Chapter 1

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Not long ago, the United States was the undisputed technological leader of the world. U.S. military equipment was meaningfully and undeniably more sophisticated than that of the Soviet Union, and our allies sought American technology for their own defense efforts. American companies developed and sold high-technology products to a world that could not produce them competitively. Defense-related developments led American technology and often ''spun-off" into the civilian sector, creating products and whole industries. This reinforced a U.S. defense posture based on using technological superiority to offset whatever advantages the Soviet Union and other potential adversaries might have.

As we approach the 21st century, much has changed. The model of U.S. technology leading the world, with defense technology leading the United States, still retains some validity. But it is a diminishingly accurate image of reality. Soviet defense technology increasingly approaches our own, and sophisticated weapons appear in the hands of third world nations not long after their introduction into Western and Soviet arsenals. At the same time, the U.S. military has been plagued with complex systems that do not work as expected, work only after expensive fixes, or simply do not work. Most are high-priced and take a long time to develop. Increasingly, leading edge technology comes from an internationalized, civilian-oriented economy, which puts a premium on exploiting technology as well as developing it.

As a result, the Nation faces a complex set of interrelated problems that bear on its ability to continue to develop and manufacture in sufficient quantity the technologically advanced materiel on which we base our national security posture. There are specific concerns about: 1) the continued ability of the Department of Defense (DoD) and its contractors to develop the technologies it needs; 2) the ability of DoD and the defense industries to turn these technologies into useful, affordable products in a timely fashion; and 3) the ability of DoD to exploit the technology that is being developed worldwide in the private civil sector.

Concern over the availability of the latest technology for defense applications, and the ability of U.S. industry to engineer and produce equipment based on that technology rapidly and affordably, led the Senate Armed Services Committee to request that OTA undertake an assessment of the defense technology base. This is the second report of that assessment. The previous report, *The Defense Technology Base: Introduction and Overview,*[1] described what the defense technology base is and presented the major problems facing the Nation. This report looks in depth into some of the issues raised in the previous report. It identifies strengths and weaknesses of the U.S. defense technology base and analyzes options for enhancing the strengths and remedying the weaknesses.

The summary of this report (ch. 3) is divided into three sections. The first addresses the strategic management of DoD technology base programs. It examines the system by which the goals of the technology base programs are identified as well as the methods used to allocate resources in order to reach those goals. The emphasis there is on the role played by the Office of the Secretary of Defense (OSD) in guiding and coordinating the efforts of the Army, Navy, Air Force, and other DoD elements. It also addresses the management of the laboratories run by the three Services. These issues are explored in greater detail in chapters 4 through 7. The second section of the summary

[1]U.S. Congress, Office of Technology Assessment, *The Defense Technology Base: Introduction and Overview—A Special Report*, OTA-ISC-374 (Washington, DC: U.S. Government Printing Office, March 1988).

analyzes delays in getting technology into the field (see ch. 8 for supporting details). The final section is concerned with ''dual use" technology, i.e., technology used in both the civilian and defense sectors (see ch. 9). Volume 2 of this report contains detailed supporting material on selected topics for those wishing to explore them in greater detail.

The remainder of this chapter provides a brief background on the topics of the report: management of defense technology base programs and facilities; technology transition; and dual-use technology. Those familiar with these subjects may wish to skip directly to chapter 2, which presents issues and options for Congress.

A large part of the technology that ultimately winds up in weapons and other defense systems is either developed or directly sponsored by DoD. This is particularly true of technology that is altogether new, makes a major difference in the performance of defense equipment, and is of little interest to commercial industry. How DoD runs its technology base programs is therefore of major importance. In recent years DoD has spent roughly $9 billion per year on its technology base programs: research (budget category 6.1), exploratory development (6.2), and advanced technology demonstration (6.3A). Roughly 40 percent of this is spent by the three Service departments (Army, Navy, and Air Force). Another 14 percent is controlled by the Defense Advanced Research Projects Agency (DARPA, formerly ARPA). Another 39 percent finances the Strategic Defense Initiative Organization (SDIO).[2] Although all of SDIO's funds are allocated in the 6.3A budget category, according to SDIO only about 15 to *20* percent is actually spent on technology base activities.

The three Services run their technology base programs and their R&D institutions differently.[3] Some of this is the result of recent planning, while much of it results from organizational 'cultures" developed over many years. The Army's effort emphasizes decentralization. The Army runs some relatively small research laboratories which focus on selected topics, while larger research, development, and engineering centers are closely tied to "buying commands."[4] The Navy stresses in-house research and development both in the Naval Research Laboratory, a broad-based corporate lab that serves and underpins the Navy's entire technology effort, and in full-spectrum research and development (R&D) centers that nurture ideas from basic research through preproduction stages. These centers have traditional ties to the equipment needs of various functional parts of the operational Navy, but are not formally tied to specific buying commands. The Air Force, which contracts out more of its R&D effort than either of the other Services, centralizes its efforts within the Air Force Systems Command. Its technology base programs are seen as a link between buying commands (the divisions of Systems Command) and the defense industry. The basic theme is to buy technology and make sure it gets to industry. The Air Force has recently adopted the position that technology base programs should be a ''corporate investment" funded at some fixed fraction of the budget. The Air Force puts a greater emphasis on R&D-related career paths than do the other Services.

With such diversity (including that added by DARPA, the other defense agencies and SDIO), if the program is to have overall planning and coordination—and not everyone agrees that it should—leadership almost has to come from the Office of the Secretary of Defense.

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[2]Other defense agencies account for approximately 7 percent of DoD technology base program funding. (See footnote 1, p. 19 of this report.)

[3]All three, however, Orient their programs heavily toward current product areas. Nontraditional ideas do not fit well into the system.

[4]A buying command is one of a number of organizations within the Armed Services responsible for developing and buying military equipment and systems.

Actual R&D is performed primarily by industry, universities, and the laboratories run by the Services.[5] In most cases laboratory is a misnomer, although a convenient shorthand. These latter institutions, as a group, perform technology base work in addition to advanced and even full-scale development. They also provide other functions to DoD. Their efforts are generally divided among performing in-house work, contracting out work (and monitoring contractors' efforts), and providing technical advice to program managers and buying commands (a function often referred to as being ''smart buyers"). It is very difficult to describe a typical DoD lab because they differ in size, in the mix of these functions, and in a number of other basic elements. However, what they all have in common is that they are owned and run by the government, staffed by government employees, and subject to a large number of laws and regulations. There has been a continuing and, in recent years, rising concern that they are inefficient, ineffective, self-serving and duplicative of industry work, and increasingly hampered in doing their jobs by the conditions of being part of the government.

DoD has some important unique characteristics, but it is not the only large organization that relies heavily on new technology nor the only establishment that runs R&D programs and facilities. Large corporations and the governments of other nations do the same. Their specific goals may not be the same: DoD buys defense equipment to meet a threat, corporations seek to develop and market products in a competitive market, and other nations seek to enhance their economic positions as well as their security. But all share the general goal of marshaling technology assets to achieve some purpose. To some extent, these other entities provide some of the background against which DoD must plan and execute its programs (certainly the evolution of the threat is another). But they also provide potential models of management techniques that might be useful to DoD in solving its management problems.

The technology base programs and laboratories produce technology, but that technology is of no use unless it makes its way into fielded systems that the military can use. There is great concern that it simply takes too long to get new technology into the field. Systems take upwards of 10 years to develop and produce, and when they finally become operational, they often embody technology that is viewed as obsolete, either because better technology exists in the labs or in industry, or because consumers can purchase better technology at their neighborhood stores. In the previous report, OTA found that delays are not a technology base problem: they occur after the technology is developed. However, delays are a major obstacle to keeping our technological lead in fielded equipment.

While a majority of the most visible technology in defense systems comes from DoD and companies that contract with it, a significant part comes from the "nondefense" sector. Mundane technology—like bolts—has often come from industries that sell to both military and civilian customers. And at the subcomponent level, much also comes from the civilian side. Increasingly, these "dual-use industries" are sources of advanced technology, sources from which DoD should be able to draw (and in some cases must draw, because the technology is ahead of what the defense world is building). Increasingly, leading-edge technology is developed in the civilian sector and then finds its way into defense applications. But government rules that make doing business with the government different from selling in the commercial sector create significant barriers to companies moving into government work. Some of these companies are heavily involved in defense work, while others now do little or no business in the defense

[5]Work is also done by other government laboratories (e.g., the Department of Energy national labs and NASA labs) and various private Profit-making and non-profit organizations.

sector. Moreover, dual-use industries are becoming increasingly internationalized, raising issues of the competitiveness of U.S. firms in the world market and dependence on foreign suppliers in defense procurement.

DoD has become less able to drive the direction of technology. While some areas are pursued primarily for defense applications, others are molded by the consumer market. Large commercial markets generate enormous amounts of capital that fuel research and development. That R&D is primarily directed toward applications and products with large potential commercial payoffs. The relatively small amount of business represented by sales for defense applications is in many cases not significant enough to swing the direction of development. There are still many important areas of development that are primarily, or exclusively, defense-oriented. But the pattern of technology originating in the defense sector and "spinning off" into the commercial sector is being replaced by parallel development and, to use the Japanese term, ''spin on" of commercial technology to military applications. Faced with this situation, DoD can buy cutting-edge technology developed in the civilian sector, or it can spend large amounts of money to keep a comparable leading edge resident in-house or with defense contractors.

As a consequence, DoD finds itself (or its contractors) having to buy from companies that do not need its business. Large aerospace companies have to play by DoD's rules: defense is their only business, or at least an overwhelming component of their business. But small, leading-edge technology companies can make much more money in the private sector without the trouble of playing by government rules. They can opt out of doing defense work.

This report examines dual-use industries through the mechanism of case studies, concentrating on three industries: advanced composites, fiber optics, and software. These present different perspectives. The advanced composites industry is heavily involved in defense business, but U.S. companies may see their commercial base erode as international competition heats up. Moreover, many of the major companies are international or integrated with foreign firms. U.S. fiber optics producers now sell very little for defense applications. But DoD has important uses for their products. Government buying practices form major barriers to these companies doing business in the defense market, and they are beginning to face stiff competition in the civilian market from foreign competitors. Finally, the software industry is one that straddles both worlds, and moves very rapidly. Software is at the heart of most new defense systems, particularly command, control, communications, and battle management systems.

All of these topics have been the subject of numerous studies, which have produced conflicting conclusions. This report pulls together much of that work, along with original research and analysis. Moreover, while DoD management and industrial/trade issues have been the subject of legislation and proposed legislation, the problems are not yet solved. The next chapter discusses the major issues before Congress.