Chapter 7

Implications for the Defense Technology Base: Options for Congress

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INTRODUCTION AND SUMMARY

Chapters 4,5, and 6 of this report are an integral package. Chapter 4 addressed broad management issues facing the U.S. Department of Defense (DoD) as it seeks to plan, execute and review the defense Science and Technology (S&T) program. It highlighted the degree of control-or lack of control—— exerted by the research and technology staff of the Office of the Secretary of Defense (OSD) over the priorities and content of the S&T program.

Chapter 5 examined how the S&T program operates at the ''grassroots level' '—the DoD laboratory. This massive and unwieldy structure presents significant management and organizational problems that DoD must solve if the defense research program is to become more relevant and productive. Chapter 6 surveyed how other sectors and other nations have tackled the problem of planning and executing S&T programs. The objective was to determine what, if anything, the Defense Department might adopt from less complex environments. The implications can be summarized as follows.

DoD's S&T program is basically a bottom-up process, with OSD serving largely in the role of monitor. While OSD's research and technology staff occasionally exerts pressure on the Services regarding specific issues, they generally yield to Service research and development (R&D) personnel on the content and direction of research programs. OSD's main role is effectively to collect the inputs from the Services, correlate them, and defend them before Congress for review. With its direct access to the Services, Congress often revises elements of a Service S&T program-with or without the agreement of the Service, and often without consulting OSD. Once the money is approved, the Services execute their own programs. The other two major S&T activities are the Defense Advanced Research Projects Agency (DARPA) and the Strategic Defense Initiative Organization (SDIO) (SDI being funded under Advanced Technology Development, budget category 6.3A). SDIO is even more independent than the Services, with the Director reporting only to the Secretary of Defense. DARPA reports to the Director, Defense Research and Engineering (DDR&E), but enjoys a degree of autonomy, on program content and priorities, from OSD's S&T monitors.

Different elements of the DoD S&T program are thus managed through three different hierarchies: for the Services, the laboratories report at a relatively low level and programmatic decisions work their way up the chain of command; DARPA reports to DDR&E, three levels removed from the Secretary; and SDIO reports to the very top. Under these circumstances, the OSD research and technology staff can do little but monitor and collect data.

This management structure also encourages duplication and a degree of inefficiency, especially considering the vast network of laboratories, centers, and other facilities responsible for research program activities. Nearly every other organization examined reflects far more centralized planning and execution of its S&T program. This is especially true in military R&D where a central authority, often reporting to the Minister of Defense (or in the case of industry, to the company president), has both the responsibility and authority to set research priorities and to ensure that the program content meets the organization's goals. With goals set from the top, there are means to exert pressure on the performing bodies to make sure that the programs are responsive. Further, at least in most governments, military research programs are generally stable over a period of several years; thus, researchers in these programs are not faced with annual—and disruptive-changes in funding or priorities. It appears that DoD is following a minority path in its conduct of S&T programs, one that is declining in popularity among governments and major companies.

Another unusual feature of DoD's S&T program is its extensive system of government-owned and government-operated laboratories. No other non-communist nation, let alone private enterprise, operates so many facilities and maintains such a large research staff. Depending on one's point of view, the DoD laboratory system is either a tremendous asset or a tremendous burden. Whether it is an asset or a burden, the structure is in place today and the Department needs to address some of the serious management and organizational problems which have beset the laboratory system.

One problem is the nature of most of the laboratories themselves. In fact, they are not laboratories; they simply lack the "critical mass" of multidisciplinary talent necessary to develop state-of-the-art technologies consistently across a spectrum of areas. Most of these organizations were created, and continue to exist, to support the mission of one of the military Services. Consequently, developing technology per se is not their primary objective. Rather, research and technology capabilities are necessary to assist a Service in performing its missions. Mission requirements can be satisfied either by conducting internal research or by contracting out to major corporations, universities, or private institutions. Each Service addresses mission support quite differently. In the Navy, a large share of the S&T budget is spent in-house. In the Air Force, the laboratories place more emphasis on becoming ''smart buyers,'* and contract out the bulk of their S&T work. The Army falls somewhere in between. With different mission orientations leading to different approaches to R&D, overlap and other inefficiencies arise throughout the system.

A second major problem with the DoD laboratories pertains to their ability to hire and retain qualified researchers. Not only are there significant salary deficiencies, but the politicized environment in which research is conducted in many laboratories often discourages qualified scientists and engineers, sending them to higher paying and more rewarding jobs in corporate research laboratories or at universities. This situation might be mitigated if there were a DoD-wide policy to contract out as much research as possible, essentially letting the research follow the scientist. But policies regarding contracting out are inconsistent, and laboratories are sometimes forced to conduct in-house research with inadequate staff.

Finally, the government-owned and government-operated laboratories are saddled with procedures that often make them less efficient than the better industrial and university laboratories. This is an issue that must be addressed because research budgets are likely to decrease as part of an overall reduction of the defense budget. Other comparable organizations structure their laboratories differently, and some—with management problems similar to those of DoD--are currently involved in basic restructuring. One approach involves aligning research according to technology areas, creating centers of excellence that assemble sufficient resources to make a difference in high-technology fields. These centers are overseen by top management and serve as corporate-wide resources. While some observers believe that this approach stifles innovation, others argue that it increases efficiency because progress is more likely once the organization decides on the line of research it will pursue.

This assessment raises other issues. Nearly every Allied government is concerned for the future of its national research and technology programs. Politicians and the civil service agree that a country's military and economic security depend on the nation's ability to produce affordable state-of-the-art products, including weapons. Most nations also concede their inability to conduct independent research programs that are sufficiently deep in more than a few technology areas to achieve technological breakthroughs sustaining industrial competitiveness in world markets, or deterring aggressors. What money is available must be wisely spent. To ensure that this happens, European governments have set policies and priorities for research and technology at the highest governmental level-often at the level of the Prime Minister or President.

A related issue is the recognition by European governments of the "dual-use" nature of advanced technology. On one hand, government officials are painfully aware of the success of the "Japanese Model" in transferring the results of science and technology programs into quality products, thereby giving Japanese companies a competitive advantage in world markets. On the other, they see continued difficulties in exploiting technology developed under U.S./European cooperative military programs, especially from the standpoint of technology transfer to civil or to third-party military markets.

There is an international trend toward decreasing the emphasis on military technology and increasing emphasis on research for enhancing national industrial competitiveness. For example, in Europe, military research budgets are declining, while investment throughout the European Community (EC) is growing substantially. Many technologies the EC is funding have clear dual-use applications; governments seem to be expecting that the results of civil research will flow into military development and production programs. In Japan, while military research budgets are growing modestly, the government is maintaining a close connection between this research and commercial applications.

Additionally, collaboration in research is becoming important. Because most nations and private organizations find the costs of sponsoring a "world-class" research program prohibitive, they have concluded that for all its problems, banding together is the only way to go. With the emphasis on civil research and the trend toward collaboration, DoD may find increasingly that it is the "odd man out," to the possible detriment of the competitiveness of America's high-tech industries. Foreign technology in the civil fields is approaching, and in some cases exceeding, the quality of DoD's military technology. As this trend continues and the line between civil and defense research gradually disappears, it may be necessary to revise policies in such areas as international collaboration, technology transfer, foreign disclosure, and export administration.

POLICY OPTIONS FOR CONGRESS

The following policy options are based on these findings. While they are by no means exhaustive, they do address several issues that strongly affect the ''health'' of the U.S. defense technology base. These options take into account the interdependence of DoD's research planning and execution with events taking place throughout the S&T community, both foreign and domestic. In its consideration of these options, Congress should bear in mind that these are extremely complex matters, and that no consensus exists among experts on any of the issues or options that are presented.

The options are grouped under five broad, and unavoidably overlapping categories: 1) high-level planning, 2) organization, 3) structure of the laboratory system, 4) laboratory management, and 5) funding and budgeting.

High-Level Planning

Option 1: Establish government-wide priorities for defense research and ensure they are followed by all DoD components and the private sector.

This option addresses the need for the Federal Government to execute an increasingly complex and expensive defense research program with constrained (or decreasing) funding. The priorities could be developed in conjunction with DoD's Program and Planning Budgeting System (PPBS) process, related specifically to the early planning activities of the Joint Chiefs of Staff (JCS) and reflected in the Defense Guidance (DG). The private sector (industry and academia) could be consulted during periodic technology-assessment exercises (e.g., the planning phase of the PPBS), kept fully informed on progress and new directions (e.g., breakthroughs and political developments), and encouraged to invest in complementary research.

The methods introduced by the European Community for its joint research projects could provide some useful insights. The EC Commission sets research priorities. A 5-year budget is adopted providing for roughly 50 percent of the needed funds and industry/academia consortia are invited to submit bids. Industry funding of half the work and university involvement are necessary conditions f-or a bid to be considered responsive. Some factors that have contributed to success include: 1) priorities set at high political levels; 2) long-term (5-year) EC funding commitment; and 3) research work at the ''precompetitive" stage, with applications left up to industry. Additionally, there is no alternative to joint research projects, because individual government funding sources are diminishing rapidly.

This model may not fit DoD's situation exactly, but it can be made to fit. The key technologies required for defense systems are largely known; and recent technology assessments, whether made by DoD or industry or both, have much in common. The Defense Science Board (DSB) could provide the connection with the private sector for periodic technology assessments. The necessary planning procedures are largely in place, i.e., the PPBS, the Joint Strategic Planning Document (JSPD) and the DG. Finally, the independent Research and Development (IR&D) program is one source of (partial) industry funding. To implement this, a top-level commitment would be needed, with the Administration and Congress providing the political and budgetary incentives.

Option 2: Reestablish OSD's corporate oversight authority for DoD% technology base programs.

It appears that Congress has provided OSD with the necessary statutory authority to exert strong centralized guidance over DoD's technology base programs. But as chapter 4 described, OSD—specifically the Director of Defense Research and Engineering (DDR&E)—appears to have relinquished to the Services much of the responsibility for overseeing the technology base. This runs counter to trends elsewhere; as chapter 6 pointed out, our NATO Allies have initiated or further strengthened the centralized management of their defense R&D. Congress could insist that OSD, exercising its statutory authority, reestablish its corporate oversight authority for DoD's technology base programs.

OSD representatives have complained of ever-increasing congressional micromanagement of their S&T programs. Pentagon officials indicate that they believe Congress is overstepping its responsibilities in dictating how OSD should structure certain technology base programs. Some of the OSD observations may be valid; nevertheless, it is a congressional perception that OSD is not sufficiently exercising its oversight responsibilities that has led Congress into a deeper involvement in shaping DoD's technology base strategy. If OSD were to assert its authority and develop a strategic R&D plan, Congress would probably find it less necessary to involve itself in individual programs.

In various discussions with OTA, some Service representatives expressed their surprise and frustration that OSD had not exerted stronger management control over DoD's S&T programs. They contended that stronger and more effective OSD technology base oversight could go far to reduce inter-Service rivalry and produce a more coherent technology base investment strategy. However, other Service representatives argued that it would not be appropriate for OSD to exercise greater authority. In their view, because the Services ultimately would use the products of R&D programs, they alone know what is needed. Moreover, they felt that OSD personnel were too far removed from technology base programs to understand them well enough or to care enough about them to defend budgets successfully. Some argued that if Service control over technology base programs were to be reduced, the Services would lose interest in—and decrease funding for—the technology base.

Option 3: Institute a strategic planning process within DoD that will lead to a coordinated Department-wide technology base investment strategy.

Currently, the Services dominate planning for DoD's technology base program. If it wanted to provide more centralized control, Congress could consider requiring the Secretary of Defense to begin a DoD-wide technology base strategic planning process directed by the Undersecretary for Acquisition [USD(A)]. Without the endorsement of the Secretary of Defense and USD(A), it will not be possible to implement a strategic plan successfully.

Such an investment strategy could: 1) facilitate OSD-directed strategic decisions, 2) diminish the likelihood of technological surprises, 3) reduce duplication of effort, 4) encourage short- and long-term technology base planning, 5) enable OSD and the Services to examine the outputs of the S&T programs and not just the inputs, 6) enhance the understanding within DoD of the importance of technology base programs within DoD, and 7) provide Congress with a more coherent defense S&T strategy.

However, in the view of some, centralized control would only add another layer of bureaucracy between the invention of new military technologies and the managers in the Services who will ultimately have to acquire the technology for weapon systems. From this perspective, OSD staff would be too far removed from the technology base to understand the needs of the user, and protect the funding for critically important technology base programs.

USD(A) could direct DDR&E to initiate a strategic planning process that would involve the participation of the three Services, the defense agencies (including DARPA), and SDIO representatives from the JCS, the unified and specified commands, and the intelligence community. One official within the Office of the DDR&E (ODDR&E) would be responsible for developing, implementing, and directing a DoD-wide technology-base strategic plan. Developing a strategic technology base planning process would require the full-time attention of the OSD official responsible for its success. '

Any strategic technology base plan will have to be tied closely to DoD's national security objectives. The principal aim of the strategic plan should be to establish near- and long-term S&T objectives, leading to the achievement of the Department's operational objectives.

Once the DoD-wide strategic technology base plan is completed and approved by DDR&E and USD(A), the Services, DARPA, and the other defense agencies can use it to develop their own technology base programs. In turn, OSD can use the plan to evaluate the Services' and DARPA's technology base investment strategies and determine the extent to which each technology base program matches the plan.[2]

Finally, in view of the high turnover rate of OSD political appointees, an accepted strategic planning process should help new appointees to draft a coherent technology base investment strategy. This existing process should reduce the need for each new top-level civilian manager to "reinvent the wheel."

Organization

Option 4: Establish a central coordinating activity within the Administration to ensure that dual-use technology is exploited in the best interests of the nation as a whole.

A serious imbalance is emerging between the United States and its allies with respect to dual-use technology. Japan spends very little on defense research and technology programs; there, civil research is the main focus. This approach helps to account for Japan's enviable record of success in world trade. In Europe, the EC has committed $6.8 billion over the next 5 years to civil research, much of which also has potential military applications. The European national governments are supporting the EC and other joint civil research projects and appear to be pulling out of defense research. The U. K., for example, has limited its defense research budget so as to prevent "crowding out" of civil research—the government openly encourages domestic industry to bring the results of research to the Ministry of Defense (MoD) "when it's ready."

In such fields as high-temperature superconductivity, high-definition television, microelectronics, fiber optics, supercomputers, and telecommunications, the United States is competing with countries (or blocs) with whom we are allied in the East-West political competition. The United States, with its focus on the Soviet threat, has placed its industries at a potential disadvantage in world markets through measures such as restrictive export and technology-transfer policies. Operating under less stringent restrictions, our allies see their industries enjoying significant sales growth in market areas previously dominated by U.S. companies.

The Administration must take these trends into account as it considers the future health of America's industrial base (recognizing that the defense industrial and technology bases are only two elements of the Nation's industrial base). A balance should be found between the need to protect defense technologies (largely at the applications stages) and the growing need for industry to exploit the same (or similar) technologies in U.S. and foreign markets. Accomplishing this tricky balancing act will require the full support of the President, Congress, and industry. It will also require the appointment of a responsible and independent official with stature and authority.

This official could be located in DoD, but if so, interagency coordination (e.g., with State, Commerce, NSF, and NASA) should have high priority. Alternatively, the Office of Science and Technology Policy (OSTP) could perform this function. In conjunction with government agencies, industry and

I The President's 1983 Private Sector Survey on Cost Control, Task Force on Research and Development, indicated that it could take 3 to 5 years to implement a strategic planning process for DoD's R&D programs. Consequently, top DoD management will have to be persistent in its support if strategic planning is to be implemented.

2 A recent Institute for Defense Analyses (IDA) task force recommended 17 technology panels to improve the coordination of DoD's S&T programs. OSD should be able to determine the extent to which each panel activities would be linked to the strategic plan; if some S&T projects have poor linkage, they could be redirected or canceled. See "Report of the Task Force for Improved Coordination of DoD Science and Technology Programs" (Alexandria, VA: Institute for Defense Analyses, July 1988).

academe, broad national technology goals could evolve, with a "crosswalk" described between technology investment plans and various applications, both military and civil. Joint research projects between agencies, with industry and/or academe, or with other nations could be encouraged. Applications would be left to individual agencies; in the case of DoD this would normally be when mission needs are matched with technologies, i.e., at the advanced development (6.3A) stage. Most projects could be unclassified, with the results flowing into civil, as well as military, applications.

Option 5: Develop a coordinate, Administration-wide program of collaboration and cooperation in defense research and technology.

This option includes two kinds of action. First, better inter-Service research cooperation would be promoted, with some consolidation of responsibilities and lines of authority to improve communication and minimize duplication. The goal should be to bring to bear on key technologies sufficient resources to "make a difference. " Second, a dedicated budget might be established for cooperation in research and advanced technology, involving joint research projects, technology demonstrations, and periodic high-level reviews to assess opportunities for cooperation, monitor progress, and set priorities.

Research collaboration within DoD (i.e., all three Services, DARPA, and SDIO) is widespread today, although much is ad hoc and conducted at a researcher-to-researcher level. This approach should be retained, but augmented with senior-level coordination on priorities, the assignment of lead organizations for key technologies, and a secondment program through which special skills are assembled into multidisciplinary research teams. Over time, this combination of approaches could encourage a ''natural rationalization" of DoD's laboratory structure. The U.K. Research Establishments have evolved this way in the face of serious budget reductions. The Establishments were first brought under a single authority-the Controller, Establishments, Research and Nuclear (CERN)---separating them from the previous direct Service orientation. Lead Establishments were then assigned to areas of technologies with the other Establishments ● 'encouraged" to follow. There was no need for draconian measures. Instead, a gradual rationalization occurred.

From this perspective, DoD and the U.S. defense industry need to exploit foreign technology far more than they do today. To achieve major gains, however, will require the easing of restrictions imposed on industry by strict technology-exchange and export-administration regulations as well as a reduction of time-consuming procedures that govern industrial collaboration. There is another imperative to increase cooperation on international defense research: our European allies are developing a coherent program of intra-European cooperation in civil and military research and technology. Unless the United States develops a policy for transatlantic research cooperation, we may become 'locked out" of their plans. NATO armaments cooperation would suffer a severe blow, and U.S. industry might well lose existing competitive advantages in world markets.

The Nunn Amendment to the fiscal year 1986 Defense Authorization Act (and its subsequent continuation) has been a "shot in the arm" for NATO armaments cooperation. It has given both the Services and U.S. industry incentives to pursue NATO (and now non-NATO) cooperative programs in systems development. A simple extension of the Nunn legislation might provide a similar incentive for research cooperation. A specific budget (6.1/6.2), obligated for cooperative research, would undoubtedly result in increased interest on the part of Services and our Allies.

Option 6: OSD could establish DoD-wide systematic guidelines to enhance the transfer of technology into new or existing weapon systems.

Congress might recommend that DoD develop guidelines for selecting, planning, managing, and evaluating all advanced technology demonstration projects. OSD could develop these guidelines with the participation of the three Services, DARPA, and SDIO. It is important to have such guidelines, since the purpose of DoD's technology base programs is to insert new technology into weapon systems as rapidly as possible.

Because DoD's current technology -transfer process relies heavily on individual initiative, it is inconsistent and haphazard. Developing a DoD-wide advanced technology demonstration process could provide a more rational basis for setting priorities, expedite the rate at which new technologies are adopted, and provide consistent guidance for evaluating the success of various advanced technology development projects.

Option 7: Appoint a civilian research advocate in DoD with oversight of all technology base programs (6.1, 6.2), and a role in coordinating advanced technology development (6.3A) with Service research heads.

The overriding task would be to ensure that the results of DoD's technology base programs are exploited by the Services as soon as possible. Three subordinate functions are critical to this task: 1) an oversight process that augments normal ''peer" review with a management review focusing on non-scientific factors, such as priority, applications, opportunity costs, and cost-benefit; 2) a means for DoD-wide dissemination of data on technologies deemed ready for transition; and 3) procedures for monitoring the efficiency of the transition (i.e., technology transfer) process.

The Administration could use parts of several models; although no single system covers all aspects of this option. In the U. K., the Chief of Defence Procurement (CDP) and in France the Delegue General pour l'Armement (DGA) have full authority over all defense R&D, and procurement. Each has a deputy for land, air, and naval systems, and a deputy for R&D, who is responsible for all "project-free" research. This approach works fairly well for these nations; however, in each case the scope of their technology base programs is less than one-tenth of DoD's—and even less is actually "project-free.'* It might not be appropriate to adopt these models in toto, but they do make a case for OSD to assert more authority over the content of technology base programs.

Neither the U.K. nor France has appointed a technology transition authority, and both have as much difficulty in this area as DoD. Some lessons, however, can be found in West Germany and Japan, especially in the civil fields. In West Germany, only broad civil research goals are promulgated from Bonn, and the private sector is organized to effect transfer. As previous chapters described, two influential private (but largely government-funded) societies are central: 1) the Max-Planck Society performs basic research and serves as a "locomotive" for other research institutes and universities, and 2) the Fraunhofer Society performs applied research and couples closely with industry to effect technology transfer into the marketplace. While not effecting direct control, a number of government-sponsored groups provide oversight and advice. In Japanese industry, teams are formed at early stages of research that consist of researchers and experts from engineering, design, manufacturing, and marketing. Their basic mission is to ensure the fastest practical transition from research to a marketable product.

DoD is well positioned to adopt this option. The Goldwater-Nichols DoD Reorganization Act established the USD(A) to oversee all defense R&D and acquisition. The DDR&E, reporting to USD(A), looks across all of DoD's technology base programs. DARPA's new role in prototyping, and its recently expanded involvement with technological initiatives, provide the framework for a "transitioning" authority. However, budgeting and review authority over most of the technology base program rests with the Services and other DoD components. Congress and the Administration could bring these elements together under DDR&E and charge this senior official with exploiting the results of the government's $10 billion annual investment in research and technology. However, this could result in greater technology push, which some believe could be detrimental to U.S. defense efforts.

Option 8: Streamline the current OSD organizational structure for RDT&E programs.

Peter F. Drucker has discussed the importance of sound organizational structure:

> Few managers seem to recognize that the right organization structure is not performance itself, but rather a prerequisite of performance. The wrong structure is indeed a guarantee of nonperformance; it produces friction and frustration, puts the spotlight on the wrong issues, and makes mountains out of trivia.[3]

[3] U.S. Senate, "Defense Organization: The Need for Change," Staff Report to the Senate Committee on Armed Services, Oct. 16, 1985, p. 92.

The current DoD organizational structure for research, development, test, and evaluation (RDT&E) appears ill-suited to its role. Both civilian and military representatives have argued that if DoD's technology base programs are primarily responsible for maintaining DoD's scientific and technological superiority, then the official in charge of the RDT&E program should report directly to the Secretary of Defense. The Goldwater-Nichols Act puts primary responsibility for the technology base program with the DDR&E, who reports to the USD(A). Unfortunately, DoD's general preoccupation with procurement issues has diverted the attention of the USD(A) from important technology base issues.

Within ODDR&E, the Deputy for Research and Advanced Technology (R&AT) is responsible for oversight of the Services' S&T programs, while the Director of DARPA reports directly to the DDR&E. This organizational arrangement has made it difficult to coordinate DARPA's activities with those of the Services fully. Although DARPA's mission is different from the Services', its ultimate responsibility is to support the development of high-risk technology for the Services. This activity could be facilitated by requiring DARPA and the Services to report to the same office.

Finally, any organizational review focusing on the technology base should include SDIO. Since the Director of SDIO reports to the Secretary of Defense, there is no formal technology base coordination with the Services and DARPA. If OSD is to develop an effective technology base investment strategy, much closer coordination will be needed between SDIO, DARPA, and OSD.

Option 9: Improve DoD's ability to attract top-quality political appointees and high-level civil servants.

Current and former DoD S&T personnel assert that DoD is unable to attract individuals of high scientific and managerial talent. They contend that this problem must be solved if competent civilian leadership is to be restored within OSD and the Services.

There appear to be three specific actions that Congress could take to help resolve this problem:

1. increase salaries of DoD science and engineering personnel,
2. amend the conflict-of-interest statutes, and
3. amend the Federal tax laws with respect to the forced divestiture of assets.

These recommendations are not new, but are presented as options to highlight a problem that appears to be deepening.

Numerous studies conducted by the Federal Government and the private sector have documented the growing disparity between compensation for top Federal S&T personnel and that of their university and private-sector counterparts. Congress could examine the possibility of eliminating pay caps for senior executives within DoD and instituting compensation that reflects the current market for such individuals.

DoD should also have a pay structure that compensates officials on the basis of their S&T management responsibilities. Unlike the private sector, the Federal pay cap fails to distinguish between a laboratory director who manages the activities of 3,500 people versus a director who oversees a 500-person laboratory-or for that matter an OSD Senior Executive Service (SES) manager responsible for supervising a 12-person staff. DoD cannot pay top scientists and engineers what the private sector can.

Past and current DoD civilian personnel assert that potential top-level political appointees—and scientists and engineers—are often reluctant to make the financial sacrifices required under the Federal conflict of interest or "revolving door" statues in order to accept a high-level DoD position. As the Senate Armed Services Committee study on the DoD organization observed, rather than altering the divestiture requirement, Congress could alter Federal tax law with respect to the forced sale of assets.[4] This would still protect the objective of maintaining public confidence in OSD officials, but it would reduce the onerous financial consequences of accepting public service.

[4] Ibid.

Structure of the Laboratory System

Option 10: Restructure the military's RDT&E organization by establishing corporate laboratories for each of the military services and creating some full-spectrum weapons development centers.

The creation of "corporate" laboratories dedicated to individual Services would rationalize the conduct of DoD's RDT&E program. Corporate laboratories could perform the bulk of each Service's technology base work, by generating research concepts and bringing them to the demonstration phase. The laboratories' mission would be to marshal the technical resources of their Services to attack new objectives. This would require DoD to increase its investment in technology base programs, rather than have the corporate laboratories compete with academe for a shrinking 6.1 budget.

The existing engineering and development centers would have to continue to establish priorities in their development programs, pursue a dialogue with the corporate laboratories, and position themselves to transition technology. At their discretion, they would also compete for that portion of the corporate laboratory's funds that would sponsor external technology base work.

The creation of corporate laboratories would involve more than establishing the equivalent of the Naval Research Laboratory for the Army and Air Force. Corporate laboratories could receive funding from a variety of sources, under procedures analogous to those by which the Department of Energy (DOE) national laboratories-and even some of DoD's federally funded R&D Centers—receive their funds. They would receive multiyear block funds to cover the programs authorized by their respective Service, plus reimbursable funds to support work for others. In this context, "others" would include the other military Services, independent Defense agencies like DARPA and SDIO, and civilian Federal agencies.

The Services might create semiautonomous units within their corporate laboratories for certain kinds of high-risk, high-payoff programs. A Service might consider a particular discipline or mission area so important that it would justify the creation of specialized units working on them, The Army has used this approach in setting up its Night Vision and Electro-optical Laboratory and the Life-cycle Software Engineering Center. Even research in highly specialized areas requires collaboration by experts in several disciplines. And if the work is well done, the results of such specialized research can flow into other areas.

Corporate laboratories could create a much richer network of external relationships----comparable to those enjoyed by DOE's national laboratories. The laboratories' work in basic research and exploratory development could make them more attractive partners for collaborative ventures. These relationships could include: technology transfer mandated by the Stevenson-Wydler Act; work for non-Federal sponsors like that done by the National Institute of Standards and Technology (NIST); and the building of formal and informal communication networks with universities and industry. Far from precluding collaborative work, the corporate laboratories' missions would virtually require it. The point is to avoid the two extremes: laboratories serving as "pass-throughs" for development money, on the one hand, and on the other, the inbreeding that results when laboratories try to do everything in-house.

Congress and DoD might also create weapons development centers to pursue work on significant military systems problems, as was suggested in a 1966 Defense Science Board (DSB) report.[5] While private industry would continue to do virtually all of the engineering and production work, these centers would encompass the full spectrum of activities from advanced development (6.3B) to the creation of feasibility models to demonstrate ''proof-of-principle" in a military environment. These centers would be project-oriented research and engineering institutions working in broadly conceived weapons areas.

As the DSB defined it, weapons development centers would have certain family resemblances. They would have a critical mass of at least 1,000 scientists and engineers; the center director would have direct control over all the necessary resources;

[5] Defense Science Board, ''Department of Defense In-House Laboratories, " report prepared for the Office of the Director of Defense Research & Engineering, Oct. 31, 1966, p. 9.

center specialists would participate in determining military requirements associated with its mission; and the center would be involved in the initial procurement of equipment. Instead of serving as pass-through agencies, each center would do most of its development engineering in-house, with contracts serving to support such work.

The advantages of this approach are straightforward. A weapons development center would have the critical mass to work on a range of problems, clear responsibility for its end products, and the ability to respond quickly to military emergencies. The existence of such centers would enable DoD engineers to work on military problems and to bring together specialists in many disciplines.

In creating such centers, certain problems would have to be solved; for example, how would a center concentrating on aeronautical development relate to one whose mission encompassed missile design? Further, each center would inevitably be biased toward its own system, even if another kind of weapon or platform would provide a better military solution. As the DSB panelists were well aware, by their nature such centers would tend to commit themselves to long-term projects, even in the face of evidence that other approaches might work better. Such centers could easily reduce their contractors to suppliers of narrowly specified equipment and services, with nothing to offer to the center's portfolio of ideas.

Option 11: Consolidate some military laboratories and close others.

A case can be made that there are too many DoD facilities whose contribution to the defense technology base is difficult to discern. In the current environment, both Congress and DoD should explore merging some facilities that can no longer stand on their own and closing others. This option appears radical only if one assumes that Federal facilities are permanent. There is no definite Federal policy on the closure of government facilities, although something can be gleaned from Office of Management and Budget (OMB) circulars barring agencies from performing activities more suitable for the private sector. Agency officials have asserted principles that might justify closing a substandard laboratory: if it has served its initial purpose, if there is no likelihood that a new role for the laboratory can be found, or if closing the laboratory would not leave a significant gap in the national capability to perform R&D.[6]

Consolidation and closure may be more palatable options now than at any time since the mid-1970s. The closing or merging of R&D facilities has not always been unthinkable. In the early 1970s, for instance, the Air Force undertook a major reorganization of its laboratories, converting its Cambridge Research Laboratories from a basic research to an "exploratory development" institution, closing the Aerospace Research Laboratory at Wright-Patterson AFB, and delisting one of its contract research centers. This was also the period when NASA closed its Electronics Research Center and transferred the facility to the Department of Transportation; and when part of the Army's Fort Detrick became a contractor-operated facility working for the National Institutes of Health.[7]

The present budgetary environment will probably encourage the Services to make difficult but necessary choices. Short of actual closure, the Services could employ a number of strategies to keep the weaker laboratories going—authorizing them to seek support from other sponsors, clarifying their roles, and redirecting them. But at some point, the Services may decide that they can no longer carry all of the research centers they currently support. For a Service, there may well be a bigger payoff in cutting, say, 20 percent of its laboratories than in slicing 20 percent from each laboratory's budget.

The advantages of this approach are threefold: first, fewer laboratories would make the remaining ones more visible to their sponsors; second, more funding available to the remaining centers would strengthen them and probably produce more worthwhile research; and third, closing some laboratories

[6] Arnold S. Levine, *Managing NASA in the Apollo Era* (Washington, DC: National Aeronautics and Space Administration, Scientific and Information Branch, 1982), p. 137.

[7] For these and other examples, see T.J. Wilbanks, "Domestic Models for National Laboratory Utilization," in Energy Research Advisory Board, *The Department of Energy Multiprogram Laboratories, Volume II: Special Studies* (Oak Ridge, TN: Oak Ridge National Laboratory, September 1982), pp. 66-67.

is a necessary step to consolidating disciplines that should go together.

DoD could possibly strengthen its technology base with fewer and larger laboratories and engineering centers, because they would have the critical mass of professional staff to move on several research fronts. On the other hand, the question of which facilities to merge or close is exceedingly complex and highly political, and changes would require several years to implement.[8] A useful precedent for an approach might be found in the recent base closure legislation. Adopting a similar "package deal" might ease the process.

Option 12: Promote the sharing of "national" facilities and the interchange of personnel between government laboratories.

In the current budgetary environment, few agencies have the luxury of duplicating existing facilities. The sheer expense of building a new wind tunnel or particle accelerator is forcing agencies to turn to collaborative ventures—a tendency that should be encouraged. At the same time, no agency will willingly depend on another to accomplish some of its most important programs. The creation of national facilities available to all qualified users is one way out of this impasse.

The multiprogram DOE laboratories are not the only ''national" entities that the government sponsors. Since 1980, NASA has opened two national facilities at its research centers: the National Transonic Facility at Langley Research Center, and the Numerical Aerodynamic Simulator at the Ames Research Center. Both are world-class facilities that keep the United States in the forefront of aeronautical research and serve all U.S. commercial, military, and scientific requirements.

The creation of such national facilities bears on the DoD laboratories in several ways. First, and most obviously. they would obviate the need for DoD to duplicate—at great expense—facilities that already exist, Second, as resources available to all qualified users, they actually make the military laboratories more productive, with no investment beyond that required for covering their share of facility operations. And third, the NASA facilities offer the options of either onsite use of facilities or remote access, via data communications networks that are now in place.

The same principle of shared use applies to NIST and the multiprogram DOE laboratories. The mission of NIST demands extensive work for other agencies in a variety of areas. At the same time, the DOE weapons laboratories are seeking a broader defense role in nonnuclear weapons research. Given their capabilities, one might expect that the DOE laboratories' multidisciplinary strengths could become a major resource for DoD.

Program budget pressures will no doubt force DoD laboratories to work more closely with each other and with those of other agencies. Congress could explore the possibility of giving corporate laboratories created by each Service the freedom to take on the work of others. Like the DOE laboratories, a certain portion of each laboratory's operating budget would include work undertaken for another Service, another Federal agency, or even State and local governments. By working for others, laboratory scientists and engineers would acquire more of a ''hands-on" acquaintance with dual-use technologies than an individual Service might be able to fund. A broader base of interests would, in turn, allow researchers from all the Services to work on many generic technologies (e.g., software engineering, weapons simulation, and high-speed processing) that could lead to Service applications.

It might also be to the DoD laboratories' advantage to promote an exchange of personnel with other facilities working in similar areas. There are precedents for such assignments. For many years, NIST has had a Research Associates program, whereby scientists and engineers from industry can come to NIST at their company's expense to work for a specified period on projects of mutual interest. The DOE laboratories have had even closer ties with outside organizations, not least because their contractor status virtually demanded it. These arrangements include joint ventures with industry, summer study programs, joint appointments with the operat-

[8] Another option, not further considered here, would be t. keep certain laboratories in the "doub~ul" category open, while leaving them free to seek support from any sponsor willing to provide it. A military Service would not be responsible for assuring a total level of support. Instead, the lab would be placed on a footing analogous to Naval Industrial Funding, with military and other customers paying for much of the cost of operations.

ing contractor, and the creation of university consortia like Oak Ridge Associated Universities.

A program to promote short-term exchanges of laboratory personnel would serve DoD aims in many ways. It would give DoD scientists and engineers a better idea of the research being sponsored at DoD and other government laboratories. It would enable professionals from different services to work on generic, or cross-cutting, technologies. Finally, it would promote the idea that DoD laboratories—particularly the corporate institutions—are resources that should be freely available to all of DoD, as well as some of its industrial contractors.

Laboratory Management

Option 13: Convert some government laboratories to government-owned, contractor-operated (GOCO) status.

From time to time, government panels like the White House Science Council and DSB have suggested that some government-operated labs should convert to GOCO status. Experience in such conversion is limited to the partial 1983 conversion of a small DOE technology center to private operation.[9] All other GOCO laboratories have had this status since their inception. The issue that DoD and the Congress should consider is what, if any, advantages would flow from a GOCO conversion that could be achieved in no other way. It is significant that, in its 1987 summer study, the DSB proposed such a conversion for existing laboratories mainly as an alternative to improving their operation within the system. As the study group put it, ''where existing government laboratories are not performing well, conversion to a GOCO laboratory has some attractive properties. " But it also added that "such conversion would involve significant disruption and political opposition. "[10]

Based on the DOE's experience, the Federal R&D community knows something of the advantages and disadvantages of the GOCO approach. The greatest of these advantages is flexibility in personnel management: flexibility in developing personnel systems; flexibility to set salaries at levels comparable to those in the private sector; and flexibility to move staff from one activity to another on short notice.[11] And provided they comply with Federal norms, GOCOs face a somewhat lighter regulatory burden than do their government counterparts.

GOCO arrangements also carry disadvantages. Some analysts claim that GOCO status reduces a laboratory's commitment to its sponsor's mission, and that there may be a perceived conflict of interest if the contractor is a for-profit corporation. Other, more fundamental criticisms are that the system fosters a lack of accountability and that, by turning technology development over to a contractor, the government loses control of the operations of its laboratories. Nor are GOCOs free from the more burdensome kinds of oversight. If anything, these institutions tend to impose on themselves the kinds of burdens from which their status as GOCOs supposedly exempts them.

In sum, GOCO status may be an option under carefully specified conditions: if an agency is considering a new facility; if government operation forecloses the possibility of improving a laboratory's operations; or if the sponsoring agency wants the expertise of an industrial contractor for production facilities or of a university for research and development. At this time, there may not be enough hard evidence either way to justify the conversion of a government laboratory to GOCO status.

Option 14: Eliminate institutional barriers to the effective operation of DoD laboratories.

Congress could facilitate change by extending practices at certain facilities to the rest of DoD's R&D community. The measures discussed below are in line with the DSB's 1987 recommendation that each Service select at least one ''representa-

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[9] In 1983, the Energy Department transferred responsibility for its Bartlesville Energy Technology Center to the Illinois Institute of Technology Research Institute (IITRI). Under a cooperative agreement between DOE and IITRI, the center, renamed the National Institute for Petroleum and Energy Research, would work for both government and industry. IITRI is responsible for the facility and shares operating costs, but receives no fee. The contract provides that fees earned from industrial clients revert to DOE, and that for basic research, IITRI must write an annual work plan for DOE approval.

[10] Defense Science Board, "Summer Study on Technology Base Management: How to Improve the Effectiveness and Efficiency of the R&D Process," report prepared for the Office of the Under Secretary of Defense for Acquisition, December 1987, p. 15.

[11] On these and Other GOCO features, see Office of Science and Technology Policy, Executive Office of the President, ' 'Final Report of the Working Group on Federal Laboratory Personnel Issues, " July 1984, p. 24.

tive" laboratory, and so alter its management that it could attract the highest quality staff, improve operations, and provide management with "authority and accountability."[12]

The most immediately obvious changes would be in personnel management. For example, Congress could extend the approach embodied in the China Lake experiment (described in ch. 5) to all DoD laboratories. This would give technical directors and their division managers added flexibility to recruit and promote effectively: broad pay bands that incorporate a simplified classification scheme; an employee appraisal system that links pay to performance; and an emphasis on performance as a primary criterion for retention. If anything, the China Lake approach could be more carefully tailored to the problems of professionals working at government laboratories. DoD might combine features of both the China Lake and NIST demonstration projects: the consolidation of 15 grades into a few broad pay bands and the delegation of classification authority to line managers that is common to both projects; and NIST's direct-hire authority and the ability to offer its professional employees total compensation "comparable" to that offered in the private sector for the same positions. In addition, Congress might consider allowing laboratories to pay exceptional scientific and engineering talent market rates above civil service ceilings, and pay competitive salaries for all technical employees.

This option raises two opposing questions. Why should an approach tried at three facilities be extended to the rest of DoD? Conversely, if the China Lake/NIST approach has been successful, why not extend it government-wide? China Lake demonstrated that a simplified personnel system could raise employee morale and lead to higher retention of more capable professionals, even if it did not automatically lead to government pay scales that were more competitive with the private sector. In answer to the question, "Why not government-wide?" it can be argued that the current DoD (and central oversight agency) approach to personnel and financial management violates a basic rule of equity: Do not treat unlike institutions as though they were alike. A scientist at the Air Force Wright Aeronautical Laboratories should not be covered in quite the same way as a Treasury official who maintains the government's central accounting system or a General Services Administration official who manages public buildings. The merit of the China Lake and NIST approaches is precisely that they recognize that different groups deserve to be treated differently.

The China Lake experiment may give technical directors and division chiefs an irreducible minimum of authority in hiring, promoting, and firing. Similarly, a laboratory technical director should have direct authority over all of his organization's functional offices, such as personnel, procurement, and data processing. Lacking such authority, no technical director can be fully responsible for his laboratory's operations.

Congress should also consider reforming the ways by which the laboratories receive and spend their operating funds. Studies have shown the effects of overmanaging and underfunding DoD laboratories. In particular, laboratory officials have to cope with uncertain funding—so uncertain that funds often do not reach them until late in the fiscal year.

Multiyear and no-year funding might give DoD laboratories the same kind of institutional stability that the DOE's national laboratories enjoy. Especially where technology base work is involved, technical directors need the assurance that work will be both fully and continuously funded, that funds will cover all expenses, and that funding will be assured over the life of a project. Block funding could very well provide this assurance. Under this approach, a laboratory would receive a lump sum sufficient to cover the full costs of technology base work, without the need for allocating funds under existing DoD budget categories.

Laboratory directors also need discretionary funding to start new work, to sustain projects where other funding is incapable of carrying them to completion, and to encourage cooperative ventures between the laboratory, universities, industry and other Federal agencies. The 1983 Packard Report recommended that between 5 and 10 percent of a laboratory's annual budget be reserved for independent R&D at the director's discretion—a range that would permit potentially important work that

[12] Defense Science Board, op. cit., footnote 10, p. 19.

now goes unfunded.[13] While officials will disagree on the appropriate size of the discretionary pot, this much must be said: if a Service considers a laboratory's mission worth doing at all, it should accord a certain percentage of discretionary funds as a matter of right.

The acquisition process is another area ripe for reform. Evidence mounts that the length and complexity of acquisition cycles impose tremendous paperwork burdens on military laboratories. Congress is aware of these problems, and has put in place mechanisms that have somewhat eased the laboratories' burdens. These include the use of Broad Agency Announcements for research and exploratory development, the exemption of certain kinds of scientific computers from the 'full and open competition" provisions of the Competition in Contracting Act, and the use of a simplified procedure for Small Business Innovative Research (SBIR) procurements. These approaches could be extended to other operations, for example, the acquisition of office equipment and general-purpose computers.

A major reform in acquisition must reflect a proper sense of the laboratories' missions. A laboratory, most of whose personnel monitor contracts, cannot easily carry on its inherently governmental functions, act as a smart buyer, and serve as a center of technical excellence. And yet the majority of military laboratories are conduits through which buying commands funnel money to industrial contractors. Instead of the laboratories acting as pass-throughs for development work, it may be that such procurements could be handled directly by the Service commands, with the laboratories providing supporting research before a buy occurs and technical consultation afterwards.

Option 15: Allow DoD laboratories to contract for those services that are not inherently governmental.

As an alternative to GOCO conversion, DoD laboratories might elect to contract for those services that are not essential to the conduct of R&D. The principal guidance on acquiring commercial products and services needed by the government is contained in OMB Circular A-76. Although that Circular specifically exempts R&D work from its coverage, it does include "severable" commercial activities in support of research and technology development. Given the blurring of lines between, say, scientific programming and the work of in-house researchers in artificial intelligence, it is often difficult to distinguish between activities that are and are not covered by A-76.

The important issues, though, concern efficiency more than policy. A facility that contracted out all support services would achieve a status somewhere between government operation and GOCO. Such contracting out would serve several purposes. It would enable laboratories to pay market rates for support services; give laboratory executives greater flexibility in hiring workers and dismissing them when they were no longer needed; and bring in professionals who would not work directly for the government. Under such a system, a laboratory could, for example, contract out facility management, supply operations, and financial and administrative processing. Scientific and engineering professionals would remain government employees, either under a reformed personnel system based on the China Lake model or some special system, like the one used to pay faculty of the Uniformed Services University of the Health Sciences.

The best example of this hybrid system can be found in the NASA centers. Since its establishment in 1958, NASA has routinely contracted out almost 90 percent of its total budget, with much of that going for center operations. NASA sponsors two kinds of contract support. First, an agency installation may be managed by government employees, with NASA awarding a master contract for housekeeping and base support and separate contracts for more specialized functions. This is the arrangement at the Kennedy Space Center, where EG&G provides base support, and at the Johnson Space Center, where Rockwell International is the prime contractor for mission support. Second, a NASA installation may be government-run, but without a master support contract. Instead, the center would let separate contracts for services such as technical writing, janitorial services, image processing, com-

[13] Executive Office of the president, "Report of the White House Science Council, Federal Laboratory Review Panel," Office of Science and Technology Policy, May 1983, p. 8.

puter programming, or the operation of tracking stations.

It is important to determine if a hybrid system along these lines could work at DoD. The advantages listed above seem clear enough. The disadvantages are not nearly so. Nevertheless, the bifurcation of support and essential functions might be difficult for a laboratory to sustain over the long run. Further, there are legal questions relating to the supervision of contract employees by government officials. It is the Office of Personnel Management's position that such supervision constitutes a personal service contract and is illegal. It could be argued, though, that so long as the sponsoring agency simply lays down a general requirement—for example, "We need someone to run this facility ''—it could remove such contracts from the prohibited category. So long as a few military laboratories are candidates for GOCO status, the hybrid arrangement could be an attractive alternative-provided the legal and other uncertainties surrounding it are removed.

Funding and Budgeting

Option 16: Institute multiyear budgeting for DoD's RDT&E program.

DoD first submitted to Congress a 2-year RDT&E budget request for fiscal year 1988 and 1989. Congress approved a 2-year authorization, but appropriated no funds for the second year. Congress might consider reviewing the feasibility of providing multiyear appropriations for DoD's technology base program.[14]

Multiyear appropriations should decrease the amount of time OSD personnel spend preparing, reviewing, and defending annual budgets. It would also add stability and efficiency to technology base activities by providing known funding levels for future S&T programs. By reducing the number of programs that have to be acted on in any one year it could also provide Congress with time for more thorough oversight activities, such as giving the Appropriations Committees more time to study the recommendations of the authorizing committees.

Certainly, there are some disadvantages to multiyear funding. Congress would be giving up some of its annual oversight powers. Further, if budget projections proved to be inaccurate it could be difficult to make mid-cycle revisions, or to accommodate changes in budget priorities. Yet, multiyear budgeting could give OSD and Congress additional time to consider technology base activities in terms of strategic options. Combined with a strategic technology base plan, a multiyear budget could improve the ways in which Congress reviews DoD's technology base programs. Lacking a coherent technology base strategy, OSD now presents its S&T budget to Congress primarily as the sum of individual program elements. An overall strategic budgeting approach would help Congress understand the trade-offs and implications of different technology base funding options.

Finally, multiyear appropriations could facilitate DoD's ambitious goals for allied R&D cooperation. By 1994, 10 percent of DoD's RDT&E budget is to be committed to joint R&D projects with NATO and other allies. Many Pentagon officials believe that this goal is not attainable under the present annual budgeting cycle. They argue that the European Allies earmark funds for 3 to 5 years for R&D programs, and that European officials may be reluctant to enter into numerous high-risk, cooperative R&D programs with the United States unless Congress is willing to guarantee funding for more than one year.

Option 17: Separate the technology base budget from the development, test, and evaluation portion of the RDT&E budget.

Although the ultimate success of many development programs may depend on underlying technology base projects, the 6.1-6.3A portion of DoD's budget is often overlooked in the "high-stakes" game of RDT&E budgeting. The Pentagon's top-level budget review committee, the Defense Resources Board (DRB), seldom considers individual technology base programs or priorities; rather, it usually addresses only broad issues of spending level.

[14] In this case, multiyear appropriations could mean a congressional funding commitment Of from 3 to 5 years, with Congress reserving the right to review the program at the conclusion of its second or third year of funding. Roughly half the Federal budget is permanently appropriated. (A permanent appropriation is budget authority that became available as a result of previously enacted legislation and does not require annual action by Congress.)

USD(A) could provide Congress with an RDT&E report that clearly highlights the achievements of the Department's research, exploratory development, and advanced technology development programs. The report could summarize current and future major thrusts of the technology base program, demonstrating the linkage between these activities and future military capabilities. It would also be useful if the report were to address potential civil applications of selected technology projects, in recognition of the increasingly dual-use nature of advanced technology.

The funding portion of the report should clearly separate technology base funding trends from the remaining "DT&E" portion of the budget. This breakdown could provide Congress with a clear picture of DoD's RDT&E funding priorities-and thus the "health" of the defense technology base. For example, if the report were produced today it would reveal that research (6.1) and exploratory development (6.2) programs have suffered significant declines in recent years. If Congress wished to do so, it could instruct USD(A) to halt this funding decline.