12 percent benefits

Assume: Facilities issues not included; one-time costs not included; and increased in-house technical support reduced need for outside scientist and engineer support.

of the three structures would, in fact, provide equal or additional value, or that any of the structures would actually be able to perform the ARL mission.

Methodology

Cost comparisons were made for the four options stated above (i.e., (1) ARL Enhanced, (2) NIST, (3) ARL Multicenter, and (4) GOCO ARL) using the methodology explained in this section.

Different institutions perform their financial accounting using very different methodologies making direct detailed comparison by common accounting terms nearly meaningless. Coopers and Lybrand examined 12 FFRDCs in 1991 and concluded that indirect cost comparison is not possible (Coopers & Lybrand, 1991). For example, general and administrative rates varied from 7.2 percent to 92.5 percent for the different institutions.

In order to provide valid comparisons, metrics had to be carefully selected. A number of metrics were considered in the course of the present study; however, the ones employed were selected on the basis of: (1) available data; (2) the meaningfulness of the parameter for comparison purposes; and (3) the committee's belief that the metric represents a true discriminator of the options. Due to the wide variation in facility accounting procedures, only cost comparisons at a very high level of aggregation were considered appropriate.

Calculable Cost Metrics

Initially the relevant costs are divided into recurring costs (i.e., annual costs required to operate ARL under each of the alternative management constructs) and conversion costs (i.e., one-time costs of converting from the current ARL management structure to an alternative management structure). All cost figures shown are adjusted to fiscal year 1993 dollars unless noted otherwise.

Total Operating Costs (Adjusted). This metric was selected because it should include all of the direct and indirect (support) costs relevant to carrying out the institution's mission. The total operating cost was adjusted to exclude the cost of contracting out research which, in general, requires a smaller amount of support, compared to carrying out the research in-house. The cost of support contracts to provide services in support of the laboratory's research functions was however included in the operating cost.

Total Operating Cost (Adjusted) Per S&E Full-Time Equivalent (FTE). It was assumed that the basic unit performing research is the S&E and that all the other operating costs are performed in his support. Consequently, total operating costs were normalized on the basis of a scientist/engineer FTE.

Average Salary. Another metric employed was the basic average salary for a scientist or engineer. Basic salaries were adjusted to represent pay for 2,088 hours per year which includes leave and other paid absences. Some of the data collected had leave costs as part of the fringe benefits. Because of the fragmentation of the fringe benefits in the government among different agencies, an absolute value of those benefits is difficult to determine. However, the fringe benefit package is the same for all government management options, but can vary fairly widely for different GOCO institutions. On the other hand, a 1992 Hay Group survey of 30 DOE management and operating contractors found that the total value of the benefits of the DOE institutions was comparable to those of the national average, or about 40 percent of gross salaries (Hay Group, 1992). The ratio of total operating cost to average cost per S&E was the primary parameter employed to obtain a meaningful loading factor to be applied to average S&E salary numbers.

Severance Pay. Severance pay for the fiscal year 1997 ARL workforce was estimated, in detail using the specific employee population expected, by ARL and is shown in Table D-8 for the 3,131 positions expected to be at ARL in fiscal year 1997. About 76 percent (744 of 3,131 is 76.24 percent) of the employees terminated would receive severance pay and 24 percent (23.76 percent) would either retire or transfer to another government position. For the options where only a portion of the personnel are RIFed, ARL estimates are prorated on a per person (per capita) cost of $21,000 per person.

Other RIF-Related Costs. These are the cost of terminating a civil servant if the operation shifts from a government-owned, government-operated to a GOCO method of operation. These costs are explained in a DOD pamphlet (Department of Defense, 1993). A June 1992 Department of the Army costing model for RIF actions provides the framework for estimating RIF costs (Department of the Army, 1992a). Costs per involuntary separation during the first 12 months following the RIF effective date are estimated at: $3,700 for severance pay, $2,800 for relocation allowances, $1,900 for lump sum annual leave payment (the Assistant Secretary of the Army [Financial Management] estimates these at $3,000), $1,300 for saved grade/pay, $2,500 for

unemployment compensation, $1,900 for retraining, and $100 for overtime associated with RIF administration. The total of the above items is $14,200 per RIFed person. ARL has provided a specific projection of the severance pay for the particular workforce so $3,700 has been deleted from the above costs leaving a total of $10,500. Since these costs were in fiscal year 1991 dollars, they have been escalated to fiscal year 1993 dollars (using a 9.3 percent factor) to arrive at a total *other* RIF costs of $11,500 per RIFed person. For management options in which ARL remains in the government structure no RIF pay is required. If ARL is converted to another type of operation, those employees that are not remaining in government in another position, and are not eligible for retirement, are entitled to severance pay, even if they accept comparable positions with the incoming contractor (Department of Defense, 1993). At one time, exemption from severance pay was possible for personnel who accepted employment with the contractor who took over management of a particular function, but authorization for that exemption was removed in 1989 by OPM (Office of Personnel Management, 1989). Current employees now have the right of first refusal for jobs for which they are qualified and which the contractor taking over a government operation is filling.

System Design and Training Cost. In converting to a NIST management option, it is assumed that internal staff will be called upon to design or adapt a personnel model for use by ARL. In addition, there are training costs involved in any conversion of employee pay or rating systems to a new system. This includes the salaries of the employees being trained, the facilities for training and the cost of the instructors.

Contracting Process. The process of selecting a contractor is both time-consuming and costly, in terms of manpower required in analyzing and specifying the requirements, performing independent government cost analyses, analyzing the proposals, and selecting a contractor.

Other Conversion Costs (Not Easily Calculated/Measured)

There are additional costs that could not be estimated accurately, either because they are too dependent on the specific contractual agreements or because insufficient data were available.

Pay Differential and the Impact of Employee "Bumping". The pay differential is an adjustment of salaries to place all existing employees and managers converting to a NIST or GOCO operation, and newly appointed managers, on a new pay scale. The cost of bumping rights, because personnel with more seniority have a right to bump someone with lower seniority from a position, is also a cost that is not easy to measure, but will result in some additional cost and disruption time.

Facilities Upgrade. This is a one-time cost of upgrading facilities and equipment, when converting to a new management structure, that will help make ARL a world-class laboratory. Since the major portion of ARL is assumed to move into the new Base Closure and Realignment-funded buildings, this cost differential could not be estimated.

Legislative and Regulatory Changes Processing Costs. The time and cost associated with getting Departmental, Office of Personnel Management, Office of Management and Budget, and Congressional waivers or approvals, as required to convert to a NIST or a GOCO operation could not be estimated.

Union Understanding and Approval. The involvement of government employee unions could require time to explain the new system to union leaders sufficiently to gain their support for the conversion. Adverse legal actions can lead to considerable delays and disruptions, as in the case of the Point Mugu conversion. In some instances (e.g., NAWC) the unionized employees were not converted to the improved personnel system.

Disruption Costs. Costs are associated with personnel performing conversion activities not related to their prime mission or decreased productivity due to future uncertainty.

Government Monitoring and Oversight Cost. This is the additional cost to the government of managing and overseeing the GOCO or contracted-out services.

Data Collection

In order to establish a baseline, ARL was visited several times, previous studies were reviewed, and additional information was prepared by ARL specifically for this effort. In addition, discussions were held with AMC which furnished specific information on ARL funding and AMC's management and oversight role (Army Materiel Command, 1993).

Two government demonstration projects, NIST, formerly the National Bureau of Standards, and NAWC at China Lake, California were visited. Each provided additional information for this project.

Sandia National Laboratories were visited as a typical GOCO operation, of the weapon systems type, and discussions were held with DOE staff members in Washington on matters related to management and oversight over the Department's national laboratories. Additional current information was available on Brookhaven National Laboratory and other nondefense DOE national laboratories.

Fragmentary current information was obtained relative to the salaries and operating costs of 13 FFRDCs and more detailed fiscal year 1991 data were obtained for 3 FFRDCs. The latter information was escalated to fiscal year 1993 for comparison purposes. Additional detailed, current information was available on one FFRDC.

The paragraphs below discuss the types of data collected from each of the different types of organizations mentioned above and provide a basis for the comparisons that were performed, as summarized below.

ARL Baseline

The baseline for this study was an ARL-97 projected manning structure provided by ARL (Army Research Laboratory, 1993). This structure, in accordance with the Army Science and Technology Master Plan (Department of the Army, 1992b) and the directives of the Base Closure and Realignment Commission (Defense Base Closure and Realignment Commission, 1991), represents a significant reduction in support staff, compared to the current ARL staffing. Current fiscal year 1993 ARL data were used to validate the fiscal year 1997 projections for reasonableness, since these projections are still very uncertain. The program data and the expenditure data furnished by ARL are shown in Table D-5 and Table D-6. Since fiscal year 1997 represents the projected steady state for ARL at the end of the Commission conversion period, estimates for that year were obtained from ARL also and are shown in Table D-5 and Table D-6. The fiscal year 1997 data are clearly more uncertain. However, the $323 million (fiscal year 1993 constant dollars) for fiscal year 1997 form the basis of comparison for all options. Should funding in that year

TABLE D-5 ARL Program Data (Then Year, $ Millions)

	ARL's Fiscal Year 1993 Program ($ Millions)		ARL's Business Plan ($ Millions)			
			FY 1994	FY 1995	FY 1996	FY 1997
ARL Operating Revenue						
Mission RDTE						
6.1	37.0	0.07	73.1	65.1	61.6	63.6
6.2	171.8	0.31	122.9	145.3	146.1	148.3
6.3	40.0	0.07	2.2	1.3	0.3	0.3
6.5 Mission	67.1	0.12	48.2	52.7	49.0	48.9
6.5 Support	50.1	0.09	62.4	60.2	51.9	48.1
6.7	1.6	0.00	6.6	6.4	5.5	4.0
Total RDTE	367.6	0.66	315.7	331.0	314.4	313.2
Other Appropriations						
OMA/FHA	9.9	0.02				
Procurement	1.6	0.00				
OSD RPM	1.5	0.00				
OSD RDTE	0.3	0.00				
Advanced Projects Research Agency	46.0	0.08				
0.11						
Total Other	59.3	0.11				
Reimbursable Customer Program						
RDECs	28.1	0.05				
PEO/PMs	50.0	0.09				
Other Army	10.3	0.02				
DOD	10.3	0.02				
Other Non-Army	6.4	0.01				
Navy	4.4	0.01				
Air Force	0.4	0.00				

Total Reimbursable	109.9	0.20	111.1	91.4	83.8	79.1
Revenues not Available for ARL Operations	(52.8)	(0.11)	(54.7)	(4.4)	(42.4)	(38.7)
Total ARL Operating Revenues	**484.0**	**0.87**	**372.1**	**378.0**	**355.8**	**353.6**
ARL Non-Operating Revenue						
Direct Cite Customer Program						
PEO/PMs	7.6	0.01				
RDECs	1.4	0.00				
Other	41.0	0.07				
Total Direct Cite	50.0	0.09	52.8	53.7	50.6	46.6
AHPCRC	4.1	0.01	4.8	36.9	4.2	0.0
Base Closure Amount	15.7	0.03	161.0	148.0	18.2	23.8
Total Non-Operating Revenue	**69.8**	**0.13**	**218.6**	**238.6**	**73.0**	**70.4**
Grand Total	**553.8**	**1.00**	**590.7**	**616.6**	**428.8**	**423.9**

Note: FHA = family housing Army
PEO = program executive officers
FY = fiscal year
PMS = program managers
OMA = operations and maintenance Army
RDTE = research, development, test and evauation
OSD = Office of the Secretary of Defense
RPM = real property maintenance

TABLE D-6 ARL Recurring Operating Cost Comparison Fiscal Year 1993 versus Fiscal Year 1997 Projection ($ Millions)

ARL Operating Costs	Fiscal Year 1993	Fiscal Year 1997
Labor	215.6	182.1
Travel	10.4	8.8
Equipment	17.2	20.6
Other	11.9	10.1
Support Contracts	61.8	60.4
Total Operating Costs (Adjusted)	316.9	282.0
(fiscal year 1993)	(257.5)	
R&D Contracts	61.8	71.6
Total Operating Costs	484.0	353.6
(fiscal year 1993)	(323)	
Workyears	3929	3144
Operating Cost/Workyear		
(fiscal year 1993)	81	82

NOTE: $323 million (in fiscal year 1993 dollars) was used to compare all options to the ARL-97 Baseline budget.

be reduced the manpower ceilings estimated in this study should be reduced proportionately. Based on available ARL projections (Army Research Laboratory, 1993), the number of S&Es is expected to remain constant (1,744), although examination of the respective Tables of Distribution and Allowance shows significant grade increases in the interim. The number of support staff is decreasing; however, and the fraction of support contracting is increasing, leaving the operating cost per S&E FTE nearly unchanged (Table D-7).

ARL also provided data related to a conversion to a non-governmental structure (Army Research Laboratory, 1993). Their analysis involved the estimation of severance pay for individuals who would still be present in fiscal year 1997, when the ARL restructuring is expected to be completed. The results of this analysis show that a total severance pay of over $54 million ($50 million in fiscal year 1993 dollars) would be required (Table D-8).

TABLE D-7 ARL Overhead Cost Comparison Fiscal Year 1993 Versus Fiscal Year 1997 Projection ($ Millions)

	Fiscal Year 1993			Fiscal Year 1997		
Overhead Costs	Indirect	G&A	Total	Indirect	G&A	Total
Labor	21.3	61.0	82.3	18.6	53.6	72.2
Travel	2.0	2.2	4.2	1.8	1.9	3.7
Equipment	2.8	3.2	6.0	2.9	3.2	6.1
Other	5.8	3.1	8.9	5.4	3.7	9.1
Support Contracts	15.5	30.0	45.5	12.8	47.7	49.7
Total (Then Year)	47.4	99.5	146.9	41.5	110.1	140.8
(fiscal year 1993)	128.9					
Total Operating Costs (Adjusted)(excluding R&D contracts)			316.9			257.5
Overhead/Operating Costs			46.4%			50.0%

National Institute of Standards and Technology

The demonstration project at NIST is still in its early stages, since the laboratory did not transition to the new structure until 1989 (Kramer, 1993; National Institute of Standards and Technology, 1993). Conceptually, NIST is a research institution, both basic and applied, not unlike ARL, and is located within the same personnel competition region as ARL. NIST has converted from the civil service pay structure to a structure involving four career paths and up to five bands in each path. Wage grade employees are not included. The pay range for each career path and the bands are shown in Table D-9 and the average pay rates are shown in Table D-10.

Supervisory personnel receive an additional 5 percent pay increment during the period in which they act as supervisors. Periodic pay increases and promotions are based on an intricate rating system; however, supervisors have much latitude in distributing the increases based on merit (Cassady, 1991).

A 1991 NIST evaluation (National Institute of Standards and Technology, 1992) by Hay Management Consultants shows that in the few years between before 1987 and after 1991, pay comparability with private sector was being approached (Table D-11).

TABLE D-8 ARL Fiscal Year 1997 Projection of Severance Cost if Converted to a GOCO

Fiscal Year 1997 Projection					
Severance Pay					
From	To	Group	Fiscal Year Positions	1.1365 Severance	Percentage of Positions
$0	$10,000	0	409	$1,858,975	
$10,000	$20,000	1	1081	$14,562,843	
$20,000	$30,000	2	447	$12,134,488	
$30,000	$40,000	3	182	$7,589,232	
$40,000	$50,000	4	120	$6,649,430	
$50,000	$60,000	5	70	$4,947,455	
$60,000	$70,000	6	56	$4,646,692	
$70,000	$80,000	7	18	$1,791,424	
$80,000	$90,000	8	3	$280,362	
$90,000	$100,000	9	1	$109,814	
$100,000	$110,000	10	1	$121,813	
Fiscal Year 1997 Severance Subtotal			**2,388**	**$54,692,528**	**76**
Retirees			744	$0	24
Fiscal Year 1997 Total Positions			**3,132**	**100**	

Assumptions: 1. The costs shown reflect only those costs incurred by ARL in fiscal year 1997.
2. These costs include the severance costs earned by calculating 1 week per year for the first 10 years, 2 weeks per year there after plus Annual Leave Lump Sum Payment.
3. There is a maximum of 52 weeks (one year's salary) for weeks earned.
4. The fiscal year 1997 ARL employment profile will be similar to today's.
5. The population total for ARL in fiscal year 1997 will be 3,132.
6. Retirement rules for a major reduction in force apply.
7. There will be no incentive pay for early retirement or RIP.
8. The inflation rate for fiscal year 1997 will be 1.1365.

Notes: 1. This revision to the July 14, 1993, report corrects the calculation of Wage Grade Salaries
2. Severance cost for annual leave included July 16, 1993.

TABLE D-9 Range of Base Pay in Each Cell of NIST Personnel Management Demonstration Project

Career Path	Pay Bands				
Scientific and Engineering Pay Plan: ZP	$31,125 I $11,903-29,338	$47,165 II $22,717-44,457	$59,849 III $33,623-56,414	$78,103 IV $47,920-73,619	$91,863 V $66,609-86,589
Scientific and Engineering Technician Pay Plan: ZT	$22,604 I $11,903-21,307	$34,702 II $18,340-32,701	$42,205 III $27,789-39,783	$55,576 IV $33,623-52,385	$66,087 V $47,920-62,293
Administrative Pay Plan: ZA	$28,512 I $11,903-26,894	$42,205 II $22,717-39,783	$55,576 III $33,623-52,385	$78,103 IV $47,920-73,619	$91,861 V $66,609-86,589
Administrative Support Pay Plan: ZS	$21,535 I $11,903-20,299	$24,922 II $14,603-23,491	$29,635 III $18,340-27,934	$34,702 IV $27,789-39,783	$42,209 V $27,789-39,783
Corresponding GS/GM Grade for ZP	1 2 3 4 5 6	7 8 9 10	11 12	13 14	15

Notes: 1. Supervisory pay ceiling for each pay band is shown in top right corner.
2. ZP, Pay Band V, pay ceiling for supervisors below Division Chief, $89,187. Division Chiefs' pay ceiling $91,861.

TABLE D-10 Average Salaries: NIST and NAWC, China Lake

NIST ZP Scale

	$19,308				$34,779				$45,450		$62,788		$81,745	
	I				II				III		IV		V	SES
GS/GM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	SES
	A				I				II		III		IV		V	
	$15,523				$32,272				$40,001		$55,488		$79,144		$103,201	

China Lake DP Scale

TABLE D-11 Salary Comparability (to Industry) Study National Institute of Standards and Technology

	Before (1987)	After (1991)
Salary Deficiency	10.9 percent	6.0 percent
Total Cash Deficiency	10.1 percent	6.4 percent
Benefits Deficiency	$306	$226
Total Compensation Deficiency	7.5 percent	4.7 percent

Naval Air Weapons Center, China Lake

The China Lake Naval facility is one of the oldest demonstration projects, having converted in 1980 (Naval Air Weapons Center, 1993a; Naval Air Weapons Center, 1993b). NAWC is less comparable to ARL than NIST since it is primarily a testing and production center and only about six percent of its budget is devoted to research and development. Furthermore, the availability of S&E personnel and industrial pay scales may not be directly comparable with ARL's. Since NIST's career path and paybanding system is adapted from NAWC's, they are very similar. China Lake does not have the 5 percent pay differential for supervisors, since they believe the two tracks (technical and management) handle the pay differences adequately. Table D-10 shows that NIST and NAWC have a comparable pay structure. Because the Navy operates NAWC on an industrially funded basis, the ratio of direct costs to indirect costs is not comparable to ARL's or NIST's.

The Naval facility at Point Mugu is now organizationally part of the NAWC. As part of the integration process the Point Mugu facility is becoming part of the demonstration project at China Lake. The China Lake conversion model is being applied to Point Mugu. A total of 1,268 S&Es at Point Mugu have been converted to the China Lake personnel management model. Conversion was being done as a cost neutral option, but no one was being paid less after conversion. Wage grade and unionized personnel were not converted.

NAWC emphasized that conversion to a demonstration model requires full command commitment and allotment of considerable staff time in designing or adapting the personnel system and training all the personnel both on the philosophical differences in the personnel system as well as the mechanics involved. NAWC furnished estimates of the conversion costs to convert 1,268 S&Es (GS-7 to GS-15):

- salary costs: $441,257 or $348 per S&E; and
- training costs: $693,000 or $546 per S&E.

Department of Energy

The general laboratory data are based on a DOE 1992 reference document (Department of Energy, 1992), using 1991 data. Only multipurpose national laboratories were examined. It is evident from Table D-12 that the operating costs per S&E FTE are much higher for the three weapons (Defense) laboratories than for the other laboratories. The operating costs per FTE for the weapons laboratories (Lawrence Livermore, Los Alamos, and Sandia) range from $351,000 to $372,000, while the other laboratories range from $218,000 to $337,000. Of the three weapons laboratories, Sandia Laboratory costs rank on the lower end since it is more engineering and production oriented compared to the other two laboratories. Lawrence Berkeley was not considered in the analysis because its extensive use of academic personnel and students decreases its operating costs abnormally. A detailed review of the items constituting the operating costs could not be made. However, it was conjectured that the higher costs for the defense laboratories are primarily due to security and safety requirements, as well as a high cost for equipment and facilities maintenance for these very expensive installations. The fraction of scientists and engineers in the weapons laboratories range from 36 percent to 40 percent as shown in Table D-12. The degree structure of the laboratories is shown in Table D-13.

The Department of Energy has relatively tight control over the management of its laboratories (Department of Energy, 1993). In her recent testimony, the DOE Secretary stated that one government field office person per 28 contract employees is employed to oversee the contracts. This does not include a significant departmental staff which also provides policy direction and oversight of the laboratories.

Sandia National Laboratories

Sandia was the specific DOE multipurpose laboratory selected by the Cost, Personnel, and Contracting panel to visit. Although only a relatively small portion of the laboratory is devoted to R&D. Basic research and exploratory technology represent about $77 million out of a total $1.3 billion for Sandia (Sandia National Laboratories, 1993; Sandia National Laboratories, 1990; and Sandia National Laboratories, 1992). Sandia corporation is a separate entity that is managed, under contract, by AT&T. Most employees belong to Sandia, as do the retirement funds. Sandia at Albuquerque is in a

TABLE D-12 DOE Laboratory Staffing and Cost Fiscal Year 1991 Dollars

Laboratory	Type	Total Employees	Operating Costs	Total S&E	Percent S&E	Operating Costs Per S&E
Lawrence Livermore National Laboratory	Defense	7,898	$1,053	3,034	38	$347,067
Los Alamos National Laboratory	Defense	7,570	$964	2,760	36	$349,275
Sandia National Laboratories	Defense	8,607	$1,135	3,448	40	$329,176
Argonne National Laboratory	Energy	4,041	$347	1,690	42	$205,325
Brookhaven National Laboratory	Energy	3,360	$262	1,204	36	$217,608
Oak Ridge National Laboratory	Energy	4,650	$477	1,551	33	$307,544
Pacific Northwest Laboratory	Restoration/Waste Management	3,774	$343	1,082	29	$317,006
Total		39,900	4,581	14,769	37	$310,176

Source: Capsule Review of DOE Research and Development Laboratories and Field Facilities. September 1992 Lawrence Berkeley omitted since it is more of a teaching facility than a GOCO laboratory.

TABLE D-13 DOE Multipurpose R&D Laboratory Employees Fiscal Year 1991

Laboratory	Ph.D.	Percent Total	M.A./M.S.	Percent Total	B.A./B.S.	Percent Total	Total Degrees	Total Employees
Lawrence Livermore National Laboratory	1,284	34	1,1225	33	1,226	33	3,734	7,898
Los Alamos National Laboratory	1,611	39	1,087	26	1,478	34	4,116	7,570
Sandia National Laboratory	1,365	31	2,088	47	975	22	4,426	8,600
Argonne National Laboratory	831	42	506	26	622	32	1,959	4,041
Brookhaven National Laboratory	656	43	345	22	538	35	1,539	3,360
Oak Ridge National Laboratory	873	40	557	25	770	35	2,200	4,643
Pacific Northwest Laboratory	486	23	615	30	981	47	2,082	3,774
Totals	7,106	35	6,421	32	6,529	33	20,056	39,886

Source: Capsule Review

Note: Includes direct and indirect personnel.

different S&E availability and comparable salary demand area than ARL, and therefore the costs are not directly comparable. AT&T has operated Sandia on a non-fee basis since 1953; therefore, when considering a truly commercial GOCO venture, additional costs for a fee, that represents a return to the parent company, must be added. Sandia is only now instituting a pay for performance system. The above data are pertinent to the operation of Sandia by AT&T; however, AT&T decided to cease managing Sandia and a new contractor has been selected.

Federally Funded Research and Development Centers

Fiscal year 1990 actual costs were obtained, which were simply escalated to fiscal year 1993 for comparison purposes (Table D-14). Detailed fiscal year 1993 information from one FFRDC indicates consistency with the previous data (Aerospace Corporation, 1993). In addition, summary fiscal year 1993 data from 13 DOD FFRDCs show the operating cost per member of the technical staff of 9 of the 13 FFRDCs to be between $170,000 to $205,000 with a median value of $186,000. Coopers & Lybrand analyses show that there is uncertainty in analyzing the financial data in greater detail because of the diversity of the accounting systems used (Coopers & Lybrand, 1991).

Analysis

The methodology used in this study assumes ARL-97 funding to be constant at $323 million for all options. The number of S&Es and total personnel affordable under this constraint were calculated. Termination and other conversion costs were also estimated. The results are summarized in Table D-15. The options analyzed were as follows:

1. *ARL Enhanced.* An improved management structure is assumed and a refocusing of the ARL business areas is considered.
2. *NIST.* The total ARL laboratory is reconstituted as a NIST-like demonstration model structure. All personnel would be retained up to the budget-constrained limit, except for S&Es not considered necessary due to reduced or redefined business areas.
3. *ARL Multicenter.* The portion of research performed by contractors outside ARL was increased from 20 percent to 70 percent of the operating budget. This caused major personnel changes to accommodate the budget and facilitate contracting out some functions.

TABLE D-14 Fiscal Year 1990 Air Force Contract Summary for Three FFRDCs ($ Millions)

	Fiscal Year 1990 $				
	"A"	"B"	"C"	Total	Fiscal Year 1993 $
Member of the Technical Staff Years*					
Program	2,378	2,525	413		
Allocable Effort	129		70		
Consultants	7		90		
Total	2,514	2,525	573	5,612	
Dollars					
Direct Labor	148	155	30	333	65
Other Direct Costs	40	63	17	120	
Allocable Effort (MOIE and other Programs)	23	11	0	34	
Total Direct Operating Expenses	211	230	47	487	
Benefits	94	76	19	188	
Other Overhead	86	74	30	190	37
Total Benefits & Overhead	180	150	48	379	74
Total Costs	391	380	95	866	170

General & Administrative	—	—	—	—	—
Fee	21	23	5	48	9
Total Price	412	403	100	163	180
Cost Per Member of the Technical Staff year (thousands)	164	160	174	163	
Overhead Rate on Direct Labor (percent)	121.5	96.8	160.9	113.6	
Fee as a Percent of Cost (percent)	5.2	6	4.8	5.6	

* Member of the Technical Staff Years = 1,808 hours
** Based on national consumer price index fiscal year 1991 = 3.4 percent, fiscal year 1992 = 3.0 percent, fiscal year 1993 = 3.5 percent

TABLE D-15 Staff and Conversion Cost Comparisons (Fiscal Year 1993 $)

	Baseline Cases		Options			
	ARL FY 1993	ARL FY 1997	ARL Enhanced	NIST	ARL Multicenter	GOCO
Operational Budget (millions)	484	323	323	323	323	323
In-House Dollars	317	257	257	257	97	0
Contracted Out Dollars	167	66	66	66	226	323
In-House Percentage	65	80	80	80	30	0
Contracted Out Percentage	35	20	20	20	70	100
Average Salary per S&E (thousands)						
In-House	52.7	52.7	52.7	61.2	52.7	NA
Contracted Out	70.0	70.0	70.0	70.0	70.0	70.0
Total Staff (S&Es and Other)	5,095	3,629	3,629	3,194	2,880	2,436
Total Staff in House	3,835	3,131	3,131	2,696	1,174	0
Total Contracted Staff	1,260	498	498	498	1,706	2,436
In-House Percentage	75	86	86	84	41	0
Contracted-Out Percentage	25	14	14	16	59	100
In-House S&Es	1,769	1,744	1,744	1,502	654	0
Contracted Out S&Es	702	277	277	277	950	1,357
Total Number of S&Es	2,471	2,021	2,021	1,779	1,604	1,357
Percentage S&Es	48	56	56	56	56	56

Business Areas	10	10	5	5	5	5
Impact of Fewer Business Areas (fewer S&Es)	0	0	436	436	0	0
People Displaced (including S&Es)	0	0	436	629	1,957	3,131
S&Es Hired with Replacement Skills	0	0	436	194	0	0
People Retiring/Transferring/Attriting (24 percent)	0	0	104	149	465	744
People to be RIFed	0	0	332	480	1,492	2,387
Conversion Costs (millions):						
Severance Pay (21,000 each)	NA	NA	7.0	10.1	31.3	50.1
"Other" Costs (11,500 each)	NA	NA	3.8	5.5	17.2	27.5
System Design Cost ($348/S&E)	NA	NA	NA	0.5	NA	NA
Training Cost ($546/S&E)	NA	NA	NA	0.8	NA	NA
Cost to Obtain Contractor(s)	NA	NA	NA	NA	7.5–21.5*	7.5
Total Conversion Cost (millions)	NA	NA	10.8	16.9	56.0–70.0	85.1

* The cost will depend on the number of independent centers of excellence which are contracted out.

4. *GOCO ARL.* All government personnel would be terminated and a contractor would be selected to operate ARL in government-owned facilities.

To accommodate the available data, a comparison metric was developed, namely the ratio of recurring total operating cost (adjusted to remove contracted-out research) per S&E FTE to average basic S&E salary. The significance of this metric is based on the assumption that if a higher paid S&Es were placed in an existing laboratory facility to perform the established mission, this ratio would likely hold, at least initially. This ratio was calculated to be 3.53 for ARL and 3.33 for NIST. Consequently, a 3.4 ratio was selected which assumes a contractor would operate in an ARL/NIST-like environment. Sandia showed a ratio of 4.5, which appeared to reflect the significant difference between the support required for a Sandia type of operation, including security, safety, and investment considerations, compared to that for an ARL-type operation. This also includes the fact that the technician to S&E ratio is higher at Sandia. It may be possible that a contractor could achieve efficiencies that could drive the 3.4 factor down in time.

The in-house/contracted ratio for the fiscal year 1997 ARL is assumed to be 80/20 as opposed to the 70/30 currently planned in the ARL. The committee has decided to use this higher ratio based on calculations using dollars available and planned numbers of in-house personnel. If the fiscal year 1997 ARL used 30 percent of its operating budget of $323 million, it would only have about $226 million for in-house personnel. Using the average salary of $52,700 per in-house scientist or engineer, multiplied by a factor of 1.558 to take into account the support staff and overhead, the fiscal year 1997 ARL would only have about 2,752 total in-house staff. This is about 400 people short of the original personnel predictions of the ARL (when this table was developed) and about 100 people short of the latest proposed figures for fiscal year 1997 found in Table 2-1. Assuming that the ARL and the Army did not want to displace any more people than they had to, the committee assumed a ratio of 80/20 which would give the fiscal year 1997 ARL 3,131 in-house total staff—which is closer to its original number.

In this analysis of options it was assumed that the estimate of total operating costs for fiscal year 1997, $323 million in fiscal year 1993 dollars, remains constant for all options. The ratio of in-house and contracted R&D varied as well as the S&E salaries. The number of S&E personnel and total personnel that can be used for each option within total cost constraints was varied. The results are shown in Table D-15. If the 3.4 ratio could be lowered in restructuring by the introduction of efficiency improvements or greater output by the higher priced personnel then the total cost could be reduced or the number of S&Es available could be increased. However, there is no hard evidence that the reduced number of personnel would or would not be able

to complete the same mission or represent a better value to the Army. In all cases, the cost for contract research, and the number of staff affordable for that research, are estimated using the same (GOCO option) rates.

It was further assumed that any option would need to refocus its business areas (i.e., fewer business areas) to support unique Army needs, and would have to pursue them more intensively. For costing purposes it was assumed that half the personnel would be affected by pursuing only half the current ten business areas. Since other areas are being pursued or enhanced, the support personnel affected would be able to be reassigned to the remaining or new mission areas. Half the scientific and engineering personnel affected could be reassigned also. Consequently only a quarter of the scientific and engineering personnel would be RIFed/retired. In this option 436 scientists and engineers would be removed and an equal number, with different skills would be rehired to keep the total constant, as shown in Table D-15 also. Refocusing could also require capital investment for equipment and facilities to meet the refocused research needs of the S&Es.

Conversion Costs

As mentioned earlier, the most significant and available conversion costs are those costs associated with (1) the actual severance pay and other costs associated with converting government personnel to contractors (for all options); (2) the new personnel system design costs and the cost of training personnel to operate in the new system (only for the NIST option); and (3) the cost of the contracting process to obtain a GOCO management contractor. Each of these is described below along with notes about other costs which the committee did not calculate.

Severance Pay. This applies in any case where government personnel cease to work for the government, whether they accept employment with the new contractor or not. In this analysis, severance pay applies to any termination of government employees involved in staff reductions. Based on the ARL fiscal year 1997 data on severance pay, 24 percent of the terminating employees are assumed to either retire or stay in the government, with 76 percent subject to RIF and severance pay. A $21,000 average severance pay, based on the ARL-furnished detailed severance pay analysis, was used for every RIFed person in every option. In the case of GOCO options, the ARL analysis showed that severance pay would amount to about $50 million (fiscal year 1993 dollars), as mentioned earlier.

Other RIF-Related Costs, based on Army-wide analysis shown in the Department of the Army Information Paper on "Estimating Costs of Reduction in Force (RIF)," and discussed previously, exclusive of severance pay, amount to $11,500 per involuntary separation.

System Design and Training Costs. This cost is only directly applicable to the NIST situation where ARL would adapt a demonstration personnel system and train the staff in its use. Using the NAWC data, and applying them to the 1,744 S&Es at ARL amounts to $607,000 in salary costs, and $952,000 in training costs. This assumes that an existing demonstration model is used for conversion. If a new model were developed, the cost could be significantly different. No severance cost would be incurred in a NIST-type conversion.

Contracting Process. On the basis of the committee's experience and expertise, it is assumed that contracting would cost $5 million to $10 million in government or support contractor time, and the committee used the average of $7.5 million for the two options for GOCO option. The cost for the Multicenter option will depend on the number of independent contracts established. A range of $7.5 million to $21.5 million reflects that the cost varies with the number of contracts.

Other Conversion Costs. As mentioned above, the pay differential, facility upgrade, legislative and regulatory change, and disruption costs were not estimated. The government management and oversight costs could be substantial if the DOE model is used. It would amount to an oversight staff of 1332/28 or 48 individuals, not counting their headquarters personnel. This cost was not included in the above analysis.

The analysis for each option involved the calculation of the personnel affected by the changes in-house and contracted-out research, using the number of S&Es at ARL in fiscal year 1997 as the starting point. The calculations for each option are explained below and summarized in Table D-15, which is exactly like Table 7-1 in Chapter 7, but also includes percentages for the in-house versus contracted-out mixture and the percentage of S&Es of the total staff to show how the personnel mix changes with each option.

The *ARL Enhanced option* maintains the fiscal year 1997 ARL number of in-house S&Es (1,744) and total government staff (3,131) and maintains the in-house/contracted ratio (80/20) as in the fiscal year 1997 baseline. This option differs from the baseline only by reducing and/or focusing the business areas and the resultant change in S&E personnel. Its only conversion costs

would involve the termination of 25 percent of the ARL's S&Es (436 of 1,744), who must be replaced by S&Es with different skills. Of the 436 who are displaced by the lowering of the number of business areas, 23.76 percent (104) would either be eligible for retirement or find other government employment, leaving 332 to be RIFed and would receive termination pay (i.e., severance pay and other allowances) resulting in a conversion cost of $10.8 million for this option. The 23.76 percent is consistent with the severance pay calculations made for us by ARL. Providing the director discretionary funding, already in the budget, or reassigning ARL to Department of Army headquarters is not expected to add any additional costs, but may result in a shift of responsibilities and personnel, and may have a positive impact on productivity.

Under the *NIST option*, salaries were permitted to rise under a pay for performance philosophy, approaching those of industry (Hay Group, 1992). For the purpose of this analysis an instant rise in salaries was assumed. The higher average S&E salary ($61,200 per year compared to $52,700 for ARL) causes the total number of S&Es affordable under the budget (1,502) and the total number of staff personnel (3,194) to be less than that for the baseline. The cost of contracting out remains constant. Reducing the number of the business areas causes 436 (25 percent) of ARL's S&Es, and 193 other staff personnel to be terminated, for a total of 629 displaced personnel. Only 194 government S&Es, with new skills, could be hired in order to stay within the affordable total of 1,502 S&Es. This reduction in business areas and refocusing will cause the actual RIF of 480 people at a cost of $15.6 million in severance and other allowances. Another $1.3 million will be required to design or adapt a NIST-like personnel system to ARL and to train the government employees in the use of that system, making the total conversion cost of this option to be $16.9 million. Of no cost consequence, but it is of interest to note that NIST was the only government laboratory visited that had a revolving investment account. Laboratory directors can draw on the fund to procure equipment and replenish the fund by amortization over a number of years.

The *ARL Multicenter option* differs from the baseline by changing the in-house/contracted ratio from 80/20 in the baseline to 30/70 in this option. Using the same rationale as was used for the other options, this causes a reduction to 654 government S&Es and 1,174 total government employees. The total government (654) and contracted (950) S&Es in the final structure was estimated to be 1,604, compared to a total of 2,021 in the baseline case, or a 21 percent reduction in S&E staff. Because 950 S&Es are being contracted for, it is expected that the contractor will have enough margin to select new employees with the newly required skills. The one-time conversion cost is $48.5 million due to the 1,492 (76.24 percent of the 1,957 people lower than the baseline number of 3,131) personnel being terminated. The range of

$7.5 million to $21.5 million is estimated to be required for the contracting process (depending on the number of contracts), each time the contracts are recompeted.

Analysis of the costs of the *GOCO ARL option* is based on a number of diverse data sources. Considerable data was obtained from DOE (Office of Personnel Management, 1989; Army Materiel Command, 1993) and further information was collected from the Sandia National Laboratories, as well as from Brookhaven National Laboratory (1993). Additionally, summary information was obtained from FFRDC sources. The Sandia personnel stated that their average S&E salary is $70,000, and that this is comparable to industrial salaries. Since ARL-97 is distributed in three geographical areas, no regional adjustment was made to this data. It was further assumed that the GOCO firm would operate in a method more analogous to ARL than to Sandia, where high security and safety concerns, as well as high equipment maintenance costs cause the overhead costs to be very high (this was true in all DOE multipurpose defense laboratories). Reducing the number of business areas can be accommodated in the conversion process, requiring that the contractor rebalance the S&E mix. Since all government employees who are not eligible for retirement or reassignment are eligible for termination pay (76.24 percent of the 3,131 people or 2,387 employees), the one-time severance pay and other allowances amounts to $77.6 million, in addition to contracting process costs of $7.5 million (average of the estimated $5 million to $10 million it would cost) each time the contract is recompeted.

Cost Findings

The most significant findings, as highlighted and discussed in more detail in the previous sections, were the following:

- All conversions to different management structures involve some one-time conversion costs. Those options shifting more of the research effort to contracted sources require larger one-time conversion costs.
- The recurring annual operating budget for all options were assumed to be the same as the current budget; therefore, the one-time conversion costs are not recoverable over time except through potential improvements in operating efficiency or research productivity.
- Table D-15 is summary of the estimated staffing levels and conversion costs for the four options which were discussed in the previous subsection. As shown in the table, when the total annual operating budget is held constant for all options, the conversion costs will be greater the farther the option is from having all government personnel at ARL. For all except the

ARL Enhanced option, the number of S&E personnel and the number of overall staff will decrease.

- The benefit or value side of the equation is extremely difficult to assess. ARL has established its vision as becoming a world-class laboratory. There is general agreement that a pay structure, for instance, that would facilitate ARL's attracting and retaining world-class scientists and engineers would bring the labs closer to this vision. It is less clear what the additional costs implied by a richer and more flexible pay plan would yield, quantitatively, in research output. It is also likely that additional capital investment will be required to maintain world-class scientists. These costs cannot be estimated without a clearer definition of the laboratory's mission in the new environment.
- The government management and oversight function over a contract operation could result in significant recurring costs, which were not calculated in this study. For example, the Secretary of DOE, in her Congressional testimony, stated that DOE oversight experience indicates a requirement of 1 field officer for each 28 contract personnel, not including the DOE headquarters personnel that perform oversight and policy functions. DOE considers the national laboratory employees to be quasi-government employees and keeps tight control over them. On the other hand a number of FFRDCs are monitored with much fewer personnel. The number of personnel performing this function depends directly on the details of the negotiated contract(s). The Army should manage this oversight function so that it does not result in such a large number of overseers and so that it does not become a major additional cost.

Limitations of the Analysis

A number of limitations apply to the results shown in this analysis. Among the most significant limitations (or caveats) are the following:

- Since there is no evidence of a Defense R&D organization having been converted from government operation to contract operation, the results of the analysis include significant uncertainties.
- There is no evidence that the alternative management structures for ARL would be able to complete ARL's mission, or whether or not such structures represent a greater value to the Army.
- It is possible that a new, aggressive management team, either governmental or contractor, could operate more efficiently (e.g., reduce the indirect to direct personnel multiplier) and thereby either operate at less cost or with more S&Es than the numbers shown.

- Any change in governance (e.g., ARL reporting to the Assistant Secretary of the Army, rather than to AMC), is not assumed to significantly affect cost but could affect value.
- It was not possible within the time available to compare above base pay benefits because of large definitional and accounting differences; however, the committee believes the cost comparisons presented form a reasonable basis on which to draw conclusions about the magnitude of costs required to achieve each option.
- The time it takes to prepare for and perform transition and the time lost during disruption could not be estimated.
- Costs may be impacted by local area situations. ARL-97 will operate in three dispersed geographical areas, but no attempt was made to refine the data collected to take this geographical factor into account.
- The one-time conversion costs do not include the cost of buying out retirements, which the Navy and the Air Force estimated to be about $43,000 to $50,000 per person, although the referenced Army study did not consider this relevant.
- The cost of additional government personnel to provide policy, manage and oversee the contract, which could result in a significant amount if based on DOE experience and Congressional requirements, is not included in the estimates. As mentioned earlier, the Army should strive to avoid the burden of large numbers of oversight personnel no matter which of the options is selected.

PERSONNEL

Key personnel issues that require an objective analysis under each of the four options (ARL Enhanced, NIST, ARL Multicenter, and GOCO ARL) include: (1) ability to hire; (2) ability to pay for performance; and (3) ability to fire. Each of these issues was examined for each option and the results are provided in the following paragraphs. Many personnel actions are now permitted under the Federal Employee Pay Comparability Act of 1990 as well as the Civil Service Reform Act of 1978, but are not implemented (Army Laboratory Command, 1991).

ARL Enhanced and Multicenter Options

Under the federal personnel system, hiring of new employees is closely regulated by OPM, which establishes the criteria that will be used to examine the qualifications of candidates. OPM also establishes the rates of pay that may be offered candidates through the classification system and its link to the

federal pay system. These controls tend to have a force-fit impact on candidates. Qualifications are specified and given specified weights in the candidate evaluation process. Variations from the established salary norms are difficult to defend and may also require agency or OPM approval. Matching a salary to the specific qualifications of any applicant who is exceptionally well qualified is restricted first by the grade of the position, and second by authority for advances in hire rates that may or may not be approved by outside authorities.

Under these options, ability to hire is closely allied to the position classification process. It is proposed that line managers classify positions and this is now permissible. Classification authority is delegated by OPM to agency heads who may delegate down through the management structure to any level deemed appropriate. There is a requirement that whoever does the classification will comply with the OPM Position classification standards, a process that requires considerable experience and time on the part of the person doing the classification. Under this option that problem would be eased by establishing an automated position classification system to support the manager. This can also be done now, and has been used successfully. It does require a considerable expenditure of time to do the initial job analysis for local positions and then create the automated program to run the system. There are generic programs available for common and mostly lower graded jobs, but it is possible to develop a database that could cover S&E jobs. This process is generally much quicker than the current ARL process and does produce an exceptional degree of accuracy and consistency. Another personnel action under this option involves using term appointments to attract distinguished senior scientists and engineers from industry or universities and would permit these temporary personnel to be removed after the term of the appointment has expired.

The ability to pay for performance under these options would not be enhanced. Current performance ratings and incentive award systems would still be used. In addition, the ability to fire employees under these options would not be improved since there are no changes proposed in basic regulations and requirements.

In summary, the ARL options would not require waivers or exceptions to any law and could be done within AMC's current authority. These actions have been linked to providing ARL with its own personnel staff. That would not be an imperative for making these changes. The pros and cons and the added cost of this change should be carefully evaluated. Another alternative under this option is for the ARL Director to participate in rating the Personnel Officer who provides him service—this would require only an agreement between the ARL Director and the host installation Commander.

NIST Option

Under this option ARL's ability to hire could be considerably enhanced by having the authority to establish their own candidate qualification examinations and hiring from the resultant list of applicants. Pay rates that can be offered for new hires cover a broad range and can be established based on comparisons to private sector rates. Technical managers perform the job classification function using simplified classification standards that are tailored to local jobs. This process can also be automated.

The ability to pay for performance is greatly enhanced by the incentive pay system which directly links performance appraisal to adjustments in base salary. No automatic increases are given on the basis of time-in-job alone. The demonstration project system also provides for bonuses and rewards, all aimed at retention of high performers. The performance appraisal and incentive pay systems are run by the technical managers.

The ability to fire an employee is also enhanced by a demonstration project system and is tied directly to the appraisal process. Any rating below *fully successful* automatically triggers a process that results in either improved performance or removal from the workforce. The demonstration project option, in total, can provide a private-industry-oriented personnel system that is responsive to management needs. While it does not offer the broad freedoms enjoyed by private industry, it is a positive step in the right direction. The Army has ventured into the demonstration-project-type system for its non-appropriated fund workforce, but has not adopted it for any appropriated fund activity. ARL may present an opportunity to do that.

GOCO ARL Option

Under this option ARL could have a powerful base of capability to hire very high-caliber talent from the workforce market. This could include full-time, part-time, and short-term employment that is limited only by overall fund restrictions in the contracts. This also permits reaching out to scientists and engineers who are attuned to the state of the art in virtually any field of R&d that is required. Salaries and fringe benefits that equate to those provided by industrial world-class laboratories or research facilities would be possible. The requirements for the contractor to offer conversion rights to all current ARL employees would create an initial restriction on hiring.

The ability to pay for performance is inherent in a GOCO operation. Many private industrial companies have highly sophisticated appraisal systems where performance evaluation is linked directly to pay and retention of the employee as part of the workforce. This also permits both monetary and honorary recognition of high performers.

In a GOCO operation it would be easier to fire an unsatisfactory employee than in any of the other options being considered. This would be particularly true of the S&E portion of the workforce where tenure need not be a consideration, but performance would drive the decision. However, in GOCO operations the impact of unions and fair labor practices acts may constrain the firing process with legal obstacles.

Personnel Findings

The most significant findings, as covered above, were the following:

- Within existing laws and regulations, much can be improved in the personnel management area.
- Of the four options being considered, the GOCO ARL option offers the greatest opportunity for achieving excellence in the personnel arena, at a greater cost.
- The demonstration project option offers relative economy plus substantial enhancements in the personnel management area.
- All of the options being considered involve labor/management relations issues that would have to be addressed at conversion time.

CONTRACTING

For the purposes of this study, contracting considerations fall into two broad and very different categories. The first of these applies only to the option of converting ARL to a GOCO for which there are contracting issues regarding the establishment of a new GOCO. These include, for example, the appropriate approvals, generation of the necessary procurement documentation, contractor selection, and oversight provisions. Detailed examination of the process for the formation of a new GOCO is beyond the scope of this study.

The second category pertains to the provisions and restrictions that apply to the various organizational types under consideration in this study in their procurement and contracting-out activities. Of particular importance are those regulations which procedurally tend to adversely impact research activities.

In general, it can be said that the farther one moves in contracting and procurement practices away from government standards and toward those of private industry, the faster and more efficient are the processes. Sluggish procurement practices have the effect of slowing down research progress and hurting staff morale. Scientists and engineers become frustrated and feel under-supported by their administrators and management. Their work is

delayed sometimes months for want of a seemingly simple item hung-up in the bureaucratic paper mill of procurement. In some cases the wrong item is delivered as a result of adherence to regulations governing bidder selection.

In all fairness, the government, in recognition of these problems, has instituted several innovative practices for low value items utilizing credit cards distributed to certain centers. These practices represent a significant improvement and, in the enhanced ARL options and demonstration project option, should be exploited fully. Further, local or service imposed constraints should be selectively eliminated. Likewise, for these options, methods for streamlining contracting-out practices should be sought and used. More extensive use of Competition in Contracting Act exceptions should be promoted.

Every indication suggests that in the GOCO ARL option, commercial practices in conformance with the Federal Acquisition Regulation and other applicable regulations, have the potential of providing high-quality support service to the S&Es. At Sandia, for example, the process of contracting out support services is streamlined by the use of pre-approved qualified vendors. The examples of speed in the procurement process cited by Sandia were mostly in the architectural and engineering area for building construction where requests for quotations are used to award contracts to the lowest bid received from the population of pre-qualified bidders. Specific contracting implications of each ARL conversion option are provided in the paragraphs below.

ARL Enhanced and Multicenter Options

Under either of these ARL options, there are to be no changes in the Federal Acquisition Regulation requirements and the only efficiency improvement possible is to follow procurement practices that have proven successful at other places. For example, the Sandia contracting process makes use of pre-qualified bidders for certain procurement—this could be done by ARL. There are ways to speed up the current Federal Acquisition Regulation processes, but most of these ways require command emphasis and a desire to get things done rapidly. The move to define small purchases as being under $100,000 should improve the speed with which procurement is completed at all federal agencies, and it would help ARL.

NIST Option

This option would still be under the Federal Acquisition Regulation and be subject to the same processes as described for the ARL enhanced options

above. There are several things being done at NIST that would improve ARL if they were used more extensively (e.g., use of a credit card for small purchases).

GOCO ARL Option

Theoretically, this option should provide the most flexible contracting procedures and the fastest completion time on all contracting actions. This would certainly be true if the contractor running the operational site(s) was independent of as many government regulations as possible. As the committee saw at Sandia and other DOE laboratories, this may not always be the case; however, when true relaxation of the procurement process rules is permitted, the committee believes that the process will move more smoothly and the end result will be more rapid completion of all contracting actions.

REFERENCES

Aerospace Corporation. 1993. Informal communication to the Cost, Personnel, and Contracting panel, Committee on Alternative Futures for the Army Research Laboratory.

Army Laboratory Command. 1990. GOCO's vs. Army Labs. Internal Report. March 23.

Army Laboratory Command. 1991. CMRL baseline study. Briefing of the Laboratory Command. April 29.

Army Materiel Command. 1993. Informal communication to the Cost, Personnel, and Contracting panel, Committee on Alternative Futures for the Army Research Laboratory.

Army Research Laboratory. 1993. Informal communication to the Cost, Personnel, Contracting panel, Committee on Alternative Futures for the Army Research Laboratory.

Brookhaven National Laboratory. 1993. Informal communication to the Cost, Personnel, and Contracting panel, Committee on the Alternative Futures for the Army Research Laboratory.

Cassady, A.1991. 1991 NIST Personnel Management Demonstration Project: Design, Implementation and Accomplishments. NISTIR 4640. July.

Coopers & Lybrand. 1991. Indirect costs survey of comparable government contractors. Letter to Aerospace Corporation. June 13.

Defense Base Closure and Realignment Commission. 1991. Report to the President. Washington, D.C. July 1.

Department of the Army. 1992a. Estimating Costs of Reduction in Force (RIF). DAPE-CPE. June 29. Information Paper.

Department of the Army. 1992b. Army Science and Technology Master Plan. November.

Department of Defense. 1991. Background material on GOCOs. Laboratory Demonstration Program Panel. June.

Department of Defense. 1993. DOD Program for stability of civilian employment, DOD displaced employees information and entitlements pamphlet. Pamphlet 1400.20-1-P. Revised April.

Department of Energy. 1992. Capsule review of DOE research and development laboratories and field facilities. Office of the Technical Advisor. September.

Department of Energy. 1993. Appendix A (Personnel Appendix) to a typical National Laboratories contract.

Hay Group. 1992. Comparison of benefits: management and operating contractors compared to national survey. March.

Heeb, M. 1991. GOCO or status quo for defense R&D labs. Department of Defense. Briefing for the Advisory Commission on the Consolidation and Conversion of Defense Research and Development Laboratories.July 17–18, 1991.

Kramer, S. 1993. An overview. Briefing by S. Kramer, Associate Director, National Institute of Standards and Technology.

National Institute of Standards and Technology. 1992. NIST evaluation of a Hay management consultants report on Total Compensation Comparability. January 10; Informal communication to the Cost, Personnel, and Contracting panel, Committee on Alternative Futures for the Army Research Laboratory.

National Institute of Standards and Technology. 1993. NIST: Research. Services. Facilities.

National Research Council. 1993. Improving the Recruitment, Retention, and Utilization of Federal Scientists and Engineers. National Research Council. National Academy Press: Washington, D.C.

Naval Air Warfare Center. 1993a. Navy demonstration project under the Civil Service Reform Act (CSRA). Series of briefings, China Lake, California, July 7, 1993.

Naval Air Warfare Center. 1993b. Informal communication to the Cost, Personnel, and Contracting panel, Committee on Alternative Futures for the Army Research Laboratory. China Lake, California.

Office of Personnel Management. 1989. Notice of proposed changes to Title 5 of the Code of Federal Regulations, Attachments 1 and 2 to FPM Bulletin 550-68.

Sandia National Laboratories. 1990. Strategic plan 1990.

Sandia National Laboratories. 1992. Sandia National Laboratories: Strategic human resource plan, Fiscal Year 1993–Fiscal Year 1991. October.

Sandia National Laboratories. 1993. Introduction to Sandia Laboratories. Series of briefings to the Cost, Personnel, and Contracting panel, Committee on Alternative Futures for the Army Research Laboratory. Albuquerque, New Mexico, July 8, 1993.

BIBLIOGRAPHY

Aerospace Corporation. 1993. Informal communication to the Committee on Alternative Futures for the Army Research Laboratory. July.

Army Material Command. 1993. Informal communication to the Committee on Alternative Futures for the Army Research Laboratory. July 18. Letter.

Army Research Laboratory. 1992. Annual report.

Army Research Laboratory. 1993a. Army Research Laboratory Business Plan: Fiscal Years 1994–2004.

Army Research Laboratory. 1993b. Informal communication to the Committee on Alternative Futures for the Army Research Laboratory.

Atwood, D.J. 1989. Laboratory demonstration program: Actions for improvement of the quality, productivity, and efficiency of DOD laboratories. November 20. Memorandum.

Brookhaven National Laboratory. 1993. Informal communication to the Committee on Alternative Futures for the Army Research Laboratory. June 15. Facsimile.

Congressional Budget Office. 1982. Contracting Out for Federal Support Services: Potential Savings and Budgetary Impacts. October.

Coopers & Lybrand. 1991. Indirect Cost Survey of Comparable Government Contractors. Letters to Aerospace Corporation, June 13.

Defense Base Closure and Realignment Commission. 1991. Report to the President. Washington, D.C. July 1.

Department of the Army. 1992a. Estimating Costs of Reduction in Force (RIF). DAPE-CPE. June 29. Information Paper.

Department of the Army. 1992b. Army Science and Technology Master Plan. November.

Department of Defense. 1991. GOCO or status quo for defense R&D labs. Briefing by Michael Heeb for the Advisory Commission on the Consolidation and Conversion of Defense Research and Development Laboratories. July 17–18, 1991.

Department of Defense. 1992. Interservice Interdepartmental, and Interagency Support. DOD Instructions 4000.19. April 15.

Department of Defense. 1992. Annual report. Tri-Service Science and Technology Reliance, Joint Directors of Laboratories. December.

Department of Defense. 1993. DOD program for stability of civilian employment, DOD displaced employees information and entitlements pamphlet. Revised April 1993 (FM&P). DOD Manual 1400.21-1-P.

Department of Energy. 1982. The Department of Energy Multiprogram Laboratories, A Report of the Energy Research Advisory Board to the United States Department of Energy. September.

Department of Energy. 1992. Capsule Review of DOE Research and Development Laboratories and Field Facilities. Office of the Technical Advisor. September.

Department of Energy. 1992. The National Laboratories of the U.S. Department of Energy.

Department of Energy. 1993. National Compensation Survey of Research and Development Scientists and Engineers. Wyatt Comparison Report for DOE. April 15.

Department of Energy. 1993. Appendix A (Personnel Appendix) to a typical National Laboratories contract.

Department of Energy. 1993. Informal communication from the Director, Employee Compensation and Benefits Division to the Cost, Personnel, and Contracting panel, Committee on Alternative Futures for the Army Research Laboratory. July 9.

General Accounting Office. 1988. Federal Productivity: DOD's Experience in Contracting Out Commercially Available Activities. GAO Report GAO/GGD-89-6. November.

Hay Group. 1992. Comparison of Benefits: Management and Operating Contractors Compared to National Survey. March.

Heeb, M. 1993. GOCO or status quo for defense R&D laboratories. Briefing to the Committee on Alternative Futures for the Army Research Laboratory, Washington, D.C. August 2, 1993.

Naval Air Warfare Center (NAWC). 1993. Navy Demonstration Project under the Civil Service Reform Act (CSRA). Series of briefings to the Cost, Personnel, and Contracting panel, Committee on Alternative Futures for the Army Research Laboratory. China Lake, California. July 7.

Naval Air Warfare Center. 1993. Informal communication to the Cost, Personnel, and Contracting panel, Committee on the Alternative Futures for the Army Research Laboratory. July 29. Facsimile.

National Institute of Standards and Technology. 1991. NIST Personnel Management Demonstration Project: Design, Implementation and Accomplishments. NISTIR 4640. July.

National Institute of Standards and Technology. 1992. NIST Evaluation of a Hay Management Consultants Report on Total Compensation Comparability. January 10.

National Institute of Standards and Technology. 1993. An overview. Briefing by Dr. Samuel Kramer, Associate Director, NIST, Gaithersburg, Maryland. May 13.

National Institute of Standards and Technology. 1993. NIST: Research. Services. Facilities.

National Institute of Standards and Technology. 1993. Informal communication to Cost, Personnel, and Contracting panel, Committee on Alternative Futures for the Army Research Laboratory. July 6. Facsimile.

National Research Council. 1993. Improving the Recruitment, Retention, and Utilization of Federal Scientists and Engineers, A Report to the Carnegie Commission on Science, Technology and Government. National Research Council. Washington, D.C.: National Academy Press.

Naval Research Laboratory. 1984. Final Report of the Working Group on Federal Laboratory Personnel Issues. July 1.

Naval Research Laboratory. 1993. 1992-1993 Fact Book. NRL Publication NRL/PU/5240-93-238. June.

Naval Research Laboratory. 1993. Informal communication to the Cost, Personnel, and Contracting panel, Committee on Alternative Futures for the Army Research Laboratory. July. Letter.

Sandia National Laboratories. 1990. Strategic plan.

Sandia National Laboratories. 1992. Sandia National Laboratories: Strategic human resource plan, fiscal year 1993-fiscal year 1991. October.

Sandia National Laboratories. 1993 Introduction to Sandia Laboratories. Set of briefings for the Cost, Personnel, and Cost panel, Committee on Alternative Futures for the Army Research Laboratory. Albuquerque, New Mexico. July 8, 1993.

Sandia National Laboratories. 1993. Sandia National Laboratories 1993.

U.S. Army Laboratory Command. 1991. CMRL Baseline Study. LABCOM Briefing. April 29.

Appendix E:

GOCO History in DOE

(by W. Kenneth Davis[1])

The Atomic Energy Commission was established in 1947 as the successor to the wartime Manhattan Project after a great debate in the U.S. Congress which concluded that the task of doing research, development, testing, and production of nuclear weapons should be undertaken by a civilian agency and, most specifically, not by the Department of Defense.

The initial function of the Atomic Energy Commission was to continue the nuclear weapons research, development, testing, and production which had been established during the war by the Manhattan District of the Corps of Engineers. The research, development, and testing had been largely done through contracts with academic institutions (i.e., University of California—the Radiation Laboratory at Berkeley and the new Los Alamos Scientific Laboratory, the University of Chicago which had established a laboratory at Argonne—not the present site, the University of Iowa through the Ames Laboratory, etc.). The Hanford facilities along with the associated research and development was run by General Electric and the Oak Ridge research and development operations (the Clinton Engineer Works of the Manhattan District), including the Clinton Laboratories, by Monsanto with considerable assistance from the University of California Radiation Laboratory.

After the war, the Atomic Energy Commission, as one of its first official actions, formed the Brookhaven National Laboratory in response to a request from Columbia, the Massachusetts Institute of Technology, Harvard, and several other universities for a major atomic energy laboratory in the Northeast (originally negotiated with the Manhattan District). Further production facilities were established at Savannah River, Portsmouth, Paducuh, and so on, in the early 1950s.

The laboratories were basically products of the work for the Manhattan District where the government built the large new facilities needed but the workers were employees of the contractors, not the government (or the

[1] Committee member W. Kenneth Davis' experience with the Department of Energy includes a two-year service as the U.S. Deputy Secretary from 1981 to 1983. In addition, he was the Deputy Director, in 1954, and then Director of Reactor Development of the U.S. Atomic Energy Commission from 1955 to 1958. For a complete biographical listing, see Appendix G.

Manhattan District of the Corps of Engineers). Even in time of war it would probably have been nearly impossible to recruit the type of managers, scientists and engineers needed if they had been forced to become government employees—and it would have been more complicated and slowed things down.

It might be noted that the Brookhaven National Laboratory was in operation in just one year from the time of the initial meeting among the universities to consider such an idea. (As he points out in his paper, Norman Ramsey invented the title *national* because he thought it sounded better in attracting scientists and engineers to the infant Brookhaven Laboratory. The general use of the term did not come until much later.)

While a most interesting and exhaustive account could, and probably should, be written about the origins and history of the *national laboratories*, the important point is that they *evolved in a way dictated by the circumstances*, proved their worth and provided the Atomic Energy Commission, Energy Research and Development Administration, and the Department of Energy with a very useful and satisfactory way of contracting for research and development (as well as other services) which has been followed until this day.

It is important to recognize that the Atomic Energy Commission, as a civilian agency, became increasingly interested in the non-weapons applications of nuclear energy and with support from various Administrations and the Congress (especially the Joint Committee on Atomic Energy) and rapidly expanded programs for other applications and, of course, changed very completely the character of most the original laboratories with Lawrence Livermore National Laboratory (with the Lawrence Berkeley Laboratory split off as the other part of the old University of California Radiation Laboratory), Los Alamos National Laboratory, and the Sandia National Laboratories still primarily and almost wholly devoted to nuclear weapons and related work.

A related development was the establishment of the Reactor Development Division of the Atomic Energy Commission which was primarily to act as a vehicle for the Naval Reactors Branch under Captain H.G. Rickover to develop reactors to power submarines. While much of the early work had been done at Argonne, Rickover transferred most of it to two other laboratories, the Knolls Atomic Power Laboratory at Schenectady, New York managed by General Electric, and the Bettis Laboratory at Pittsburgh operated by Westinghouse. These became (and still are) *captive* laboratories for the Naval Reactors program.

The Reactor Development Division soon had an Aircraft Reactors Branch, an Army Reactors Branch, a Maritime Reactors Branch, and then a small branch for Civilian Power Reactors. It also had an Engineering Development Branch inherited from its predecessor, the Engineering Division of the Atomic Energy Commission. In addition, both the Research and Medical Divisions of the Atomic Energy Commission greatly expanded their

non-military research support activities both at universities and at the national laboratories, as well as some industrial research laboratories.

The Division of Military Applications continued, of course, to carry out an expanded program of weapons research, development and testing at the Radiation Laboratory (Berkeley and Livermore), the Los Alamos Scientific Laboratory, all managed by the University of California, and soon set up the Sandia Laboratories for weaponization which was managed by Western Electric. While primarily focused on weapons work these laboratories increasingly undertook other research and development such as fusion, accelerator development, etc.

It must be kept in mind that the customers for the non-weapons work of the Department of Energy National Laboratories are the public (generally and through private sector initiatives to serve the public) and that, to a large extent, the objectives and approaches have been and are different than that for the Department of Energy nuclear weapons work or the Army Research Laboratory work for the Army.

ARL today appears to be primarily operating in the mode of providing research and development services to the Army in response to rather specific requirements (user pull). In contrast, even in the case of the Weapons Program in the Department of Energy laboratories, the emphasis has been on developing new technologies and then deciding how they might best be used (technology push)—with considerable expressions of what would be useful from the Department of Defense if it were developed.

Sandia (now National) Laboratories was originally established at Albuquerque as a Los Alamos activity and then run as a separate laboratory by Western Electric (with support from Bell Telephone Laboratories) to provide the transition from weapons research, development and testing to practical weapons systems useful to the Department of Defense when the University of California declined to continue its operation of its contract in 1948. However, the client relationship in the research and development areas of ARL is substantially different than that between ARL and the various Army organizations functioning as the principal ARL Army client agencies. (Although, it is not substantially different than that which the Department of Defense has with its federally funded research and development centers.)

Today the national laboratories are doing much for the Army and the nation in areas outside of nuclear weapons. The Lawrence Livermore National Laboratory recently applied its expertise to assist with problems in the aftermath of Operation Desert Storm. Three examples are:

- The development of an oil/gas separation to be used during the oil-well-fire debacle in Kuwait. It offers significant improvements over traditional methods for quenching oil-well fires and may prove particularly

useful for containing underwater oil leaks. However, the fires were put out by conventional means before the system could be shipped to Kuwait.

- Airborne detection of buried minefields. Using a combination of dual-band infrared imaging and automatic target recognition, the Livermore system can find live anti-tank mines covered by up to 15 cm of soil from a height of 60 m.
- The Laboratory's Atmospheric Release Advisory Capability provided real-time evaluations of the potentially hazardous airborne effects of Operation Desert Storm.

The nonnuclear weapons laboratories are also assisting the Department of Defense. The Brookhaven National Laboratory's support of radiological response teams and the MITRE Corporation's efforts with the Joint Surveillance Target Attack Radar System and other good examples of the GOCO/FFRDC link with the Department of Defense.

The national laboratories will continue to support the nation through their ability to reorganize to meet changing demands. At the Administration's request, they have devoted 10–20 percent of the budgets to creating collaborative ventures with industry. They are also looking toward more international ventures. They will preserve our nation's basic research assets.

Appendix F:

Schedule of the Committee's Briefings and Site Visits

Meetings of the Committee on Alternative Futures for
the Army Research Laboratory
Cecil and Ida B. Green Building
National Research Council
Washington, D.C.

May 24–26, 1993

John Bachkosky	Deputy Director, Defense Research and Engineering, U.S. Department of Defense
William Happer	Director, Office of Energy Research, U.S. Department of Energy
Gerald Iafrate	Director, Army Research Office
Raymond Kammer	Deputy Director and Acting Director, National Institute of Standards and Technology
Robert Selden	Associate Director for Laboratory Development, Los Alamos National Laboratory
Richard Vitali	Acting Director, Army Research Laboratory
Norman Waks	Chief Management Scientist (*Retired*), The MITRE Corporation

August 2–4, 1993	
Michael Heeb	Deputy Director, Office of Environmental Restoration and Waste Management, Office of Technology Development, U.S. Department of Energy
August 30–September 2, 1993	
John Lyons	Director, Army Research Laboratory

Meeting of the GOCO ARL Option Panel
Cecil and Ida B. Green Building
National Research Council
Washington, D.C.
June 28–30, 1993

Anthony Gamboa	U.S. Army Office of General Counsel
Albert Narath	President, Sandia National Laboratories
Stanley Kaufman	Office of Federal Procurement Policy

Meeting of the Executive Panel
Cecil and Ida B. Green Building
National Research Council
Washington, D.C.
September 22, 1993

George R.	Abrahamson Chief Scientist, U.S. Air Force
Kenneth Lackie	Science Staff Assistant to the Director, Naval Research Laboratory

Site Visits of the Committee on Alternative Futures for the Army Research Laboratory		
April 20	Army Research Laboratory Adelphi, Maryland	Chuck Denney, Executive Assistant to the Director of Operations John Holmes, Special Assistant to the Director Sidney Kelly, Operations Research Analyst/Cost Analyst Rick O'Sullivan, Operations Research Analyst/Cost Analyst
April 29	Army Research Laboratory Adelphi, Maryland	Chuck Denney, Executive Assistant to the Director of Operations John Holmes, Special Assistant to the Director
May 11	U.S. Department of the Army The Pentagon Washington, D.C.	George Singley, Deputy Assistant Secretary for Research and Technology
May 11	Army Materiel Command Alexandria, Virginia	General James Ross, Commanding General
May 13	National Institute of Standards and Technology Gaithersburg, Maryland	Allen Cassady, Chief, Demonstration Project Robert Hebner, Deputy Director, Electronics and Electrical Engineering Laboratory Samuel Kramer, Associate Director
May 26	National Institute of Standards and Technology Gaithersburg, Maryland	Allen Cassady, Chief, Demonstration Project Norman Osinski, Chief, Acquisition and Assistance Division
June 2	National Institute of Standards and Technology Gaithersburg, Maryland	JoAnn Beck, Chief, Justification and Analysis Group Tom Gary, Budget Officer

June 14	Army Materiel Command Alexandria, Virginia	Major General John Wilson, Chief of Staff George Jones, Deputy Chief of Staff for Personnel Roger Rogowski, Assistant Deputy Chief of Staff for Acquisition Robert Weidenmuller, Assistant Deputy Chief of Staff for Resource Management Edmund Westcott, Assistant Deputy Chief of Staff for Research, Development and Engineering Robert McFarlane, Deputy Command Counsel
June 14	Army Research Laboratory Adelphi, Maryland	Richard Vitali, Acting Director Bruce Fonoroff, Director, Advanced Concepts and Plans Jerry Reed, Director, Operations John Holmes, Special Assistant to the Director Kevin Kirby, Office of the Director
June 15	Weapons Technology Directorate Army Research Laboratory Aberdeen, Maryland	John Frasier, Directorate Executive of Weapons
June 15	Night Vision and Electronic Sensors Directorate Fort Belvoir, Virginia	Rudolf Buser, Director
June 16	U.S. Army Armor Center Fort Knox, Kentucky	David Porter, Director, Mounted Battlespace Battle Lab
June 17	U.S. Army Armament RDEC Picatinny Arsenal, New Jersey	Major General Harvey Brown, Commander Thomas Davidson, Technical Director Joseph DeLorenzo, Chief, Heavy Armament Division Howard MacGrady, Deputy Product Manager for Fuzes Renata Price, Associate Technical Director for Systems, Concepts, and Technology
June 22	Army Research Laboratory Adelphi, Maryland	Jerry Reed, Director, Operations Chuck Denney, Executive Assistant to the Director of Operations

June 29	Army Research Laboratory Adelphi, Maryland	Richard Vitali, Acting Director Bruce Fonoroff, Director, Advanced Concepts and Plans Jerry Reed, Director, Operations John Holmes, Office of the Director Kevin Kirby, Office of the Director
June	U.S. Army Missile Command Redstone Arsenal, Alabama	William Leonard, Lab Demo Program Office William McCorkle, Technical Director, and member of the Commission on Federal Laboratories Richard Rhoades, Associate Technical Director, and Chairman, Management Subpanel, TriService Laboratory Demonstration Executive Panel Walter Wharton, Director of Weapons Science
July 2	Office of Contractor Human Resource Management U.S. Department of Energy Washington, D.C.	John J. Edmonson, Director Stephanie Weakley, Director of Employee Compensation and Benefits Pat Powers, Industrial Relations Specialist
July 7	Naval Air Warfare Center China Lake, California	Phil Arnold, Head, Weapons Planning Group Nancy Crawford, Head, Management and Manpower Group Diana Eggleton, Professional Recruitment Coordinator Bob Fitzpatrick, Employee Relations Specialist Jerry Macy, Deputy Comptroller Florence Taylor, Management Analyst/Demo Program Coordinator

July 8	Sandia National Laboratories Albuquerque, New Mexico	Ralph Bonner, Director, Human Resources Center Don Ellis, Administrative Assistant to the Chief Financial Officer Neal McEwen, Accounting Services Department John Meinhardt, Executive Assistant to Defense Programs Sector Manager Pace Van DeVender, Director, National Industrial Alliances Dave Wallace, Manager, Procurement Department Gloria Zamora, Protocol
September 1	Advanced Research Projects Agency Arlington, Virginia	Richard Dunn, General Counsel James Richardson, Special Assistant
October 8	U.S. Department of the Army The Pentagon Washington, D.C.	George Singley, Deputy Assistant Secretary for Research and Technology
November 3	Army Materiel Command Alexandria, Virginia	General James Ross, Commanding General

Appendix G:

Biographical Sketches

Dr. Charles A. Zraket, Chairman

Dr. Zraket was graduated with a bachelor of science degree in electronic engineering from Northeastern University, a masters degree from Massachusetts Institute of Technology, and an honorary doctorate from Northeastern. His distinguished career in research, engineering, and acquisition of electronic, energy, and environmental systems with the MITRE Corporation involved various management positions, including President and Chief Executive Officer. He continues to serve MITRE as a Trustee. Currently, Dr. Zraket is also a Scholar-in-Residence at the Center for Science and International Affairs at the Kennedy School of Government, Harvard University. In addition, Dr. Zraket comes to the committee as chairman of the Committee on International Security Studies of the American Academy of Arts and Sciences, a member of the American Association for the Advancement of Science Committee on Science and International Security and of the Council on Foreign Relations. He has been awarded the DOD Medal for Distinguished Public Service and is a member of the National Academy of Engineering.

Dr. Daniel P. Schrage, Vice Chairman

Dr. Schrage was graduated with a bachelor of science degree in general engineering from the United States Military Academy, a masters in science degree in aerospace engineering from the Georgia Institute of Technology, a masters in arts degree in business administration from Webster University, and a doctorate in mechanical engineering from Washington University. Dr. Schrage served 11 years on active duty as a field artillery officer and Army aviator and continues to serve in the U.S. Army Individual Ready Reserves. His current rank is Colonel and he is assigned as an Individual Mobilization Augmenter to the Department of Civil and Mechanical Engineering, the United States Military Academy. He spent six years working as a senior executive for the U.S. Army, primarily in various scientific and engineering

management positions with the U.S. Army Aviation Systems Command. His last assignment was Director for Advanced Systems. In 1984, Dr. Schrage joined the faculty at the Georgia Institute of Technology as a professor in the School of Aerospace Engineering. With his primary interest in the education and research in the design, analysis, and assessment of aerospace systems, including the application of Total Quality Management and Concurrent Engineering, he assumed the positions of Director of the Center of Excellence in Rotorcraft Technology in 1986 and the Director of the Flight Simulation Laboratory in 1990. He serves as a consultant for the aerospace industry and various external advisory boards, including the Army Science Board, NASA Aeronautics Research and Technology Subcommittee, and the Institute for Defense Analysis, and is an active member of a number of professional societies. He is the author of over five book chapters and over 50 technical papers. Dr. Schrage is recipient of numerous, distinguished military decorations, including the Distinguished Flying Cross.

Dr. Martin Blume

Dr. Blume was graduated magna cum laude from Princeton University with a bachelor of arts degree in physics, a masters of arts degree and a doctorate from Harvard University. Following a Fulbright Fellow appointment to Tokyo University and an AERE appointment, he joined Brookhaven National Laboratory in 1962 as an Associate Physicist, where he has progressively advanced into management positions. Dr. Blume currently serves as Deputy Director of the Laboratory. During his distinguished career he has served on many review and visiting committees and editorial boards. He is an active member of several professional organizations, including the American Physical Society, the New York Academy of Sciences, and the American Association for the Advancement of Science. Dr. Blume has participated in over 100 lectures and seminars worldwide and has made presentations at numerous international conferences. He has served on many committees of both the National Research Council and the National Science Foundation and as acted as a consultant on a myriad of other panels. Dr. Blume's research interests include theoretical solid state physics; the theory of magnetism; phase transitions, slow neutron scattering; and synchrotron radiation.

Mr. Allan J. Boardman

Mr. Boardman was graduated with a bachelor of science degree in aeronautical engineering from Massachusetts Institute of Technology. He is Group Vice President of the Administration Group and Treasurer of the

Aerospace Corporation. He joined the Aerospace Corporation in 1962 as a Staff Engineer. Mr. Boardman's numerous management positions within Aerospace have included Principal Director of the Electronics and Optics Subdivision; Principal Director of the Navstar/Global Positioning System, Satellite Systems Division; General Manager of the Electronics and Optics Division of the Engineering Group; and Vice President, Advanced Orbital Systems Operations, Development Group. In 1987, he was elected Group Vice President of the Administration Group, which was followed in 1989 by an election to Treasurer of Aerospace. Mr. Boardman is a member of the American Institute of Aeronautics and Astronautics and a senior member of the Institute of Electrical and Electronic Engineers.

Mr. Edward C. Brady

Mr. Brady was graduated with a bachelor of science degree in engineering from the U.S. Naval Academy, holds a masters in sciences in management science from American University, and completed coursework for a masters in science in foreign service and a doctorate in economics at Georgetown University. He spent 16 years with the MITRE Corporation, culminating in the position of Group Vice President, Washington Group. In 1991, Mr. Brady founded Strategic Perspectives, Inc., an investment and strategic management consulting firm. He is a member of the Army Science Board and the Science Advisory Group, Defense Information Systems Agency. In addition, Mr. Brady also serves on the Physics and Applied Science Advisory Committee of Lawrence Livermore National Laboratory, and the Industrial Advisory Board of the School of Engineering, University of Virginia. He has chaired dozens of national conferences for government and professional societies, has served as president of numerous societies, and is fellow of the Military Operations Research Society, Associate Fellow and member of the Board of Directors of the AIAA, Chairman of the IEEE/AFCEA Military Communications Conference Board. Mr. Brady received seven decorations for valor in the war in Vietnam.

Mr. W. Kenneth Davis

Mr. Davis was graduated with a bachelor of science and masters of science degrees in chemical engineering from Massachusetts Institute of Technology. He began his career at what is now the Chevron Oil Company and at the University of California at Los Angeles. In 1954, Mr. Davis joined the U.S. Atomic Energy Commission as Deputy Director where he eventually became Director of Reactor Development. From 1958 to 1981, he served as a

corporate vice president of Bechtel. Mr. Davis' distinguished career includes having served as the U.S. Deputy Secretary of Energy from 1981 to 1983. He currently serves as a consultant on management and engineering to several government and private organizations, including Bechtel. Mr. Davis has served as an officer to numerous associations, societies, and forums, has participated on advisory boards to the Administration and the Congress, and has presented over 200 papers at national and international meetings. He is the recipient of many honors and awards and is a member of the National Academy of Engineering.

Mr. John C. Fielding

Mr. Fielding was graduated with a bachelor of science degree in engineering from the University of California at Los Angeles and a masters of science degree in electrical engineering from the Massachusetts Institute of Technology. In 1961, he joined MIT Lincoln Laboratory as a staff member, working, in part, with Ballistic Missile Defense (BMD) systems analyses. He served in that position until he joined the General Research Corporation in 1968 as leader of a project to provide technology support to the U.S. Arms Control and Disarmament Agency in their negotiation of the BMD treaty, and in 1970, assumed responsibility for the direction of studies in Anti-Submarine Warfare and Air Traffic Control, as well as BMD. In 1974 Mr. Fielding was a co-founder of the Delta Research Corporation and conducted studies for the Office of Civil Rights, Department of Health, Education and Welfare. He returned to Lincoln Laboratory in 1978, where he has served as Associate Division Head of the Surveillance and Control Division since 1987. Mr. Fielding is a member of IEEE, has worked with the Department of Defense, the National Research Council, and the Defense Science Board, and completed the John F. Kennedy School of Government Program in National and International Security at Harvard University.

Mr. William M. Frailey

Mr. Frailey was graduated with a bachelor of science degree in psychology from the University of Utah. Additionally, he participated in the program for Senior Managers in Government at Harvard University, the Data Automation Symposium at the Honeywell Corporation, the Senior Executive Service Seminar at Princeton University, and the Brookings Institute Conference on Business in Contemporary Society. Mr. Frailey has over 25 years experience in personnel, compensation, position classification, salary and wage administration, and employee and labor relations with the U.S. Department

of the Army. During his civilian career with the Army, he has served as Chief, U.S. Army Civilian Personnel Center, and Chief, Non-Appropriated Fund Branch, Civilian Personnel Division Headquarters, U.S. Army Europe. As a contractor specialist, he has travelled around the globe on teams engaged in compensation surveys and position classification audits. Mr. Frailey has recently worked as a contract specialist on an Agency for International Development restructuring project, and is currently a senior classification specialist with the Department of Labor, Office of the Solicitor. He has received numerous prestigious decorations for his civilian service to the Army.

Dr. Philip H. Francis

Dr. Francis was graduated with a bachelor of science and a master of science degrees in mechanical engineering from the California Polytechnic State University and the University of Iowa, respectively, a doctorate in engineering mechanics from the University of Iowa, and a master of business administration from St. Mary's University in Texas. He began his career in 1960 at McDonnell-Douglas Corporation and then at the Southwest Research Institute where he held various research and management positions until 1979. Dr. Francis then spent five years at the Illinois Institute of Technology where he served as professor and ultimately chairman of the Department of Mechanical and Aerospace Engineering. His distinguished career has included Director of the Industrial Technology Institute in Ann Arbor, Michigan, and Director of Advanced Manufacturing Technology, General Systems Group at Motorola. Dr. Francis joined Square D Company in 1988 as Vice President of Technology and Chief Technical Officer. Dr. Francis is a member of the American Society of Mechanical Engineering (ASME), the Army Science Board, and the Board of Assessment for the National Institute of Standards and Technology. He founded and directed the ASME's Manufacturing Science & Technology Program, founded and served as editor-in-chief of *Manufacturing Review*, and has authored or edited 3 books and over 60 journal articles and book chapters in technical and management subjects.

Dr. Richard L. Hartman

Dr. Hartman was graduated with a bachelor of science, master of science, and doctorate degree in physics from the Carnegie Institute of Technology, as well as a science masters in management from the Massachusetts Institute of Technology. He retired from the U.S. Department of the Army in 1988 after 23 years of distinguished service. In his final position as Director for Research, U.S. Army Missile Command, he had staff responsibility for all

research programs of the Army Missile Command and line responsibility for the Research Directorate. After his retirement he founded Hartman Associates, a science and management consultant firm where he consults with industry and universities on independent research and development strategy, proposal Red teams, international technology transfer, weapons systems technology, and advised government agencies on Advanced Systems Concepts, laboratory management, and optics technology. He also serves as president of Advanced Optics Systems, Inc. Dr. Hartman has served on a myriad of committees and boards for the Army, NASA, the Army Science Board, and the National Research Council, among others.

Dr. L. Charles Hebel

Dr. Hebel was graduated with a bachelor of arts degree from DePauw University and a doctorate in physics from the University of Illinois. In 1957, he began his career at Bell Telephone Laboratories as a member of the technical staff, and joined Sandia National Laboratories in 1968 as Director of Physical Research. In 1973, Dr. Hebel joined the Xerox Corporation as Manager of Physical and Chemical Sciences at the Webster Research Center, NY. He moved in 1976 to his current location of the Palo Alto Research Center, California, and currently acts as Manager of Technology Evaluation where he is responsible for evaluating technologies and research for the purposes of assessing prospective use and proprietary protection. For two years, he worked in cooperation with the U.S. Department of State in the International Nuclear Fuel Cycle Evaluation concerned with non-proliferation of nuclear weapons technology. Dr. Hebel is a fellow of the American Physical Society, and a member of both the New York Academy of Sciences and the American Association for the Advancement of Science. During his career, he has participated in numerous studies and advisory panels for the American Physical Society, the Battelle Corporation, the National Institute of Standards and Technology, and the National Research Council.

Dr. Edward A. Miller

Dr. Miller was graduated with a bachelor of science degree from the University of Maryland and a LLB/ Juris Doctor from the Salmon P. Chase College of Law in Cincinnati, and in addition, graduated from a three-month resident general management course conducted by the Harvard University School of Business. He has extensive experience in industry, having served as various management positions with General Electric Company, Ford Aerospace Corporation, Fairchild Space and Electronics Company, and ITEK

Corporation. From 1975 to 1977, Dr. Miller served as the Assistant Secretary of the Army, Research and Development, and was awarded the Department of the Army Decoration for Distinguished Civilian Service in 1977 for his contributions. In 1977, he joined Sanders Associates Incorporated, a high-tech NYSE corporation engaged in research, development, and manufacturing of advanced electronics, mechanical, aeronautical and computer systems and products, where he ultimately became Executive Vice President in 1984. Dr. Miller has worked as a private consultant since 1987. In addition, he has served as a member of the Board of Directors of the New England Microwave Corporation, including a two-year term as chairman, and as a member of a number of the Army Science Board studies. Dr. Miller was selected as an eminent engineer in Tau Beta Pi, the National Engineering Honor Society, and is also a member of the Phi Alpha Delta Law Fraternity. He served for 9 years in the U.S. Army Corps of Engineers and has numerous professional affiliations.

Lieutenant General (Retired) Robert L. Moore

Lieutenant General (*Retired*) Moore was graduated with a bachelor of science degrees in building construction from the Virginia Polytechnic Institute and in civil engineering from the University of Missouri, and a master of science degree in business administration from the George Washington University. He retired in 1986 from the U.S. Department of the Army after a distinguished 33-year career. In his last position for the Army, he served as Deputy Commanding General for Research, Development and Acquisition, Army Materiel Command, where he was responsible for and directed all Army Material Command Development Centers, Test and Evaluation activities, laboratories, research offices, and designated project managers. In addition, General Moore spent three years as Commander of the U.S. Army Missile Command, overlooking program, budget, and execution of all Army missile programs, their acquisition, logistics support, and eventual obsolescence. From 1986 to 1991, he was affiliated with the Hilton Systems, ultimately serving as Executive Vice President. General Moore currently is consulted by major corporations in responding to government requests and maintaining program control.

Dr. K. Bradley Paxton

Dr. Paxton was graduated with a bachelor of science degree in electrical engineering from the Rensselaer Polytechnic Institute and a master of science degree in applied mathematics and a doctorate in electrical engineering from

the University of Rochester. In addition, he attended the Wharton Advanced Management Program at the University of Pennsylvania. In 1960, Dr. Paxton joined the Eastman Kodak Company in development and engineering. His illustrious career at Eastman Kodak included General Manager and Vice President of both the Electronic Photography and the Printer Products Divisions, and the Director of Electronic Imaging Research Laboratories, where he was responsible for all electronic imaging related research. He retired in 1992 after 32 years of service. He is currently President of KB Paxton, Inc., a consulting firm specializing in electronic and hybrid imaging. Dr. Paxton has published ten papers in professional journals and is the holder of two U.S. patents.

Dr. Maxine L. Savitz

Dr. Savitz was graduated with a bachelor of arts degree in chemistry from Bryn Mawr College and a doctorate in organic chemistry from the Massachusetts Institute of Technology. From 1974 to 1983, she held various management positions with the U.S. Department of Energy, including a five-year term as the Deputy Assistant Secretary for Conservation. In addition, she served as President of the Lighting Research Institute from 1983 to 1985. In 1985, Dr. Savitz joined the Garrett Corporation as an assistant to the Vice President of Engineering. She assumed her current position of General Manager, AlliedSignal Ceramic Components in 1987. Dr. Savitz is the recipient of several awards including the outstanding service medal from the U.S. Department of Energy and the President's Meritorious Rank Award, as well as election to the National Academy of Engineering. She is the author of over 20 publications, has an extensive record of service to the National Research Council and the Oak Ridge National Laboratory, and participates on numerous advisory boards and society memberships.

Mr. Gary L. Sorrell

Mr. Sorrell was graduated with a bachelors and masters degrees in mathematics and has completed coursework for a doctorate in operations research/computer science at Johns Hopkins University. For over 26 years, he has been developing and applying analysis and computer system techniques in government and industry. His background includes President of Management Consulting and Research, Inc.; a Senior Associate of J. Watson Noah Associates, Inc.; a Program Director with GENTECH, Inc.; and Manager of the Maryland Operations for Teledyne Brown Engineering. In addition, he has eight years of government service for the National Security

Agency and the U.S. Postal Service, including serving as Director of Analytic Studies at the National Security Agency. Currently, Mr. Sorrell is Chairman of CALIBRE Systems, Inc., a firm which specializes in resource analysis studies and the development of automated resource management systems. He is a certified cost estimator/analyst and is past president of the Washington, D.C. chapter of the Society of Cost Estimating and Analysis. He is also the past president and Trustee of the Washington Operations Research/Management Science Council. He has participated in and presented papers on cost analysis and information systems at numerous national and international meetings and is active in a number of professional societies.

Dr. Robert Weigle

Dr. Weigle was graduated with a bachelor of civil engineering degree in structures, a masters of science degree and a doctorate in mechanics from the Rensselaer Polytechnic Institute. After spending four years as an Associate Research Scientist at Rensselaer, in 1959 Dr. Weigle assumed the positions of Chief Scientist of the Watervliet Arsenal and Technical Director, ultimately Director, of the Benet Weapons Laboratory. In this capacity, he was responsible for all scientific and engineering projects in support of artillery cannon, tank cannon, and mortar weapons development. From 1977 to 1982, Dr. Weigle served as the Technical Director for the U.S. Army Armament Research and Development Command, where he was responsible for the technical direction of the Army research development, engineering design, product engineering, quality assurance, and the manufacturing methods and technology program. Dr. Weigle's service to the Army culminated as Director of the U.S. Army Research Office, from 1982 to 1988. As such, he headed the Army research program conducted under contract to the university/industry community and the internal Army Materiel Command Laboratory research program. In 1988, he assumed his current position as the Director of the Physical Science Laboratory of the New Mexico State University which conducts research and development projects sponsored by various agencies of the U.S. government. Dr. Weigle is a member of numerous professional societies and has authored or coauthored a number of technical reports. In addition, he has participated as chairman in many Department of Defense and Army committees dealing with science and technology issues.