Chapter 1

Introduction and Principal Findings

WHY BE CONCERNED?

For roughly three decades, U.S. national security planning has rested heavily on the premise that superior technology can offset Soviet advantages in numbers of military personnel and major military equipment. But in the past few years there has been mounting concern that the United States is not maintaining the necessary technical lead. If the United States cannot maintain a meaningful technological lead and there are no fundamental changes in the competition between the two superpowers, the nation will be faced with a choice among accepting a significantly decreased level of security, relying more heavily on our allies, or making major increases in the size of its armed forces.

There are several ways to assess a technological lead, but in defense the most important indicator of technological advantage-perhaps the only one that ultimately matters—is the technological lead in fielded military equipment. Wars are not fought or deterred by engineering drawings, but by existing forces.[1] However, major technical advances that are still under development can have profound effects on superpower relationships, as the Strategic Defense Initiative (SDI) has illustrated.

Maintaining a technological lead in fielded military equipment is a far more difficult task than catching up.[2] It requires a dynamic, creative, and innovative technology base, as well as an efficient industrial structure that can rapidly translate technical developments into meaningful numbers of effective products in the field. In trying to close the technology gap, the Soviets have the advantage of following rather than leading. They can learn from U.S. successes and failures, saving billions of dollars by adopting existing technology and avoiding activities already demonstrated to be unpromising. Furthermore, their massive military production capacity can quickly turn new system designs into large numbers of fielded systems. The Soviets could never overcome our lead if they only played catch-up, but they can also draw on a large and improving technology base of their own.

There are troubling indications that the U.S. technological lead in fielded equipment, as well as in some underlying technologies, is eroding. The Defense Department's position is that "In recent years, the U.S.S.R. has significantly reduced the lead previously held by the United States and its Allies *in* technologies of military importance."[3] Both the time to produce the next generation of major items of equipment (tanks, airplanes, ships, missiles, etc.) and the time to translate new technological discoveries into fielded equipment are increasing. The latter is particularly ominous because once a technology is discovered, the United States is more or less in a race with the Soviets to get it into the field. If, for example, the United States develops a particular technology 3 years before the Soviets learn about it, but takes 4 years longer than the Soviets do to turn it into fielded equipment, the U.S. lead will have been negated. Furthermore, if each year the Soviets produce three times as many pieces of equipment using that new technology as the United States does, the United States will find itself behind in fielded capability.

U.S. equipment tends to be complex and costly, and therefore tends to get built slowly

[1] Quality of equipment is not the only factor that matters. Numbers, particularly numbers of the most advanced equipment actually in the field, are important. So are factors such as training, leadership, geography, and logistics.

[2] The difficulty of maintaining a meaningful technological lead may itself call into question the validity of relying on a strategy that requires such a lead. That, however, is a separate topic. This report begins with the premise that the United States seeks to maintain its technological lead.

[3] U.S. Department of Defense, Soviet Military *Power,* 1986, p. *103.*

once production starts. Much time is taken getting the "bugs' out of new systems and training crews to be proficient in their use. This reflects a technological emphasis on higher military performance at the expense of factors such as cost and maintainability, and an emphasis on the technology of design over the technology of production. Cost reductions on the subsystem and component levels generally fail to translate into less costly systems. On the bright side, once the bugs are out, many recent U.S. systems have proven more reliable, available, maintainable, and operable than their predecessors. And as Soviet equipment becomes more complex it also tends to be plagued with the problems attributed to U.S. systems.

Congress is concerned over the health of the defense technology base. Particular concerns include the apparently lengthening time to translate laboratory advances into effective and dependable fielded systems; declining U.S. leadership in vital high-technology industries; and a downward trend in the proportion of the defense budget devoted to the technology base. The Senate Committee on Armed Services has asked the Office of Technology Assessment (OTA) to examine the health of the U.S. defense technology base and suggest options for exploiting its strengths and remedying its weaknesses. This special report is the first product of that project. It describes the defense technology base, presents significant technology base problems now facing the Nation, and discusses the issues Congress will confront in dealing with those problems. It also describes how the Department of Defense is organized to manage its technology base programs and discusses the roles of the major government research organizations that contribute to the defense technology base. In the course of the discussion it mentions, but does not analyze, solutions that have been proposed to some of the problems. These suggested solutions, and others, will be explored in later OTA work.[4]

The remainder of this chapter presents the principal findings of this special report. Because this is an interim product, these are largely observations of the staff and outside experts. Chapter 2 is a summary of the report, which elaborates on the principal findings and provides background material. Chapters 3 through 5 present the data and analyses on which these findings are based.

[4]Solutions have been suggested and analyzed in the 1987 *Defense Science Board Study on Technology Base Management,* Office of the Under Secretary of Defense for Acquisition, March 1988.

PRINCIPAL FINDINGS

The health of the defense technology base depends on many complex factors and is affected by policy in diverse areas. It responds to actions Congress takes regarding the Defense Department technology base programs; overall government science and technology policy; and industrial, trade and fiscal strategies that are relevant to vital high-technology industries. In deciding what to do about the defense technology base, Congress faces two broad issues:

1. Are the government programs that affect the health of the defense technology base appropriately organized, staffed, managed, and funded; and what can be done to ensure that they are?
2. Do government policies toward industry support the existence and maintenance of a healthy industrial technology base, both defense-oriented and commercial, from which defense developments can be drawn; and what can be done to ensure that they do?

Resolving these broad issues will entail addressing a number of component issues.

- The defense technology base resides in a broad range of institutions that includes

DoD laboratories, other government laboratories, universities, private research facilities, defense industries, and "dual-use' civilian industries. As the civilian industries move increasingly to the cutting edge of technology, the defense technology base becomes embedded in—and largely inseparable from-the national technology base. The Defense Department technology base programs are major contributors to the defense technology base, but they are far from all of it.

The Defense Department's system for managing its technology base programs has recently been overhauled as part of the general reorganization of the acquisition system. But it remains to be seen whether this will lead to fundamental improvements in the way technology base programs are planned and managed. One basic question is whether the system works as well as can be expected, or whether major improvements can be brought about.

- Observers in government and industry believe that DoD is finding it increasingly difficult to attract and keep the skilled management personnel necessary to the functioning of its technology base programs. This appears to be, at least in part, a result of Civil Service salary structures and Congress' efforts to limit the movement of personnel between industry and the Defense Department.
- Funding for technology base programs is particularly vulnerable during times of tight budgets. The rapid spend-out rates of technology base programs mean that cuts in R&D go farther toward reducing deficits than similar size cuts in procurement programs. And the lack of obvious, tangible outputs from R&D projects makes the value of individual programs difficult to define. Technology base programs are particularly vulnerable to "raiding' to support programs in procurement or the later stages of development. Congress will have to determine what it thinks are proper levels of funding, which may entail acting as an advocate for technology base funding when DoD seeks to reduce it. The optimal level of funding is difficult, if not impossible, to gauge accurately. However, funding that fluctuates widely from year to year is inefficient and can be very disruptive. Congress faces the very difficult decision of whether it should be actively involved in the selection of technology base programs and the determination of specific funding levels, or whether instead it should give DoD managers wide latitude to construct programs within agreed overall funding levels.
- The government laboratories that together perform about one-third of the technology base program work have been the subject of a vast amount of study and discussion. There has been significant concern over the quality and *value* of their work, and the ability of the laboratories to attract and keep top-quality personnel. Many experts perceive them as uneven in quality and utility. Suggestions have been made regarding changing the relationships of some laboratories to their parent organizations, altering laboratory management structures (i.e., removing them from Civil Service), and improving their ability to compete for and compensate researchers.
- The United States is becoming increasingly dependent on foreign sources for defense technology. Some of this-like increasing involvement in NATO cooperative programs —is intentional. But much of it is a consequence of the movement abroad of high-technology industries, particularly those that deal primarily in the commercial marketplace. Reliance on foreign sources makes more technology available, distributes the costs of technical advances, and ties the Nation closer to its allies. But dependence on others risks losing access to technology, if political or economic conditions change. The United States faces basic policy issues of how much dependence on others for defense technology is advisable, and how much the Nation should spend to retain domestic sources of technology.

- The foreign dependence issue is most pronounced in the "dual-use" sector: those high-technology industries that sell primarily in the international commercial marketplace, but provide important technology and products as components of defense systems. High-technology products are increasingly manufactured outside the United States, raising concern that the ability to design at the leading edge will follow manufacturing, reducing DoD's access to the technology it needs. Other nations have national policies to attract, nurture, and protect high-technology industries. These tax, trade, and other policies contribute to the continuing deterioration of U.S.-based industries. Failure to counter conditions which cause U. S.-based companies to move offshore will allow the deterioration to continue, affecting national defense. If Congress chooses to address these issues, it is important that national security be part of that consideration.
- The defense industry is highly regulated. Government controls and regulations tend to discourage innovative small- and medium-sized companies from entering the business and create competitive advantages for those companies with experience in the specifics of selling to the government. Detailed specifications for military hardware tend to limit the availability of commercial products for defense needs. Moreover, many in industry believe that the government maintains an adversarial relationship with industry, to the detriment of the defense effort.
- There is concern that, in the defense sector, government regulations inhibit both product innovation and the application of advanced manufacturing technology to plant modernization. Companies can recover part of the cost of innovation from the government through the Independent Research and Development (IR&D) reimbursements. But this program has been controversial, in part because it has become complex and difficult to understand.
- Despite the United States' superior graduate education programs, there is concern—particularly within DoD and the defense industries-that U.S. citizens are not becoming scientists and engineers at a sufficiently high rate.
- Many experts believe that the long delays in getting new technology into the field arise not in the technology base, but in the subsequent programs that translate the products of the technology base into new systems. Full-scale development and production times are increasing, and the longer it takes to develop and build a system, the older its technology will be when it finally reaches the field. Unfortunately, adding new technology to a system already under development is likely to delay it still further. Inserting new technology through retrofitting fielded systems or block upgrades of systems in production might get new technology into the field faster than waiting for an entirely new system to be developed. Changes in the organizational links among developers, planners, operators, and technologists also have the potential for speeding the progress of technology into the field.