Redesigning Defense: Planning the Transition to the Future U.S. Defense Industrial Base

July 1991

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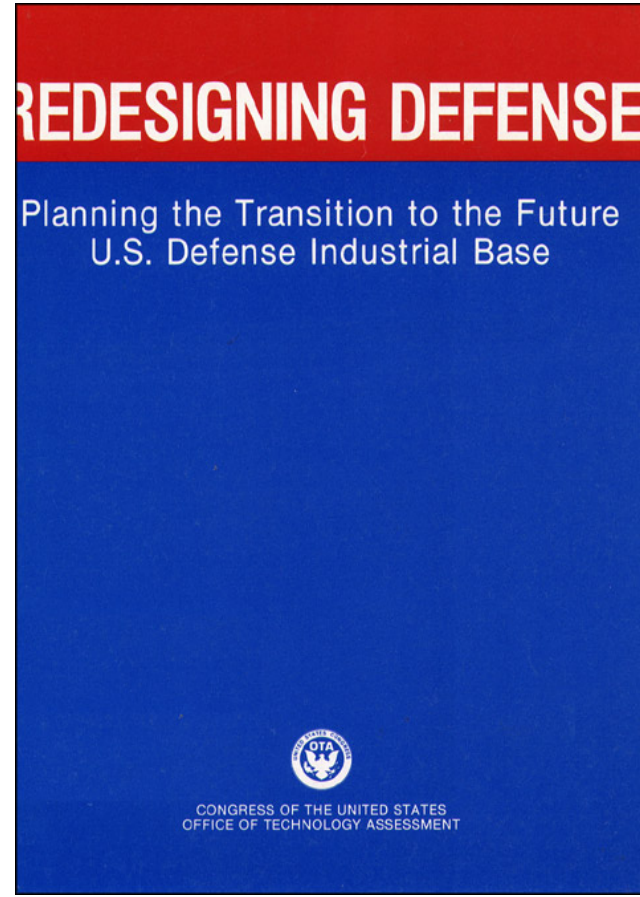

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Foreword

The defense technology and industrial base (DTIB) is a crucial element of U.S. military strength because it provides the capability to develop, produce, and support military systems in peacetime and to respond to additional military requirements in crisis or war. The recent conflict in the Persian Gulf once again demonstrated the vital importance of the DTIB, even as recent changes in the international security environment have raised fundamental questions about its future size and character.

This report is the second publication responding to a request by several congressional committees and individual Members of Congress for OTA to assess what form the future base should take and what government policies can best facilitate the transition from the base's cold war configuration. A background paper published in February 1991, *Adjusting to a New Security Environment,* defined the DTIB, discussed how the United States has used its technological and industrial strength to assure its national security in the past, and outlined some of the challenges currently facing the Nation. *This Report examines emerging U.S. national security requirements, surveys the current conditions and trends in the DTIB, and proposes some desirable characteristics for the future base. The* report concludes with a discussion of the broad strategic choices and tactical decisions that must be considered as the Nation moves to this future base.

The objectives of the report are to provide a framework for the debate over the size and character of the future DTIB, and to assist Congress in selecting criteria for making the difficult policy and budget choices that will be required to facilitate the transition. The industrial base characteristics proposed in this report differ significantly from those of the current base. *Probably the most fundamental difference is the separation of the R&D process from the expectation of major production runs.* To maintain both technological development and manufacturing skills in a period of reduced defense budgets, OTA describes a process of continuous competitive prototyping that tests new concepts, incorporates new technology into fielded systems, but results in the manufacture and deployment of new systems only when required. These steps, and others examined in the Report, carry risks to both the R&D and manufacturing elements of the base. However, the new fiscal and security realities facing the Nation force difficult tradeoffs that include such risks. It is also clear that managing this change will require improved and better-integrated management in the future.

The final report of this assessment, to be delivered in the spring of 1992, will address specific policy options arising from the strategic choices and tactical decisions discussed here.

In undertaking this report, OTA sought information and advice from a broad spectrum of knowledgeable individuals and organizations whose contributions are gratefully acknowledged. As with all OTA studies, the content of the report is the sole responsibility of the Office of Technology Assessment and does not necessarily represent the views of our advisers and reviewers.

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NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

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Chapter 1
Summary, Major Findings, and Policy Issues

INTRODUCTION

Changes in the international security environment present the United States with some far-reaching decisions about the size and character of the Nation's future armed forces and the defense technology and industrial base (DTIB) supporting those forces. The DTIB is the focus of this report. A crucial element of U.S. military power, the base has two principal functions:

1. developing, producing, and supporting military systems in peacetime; and
2. responding to increased military requirements in crisis or war.

The deployment and support of U.S. forces in the Persian Gulf and the performance of U.S. weapon systems in Operation Desert Storm provided some indication of the ability of the current DTIB--built up over decades of cold-war spending-to meet the Nation's security needs. But a key question facing Congress is how to retain the technology and industrial capabilities essential for the defense of the Nation and its interests with much reduced defense budgets. This problem is extremely complex, requiring difficult choices involving tens of thousands of skilled jobs and major shifts in defense spending. Although the consequences of this restructuring will be felt more strongly in some States and congressional districts than in others, the transition to the future DTIB can be expected to generate considerable public debate. The purpose of this report is to provide a framework for that debate, enabling Congress to look beyond the immediate political concerns of individual districts and States to the national security requirements of the Nation as a whole.

The DTIB is the combination of people, institutions, technological know-how, and facilities used to design, develop, manufacture, and maintain the weapons and supporting defense equipment needed to meet U.S. national security objectives.[1] The base consists of three broad components: a research and development component, a production component, and a maintenance and repair component, each of which includes private- and public-sector employees and facilities. The base can also be divided into three tiers: prime contractors, subcontractors, and parts suppliers. While the DTIB is usually thought of as an independent entity, it is in fact a part of the larger civilian technology and industrial base and is increasingly international.

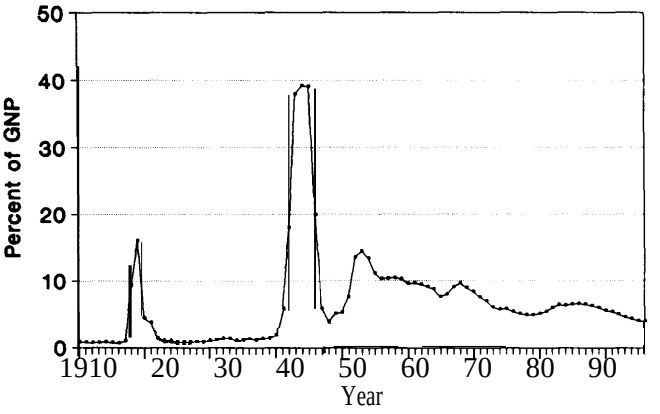
Since 1950, the size and structure of the DTIB have been shaped primarily by the demands of containing the Soviet military threat. While the sweeping changes in the Soviet Union and Eastern Europe provide an opportunity to reduce U.S. defense spending and redirect some technological and industrial resources to meet other vital needs, there is still considerable uncertainty about the durability of the positive changes in the Soviet Union and the nature of other potential threats. The complexity of the current security environment was illustrated by the administration's 1992 defense budget request, which supported a smaller, post-cold war military establishment even as the United States and its coalition partners were engaged in the war to liberate Kuwait.

There appears to be consensus among government policymakers that the United States will remain globally engaged and must retain significant military forces and the means to arm and support those forces. Yet it is equally clear that the defense budget will be cut substantially. Overall defense spending is expected to decline from a peak of 6.4 percent of Gross National Product (GNP) in 1985 to about 3.8 percent of GNP in 1996, the smallest proportion since before World War II (see figure l-l). At the same time, procurement in real terms is projected to fall almost 50 percent between fiscal years 1985 and 1996, from $123.9 billion to $64.3 billion (both figures in 1992 dollars). Between 1990 and 1993, budget authority for aviation is projected to decline by 23 percent, shipbuilding by 26 percent, and weapons and tracked vehicles by about 77 percent.[2] While production of munitions and other consumables may increase temporarily to replenish stocks

[1] U.S. Congress, Office of Technology Assessment, *Adjusting to a New Security Environment: The Defense Technology and Industrial Base Challenge—Background Paper*, OTA-BP-ISC-79 (Washington, DC: U.S. Government Printing Office, February 1991).

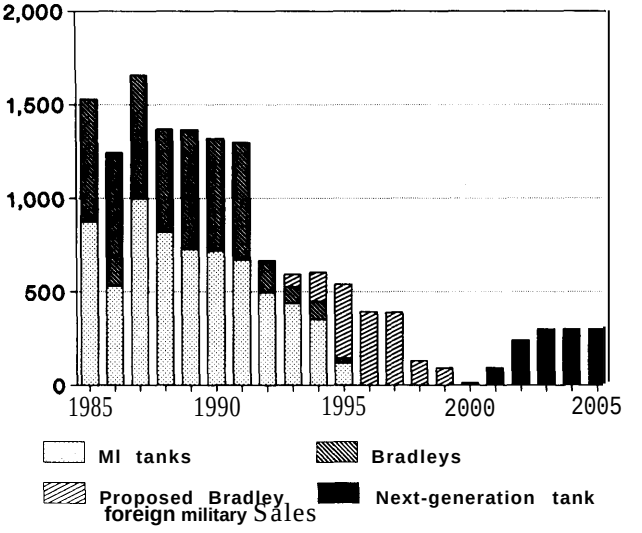
[2] Stephen A. Cain, *Analysis of the FY 1992-93 Defense Budget Request* (Washington, DC: Defense Budget Project, Feb. 1991), tables 7 and 8.

Figure 1-1—U.S. Defense Spending as a Percent of GNP



SOURCE: *Budget of the United States Government, Fiscal Year 7992* (Washington, DC: U.S. Government Printing Office, 1991), part Seven, historical tables, table 3.1; and Stephen A. Cain, *Analysis of the FY 1992-93 Defense Budget* Request (Washington, DC: Defense Budget Project, February 1991), table 15.

Figure 1-2—Armored Vehicle Production Projected Through 2005



NOTE: MI tank figures include proposed foreign military sales to Saudi Arabia and Egypt, with Egyptian coproduction.

SOURCE: U.S. Department of the Army, May 1991.

consumed during the Gulf War, procurement of major weapon platforms will decline sharply over the next decade because of large existing inventories and Shrinking force."

Direct funding for defense research and development (R&D) is expected to fall 23 percent.[3] This latter figure substantially understates the actual total reduction in defense R&D funding that is likely to occur, however, since much private-sector R&D is linked to procurement levels, which are also falling rapidly.[4]

The projected changes in the production and R&D budgets will have profound effects on many defense sectors. In addition to overall reductions, there will be a reallocation of funding priorities as the Services end current programs and move ahead with modernization. The reduced demand for weapon platforms will result in a production "trough' over the next 5 years in defense sectors such as armored vehicles (see figure 1-2), followed by longer intervals between procurement cycles. As a result, there maybe gaps between the end of several current programs and the start of production of next-generation systems. Decisions about the DTIB made over the next few years will determine the survival of some defense firms and government organizations. More importantly, these decisions will determine in large measure the Nation's ability to develop and deploy advanced military weapons systems in the opening decades of the next century. Once plants and laboratories are closed and their personnel scattered, they can take years to reconstitute; the unique skills embodied in the design and engineering teams that conceive of and build weapons like the F-15 fighter and the Tomahawk cruise missile are neither easily maintained nor quickly replaced.

An example of the difficult choices facing Congress is whether the United States should cease production of Ml tanks and Bradley Fighting Vehicles. The production trough shown in figure 1-2 makes it clear that the Nation must decide which armored vehicle R&D and production capabilities it should attempt to preserve, and how these capabilities (people, facilities, organizations, and subtier producers) might be maintained with limited or no new production. Possible strategies include terminating production and concentrating on R&D, increasing foreign sales, continuing procurement for U.S. forces, and upgrading older Ml tanks and Bradleys. A host of other weapon systems raise similar choices about preserving defense R&D and production capabilities.

In making such choices, Congress should recognize that technology is changing so rapidly that by the time a major new threat arises, totally new types

[3]Ibid., table 9.

[4]Defense contractors invest in R&D primarily through government-reimbursed Independent Research and Development (IR&D), which is tied to ongoing procurement contracts, or other corporate funds in the expectation of winning a production contract.

of weapons and defense manufacturing capabilities may be required. Although those charged with fighting a potential war always worry about not having the most capable weapons on hand, weapons eventually become obsolete. Thus, a period free from an immediate large military threat allows opportunities to investigate new weapon concepts and potentially to leapfrog a generation of systems. Between World Wars I and II, for example, the Army's DTIB strategy for armored vehicles concentrated on component development and the design and limited prototyping of new tank models, which were subsequently produced during World War 11.[5] Some aircraft designers argue that the United States could maintain its performance edge in fighter aircraft with a similar emphasis on prototype development, combined with limited, intermittent production to modernize forces when necessary.

While the DTIB has produced some outstanding weapon systems, as demonstrated in the Gulf War, it also has a number of serious weaknesses that will affect its ability to meet national goals of peacetime production and crisis response. Numerous studies conducted over the past decade have detailed these weaknesses, including the high cost of weapon programs, growing dependence on foreign sources for critical components, and a shrinking number of subcontractors doing defense business. The causes of these adverse trends are two-fold: regulatory controls that increase the cost of conducting defense business and discourage many firms from participating in defense efforts; and the lack of a national defense technology and industrial strategy and predictable funding levels that would enable both private firms and government organizations to prepare for the future.

Firms are responding to current and anticipated budget reductions by attempting to increase arms sales abroad, reducing facilities, cutting investment in new technology and physical plant, eliminating personnel, and, in some cases, attempting to diversify into the civil sector. The ad hoc nature of the reductions to date has further exacerbated the overall problems of the DTIB.

There has been a tendency to treat the private-sector portion of the base like any other private business, with contracts bid competitively and working capital provided by loans or equity investments. In fact, this element of the DTIB does not operate in a free market. The government is the only customer for defense products and regulates profits, production processes, product design, and a host of other factors. This monopsony (single-customer) relationship gives the government considerable power.[6] In the Past, the government used its power to entice firms into the defense business by reducing financial risks and providing guaranteed profits. Beginning in the 1980's, however, the government focused on expanding competition while limiting potential profits, thereby increasing business risk.

To obtain a better grasp of the changes that are occurring in the DTIB and what congressional actions, if any, might be called for, Congress asked the Office of Technology Assessment (OTA) to examine the Nation's defense technology and industrial needs in the emerging security environment and to suggest options for moving to a smaller and more efficient DTIB that can meet those needs. The objectives of this report are as follows:

1. to survey ongoing changes in the international security environment that will affect DTIB requirements,
2. to describe the current condition and trends in the DTIB,
3. to identify the desirable characteristics of the future DTIB, and
4. to sketch out broad alternative strategies available to the Nation for moving to the future base.

A separate report, scheduled for release in the spring of 1992, will explore in greater detail specific policy options to support these strategies.[7]

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[5] Richard M. Orgorkiewicz, *Armor* (New York, NY, Frederick A. Praeger, 1960); and R. P. Hunnicut, *Firepower* (Novato, CA: Presidio Press, 1988).

[6] Office of the Under Secretary of Defense for Acquisition, Final Report of the Defense Science Board 1988 Summer Study, *The Defense Industrial and Technology Base (Washington DC:* October 1988), p. 12.

[7] This assessment is part of a broader effort t. identify trends in the U.S. technology and industrial base and examine U.S. policy options. A companion OTA assessment, *Technology Opportunities for Economic Conversion, is ongoing in the* Industry, Technology, and Employment Program. Other recent related OTA reports include: U.S. Congress, Office of Technology Assessment, *Holding the Edge: Maintaining the Defense Technology Base,* OTA-ISC-420 (Washington DC: U.S. Government Printing Office, April 1989); U.S. Congress, Office of Technology Assessment, *The Defense Technology Base: Introduction and Overview,* OTA-ISC-374 (Washington, *DC:* U.S. Government Printing Office, March 1988); U.S. Congress, Office of Technology Assessment, Global *Arms Trade: Commerce in Advanced Military Technology and Weapons,* OTA-ISC-460 (Washington DC: U.S. Government Printing Office, June 1991); and U.S. Congress, Office of Technology Assessment *Making Things Better: Competing in Manufacturing,* OTA-ITE-443 (Washington, DC: U.S. Government Printing Office, February 1990).

ORGANIZATION OF THIS REPORT

The report is organized into five chapters and two appendices. This chapter summarizes key findings and policy issues. Chapter 2 outlines potential threats to the United States and its allies, the future U.S. force structure that may be developed to counter these threats, and the implications of alternative force structures for the DTIB. Chapter 3 surveys the structure and current condition of the DTIB, and chapter 4 examines trends and problems in the base, including strategies of defense companies for responding to continuing budget cuts. Chapter 5 outlines some desirable characteristics of the future DTIB and discusses alternative national strategies for moving to a base that is capable of meeting the Nation's long-term security needs. Appendix A describes the integrated U.S. and Canadian defense industrial complex, known as the North American Defense Industrial Base, and explores some of the implications for the DTIB of increased economic integration with Mexico. Appendix B contains a brief discussion of defense industrial databases and industrial base analytical models.

As part of this study, the OTA assessment team sent surveys to several hundred defense industry executives requesting their views on changes in the DTIB and actions being taken or that could be taken to ensure a viable future base (see box l-A). Information from the survey, as well as from subsequent interviews with company and government personnel, is incorporated in the text of this report. In addition, selected survey observations appear in boxes marked 'OTA DEFENSE INDUSTRY SURVEY. ''

FINDINGS

Changes in the Security Environment

The threat of a short-warning Warsaw Pact military attack against Western Europe has disappeared. The integrated command structure of the Warsaw Treaty Organization was dissolved on April 1, 1991, and Soviet armies that only a few years ago were deployed in the heart of Europe are now withdrawing to the borders of the U.S.S.R. These changes have transformed the former threat of a short-warning conventional attack into a long-warning threat. A Soviet attack on NATO's central front would require the Soviet Union to reconstitute

OTA DEFENSE INDUSTRY SURVEY

Box l-A—Defense Survey Approach

The OTA Defense Industry Survey solicited industry views on three main topics:

1. the size and composition of the future defense technology **and** industrial base (DTIB) in the year 2000,
2. how the transition to the future base ought to take place, and
3. how the future base ought to be managed.

Respondents were provided with the definition of the DTIB and the force structure forecasts used by OTA.

The survey was divided into three areas: 1) **General Observations on the Defense Technology and Industrial Base** (soliciting general information on size of respondents' firms, estimates of future Us. defense budget changes and corporate responses, and challenges facing the firms); 2) **Assessments of Specific Policies and Problems** (soliciting views on government acquisition regulations, competition, and special programs such as **Manufacturing Technology);** and **3) New Ideas** (soliciting industry's suggestions for the restructuring of acquisition, the management of research and development, and manufacturing). Survey questions were designed to allow respondents to provide their views m essay format.

The American Defense Preparedness Association (ADPA) and the National Security Industrial Association (NSIA) assisted **OTA in** reaching a wide range of industry. The survey was sent to members of the Manufacturing Management Committee and Procurement Committee of the NSIA and to the general membership of the **ADPA. The OTA** assessment team appreciates the assistance of **ADPA** and NSIA in reaching industry. The associations, of course, had no role in developing the conclusions of this report. In cases where several executives from the same corporation received the survey, many corporations chose to consolidate their replies. While the response rate cannot, therefore, be calculated exactly, overall it exceeded 25 percent. The OTA assessment team was impressed by the care and thoroughness that many respondents gave to their replies and thanks them for their time and effort.

Photo credit: Wick World Photos

Probably the clearest sign of the end of the cold war is the destruction of weapons such as these Czech tanks being dismantled with cutting torches.

its forces over a period of years and then fight its way across Eastern Europe. With the reduction in East-West tensions, the danger of nuclear war has also diminished considerably, as reflected by the reduced alert status of U.S. nuclear forces.

Nevertheless, the global security environment remains complex and frill of uncertainties. The United States must hedge against a possible Soviet reversion to global confrontation or new challenges to U.S. security from other sources. In addition, regional conflicts are more likely to involve the use of advanced conventional weapons, ballistic missiles, and chemical, biological, and nuclear weapons. Thus, instead of a "clear and present danger, ' the United States faces a spectrum of lesser but more ambiguous threats in an overall security environment characterized by increased fluidity and uncertainty.

At the same time that the global security environment is undergoing a major transformation, severe fiscal constraints arising from the ballooning Federal deficit and competing domestic needs are also forcing cuts in the U.S. defense budget. Internationally, the Nation faces persistent trade deficits and mounting competition in industrial and technological areas that formerly went almost uncontested. As a result, many policy analysts have urged the redefinition of U.S. national security to emphasize the vitality of the domestic economy, the welfare of the American people, and the international competitiveness of civilian industry.

In light of these fiscal and security trends, both the administration and Congress have advocated prudent reductions in U.S. armed forces, with the aim of retaining a military flexible enough to respond to a wide range of unforeseen circumstances. President Bush has outlined the administration's vision of "deliberate reductions to no more than the forces we need to guard our enduring interests-the forces to exercise forward presence in key areas, to respond effectively to crises, [and] to retain the national capacity to rebuild our forces should this be needed.'

[8]Weekly compilation of Presidential Documents, vol. 26, No. 31, Aug. 6, 1990, pp. 1190-1194.

To this end, the Nation will need ready forces and equipment capable of dealing with limited regional conflicts, along with the ability to reconstitute larger forces in the event of a serious crisis or war. By the end of the decade, the U.S. military will likely consist of fewer active and reserve forces armed with advanced weapons, many of them upgrades of current systems. American forces will have a reduced overseas presence and will therefore need greater strategic mobility; they will also be more dependent on mobilization of reserves to respond to major military threats (see table l-l).

These changes in U.S. force structure, together with fiscal constraints, will have important implications for the DTIB, as discussed in chapters 2 and 5. A few examples illustrate these implications. First, a reduction in Army heavy divisions and Navy carrier task forces could result in a several-year hiatus in tank and aircraft carrier production. Second, changes in military operations may necessitate the development of new types of weapons and may also create different surge requirements for theater conflict. Third, the general reduction in procurement funds will require more attention to lowering the cost of systems and increasing the reliability of fielded systems. Finally, a reconstituted Soviet threat can no longer be the principal planning contingency, with all other potential threats subordinated to it.

These implications for the DTIB helped establish the parameters for OTA's assessment of how the Nation can rationally reduce the base to preserve essential capabilities. The results of this assessment are a list of proposed characteristics of the future DTIB and identification of the strategic choices and tactical decisions involved in the transition to that base, as discussed in chapter 5 and outlined below.

Table l-l--Characteristics of Future U.S. Forces

- Smaller active and ready reserve forces
- Less forward basing, greater strategic mobility
- Continuing weapons performance advantage
- Substantial nuclear capability
- Chemical and biological defense capabilities
- Greater dependence on mobilization

SOURCE: Office of Technology Assessment, 1991.

Table 1-2—Desirable Characteristics of the Future Base

- Advanced research and development capability
- Ready access to civilian technology
- Continuous design and prototyping capability
- Limited, efficient peacetime engineering and production capabilities in key defense sectors
- Responsive production of ammunition, spares, and consumables for theater conflict
- Healthy, mobilizable civilian production capacity
- Robust maintenance and overhaul capability
- Good, integrated management

SOURCE: Office of Technology Assessment, 1991 ."Characteristics are not necessarily listed in order of priority.

Desirable Characteristics of the Future Base

Desirable characteristics of a DTIB that would support future military needs are listed in table 1-2. First, and most important, the future base will need to retain an advanced R&D capability. In a period of uncertainty about the nature of future threats and acknowledged concern over the state of U.S. technological competitiveness with other countries, preserving the R&D component of the base must receive first priority. While production will still receive more overall funding, a relative increase in R&D funding will help reduce pressures to move rapidly into full-scale production, thereby promoting a more deliberate approach to the defense acquisition process. The defense base must also have greater access to civilian technologies in sectors, such as electronics and telecommunications, where innovation is driven increasingly by commercial applications. Such access will require changes in current defense procurement laws and regulations that have increasingly isolated the DTIB from civilian industry.

Maintaining defense R&D and production capabilities in a constrained fiscal environment will revolve around continuous design and prototyping. Since it is more difficult and time-consuming to rebuild technological and industrial capabilities than to mobilize manpower, retaining the capability to develop the next generation of weapons and to mobilize against a reconstituted threat will require preserving facilities and personnel devoted to design, systems integration, prototype testing, and manufacturing. Thus, future DTIB decisions must maintain enough design and engineering teams to produce new components and systems on demand. In a period characterized by more research and less production, it will be necessary to build and test prototypes between major procurement cycles. Another consequence of smaller defense budgets and longer weapon development cycles will be an increased emphasis on improvements and retrofits of existing platforms, which will help sustain the

ability to manufacture subsystems and keep both subtier firms and primes in the defense base.

The DTIB will continue to need a responsive production or "surge" capacity to support limited conflicts, but that capacity should be small and geared toward essential materiel such as ammunition, spare parts, and consumables.[9] If cuts in U.S. active forces are accompanied by proportionately smaller inventories of these items, there may be a greater need for defense industrial surge in response to a limited crisis or war. Responsiveness must be funded and periodically tested.

The wartime consumption and production rates needed to meet a reconstituted Soviet threat would likely be hundreds of times larger than peacetime production. The Nation cannot afford to maintain a "warm" defense industrial base large enough to satisfy this contingency. Since a reconstituted Soviet threat or major new threat will take years to develop, however, the wartime mobilization base for a major conflict can be less responsive than was required in the past. This wartime mobilization base would consist of two elements: a dedicated defense base for the procurement of major platforms, and a mobilizable civilian production capacity. The first of these elements would be sized to meet peacetime defense procurement needs, yet flexible enough to form the core around which the larger wartime-mobilization base could be regenerated when needed. The second element requires a healthy national manufacturing base, with sufficient quality personnel that can shift their knowledge and skills from commercial production in peacetime to defense work in a national emergency.

Since military weapon systems will likely remain in inventory longer than in the past, maintenance will become more important. The shift from the urgent production and deployment of new systems during the cold war era to the overhaul, remanufacturing, and upgrading of deployed systems over the coming decades will have important implications for the structure of the maintenance base, requiring a reexamination of the mix between the public and private sectors. It will also require additional emphasis on designing systems for improved reliability to reduce the need for future repair and overhaul.

Photo credit: U.S. Department of Defense

The B-52, first deployed in 1955, demonstrates that a weapon platform can be upgraded by improving components or munitions.

Finally, the DTIB must have good, integrated management to achieve its objectives in a fiscally constrained environment, avoiding both extremes of micromanagement and neglect. The test of management is whether the DTIB adequately meets the goals of affordable peacetime acquisition and wartime responsiveness. Despite the success of Operation Desert Storm, projected modernization costs of strategic bombers and other systems indicate that current base management does not pass the affordability test. If the base is allowed to restructure in the current ad hoc manner, it may be unable to respond to a future crisis. An essential requirement for managing the transition to the future DTIB is to ensure better communications between peacetime acquisitions personnel and the officials who plan for defense industrial responsiveness in crisis and war.

Broad Strategic Choices

To achieve the desirable DTIB characteristics outlined above, the United States will need a long-term defense technology and industrial strategy for identifying and maintaining the critical facilities, technological know-how, and people needed to develop future systems and to provide a core for

[9] Office of Technology Assessment, op. cit., footnote 1, p. 3. This report maintains the definitions of surge and mobilization used in *Adjusting to a New Security Environment. Surge is the* term used within DoD to refer to the expansion of military production in peacetime without the declaration of a national emergency. *Mobilization* refers to the rapid expansion of military production to meet materiel needs in a war and involves the declaration of a national emergency. Several types of mobilization are considered. *Full mobilization* refers to mobilization to fill the existing or "program force" structure. *Total mobilization* describes a mobilization effort that expands beyond the existing force structure.

regenerating expanded defense industrial capabilities in a timely manner. The Nation faces some broad strategic choices about the nature of the future defense base, including:

- the degree of national autonomy versus international interdependence,
- reliance on an arsenal system versus civil integration, and
- the allocation of resources to current production versus future potential.

Autonomy v. Interdependence

One strategic choice relates to the extent to which the DTIB is integrated into the world economy. The Nation must choose the degree of defense industrial autonomy that is necessary and possible in an increasingly global technological environment. There are risks both in excessive reliance on foreign sources and in attempting to be fully autonomous. In the former case, the Nation risks losing to offshore competitors both critical capabilities and control over which technologies are pursued; in the latter case, it risks higher procurement costs, protected industries that lack innovative drive, and loss of access to foreign technological developments. The optimal tradeoff between interdependence and autonomy will depend on the industrial and technological sector and the military importance of the technology, as discussed in chapter 5.

Arsenal System v. Civil Integration[10]

A second choice relates to the internal structure of the base. There are two alternatives for dealing with reduced levels of defense procurement. On the one hand, the Nation can rely on arsenals, either government or privately owned, that might be sole-source producers of particular military systems. On the other hand, the Nation could modify its military requirements to conform with what might be available from the commercial sector. Either choice will require changes in government procurement laws and regulations. In the absence of deliberate policies, the DTIB is likely to converge toward an arsenal structure as current procurement laws impede civil-military integration and reduced levels of production eliminate competition. An optimal strategy may be to rely on the civilian industrial base whenever possible, depending on arsenals for those areas of defense development and production having little or no overlap with civilian technology, or where only monopoly producers can survive.

Potential v. Current Capability

A third choice concerns the allocation of resources between maintaining current military capability and future military potential. While current capability is needed for theater requirements (as opposed to global conflict), two factors are shifting the Nation's relative emphasis toward future potential: fiscal constraints are limiting procurement, while the less immediate threat of a major conflict allows more time for development of new systems. While the actual choice of this strategy will depend on the defense industrial sector of interest, an overall approach of emphasizing future military potential will remain prudent as long as any large threat remains remote.

Tactical Decisions

In addition to considering the broad strategic choices outlined above, the Nation will need to make a number of tactical decisions about how best to achieve the desired characteristics of the future DTIB outlined in table 1-2. These tactical decisions are discussed in detail in chapter 5.

Advanced R&D Capability

Maintaining a viable defense R&D base in a constrained fiscal environment will require identifying "core competencies," or areas of technological know-how critical for the development and production of major U.S. weapon systems. Since these core competencies are largely embodied in the skills and knowledge of individuals, the major challenge facing defense R&D policy is to attract and retain key personnel and to develop a system in which they can be most creative. Over the longer term, interesting and meaningful work is thought to be the primary motivator for such people. Thus, while downsizing the base, it will be necessary to maintain R&D funding and to provide challenging tasks for defense R&D personnel, possibly through research contracts and programs not directly tied to production.

[10] Arsenals are usually considered to be government-owned facilities that manufacture military materiel. As discussed in this report, however, an arsenal system is composed of either government facilities such as Watervliet Army Arsenal, or private firms that might be sole-source producers of a particular defense technology. The key point is that an arsenal is a single source that maintains a technology that does not exist in the civil sector.

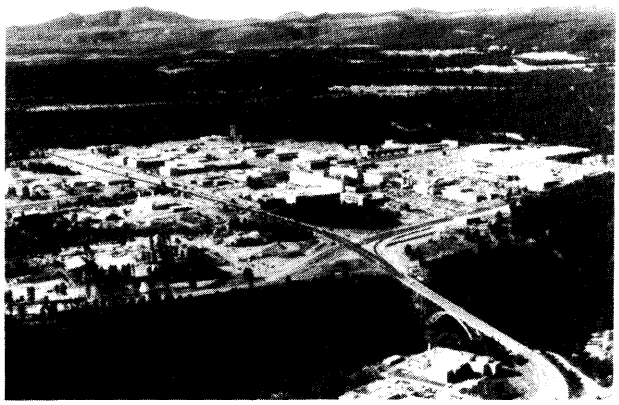


Photo credit: Los Alamos National Laboratory

The Los Alamos National Laboratory, managed by the University of California under contract to the Department of Energy, conducts both nuclear and non-nuclear defense research as well as non-defense R&D.

With less opportunity for traditional competition, new ways must be found to discipline, guide, and evaluate R&D. To this end, new forms of competition might be pursued, such as competing design teams within firms or increased international competition. A teaming or consortium approach involving collaboration among two or more firms may also work in lieu of competition in some cases. The process of prototyping, discussed below, would offer a means of maintaining competitive design and manufacturing capabilities in a severely constrained fiscal environment.

Design and Prototyping

Defense R&D will need to follow a dual-track strategy, emphasizing on one track the development of advanced components and subsystems for upgrading existing weapon platforms, and on the other track, the continuous prototyping of future weapon systems as a hedge against technological surprise. Competitive prototyping would provide information about design concepts and new materials while helping to preserve industrial design teams and innovation in a constrained fiscal environment. Great strides in computer hardware and software have opened up new capabilities for simulation and computer-aided design with enormous potential for future defense R&D, including prototype development.

A prototyping strategy might involve developing several cycles of "technology demonstrators' before one of them suggests a significant new military capability, such as an operational electromagnetic tank gun or improved stealth aircraft (see figure 1-3). A limited production run incorporating the new capability would allow investigation of production processes and field testing of operational concepts. If the system lives up to expectations, a force modernization decision could be made. In addition to testing of operational performance, prototypes should be evaluated by a wide variety of criteria including affordability, relative ease of manufacturing, reliability in the field, and maintainability.

Responsive Production

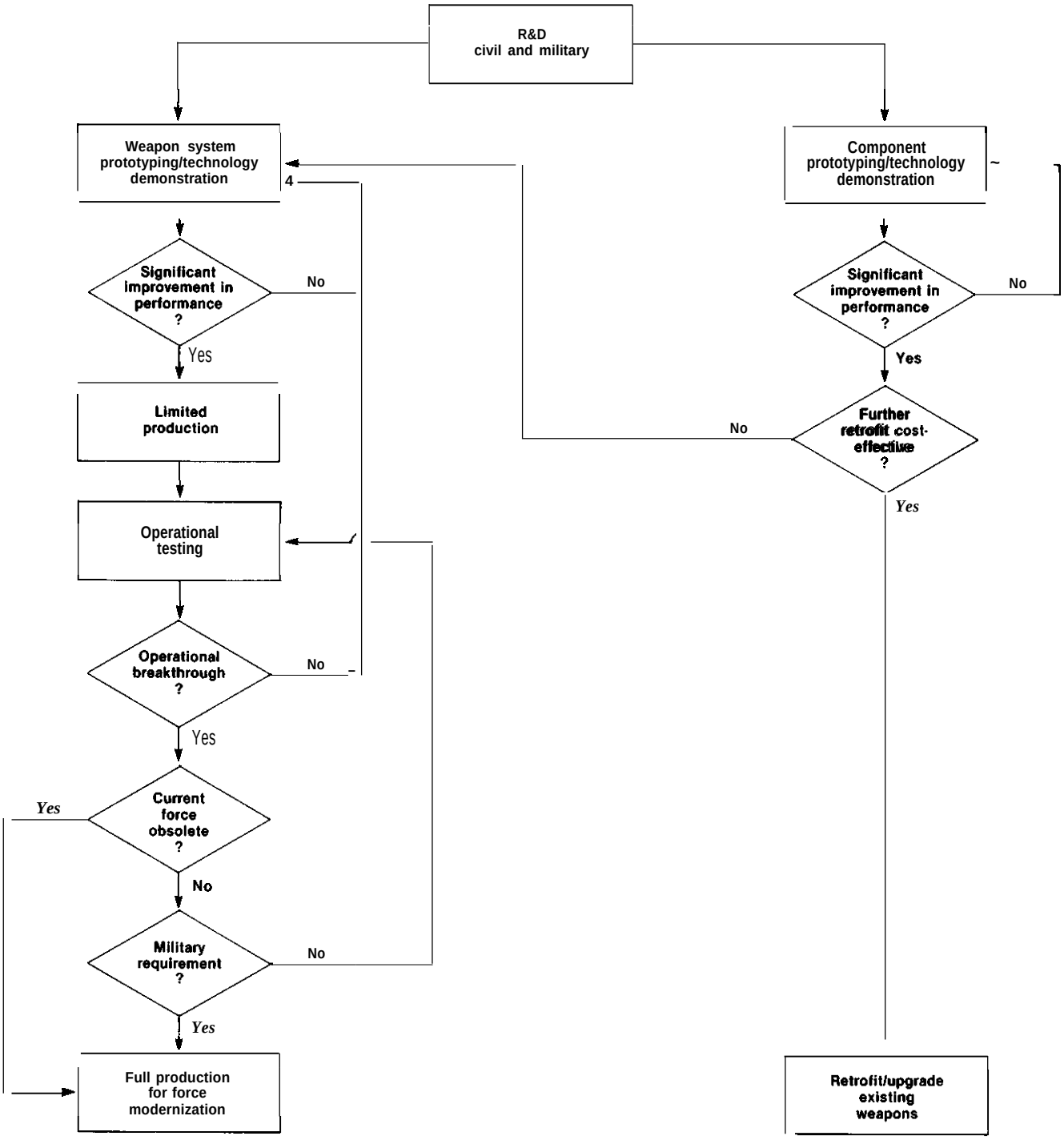
The responsive base that must be capable of surge production can be limited to those consumables, spare parts, and munitions that theater commanders consider critical to their war-fighting needs. Much of this responsive element will probably have to be maintained in a dedicated defense base, although some elements (e.g., clothing and food) can be made to have sufficient commonality with civilian production to allow for greater use of the civilian base. The key to having a responsive base is to develop priorities and provide funding for a surge capability. Industrial preparedness planning requires a coherent management approach that includes maintaining realistic war reserve stocks. Some degree of foreign dependence is unavoidable, but foreign vulnerability can be minimized by identifying multiple foreign suppliers and by stockpiling foreign-sourced parts.

Mobilizable Production Base

While the responsive portion of the DTIB enables the Nation to cope with less challenging but more likely theater-level contingencies, producing military equipment in peacetime at affordable prices requires a much larger industrial base-partly dedicated to defense production and partly in the civil sector. This component of the base would also provide a hedge against a reconstituted Soviet threat or other great-power threat that could arise over a period of years. Since a surge capability in this portion of the base is neither affordable nor necessary, the manufacturing facilities in the mobilizable production base dedicated to defense production (e.g., military aircraft and armored vehicles) should be sized for small, realistic production rates.

Mobilization plans for this larger base might be driven as much by what technologies are

Figure 1-3-Dual-Track Prototyping Strategy



SOURCE: Office of Technology Assessment, 1991.

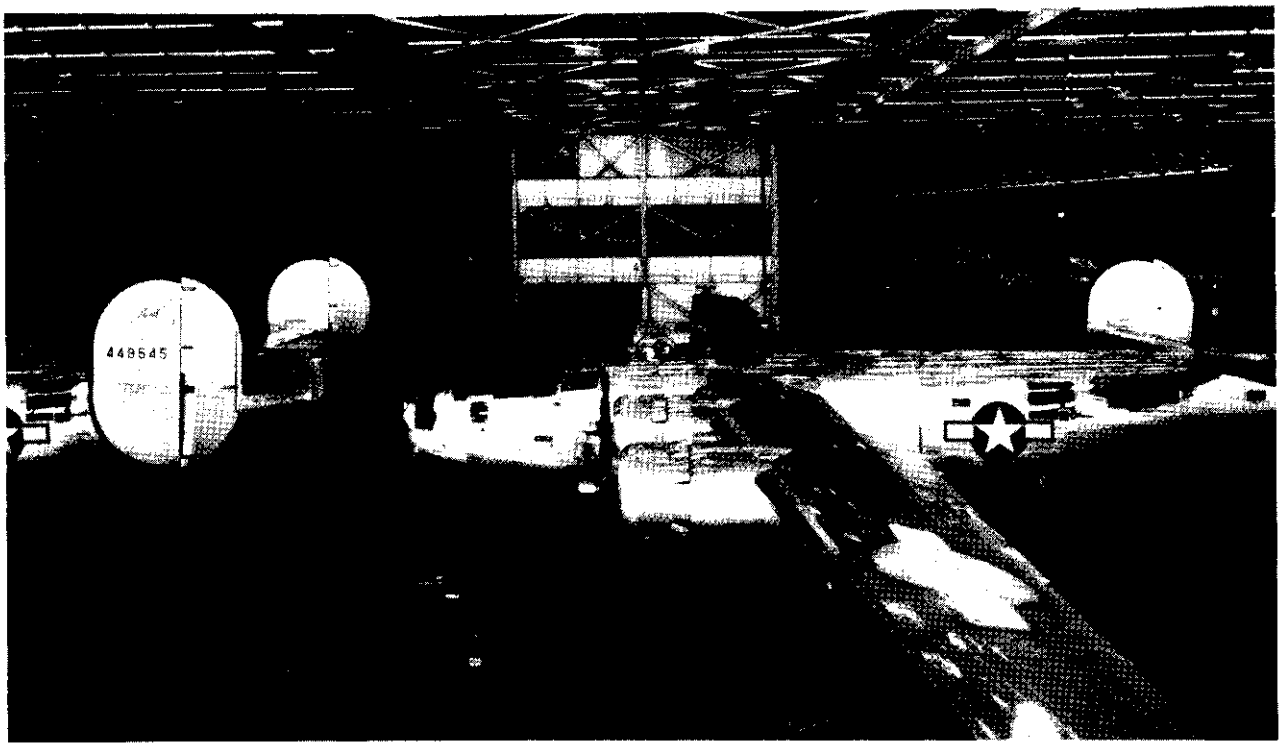


Photo credit: Ford Motor Co. Archives

The mobilization of civilian industry will always be required to meet large-scale threats. During World War II, Ford's Willow Run aircraft factory was the world's largest industrial structure under one roof and turned out 428 bombers a month.

commercially available as by the desire to maximize military performance. If the Department of Defense (DoD) is to make more effective use of the broader civilian base, it will require better data about the commercial availability of dual-use products so that it can identify the industrial sectors in which civilian and defense production can be integrated most effectively. Moreover, since the mobilizable component of the defense base is embedded in the larger civilian base, the ability to mobilize will rely on a strong, competitive U.S. economy. The transition strategy for this component of the DTIB might therefore be shaped by policies to improve the international competitiveness of the broader U.S. industrial base. Policies must also consider the change in corporate culture that must occur if defense firms are to work effectively in a civilian environment. Many of the steps argued to be necessary for strengthening the broader base, such as tax reform and improved technical education, are outside the purview of DoD and the other national-security agencies of the Federal Government.

A recent OTA assessment of international arms cooperation noted that foreign defense firms in Europe and Japan are structured to make much more use of their civilian capabilities.[11] This structure has resulted, at least in part, from different approaches to acquisition and accountability. An essential step in the transition to the future DTIB is a major review of the defense acquisition laws to identify changes that allow greater integration of the civilian and defense sectors. Some of these specific changes are discussed in chapter 5.

Maintenance and Overhaul

The expected longer service life of deployed systems will ultimately increase the importance of maintenance and overhaul capability. Traditionally, this activity has been performed mainly by the military services, but a growing number of manufacturing firms are interested in maintenance, remanu-

[11] U.S. Congress, Office of Technology Assessment, *Global Arms Trade: Commerce in Advanced Military Technology and Weapons*, OTA-ISC-460 (Washington DC: U.S. Government Printing Office, June 1991).

Table 1-3—Options for Change in the DTIB

		Tiers of the base				Ownership
		Prime	Subcontractor	Supplier	Private	GOCO[a]
R&D	Current base	Emphasis on systems development for production	Subsystem R&D funded through production contracts from primes	R&D generally driven by civil requirements	scaling back on investment in R&D	Isolation from civil sector
	Desired future base	Emphasis on technology demonstration, prototyping, and potential production	Subsystem R&D funded through government or commercial development	Same as above	Explicit government funding of military-unique R&D; greater access to dual-use technologies	More integration of commercial technologies and technology transfer to the civil sector
Production	Current base	Excess capacity, rapid production to field new systems and minimize unit costs	Respond to subsystem requirements from primes for new platforms	Extensive integration with civilian base, concern over increasing internationalization of the supplier base	Largest element; operates competitively in a relatively high-risk environment	Limited Competition and reduced capital requirements; government moderates risk by providing some facilities and tools and gains efficiency of private management
	Desired future base	Reduced overall capacity, low rates of production to maintain warm base and personnel skills	Respond to subsystem requirements for retrofit of current platforms and new platforms	Rationalize supplier base to protect against potential vulnerabilities	Reduced risk through multi-year contracting and more rational application of competition	Relatively more reliance on GOCOs as a result of reduced peacetime production requirement and to meet surge targets for theater conflict
Maintenance	Current base	Essential but limited involvement in maintenance	Maintenance of subsystems	Not applicable	Essential but limited involvement in maintenance	Maintenance of nuclear weapons primarily
	Desired future base	Increased involvement in maintenance	Same as above	Not applicable	Increased involvement in maintenance to maintain production capability	Increase use of GOCOs to reduce business risk, provide greater management efficiency

a Government-owned/Contractor-operated.
b Government-owned/Government-operated

SOURCE: Office of Technology Assessment, 1991.

facturing, and retrofitting systems as a means of surviving in a period of reduced production. As noted above, however, the dual-track approach to prototyping may help to maintain key design and systems engineering capabilities. The Services are also wary of placing too much reliance for maintenance on private firms. Allocating maintenance contracts between Service depots and private firms should therefore be aimed at preserving a reliable in-house capability while helping to support the commercial production base.

Good, Integrated Management

During the period of rapidly increasing defense budgets in the 1980's, defense procurement laws and regulations were developed to provide wide access to government funds through mandated competition and to ensure accountability in the use of those funds through extensive auditing procedures. Some of these laws and regulations now appear inappropriate for dealing with the transition to a smaller future DTIB. An improved management strategy would modify these laws and regulations, would attempt to make funding more predictable (e.g., through greater use of multiyear procurement contracts or adoption of multiyear defense budgets), would link defense industrial policies explicitly to operational plans, and would take steps to improve the quality of personnel involved in managing the DTIB.

ISSUES FOR CONGRESS

Congress will play an important role in defining the nature of the Nation's future defense technology

Table 1-3—Options for Change in the DTIB—Continued

	Industrial sectors				
GOCO[b]	Defense electronics	Combat vehicles	Shipbuilding	Aerospace	Ordnance
Fragmented lab structure, lack of R&D strategy	Commercial sector dominates	Military-unique, geared toward production	Defense sector dominates, commercial sector not competitive	Robust, but largely focused on system development for production	Military-unique, geared toward production
Consolidate tabs to become world-class developers of specific military technologies	Greater use of commercial developments	Greater use of prototype development that may or may not lead to production	Same as above	Shift in emphasis toward a more deliberate development strategy and use of technology demonstrators	Greater use of prototype development that may or may not lead to production
Preserve unique military technologies that would be too costly or risky to produce in the private sector	Strict military requirements and specifications have isolated defense from civil sector	Tremendous over-capacity, anticipated trough in production	Inadequate demand to maintain competition among shipyards	Overcapacity, anticipated trough in production	Overcapacity, including mothballed munitions plants, yet questionable surge capability in many systems
Same as above	Modified requirements and changed procurement procedures to allow increased use of civil sector	Size plants for smaller, more realistic production rates	increased reliance on single sources for production of warships and submarines	Less frequent modernization, with retrofits and upgrades of existing platforms	Reduced capacity, improved surge capability for selected items
Major element of maintenance base, now undergoing consolidation	Maintenance performed mainly by Services	Maintenance performed mainly in Service depots	Maintenance performed in both public and private shipyards	Maintenance performed mainly in Service depots	Maintenance performed mainly by Services
Relatively reduced use, with sufficient depots to maintain core capabilities	New designs decrease maintenance requests	Competition between Service depots and private sector	More private sector maintenance	Increased competition between Service depots and private sector	Same as above

and industrial base. The desirable DTIB characteristics developed in this report provide a point of departure for congressional debate. These characteristics imply fundamental changes in the way the U.S. Government acquires military materiel and applies its technological and industrial strength to national security. Table 1-3 outlines options for change in the DTIB in terms of four perspectives discussed in chapter 3: functional area (R&D/production/maintenance), size of firm (prime/subtier/supplier), ownership (private/government-owned), and industrial sector (e.g., ammunition or shipbuilding).

The research and development effort, for example, is characterized in the current DTIB by emphasis on systems development for production but would change in the future base to place more emphasis on technology demonstration, prototyping, and ***potential*** production, as outlined in chapter 5. This shift in the orientation of defense R&D away from assumed production of a future system has many implications that require congressional consideration. One particularly difficult issue arises from the fact that considerable component research and development is currently embedded in freed-price contracts that flow from prime contractors to the subcontractors who actually produce subsystems. These subcontractors, many of whom survive by virture of proprietary technical data that gives them a competitive edge, are reluctant to take direct R&D contracts because of concern over loss of technical data lights to the prime contractor and the government. Congress may wish to take action to limit

government rights to technical data, thereby making it easier to incorporate commercial technology into defense systems. Unless this concern is addressed adequately, many more subcontractors may leave the defense business. Table 1-3 contains a number of other similar issues that could lead to legislative action.

Congress will shape the ultimate choices the Nation makes with regard to the broad strategies outlined earlier, all of which involve tradeoffs between national risks and benefits. As noted above, the choice between national autonomy and interdependence involves balancing the risks of relying on other nations for critical defense goods against the benefits of access to the growing number of technologies developed abroad and the synergies that arise from cooperation with economically strong allies. The choice between arsenals and civilian integration involves balancing the risk of losing key military technologies against the benefits of access to a broad range of useful civilian technologies and a greater latent mobilization capacity. The choice between military potential and current capability involves balancing the risk of being inadequately prepared to meet near-term threats against the benefit of developing more effective future weapons. None of these broad strategies is likely to be pursued in absolute terms, and the application of any given strategy will be tailored according to ownership, tier of the base, functional area, and industrial sector.

Congress will have a deciding role in which tactics to pursue to achieve and maintain the desired characteristics of the future DTIB. First, congressional action will be required for the explicit full funding of R&D previously supported by production. Since the government's calculation of past R&D costs have often not included the money that firms have spent from profits, the explicit R&D funding requirements may appear high. Second, Congress will want to examine new forms of competition that are more amenable to a fiscally constrained environment, such as competitive prototyping or encouraging radically different approaches to achieving a given military objective instead of competitions between similar platforms. Third, Congress will want to consider the tactic of using foreign sales to maintain production lines, including an assessment of the long-term national security implications of the proliferation of advanced conventional weapons.[12]

Obstacles to redesigning the DTIB arise from incentives in both government and the private sector to maintain current capabilities rather than to restructure the base to emphasize future military potential. In addition, anticipating changes in the base involves asking both industry and DoD to make decisions that entail definite short-term costs in the interest of obtaining uncertain long-term benefits. To cut through these constraints, the Nation needs a long-term defense technology and industrial strategy that provides a predictable planning environment for government organizations and fins. The strategies and tactics laid out in this report could provide the basic elements of such a planning environment.

All of these policy options demand fundamental reexamination of, and specific changes in, procurement laws, regulations, and specifications. The current procurement process discourages many qualified firms from bidding on defense contracts because of the large amounts of paperwork involved and military specifications that are often excessively demanding. Another problem stems from the twin objectives of access and accountability, which have driven the competitive approach to defense procurement. Numerous Federal laws and regulations have been designed to ensure access to DoD contracts by the maximum number of firms, as well as accountability of government funds by those winning such contracts.

Congress has viewed competition as an ideal way of reducing costs, increasing access to new fins, and stimulating innovation. These goals are embodied in statutes mandating competition for defense contracts, such as the Competition in Contracting Act (CICA) and laws that require "setting aside" certain percentages of defense contracts for small and disadvantaged businesses. Unfortunately, as discussed in chapter 4, competition as currently practiced often ends up increasing overall procurement costs while doing little to foster innovation. Although the law allows exemptions from competition where it is inappropriate, in practice the exemptions are rarely exercised because of a lack of bureaucratic incentives for doing so. Competition is thus an important management tool that should be

[12] OTA, *Global Arms Trade*, ibid, addresses the proliferation issue in detail.

structured differently in the future. One way maybe to emphasize competitive design and prototyping, as discussed in chapter 5.

The principle of accountability also warrants a new look by Congress. Large increases in defense expenditures in the early 1980's and revelations of criminal conduct by some defense contractors led to growing congressional concern with ensuring the proper use of government funds. While accountability is clearly essential, there are indications that the current approach is counterproductive. Government and company auditors consume large amounts of time and money contesting what is or is not allowable, and the criminal sanctions associated with violations of many defense-procurement laws cause contractors to fear that honest mistakes could lead to prosecution and possible prison terms. Under these conditions, companies have a strong incentive to err on the side of caution, even if this means taking measures that increase procurement costs considerably. Moreover, the government's special auditing requirements have the unintended effect of isolating the defense industry from the civilian sector. Given budgetary constraints, Congress may wish to reform the current approach to ensuring accountability by moving more in the direction of commercial business practices.

Finally, U.S. procurement law in the 1980's stressed competition and accountability in a way that transferred more risks to the defense industry. Since defense spending was increasing rapidly and the overall economy was engaged in a national borrowing spree, companies were generally willing to build new manufacturing facilities and to accept small near-term profits in the expectation that future sales based on projected production would amortize the investment. Yet the sharp downturn in defense spending is now confronting the industry with financial problems that may well result in the loss of critical elements of the DTIB. Congress may therefore wish to examine new ways of rationalizing the base so that the Nation retains a sound defense industrial capability and not simply a collection of lucky survivors.

SUMMARY

This report provides the framework for congressional debate over the transition to a downsized but still robust DTIB. In the aftermath of the cold war, the Nation no longer faces a single predominant threat to its security and global interests but rather an array of lesser, ambiguous threats. Dramatic changes in the security environment-the dissolution of the Warsaw Pact, the withdrawal of Soviet forces from East-Central Europe, and the growing turmoil within the Soviet Union-combined with increased fiscal constraints in the United States, are resulting in significant cuts in U.S. defense spending.

The decline in budget authority since 1985 and the expected sharp drop in procurement contracts over the next 5 years has already affected the DTIB. Defense contractors, both prime and subtier, are adapting to a shrinking market by diversifying or leaving the defense business altogether. At the same time, procurement laws relating to military specifications, competition, and accountability, many of them written during a period of rising military budgets, now create serious obstacles to the rationalization of the base and the greater integration of civilian and defense production. If this ad hoc restructuring process is allowed to proceed, it could jeopardize the Nation's future ability to develop affordable, high-performance weapon systems and to mobilize its defense industrial capacity in crisis and wartime.

A rational transition to a downsized but viable DTIB will entail preserving critical, long-lead-time design and production capabilities. This task will in turn require Congress to demonstrate leadership by taking a broad strategic approach to the Nation's future national security needs, even at the expense of some immediate political and economic concerns on the part of States and congressional districts.

Chapter 2

Threats, Forces, and Operations

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Chapter 2
Threats, Forces, and Operations

INTRODUCTION

The defeat of the Axis powers, the end of World War II, and the beginning of the cold war required a complete review of U.S. national security policy. A similarly comprehensive review is warranted in the aftermath of the cold war, including reexamination of the size and structure of U.S. military forces and their supporting industry. Restructuring the forces entails policy choices with important consequences for defense technology and industrial base (DTIB) planning. This chapter is not meant to provide an answer to the question of what the future structure of U.S. forces *should be,* but rather to provide a useful and considered estimate of what it will be, for the purpose of assessing the effects on the DTIB.

CHANGING U.S. STRATEGY

After the Second World War, several events combined to create new security challenges for the United States and the world. The Soviet Union's totalitarian system, expansionist ideology, and imposition of client regimes in Eastern Europe made it a military threat to the West. Clear and apparently irreconcilable ideological differences between the Communist countries and the Western-oriented democracies forced most nations into one of the two camps, forming a' 'bipolar' world. With the Soviet development of atomic weapons, the nuclear threat hung over every calculation of war and created for Americans an unprecedented sense of national vulnerability. At the same time, the United States came to view regional conflicts throughout the world through the prism of the superpower rivalry.

The North Korean invasion of the South in 1950 and the continuing confrontation in Europe created the impression that the Soviet Union was intent on expansion, that another world war might be imminent, and that such a war would be nuclear and devastating. These perceptions led the United States to implement a new policy of "containing" the Soviet Union by reversing the post-war dismantlement of the U.S. military and its supporting industry.[1] Defense spending shot up from $78 billion to $331 billion (in fiscal year 1990 dollars).[2] The United States hoped that the strategy of containment would prevent the Soviet Union from dominating the Eurasian continent while avoiding a third world war. This state of tense, alert peace came to be called the "cold war."

The cold war and containment required something new of the United States. U.S. policymakers feared that Soviet conventional military capabilities in Europe were so formidable, and the destruction from a nuclear strike would be so devastating, that the Nation would be unable to recover from a surprise attack and mobilize over a year or more as it had in World War II. Thus, highly ready forces had to be deployed both at home and abroad to counter similarly ready Soviet forces. The United States settled into a state of continuous military alert and partial defense-industrial mobilization.

During the cold war era, the clarity of American security objectives owed much to the clarity of the Soviet threat. Although great debates raged at times over details and execution, there was a general

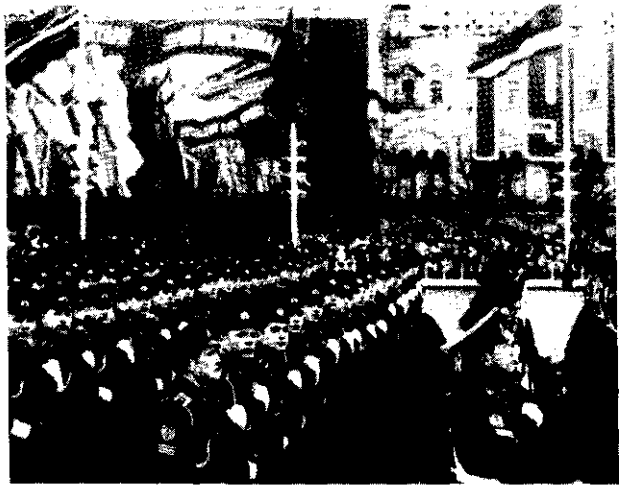


Photo credit: U.S. Department of Defense

During the cold war the annual parade through Moscow's Red Square demonstrated Soviet military power and emphasized the global military confrontation.

[1] X (George Kennan), "The Sources of Soviet Conduct," *Foreign Affairs, vol. 25, No. 4,* July 1947, pp. 566-582.

[2] William Kaufmann, *Glasnost, Perestroika, and U.S. Defense Spending* (Washington, DC: The Brookings Institution 1990), table 1.

consensus about the basic objectives of U.S. national security policy. As Paul Nitze writes:

> For over forty years the foreign and defense policies of the United States have been guided by a central theme, a well-defined basic policy objective. That goal, throughout the Cold War, was for the United States to take the lead in building an international world order based on liberal economic and political institutions, and to defend that world against communist attack.[3]

Because the cold war mobilization was a direct response to East-West tensions, the diminution of those tensions may result in a comparable degree of demobilization.

Planning future military forces requires some idea of a future national strategy. As the singular military threat from the Soviet Union diminishes, however, designing a national security strategy will become more subtle and complex. There are two major changes in the security environment: the diminished military threat, and the increased importance of non-military factors. While economic performance, access to raw materials, capital accumulation, and ideological appeal are all part of any security calculation, the relative contributions of each and the balance between military and non-military considerations are shifting.

By the broadest definition, economic problems are ultimately security problems because the extent of a nation's military power is limited by its economic resources and by necessary tradeoffs between social-welfare and defense spending. The ability of the United States to manufacture weapons will be constrained by a decline in its overall manufacturing capabilities. In addition, the military requires goods, such as food and fuel, that are clearly "civilian" yet are critical to military operations. Although defense procurement makes up only about 3 percent of the U.S. gross national product (GNP), the fact that it constitutes 21 percent of capital goods manufacturing and that in a major war a far greater percentage of GNP would be applied to military production (39 percent in World War II) indicates that the Nation's overall economic performance is an important determinant of its military potential.

This report, while recognizing that there is no sharp dividing line between civilian and military industry, concentrates on that part of the U.S. industrial base specifically devoted to weapons and other critical military equipment. The broader economic issues treated here are those that most concern military capabilities, such as how the state of the U.S. electronics industry affects the military's access to critical electronic components.

U.S. Security Objectives

According to a recent statement by the President, the United States has four basic national security objectives:

1. ensuring the survival of the Nation as a politically independent entity,
2. promoting economic prosperity for Americans and the world,
3. maintaining a stable world order conducive to liberty, and
4. forging strong ties to allies and like-minded nations throughout the world.[5]

For the foreseeable future, attaining these objectives will require military forces to supplement economic and diplomatic tools.

Preserving national survival and sovereignty are the foremost objectives of any state. Beyond these basic needs, however, the United States has the power and resources to pursue other objectives. First, the United States seeks to promote its own prosperity and that of friendly nations through a stable international environment. Second, the United States is a liberal democracy, supports like-minded democracies around the world, and officially promotes the process of democratization in other countries.

Strategic Alternatives

The future national security strategy of the United States may follow one or more of the following paths:

1. the Nation may try to maintain its current military security arrangements with the minimum changes possible,

[3] Paul H. Nitze, "America: An Honest Broker," *Foreign Affairs*, vol. 69, No. 4, fall 1990, pp. 1-14.

[4] Under Secretary of Defense (Acquisition), Bolstering *Defense Industrial Competitiveness* (Washington DC: Department of Defense, July 1988), p. v.

[5] President Bush, *National Security Strategy of the United States* (Washington, DC: The White House, March 1990), pp. 2-3.

Photo credit: Bettman Archives

Indicative of the profound changes in European security since 1989, a driver and mechanic prepare Soviet tanks for departure. The poster reads, "Farewell, Czechoslovakial" ' "

2. it may withdraw economically and militarily and become more isolationist,
3. it may remain internationally engaged but act unilaterally or through ad hoc alliances, abancloning the permanent alliances designed primarily as counters to the Soviet Union, or
4. it may act increasingly through multinational organizations such as the United Nations.

The **actual strategy most likely will be composed** of some combination of these alternatives. Current evidence suggests, however, that a major disengagement is the least likely route for the United States to follow. All of the other strategies require military force that can be projected across the world. Moreover, since the beginning of World War II, the United States has sought to act within an alliance context for military and political support. Without an immediate Soviet threat, however, alliances such as the North Atlantic Treaty Organization (NATO) may lose their primacy. Instead, the ad hoc alliance formed to counter Iraq maybe the model for future alliance relations, although the United States may not take the lead every time.

THE NATURE OF FUTURE MILITARY THREATS

Europe

U.S. policymakers have long recognized that economic and industrial power create military potential. Thus, the United States has considered the domination by any single power of Europe's industrial production—and hence its military potential—to be a long-term threat to American security. This concern was a major factor in U.S. cold war policy.

The security of Europe retains its historical importance to the United States. The difference now is that the threat of a large-scale conventional attack has greatly diminished: estimates of warning time have increased from 2 weeks to as much as 2 years. Even if the Soviet Union remains intact and powerful, an important buffer now exists between Soviet military forces and NATO Europe.

Military security is difficult to measure on an absolute scale, but the situation today suggests that the relative likelihood of a major war in Europe involving the United States has fallen to its lowest level since the end of World War II. Yet even without a threat of short-warning surprise attack, Europe may still need the U.S. long-term potential for reinforcement and mobilization to counter a reconstituted Soviet conventional threat. Moreover, non-nuclear European nations, like Germany, may still want a U.S. nuclear guarantee.

Instability in Eastern Europe or the Soviet Union itself, while not a "threat' in the normal sense, could pose a danger to U.S. and NATO security. One can envision widening circles of chaos that could draw the United States into a conflict. Thus, President Bush can say with some justification that the enemy is "instability." Having intervened in two World Wars that began in Europe, the United States clearly has an interest in maintaining stability in that critical region.

Third World

The importance to U.S. security of countries outside the advanced industrial nations, often lumped together as the "Third World," has been much debated. There are two basic schools of thought.[6] One school argues that the United States should concentrate almost exclusively on the security of the world's industrial centers and oil-rich regions because they are the sources of economic and military power. Since the Third World's economic power is limited and diffuse, it is of secondary security interest to the United States except for a few special cases such as Panama, Saudi Arabia, and Kuwait.[7] Members of the opposing school contend that straightforward calculations of industrial power are too simplistic. They argue that while the geographic position and resources of any single Third World country may not be vital to the United States, the loss of access to resources or basing rights in several Third World countries could affect the global balance of power. In addition, while war in Europe would be far more damaging than conflict in the Third World, the latter is so much more likely that it deserves greater attention.[8]

Much of the past argument about the strategic importance of the Third World concerned its role in the global competition between the Soviet Union and the United States. Since the Soviets have essentially withdrawn from that competition, however, balance-of-power arguments supporting U.S. intervention in Third World conflicts are no longer compelling. A few geopolitical considerations may survive the end of the cold war, but they have also been weakened. The United States will always be concerned about potential instability in Mexico and other neighboring states, but threats to straits and other transportation choke-points were most significant in the context of a potential global conflict with the Soviet Union. Even then, it was easy to exaggerate the significance of these threats, since there were always alternative transport routes.[9] For example, anyone with a map can point out the vital importance of the Suez Canal, yet it was closed for years after the 1967 Arab-Israeli War without disastrous effects.

Some observers argue that the Third World's soaring populations, shortages of food and other resources, rising religious fundamentalism, and expanding arsenals of modem weapon systems may make it a zone of perpetual crisis. Other analysts, however, suggest reasons why the Third World may become more stable: the process of decolonization is essentially complete, nation-building is well advanced, and the Soviet Union's ideologically driven intervention has ended. It is therefore uncertain whether the world outside Europe and North America will experience more or less civil and interstate conflict in the future.

[6] For a good comparison of the main arguments on both sides, see Michael C. Desch, "The Keys That Lock up the World: Identifying American Interests in the Periphery,' *International Security,* vol. 14, No. 1, summer 1989, pp. 89-121.

[7] For a succinct exposition of this view, see Stephen Van Evera, ' 'American Strategic Interests: Why Europe Matters, Why the Third World Doesn't," *Hearings before the Panel on Defense Burdenshanng, Committee* on Armed Services, U.S. House of Representatives, Mar. 2, 1988.

[8] See Steven R. David, "Why the Third World Matters," *International Security,* vol. 14, No. 1, summer 1989, pp. 50-85.

[9] Robert H. Johnson, "ExaggeratingAmerica's Stakes in Third World Conflicts," *International Security,* vol. 10, No. 3, winter 1985-86, pp. 32-68.

Photo credit: U.S. Department of Defense

American troops continue to patrol the cease-fire line between the two Koreas.

In any case, most Third World conflicts are the result of long-standing *local* animosities that do not automatically imply threats to Western security .[10] While the United States will continue to have moral and humanitarian concern for the poor Third World, such countries are unlikely to pose threats to U.S. security interests that would warrant a large-scale intervention by American forces. Moreover, even in those rare cases where U.S. intervention proves necessary, the very large majority of nations of the world have such limited military capabilities and potential that even a relatively small U.S. force would be adequate to handle most contingencies.

Other than the Soviet Union, only a handful of nations have substantial military capability and also control a vital resource (in practice, this means oil) or threaten a U.S. ally or important U.S. interests. The number of potentially serious threats is small enough that instead of planning for a "generic" Third World threat, specific cases can be considered. North Korea and a number of countries in the Middle East represent the most challenging potential threats, providing a yardstick for future U.S. force requirements.

The United States, of course, calculates its military requirements in context, such as including South Korea's substantial military capability when estimating the potential threat from North Korea. Nevertheless, since the United States must fight far from its shores and may be constrained in its military options by political considerations (e.g., access to foreign bases), U.S. force requirements may be greater than a simple comparison of size and economies would suggest.

The types of military operations that the United States would conceivably undertake in most parts of the Third World might require tailored intervention forces with special equipment and training, but one would have to postulate unexpected reversals and protracted conflict involving U.S. forces before the military requirements would be taxing. Moreover, those Third World crises that do flare up should be much easier to handle without the threat of Soviet intervention hanging over every move. Imagine the recent Persian Gulf War if Iraq had still been a Soviet client state. Each U.S. action would have been weighed against the risk of Soviet intervention, and the Syrians and several other Arab states most likely would have withheld support from the United States or even sided with Iraq. The West Europeans, worried about antagonizing the Soviets, would have been much less forthcoming. What was already a formidable task could have become paralyzingly complex.

While only a handful of Third World nations have any significant domestic weapons production capacity and none has a comprehensive defense technology and industrial base (see table 2-l), Third World weapon production capability is increasing, often

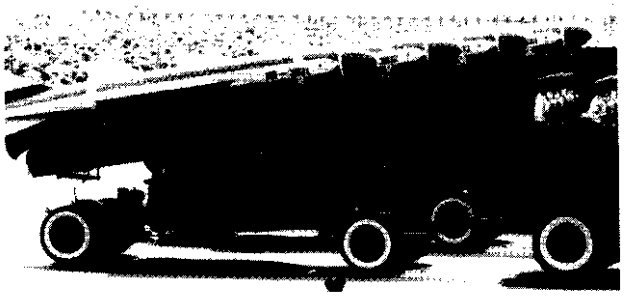


Photo credit: U.S. Department of Defense

An ever-increasing number of Third World countries produce and export weapons. In the hands of a hostile regional power, the Chinese Silkworm missile could greatly complicate U.S. military planning.

[10] Eliot Cohen, "Distant Battles: Modern War in the Third World," *International Security*, vol. 10, No. 4, spring 1986, pp. 143-171.

Table 2-l-Countries Producing Weapons—Now Through 2000

Major independent weapon production	Indigenous production of a wide range of weapons	Limited production of many types of weapons	Limited production of a few types of weapons	Minimal weapon production capability
United States	Brazil	Chile	Argentina	Algeria
Soviet Union	India	Greece	Egypt	Iraq
France	Israel	Indonesia	North Korea	Libya
Germany	South Korea	Iran	Taiwan	Morocco
United Kingdom	Yugoslavia	Malaysia	Canada*	Syria
China	South Africa	Singapore		
Poland	Spain*	Pakistan		
Czechoslovakia		Thailand		
Italy		Turkey		
Sweden				
Japan*				

● Additional estimates by OTA.

SOURCE: Briefing by David Louscher, "Patterns of Demand and Supply of Weapons."

with Western help.[11] The problem is not just production but the widespread availability of weapons on the open market. Other than nuclear weapons, there is very little that any country with the money cannot buy. Some Third World nations, especially those with oil reserves, have been able to acquire large arsenals. Several nations have bought sophisticated weapons such as antiship cruise missiles, which, even if not possessed in large numbers, could severely complicate U.S. defense plans. In addition, some of the existing inventory in Europe may be sold off on the international market as surplus. Although the U.S. defense industry favors promoting arms sales to support the DTIB, this policy makes little sense if it encourages transfers of weapons to countries that may foster regional instability or become adversaries in the future.

In summary, the transformation of the global security environment will result in changes in U.S. force structure, in turn imposing new demands on the supporting defense technology and industrial base. Competing and conflicting requirements may create conundrums for DTIB planners. On the one hand, the large increase in warning time available before the Soviet Union could launch a credible conventional attack, as well as the buffer of newly independent states between NATO and the Soviet Union, are transforming the challenge of meeting a Soviet threat into one of reconstituting a large U.S. military capability over a period of years. On the other hand, there are many lesser contingencies that require forces-in-being. The defense-industrial requirements of these ready forces will be very different from those needed for long-term force reconstitution. Allocating limited resources between these two sets of requirements is an important policy issue affecting the DTIB in the coming decade.

The Continuing Nuclear Threat

Although the threat from Soviet conventional forces is much reduced, there has been no comparable reduction in the destructive capabilities of Soviet strategic nuclear systems, which continue to pose a direct threat to the United States. Even so, it is generally believed that the nuclear threat has diminished, for several reasons.

First, although prudent military planners often contend that one should not consider intentions but concentrate only on capabilities, that approach is too simplistic. Both the British and the French have nuclear arsenals that could destroy the United States as a modem society, yet Americans do not worry about those capabilities because of their confidence in the intentions of these allies. The Soviet Union clearly has become less belligerent over the last several years, and the circumstances in which the Soviet leadership would consider using nuclear weapons are almost certainly less likely than in the past. Thus, U.S. warning and nuclear readiness levels have begun to be reduced.

Second, nuclear war would be so horrible that no one can easily imagine a provocation strong enough to start one. Most military planners have judged that the most plausible route to nuclear war is escalation from conventional war. Yet the United States has supported President Gorbachev in his difficult efforts at reform and has made it clear that NATO

[11] U.S. Congress, Office of Technology Assessment, *Global Arms Trade: Commerce in Advanced Military Technology and Weapons*, OTA-ISC-460 (Washington DC: U.S. Government Printing Office, June 1991).

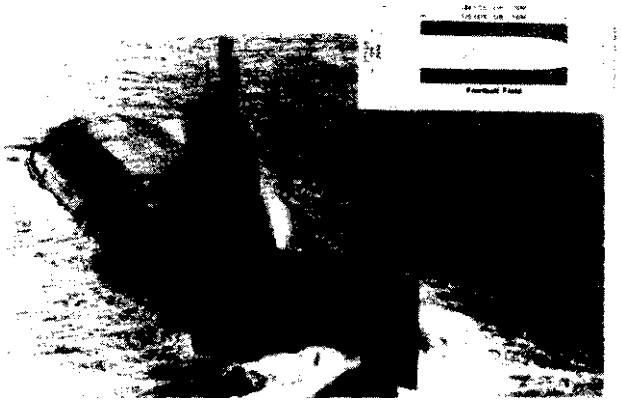


Photo credit: U.S. Department of Defense

Although the Soviet conventional threat to Europe is much reduced, Soviet nuclear capabilities, such as this Typhoon missile-launching submarine, remain formidable.

does not threaten Soviet security. The risk of conventional war has accordingly declined, and without a conventional war little nuclear incentive exists.

Finally, the sea-change in U.S.-Soviet relations might allow a slowing of the quantitative and qualitative nuclear arms competition. Each side's modernization efforts drive the other's to some extent and require costly countermeasures to maintain an assured second-strike capability. Even if the two superpowers remain wary of each other, changes in the Soviet Union make it at least conceivable that retaliatory security can be assured by a substantial reduction in the number of strategic nuclear weapons on both sides. The current START negotiations are a move in that direction.

Perhaps the greatest potential for an *increased* threat from Soviet nuclear weapons would follow from instability or breakup of the Soviet Union. Centralized control over nuclear weapons might then be lost or pass to small, untested, perhaps unstable governments. While it is difficult to imagine any of the potential new governments starting a war with the United States, the presence of nuclear weapons increases the dangers of instability.

The U.S. policy of extended deterrence has assigned some role in deterring conventional aggression in Europe to both theater nuclear forces based on European soil and central strategic systems in the United States. As the conventional threat to Europe diminishes and the possibility of a Soviet military victory recedes, nuclear weapons will become, in ***NATO'S*** words, "truly weapons of last resort."[12] With deterrence of war provided primarily by NATO conventional weapons strength, the portion of the U.S. nuclear force dedicated to NATO could be reduced.

Although the Soviet nuclear threat may be diminishing, the second tier of nuclear powers and the spread of nuclear weapons to other nations remain sources of concern. Nuclear weapons are so destructive that the possession of small numbers by even one hostile nation could be a significant threat to U.S. security. Fortunately, past predictions of the expansion of the nuclear club have turned out to be overly pessimistic, since many states with a nuclear weapon potential have chosen to forego the option.[13] The problem is not a general worldwide rush to go nuclear by every country that is technologically capable of it, but rather the efforts of a few renegade nations such as Iraq, North Korea, and Libya. Although these cases present a challenge, sanctions are more effective against a small number than against a general trend.

POSSIBLE FUTURE FORCE STRUCTURES

Future military force structure will be the result of decisions based ultimately on judgments about the size and character of the threat and on the resources available to develop and maintain the forces. Four major force-structure judgments will affect requirements for the defense technology and industrial base:

1. the expected size and type of the threat that must be countered,
2. the desired rate at which forces should be committed and the length of time they should be sustained,
3. the autonomy desired for U.S. forces, and
4. the expected performance of U.S. weapons compared to those of potential adversaries.

The assessed size and type of threat clearly affects the desired overall size of U.S. forces and, hence, the size of the peacetime DTIB. The desired rate of force commitment determines the readiness of the force,

[12] London Declaration Summit of NATO Heads of State and Government, July 5-6, 1990.

[13] Joseph Nye, "Nonproliferation: A Long-Term Strategy," *Foreign Affairs*, vol. 56, No. 3, April 1978, pp. 601-623.

Table 2-2—Force-Structure Choices Affecting the Defense Technology and Industrial Base

National security policy choice	Military force indications	DTIB indications
Size and natureof contingency planned for	Size and capability of overall force	size of sustaining base, surge and mobilization capacity
Urgency of dealing with contingency	Readiness of force, active/reserve ratios, training tempo, war reserves	Responsiveness, lead times
Autonomy of action	Degree of integration with allied forces, size and readiness of forces, composition of force	Use of foreign technology, use of foreign production, cooperative logistics planning
Qualitative or quantitative emphasis in weapons	Performance and number of weapons	Sophistication of supporting technology base, allowed dependence on global commercial technology

SOURCE: Office of Technology Assessment, 1991.

Table 2-3—Major Military Elements Under Several Proposed Defense Reductions

Forces	Current	CBO[i] "Alternative i"	CBO "Alternative V"	Kaufmann[i] "Case D"	Comm. for Nat. Sec. and Def. Budget Proj.	Admin.[k] 25%. Force Reductions
Divisions[a]	(21/11)[b]	(19/1 1)	(12/8)	(10/1 1)	(10/10)[j]	22[l]
Carriers		14		6	9	12
Attack submarines	9 2[d]		7 2[h]			—
Tactical Air Wings[a]	(27/13)[c]	(27/13)	(17/8)	(15/12)	(12/12)j	25
Missile submarines	34"	23	17	17		20
ICBMs	1000	50 MX+500 SICBM	50 MX+500 MM-iii	100 MM-iii	950 MM	500
Bombers	260[g]	97 B1 +132 B2	23 B52+97 B1 +15 B2	41 B1	97 B1+15 B2	200

a(active/reserve)
b Army (18/10) + Marine (3/1) divisions--does not include nondivisional assets. See CBO, Security Needs, p. 3, Mil Bal, pp. 17, 20.
c Air Force (24/12) + Marine (3/1) airwings. See CBO, p. 3 and Mil Bal, pp. 21-22.
d CBO, p. 46.
e Mil Bal, p. 16.
f Minimum reductions to meet expected START& CFE limits.
g Mil Bal, p. 16 (excludes FB-111s).
h CBO, p. 46.
i Kaufmann, Table 32. Kaufmann calculates force levels in terms of "division equivalents."
J Excludes Marine forces.
k From OSD briefing, "Budget impact of Illustrative 25% Force Reduction," June 1990.
l Active and reserves were not broken out.

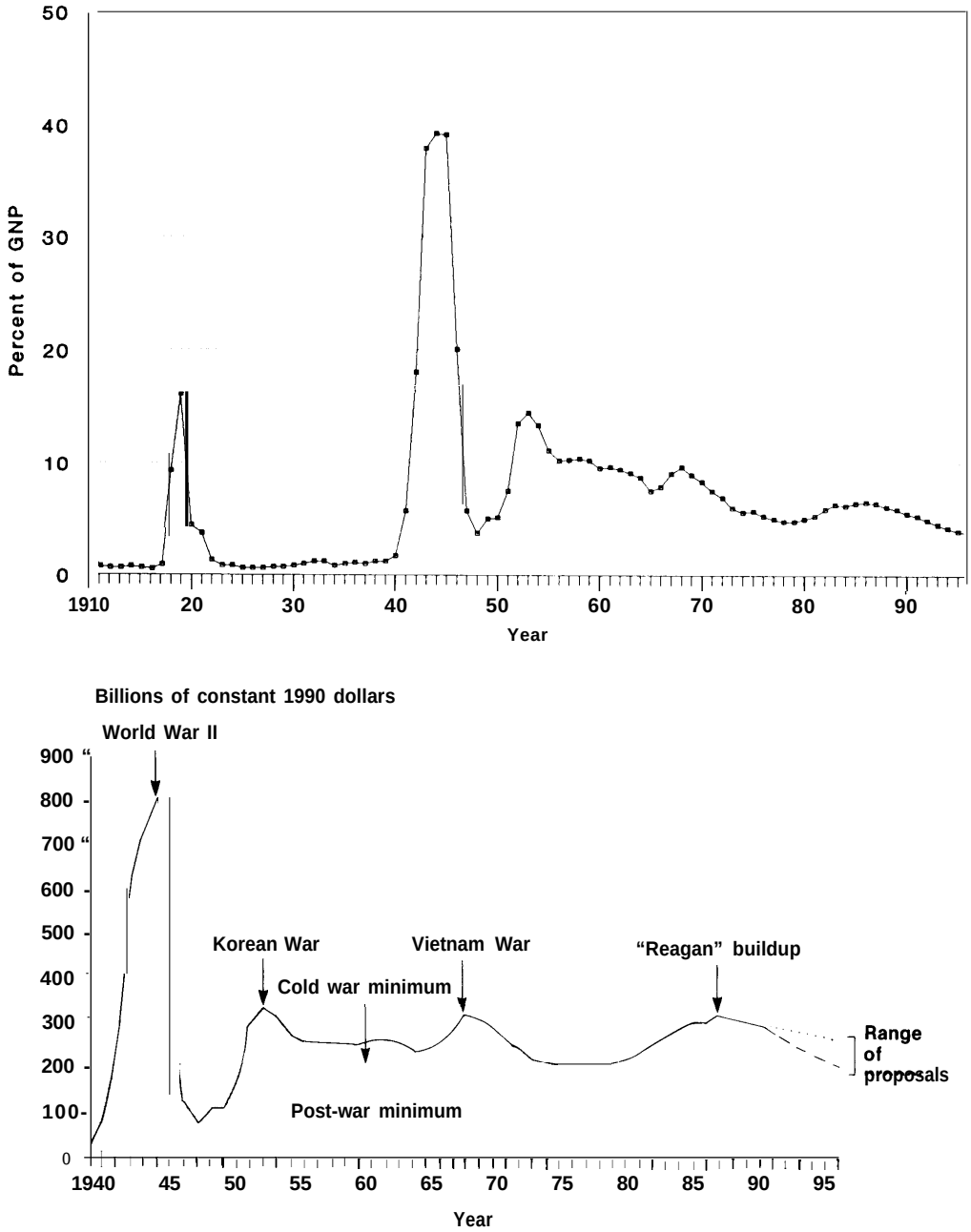
"CBO" refers to *Meeting New National Security Needs: Options for U.S. Military Forces in the 1990s,* Congressional Budget Office (February 1990).
"Kaufmann" refers to William Kaufmann, Glasnost, Perestroika, and *U.S. Defense Spending* (Washington, DC: The Brookings Institution, 1990).
"Mil Bal" refers to *The Military Balance, 1989-7990* (London: International Institute for Strategic Studies, 1989).
"Comm. for Nat. Sec. & Def. Budget Proj.," refers to *Restructuring the U.S. Military: Defense Needs in the 21st Century* (Washington, DC: Defense Budget Task Force of the Committee for National Security and The Defense Budget Project, 1990).

SOURCE: Office of Technology Assessment, 1991.

which refers to the level of training, the peacetime operational and maintenance tempo, the required stockpiles of ammunition and spare parts, and the planned surge capability of the DTIB. Autonomy of U.S. forces means the degree to which they can operate without foreign forces, weapons, or bases and infrastructure, and the extent to which the Nation will allow itself to use foreign technology. The desired performance edge of U.S. weapons should determine, in part, the extent of the Nation's investment in defense R&D. These choices are listed in table 2-2.

Several recent studies have proposed force reductions of various extent and speed, as summarized in table 2-3. Most proposals envision at least a 25-percent cut, and some sketch out 50-percent cuts, usually over 7 to 10 years. How severe such cuts appear depends on one's view of the appropriate baseline. Figure 2-1 shows overall U.S. defense spending as a percentage of GNP since the beginning of the century and spending in 1990 dollars since the beginning of World War II. There were three major peaks in spending: World War I, World War II, and the cold war mobilization begun in 1950.

Figure 2-l—United States Defense Spending



SOURCES: *Budget of the United States Government Fiscal Year 1992, Historical Tab/es* (Washington, DC: U.S. Government Printing Office, 1991); Stephen Alexis Cain, *Analysis of the FY* 1992-93 *Defense Budget Request with Historical Budget Tables* (Washington, DC: Defense Budget Project, 1991); William W. Kaufmann, *Glasnost, Perestroika, and U.S. Defense Spending* (Washington, DC: The Brookings Institution, 1990).

Spending during the cold war had a floor of over $200 billion in 1990 dollars. Lesser peaks in spending over the cold-war minimum were associated with the Korean and Vietnam Wars and the peacetime buildup of the eighties. After these peaks, spending in 1990 dollars gradually returned to the cold-war minimum, and the expanding economy resulted in a downward trend in percentage of GNP devoted to defense. If one believes that the cold-war minimum is still appropriate, then some proposed

Box 2-A—Forecasts of Future Forces

The Electronic Industries Association (EIA) makes periodic forecasts of defense spending that are widely respected for their accuracy. The latest EIA study,[1] which was completed after the Iraqi invasion of Kuwait but before Desert Storm, predicts that overall U.S. defense spending will decline steadily to about $200 billion (in 1991 dollars) by the turn of the century. It predicts force cuts of more than 40 percent in the Army and the tactical Air Force, about 40 percent in the Navy, and about 25 percent in the Marines and the strategic nuclear forces.

The President's 1992 budget request calls for a reduction from 18 to 12 active Army divisions by 1995. Both the budget request and the EIA study foresee less forward basing and relatively greater emphasis on light forces rather than heavy armored forces. Accordingly, the Army plans very limited procurement of new armor. Despite the Army's decision to proceed with the next-generation LH helicopter, the ultimate investment is uncertain. Some experts contend that upgrades of existing helicopters would be adequate for the foreseeable future and much cheaper.[2]

DoD plans to reduce the total number of Navy warships by 17 percent to 451 by 1995 but would eliminate only a single aircraft carrier, from 13 to 12. The EIA study predicts a 32-percent cut in active Navy forces by the year 2000, down to a 400-ship navy with 10 aircraft carriers. Budget cuts and arms control treaties will almost certainly limit the Trident submarine fleet to 18 boats. Current procurement plans for the SSN-21 Seawolf-class attack submarine call for about 15 boats by 2000, half the production rate planned for in 1989.[3] The recent cancellation of the Navy's A-12 carrier-based attack plane will, of course, have a major effect on naval aircraft procurement. At least in the short term, the cancellation will result in more attention to upgrading existing models.

For the Air Force, DoD plans call for a reduction from 24 to 15 active tactical airwings and from 12 to 11 reserve airwings. The EIA study foresees a 41-percent cut in active forces, with a disproportionate share in tactical air, shifting the relative emphasis to strategic missions. The President has asked for continued funding for the B-2 strategic bomber, but congressional support is very thin. Congress has also eliminated funding for rail-garrison basing of the MX intercontinental ballistic missile and, while no final decision has been made, there is support for only one new ICBM, either the MX or the Small ICBM (Midgetman). The one area of growth anticipated by the EIA study is in Air Force airlift capacity.

[1] Electronics Industries Association *Defense Electronics Market Ten-Year Forecast, U.S. Department of Defense and National Aeronautics and Space Administration Budgets, FY 1991 -FY-2000*, Oct. 16, 1990.

[2] See Congressional Research Service, *Major Legislation of the Congress*, summary issue, 101st Cong., December 1990, MLC-088.

[3] Ibid., MLC-100.

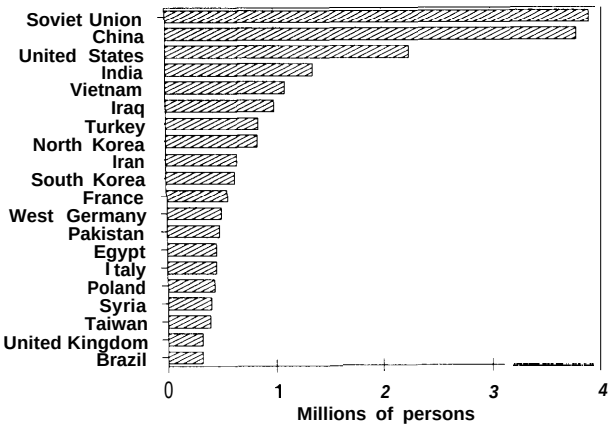
cuts could seem dangerously large. But if one believes that the pre-World War II spending levels and the post-war peacetime minimum are more appropriate to the current security environment, then a 25-percent cut would merely return us to "normal' cold-war levels, while a further 25-percent cut may be a justifiable response to the end of the cold war.

When these proposed force reductions were first presented, a 25-percent reduction appeared most likely, while a 50-percent reduction seemed radical. Since then, however, the President presented his fiscal 1992 defense budget request, which proposes a 30-percent reduction in budget authority between 1985 and 1996. (Reductions in actual outlays would be smaller because all of the money authorized in previous fiscal years has not yet been spent.) As the evaluation of future U.S. defense needs evolves, reductions by the end of the century may be closer to the previously "radical" 50-percent cuts than to 25-percent cuts (see box 2-A).

Most proposals for cutting forces would achieve reductions by retiring old inventory and terminating current production with those items already started (hence the proposal for 15 B-2 bombers) or contracted for at the time of the proposal (hence 17 Trident submarines). Thus far, not enough attention has been given to maintenance of the DTIB during the transition.

While all force-structure decisions will have some effect on the DTIB, a few key decisions may present particular challenges. Reductions in the heavy armor force and completion of force modernization without additional upgrades could result in a complete halt in the production of heavy armored vehicles. Similarly, the production of the Trident submarine

Figure 2-2—Active Armed Forces Personnel, 1988



SOURCE: U.S. Arms Control and Disarmament Agency.

will end with the additional boat funded this year. Some attention must therefore be given to the problem of how to maintain the skills, knowledge, capabilities, and equipment that will be required to develop and produce major categories of weapon systems or their replacements. If the United States produces no bombers, tanks, or submarines for a decade, how much will it cost to restart production, and would the Nation lose the ability to make such platforms in the future?

The sections below examine in more detail the tradeoffs and the risks associated with various choices about force structure, including size and type of contingency, force readiness, autonomy, and weapon performance. There then follows a discussion of the implications of these choices for the DTIB.

Size and Type of Contingency

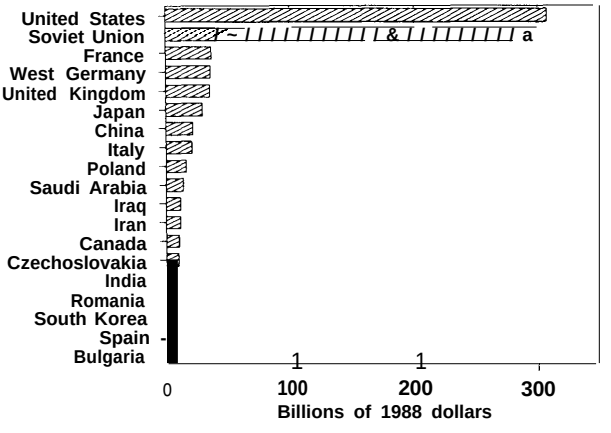
The size and structure of future U.S. forces will be influenced by judgments about the size and type of military contingencies that may face the United States, the likelihood of these contingencies, and the risks of not being able to handle them. Examining the personnel under arms and defense budgets of the leading military powers provides some perspective on the potential military challenges facing the United States.

Perhaps the most straightforward comparison of possible threats is total personnel under arms (see figure 2-2). By this measure, the United States does not stand out clearly, nor is there a sharp cut-off that divides the great from the small. Because the United States expects to be able to fight across the globe, much of its personnel is in the Navy and combat support. American *combat ground forces are,* therefore, relatively smaller than figure 2-2 would suggest. Moreover, political constraints on casualties means that U.S. involvement in the Third World could require the use of massive, overwhelming force to assure a quick, relatively painless victory, as it did in the Persian Gulf War. Yet even if the United States halved its total number of personnel, it would still count among the largest forces in the world and would lose relative rank only to India and Vietnam.

A better comparison of capability in modem conventional war is total military resources, which corresponds to the investment in modem weaponry and the skilled manpower to operate it. Although there is great variation in costs from nation to nation, particularly manpower costs, the armed forces of advanced industrial nations are trained to operate sophisticated weapons. Thus, financial measures indicate the extent of capital investment in modem weapons and skilled manpower and can provide a gross assessment of military strength. Figure 2-3 shows military spending of those countries with the largest military budgets. The United States and the Soviet Union overwhelm every other nation's military spending. Further, the second tier is composed predominantly of U.S. allies: the United Kingdom, France, Germany, Japan, Italy, and Saudi Arabia.

All of the U.S. force structure studies summarized in table 2-3 were completed before the recent war in the Persian 'Gulf. But since these proposals presumably considered contingencies like war against Iraq,

Figure 2-3--Major National Military Budgets, 1988



SOURCE: U.S. Arms Control and Disarmament Agency.

they should still be relevant to long-term planning. A reasonable test is whether the forces in each of these proposals could have handled the requirements of that conflict. Even for the proposed U.S. force structure with the deepest cuts, and even though Iraq was—at least on paper--one of the most challenging cases, the answer is a qualified yes. Coalition forces would still have been victorious over Iraq, but U.S. military responses would have taken longer, more reliance would have been placed on reserves or on allies, fewer U.S. forces might have been held in reserve to deal with other contingencies, and the actual operational plan might have differed.

A more critical policy issue than the size of a Third World contingency is how many such contingencies the United States must be able to handle at once. The difference between using Iraq or North Korea as a nominal planning threat might be small, but the difference between being able to handle Iraq or North Korea and being able to handle both contingencies simultaneously is bound to be close to a factor of two. The policy decision is how much the Nation is willing to pay for an insurance policy against U.S. involvement in two concurrent wars in the Third World.

In addition to force size, analyses of potential contingencies will require decisions about the composition of the forces needed to fight in different types of theaters. Will there be a change in emphasis among land, air, and sea forces, or between conventional and strategic forces? The emphasis could also shift within the Services, for example, from heavy to light armored forces in the Army or from submarine to surface forces in the Navy. Such changes in force size and composition will have important implications for the DTIB.

Force Readiness

After deciding the size and composition of U.S. forces, the next most important policy decision is to determine their state of readiness. As a military term, readiness refers to the extent to which the force is sufficiently well-trained and equipped to be committed to combat quickly and to perform effectively. According to the Department of Defense (DoD), the factors determiningg readiness include the quality, training, and manning levels of military personnel; the condition and maintenance of equipment; the training of units and crews; the quality of command, control, communications, and intelligence support; the location and mobility of forces; and logistics support.[14]

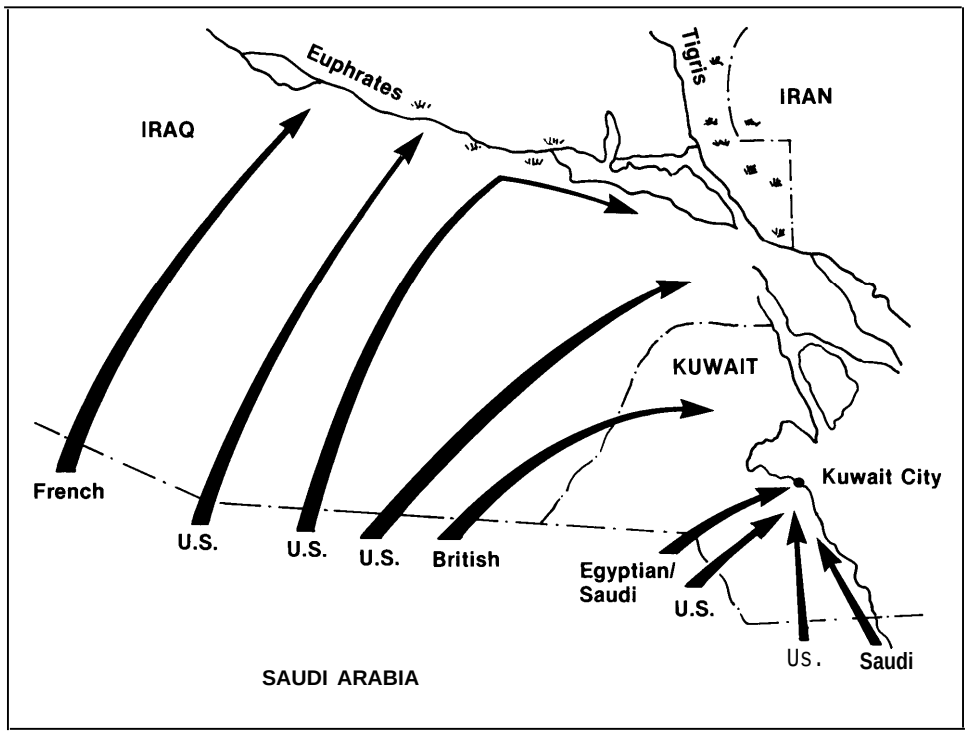
Decisions about readiness will require an analysis of costs and benefits. While full levels of troops, modem equipment, and realistic training are clearly expensive, the costs of being unready are harder to assess. The greatest danger arises when a hostile power can attack so quickly and with such force that the victimized state cannot recover in time to defend itself. This situation characterizes the vulnerability of small nations the world over. Fortunately, the United States is large, militarily powerful, and separated from potential enemies by great oceans, and thus much less vulnerable to a conventional-as opposed to nuclear-surprise attack. The United States may pay a price for not being ready to meet conventional aggression, but its national survival will not be in jeopardy.

Nevertheless, wars and threats can flare up quickly in places where the United States has vital interests. While it is not always necessary to respond immediately to aggression, costs can sometimes be incurred by waiting. The North Korean attack on the South in 1950 provides an example. Had the United States completely lost its foothold on the Korean peninsula, the cost—both in materiel and lives-of later making a "forcible entry" would have been much higher. Whatever the level of force readiness the Nation chooses, it must be matched by the responsiveness of the DTIB.

Autonomy of Forces

The degree of autonomy of U.S. forces really entails two questions. First, in how wide a range of contingencies should U.S. forces be able to operate without allied support? The required level of autonomy is determined by the extent the United States is willing to depend on allies to defend common interests. In the past, the United States has often sought to fight alongside allies for political reasons, even when it was not required militarily. Second, and more relevant to the DTIB, to what extent should the weapons employed by U.S. forces be products solely of the U.S. defense industrial base? The degree of autonomy of the U.S. base has varied greatly in the past, from nearly complete dependence

[14] Frank Carlucci, Secretary of Defense, *Annual Report to the Congress*, fiscal year 1990, p. 7.



Credit: Office of Technology Assessment

The United States has fought alongside allies whenever possible; the ground campaign to liberate Kuwait, shown in this map, was only the most recent example. Thus, allied contributions and materiel requirements should be figured into U.S. contingency planning.

on allies for heavy equipment in World War I, to an integrated Anglo-American production base in World War II, to the more autonomous base of today. The United States is fortunate to be allied with most of the leading industrial nations; otherwise, military-technical cooperation would be almost impossible.

A decision to exclude foreign production from U.S. weapons would have important consequences for the DTIB. While military planners may prefer that the base not become any more dependent on off-shore production than it already is, the increasing globalization of industry and technology may make defense industrial interdependence with other nations difficult to avoid or even track.

Desired Performance of Weapons

Throughout the cold war, the United States sought to match greater Soviet numbers with fewer but higher performance weapons. This approach has been followed for so long that today it has become nearly axiomatic. The Nation should not forget, however, that this procurement strategy is a policy choice and not an inevitable result of circumstances. A comparison of populations and productive capacity reveals that NATO certainly had the option of matching the Warsaw Pact man-for-man and tank-for-tank, had it so desired. The United States has chosen high-performance forces for a variety of reasons, including the desire to minimize battlefield casualties and expected cost-effectiveness. But the quality versus quantity debate will never go away. The country may want better tanks and airplanes than those of an adversary, but how much better? Is twice the performance preferable to a two-to-one numerical advantage?

The waning of the military competition with the Soviet Union could have an important effect on the performance requirements of U.S. weapons. Since the end of World War II, U.S. weapon performance has been measured against Soviet weapons. In the new security environment, however, more emphasis may be placed on low maintenance costs and high reliability for systems that might be in inventory for many years and used against technologically less sophisticated opponents. Moreover, as security concerns shift toward the Third World, the United States will become increasingly likely to face hostile forces armed with U.S. or European weapons. For this

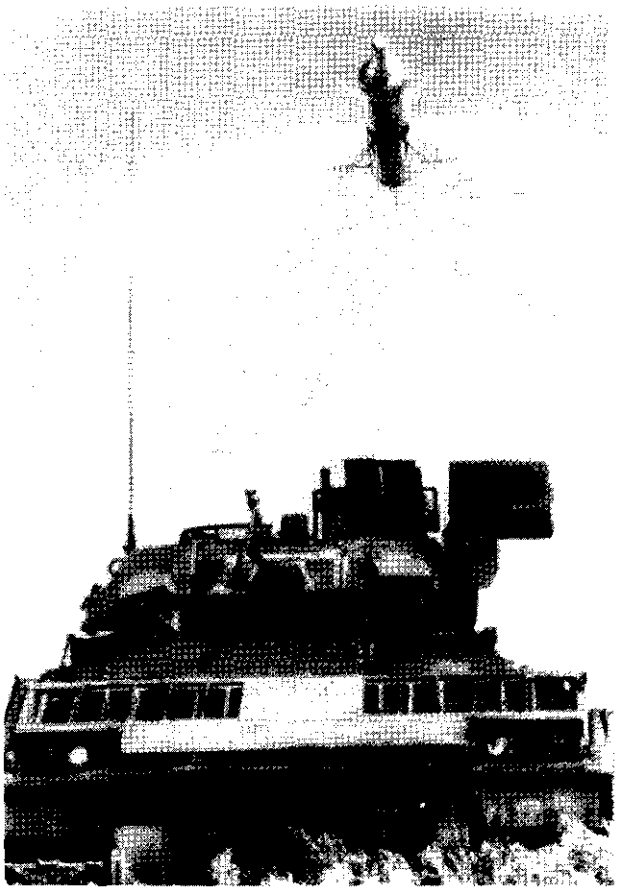


Photo credit: U.S. Department of Defense

The United States has emphasized high-performance weapons, such as this wire-guided TOW missile, rather than depend on sheer quantity. This strategy requires an active research and development program.

reason, choices relating to the performance of U.S. weapons in the future maybe affected by the extent of controls on international arms transfers. The performance required of U.S. weapons will in turn determine the requirements placed on the DTIB and, in particular, continuing levels of defense R&D.

EFFECTS ON THE INDUSTRIAL BASE

The likely characteristics of future U.S. forces are listed in table 2-4. While it is impossible to predict the nature of U.S. forces a decade hence, this analysis assumes that overall force structure will decline by nearly half over that period. Almost all possible force structures place relatively greater emphasis on reserves, but future force readiness levels remain uncertain. While military planners

Table 2-4-Characteristics of Future U.S. Forces

- Smaller active and ready reserve forces
- Less forward basing, greater strategic mobility
- Continuing weapons performance advantage
- Substantial nuclear capability
- Chemical and biological defense capabilities
- Greater dependence on mobilization

SOURCE: Office of Technology Assessment, 1991.

express a preference for readiness over force size, in the only vote that counts-the Service planning documents-they continue to prefer funding major weapon systems even at the expense of readiness. Finally, there is every indication that the United States will want to maintain superiority in weapon performance over that of potential adversaries, which will require preserving the U.S. lead in the requisite technologies.

How the transition to the future force structure is carried out is at least as important for the DTIB as the size of the reduction. To provide a simple example, if a force is made up of a uniform age distribution of weapons with a 20-year lifetime, a reduction of one-half can be effected over 10 years simply by halting procurement and retiring the weapons as they wear out. This approach is appealing because of the procurement money saved, but what happens to the production base in the meantime? For some systems, this illustration is not too far from reality. A reduction in Army heavy divisions and Navy carrier battle groups could result in a hiatus of several years in tank and aircraft-carrier production. While terminating production with the expectation of restarting it some years into the future maybe the only affordable approach, careful attention must be given to the problem of preserving critical skills, facilities, and technology during the intervening period.

Apart from the size of the force, how the force will be used will also affect DTIB requirements. For example, the surge capability of the base should be matched to the readiness of the forces, how long they may need to be sustained, and the size of stockpiles of materiel. Ironically, if active forces and munitions stockpiles get smaller-making industrial surge necessary for a greater number of contingencies—surge requirements may increase just as baseline production goes down.

Surge capability is also related to the problem of optimizing production efficiency. In the past, surge capacity was rarely funded explicitly; instead, some

extra capacity **was** hidden in the inefficiency of varying production rates, which often gave factories considerable surplus capacity. As total production diminishes, however, economies of scale are less likely to be realized, requiring evermore attention to production efficiency. One way to increase the efficiency of peacetime production is to avoid year-to-year variation in production rates and thereby eliminate surplus capacity, yet doing so would reduce surge capability in a crisis. This observation suggests that in the future, explicit funding of surge capacity for selected items will be required.

The desired level of autonomy of U.S. forces will affect DTIB requirements in two ways: by influencing decisions about the overall size and composition of the force, as described above, and by determining the allowed degree of interdependence of the DTIB with the global industrial base. Autonomy will not bean all-or-nothing decision. The appropriate level of national autonomy will vary for each type of weapon; foreign dependence may be acceptable for sidearms but never for nuclear warheads.

Even when autonomy is desired, it may be difficult to achieve. As the civil economy becomes more internationalized and parts of the DTIB come to depend more on the civil economy, it may simply not be possible to maintain complete autonomy in many areas. Moreover, foreign dependence does not necessarily equate to foreign vulnerability: if the United States has a dozen different suppliers of some critical part spread around the globe, the chances of a cutoff are slim, and indeed, the supply maybe more reliable than from a single domestic producer. Still, there are some critical technologies for which the Nation should preserve a domestic knowledge base and production capability.

Finally, future weapon performance goals will affect the requirements of the DTIB. The main risk associated with a "low-tech" approach is the possibility of technological surprise. If a potential adversary makes unexpected technical breakthroughs —which in the past have included radar, the transistor, and the atomic bomb--the military and strategic implications for the United States could be severe. The Nation will therefore wish to maintain some ongoing weapons R&D as a hedge against such an eventuality.

If the policy decision is made to continue emphasizing weapon performance, the Nation will require a continuing robust research and development effort. Yet there is no reason to maximize performance for its own sake; it must have some clear utility from a military operational perspective. At any given level of technology, better performance is available by paying more, but there is a point of diminishing returns. For example, the last 10-percent improvement in performance may be extremely expensive yet contribute little to combat effectiveness.

Since there is little doubt that future procurement of large expensive weapon platforms will be substantially reduced for a period of several years, R&D efforts should concentrate more on upgrading and retrofitting existing platforms to increase their performance, life expectancy, or reliability. Emphasis could also be shifted from developing new tanks, ships, and aircraft to improving their subsystems and the munitions they carry. Such shifts in R&D focus will also affect production. For example, relatively greater resources may go to production of munitions rather than new platforms, and of improved components and subsystems rather than complete weapon systems.

This chapter has reviewed important future choices about U.S. military force structure and discussed their potential effects on the DTIB. The next two chapters describe the structure of the DTIB and examine current trends and problems that must be taken into account in planning the transition to the future base.

Chapter 3

Structure of the Current Base

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Chapter 3
Structure of the Current Base

INTRODUCTION

The defense technology and industrial base (DTIB) has two broad functions. The first is to conceive of, develop, produce, maintain, and upgrade both modern weapon systems and supporting equipment in peacetime; the second is to respond to crisis or war with increased production of current materiel and the development of new systems.[1] These objectives are to some extent in competition for limited resources, and one of the primary challenges of DTIB planning and management is finding the proper balance between the two.

In considering the transition to the future DTIB, it is important to understand the overall structure and condition of the current base, including both its strengths and its weaknesses, and the policies that have led to the current situation. This chapter draws together the findings of numerous assessments over the past decade, as well as information from surveys and discussions conducted by OTA. The chapter provides insights into the current structure of the base, explains the differing requirements of elements of the DTIB, and outlines its current management structure.

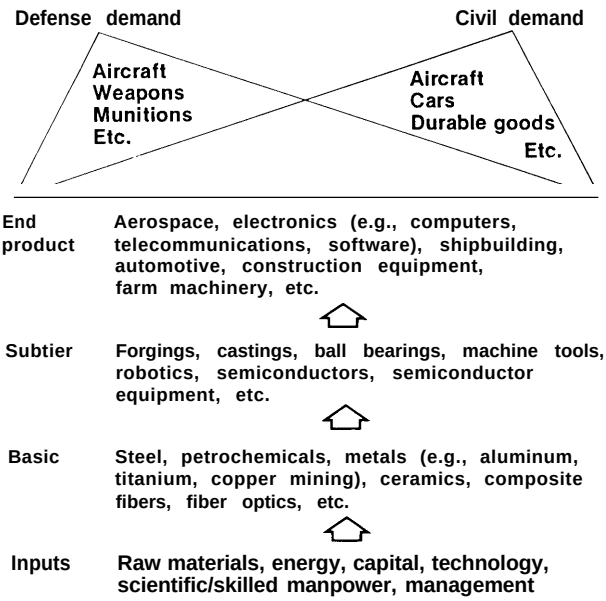
STRUCTURE OF THE CURRENT BASE

The DTIB can be broadly defined as the combination of people, facilities, institutions, and skills required to design, develop, manufacture, test, and maintain the weapons and supporting equipment for the U.S. armed forces. It is composed of three functional elements: research, development, and engineering; production; and maintenance and repair. The base comprises the U.S. and Canadian defense industries, as well as offshore foreign firms that supply goods and services to North American manufacturers.[2]

The broad 'guns v. butter" tradeoffs that must be made at the national level are suggested by the dual-pyramid demand model in figure 3-1. As military threats increase, goods and services are shifted from civilian to defense use; as threats recede, demand shifts back to the civil sector. For example, defense demand increased dramatically relative to civil demand during World War II, when defense spending went from 1.7 percent of GNP in 1940 to over 39 percent in 1944.[3]

Under the wartime conditions existing from 1942 through 1945, this massive shift in allocation was tightly controlled by the Federal Government. During periods of reduced external threat, market

Figure 3-l—Dual-Pyramid Demand Model



SOURCE: Roderick L. Vawter, *Foreign Dependency and Foreign Vulnerability: Part 1, A Survey of the Literature* (Washington, DC: Mobilization Concepts Development Center, National Defense University, Ft. McNair, September 19S6).

[1] U.S. Congress, Office of Technology Assessment, *Adjusting to a New Security Environment: The Defense Technology and Industrial Base Challenge,* OTA-BP-ISC-79 (Washington, DC: U.S. Government Printing Office, February 1991), pp. 4-6.

[2] The integrated U.S.-Canadian defense industrial base has evolved over a period of four decades because of its benefits to the security and economic interests of both countries. Guidelines for this collaboration laid down in numerous letters of agreement and memoranda of understanding known collectively as the Defense Development and Defense Production Sharing Arrangements (DD/DPSA), have led to the emergence of a North American Defense Industrial Base. For further discussion see App. I.

[3] Office of Management and Budget, *Historical Tables Budget of the United States Government, 1990* (Washington, DC: Government Printing Office, 1989), table 6.2 "Composition of Outlays in Percentage Terms: 19401994," p. 132.

incentives are more often used to reallocate resources. Industrial production is not a zero-sum game, and a shift of resources to defense does not necessarily entail an absolute loss to the civil sector. In periods of increased security threats and improving economic conditions, both the defense and civil bases can increase in size, as occurred during the Korean and Vietnam wars and the peacetime military mobilization for the cold war.

The complexity of the DTIB means that no single view or model is adequate for policy development. Figure 3-2 indicates some of the relationships between the defense elements and the broader base, as well as among the components. The DTIB has its source in the global science and technology base and is fed by the national industrial base. Because of legislation, however, the national base has evolved separate elements that perform defense functions.

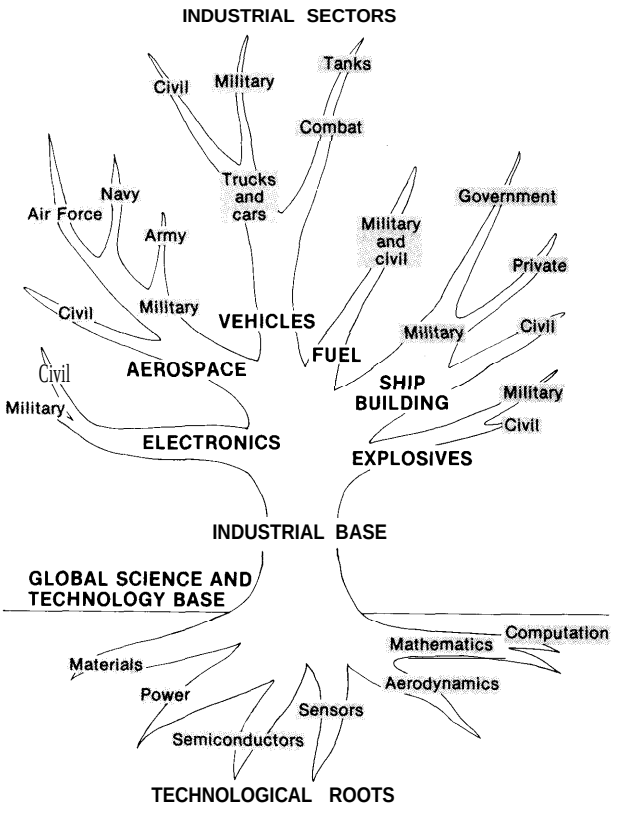
Combining views from several perspectives yields a more comprehensive picture of the DTIB and its relation to the larger national industrial base that is useful for considering policy choices and the implications of those choices. The following sections describe the DTIB from four perspectives:

1. *the tiers* associated with the weapon development and assembly process (primes, subcontractors, and suppliers);
2. *ownership* (private and public);
3. different *industrial sectors (e.g.,* shipbuilding and electronics); and
4. *functional areas* that correspond generally to the steps of the procurement cycle (R&D, production, and maintenance).

Tiers of the Base

The DTIB is part of the larger national industrial base and increasingly a part of a global industrial base. Figure 3-3 illustrates the structure of the defense base from the standpoint of the weapon development and assembly process. The larger truncated pyramid represents the overall North American industrial base (both civilian and defense elements), while the smaller embedded pyramid contains defense-specific elements. A 1988 report by the Under Secretary of Defense for Acquisition noted that the DTIB "generally comprises the same manufacturers that produce goods for the general public. . . . [The Defense] Department depends on virtually every sector of the manufacturing base for materiel.'[4] While figure 3-3 highlights the interrelationship between the DTIB and the overall industrial base, it fails to capture adequately the suppliers and producers located outside of North America.

Figure 3-2—Relationships Among Defense Sectors and the Broader National Industrial Base

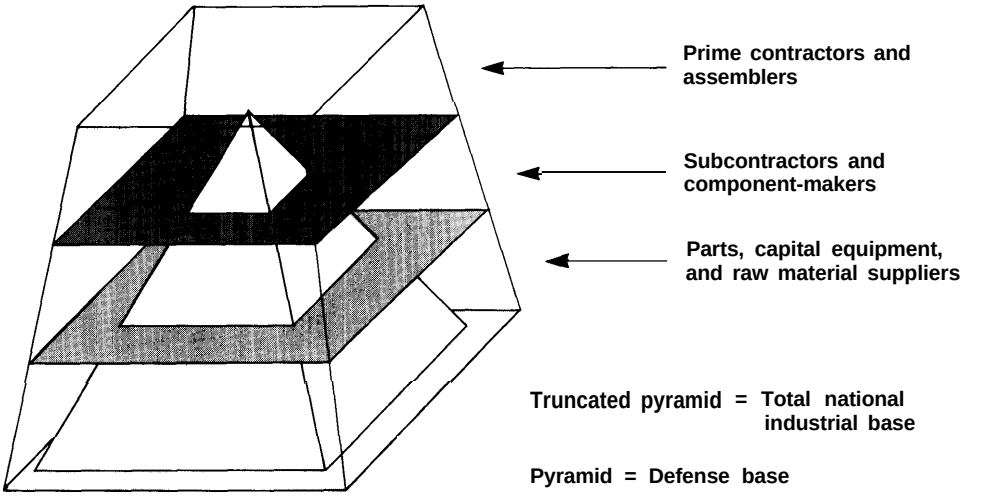


SOURCE: Office of Technology Assessment, 1991.

Both the larger national technology and industrial base and the embedded DTIB are fed by inputs that include raw materials, manpower, and capital. At the lowest level are basic industries such as steel and aluminum; at the middle level are industrial producers of items such as forgings, castings, and semiconductor chips; and at the top level are final assemblers of end-products such as military or civilian aircraft. Elements of a single firm might operate at all three levels.

[4]Report to the Secretary of Defense by the Under Secretary of Defense (Acquisition), *Bolstering Defense Industrial Competitiveness,* July 1988, p. v.

Figure 3-3-Tiers of the Defense Technology and Industrial Base



SOURCE: Office of Technology Assessment, 1991.

One of the chief concerns expressed in interviews conducted by OTA and numerous recent studies is that the national base, viewed from the standpoint of the weapon development and assembly process, increasingly lacks key supporting firms. While this concern appears to have merit in some sectors, in aggregate the national base can still be thought of as a truncated pyramid of supporting firms and capabilities that potentially can be used for weapons development and production. How firms might be moved from being potential to actual producers is a key policy question.

Firms within the DTIB are often divided into three tiers according to size and function: 1) large prime contractors acting as systems integrators and assemblers; 2) subcontractors and component manufacturers; and 3) parts, capital equipment, and material suppliers. This division is particularly useful in considering alternative DTIB policies, since many policies appropriate to large prime contractors are not suitable for supporting subtier firms and material suppliers.

Prime Contractors

The top tier of the defense industrial pyramid consists of large prime contractors such as General Dynamics, McDonnell Douglas, and Lockheed, which perform the overall assembly and integration of weapon systems, as well as some parts fabrication (table 3-l). Studies indicate that 40 to 60 percent of defense procurement funds for any particular weapon system stays with the prime contractors, while the remainder is passed on to supporting subcontractors.[5] Prime contractors generally retain large design and engineering staffs, which conduct applied research and development and also perform some of the more basic R&D.

While some prime contractors are highly dependent on defense work, others are more diversified. In 1989, for example, Department of Defense (DoD) contracts comprised 73 percent of total revenue for General Dynamics, 62 percent for McDonnell Douglas, 57 percent for Martin Marietta, and 64 percent for Grumman. For more diversified fins, DoD contracts comprised a smaller share of total revenue, including 18 percent for United Technologies, 16 percent for Rockwell International, 15 percent for Boeing, 13 percent for Westinghouse, and 11 percent for General Electric.[6] As a group, prime contractors are more international in outlook than smaller, more specialized firms in that they are willing to source goods and services from abroad, and also seek to export.

[5] Jacques S. Gansler, *Affording Defense* (Cambridge, MA: Massachusetts Institute of Technology Press, 1989), p. 247.

[6] Tom Shoop, "The Top 25 Government Contractors," Government Executive, vol. 22, No. 8, August 1990, pp. 32-44, and 123-132.

Table 3-l—Top 25 Department of Defense Contractors, Fiscal Year 1989

Rank	Parent company	Total DoD ($ billion)
1	McDonnell Douglas	$8.99
2	General Dynamics	7.28
3	General Electric	5.87
4	United Technologies	3.54
5	General Motors	3.38
6	Martin Marietta	3.35
7	Raytheon	3.29
8	Boeing	3.11
9	Lockheed	2.56
10	GTE	2.35
11	Grumman	2.35
12	Rockwell International	2.02
13	Litton Industries	1.99
14	Westinghouse Electric	1.66
15	Honeywell (since 1990, Alliant Techsystems)	1.54
16	Textron	1.41
17	TRW	1.30
18	IBM	1.26
19	III-	1.25
20	Unisys	1.02
21	Gibbons, Green & Van Amerongen	0.95
22	Allied-Signal	0.90
23	Tenneco	0.89
24	Avondale Industries	0.88
25	FMC	0.79

NOTE: Rankings are based on prime contracts of $25,000 or more for the Department of Defense.

SOURCE: James Kitfield, "Stepping Back From Reform," *Government Executive,* vol. *22, No. 8,* August 1990, pp. 24-25.

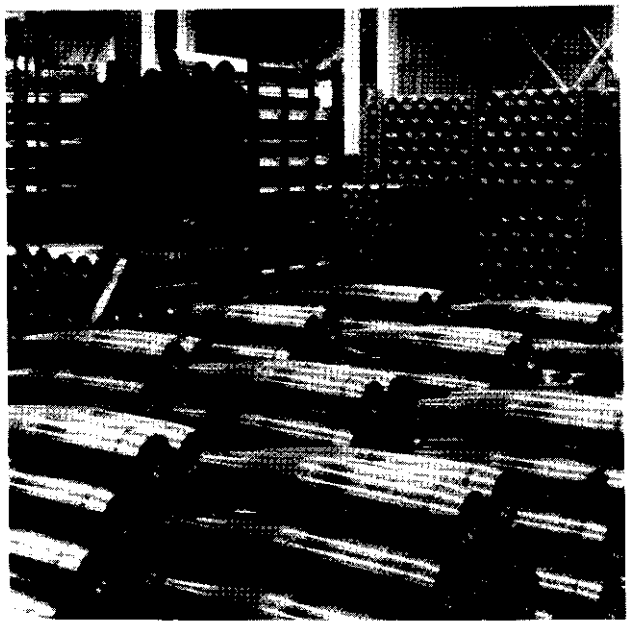


Photo credit: Royal Ordnance plc

Artillery shells for 155mm howitzers are manufactured by Royal Ordnance of Great Britain, one example of the international defense technology and industrial base.

Subcontractors

The middle tier of the defense industrial pyramid is composed of subcontractors that manufacture major subsystems and components of weapon systems, such as radars, computers, engines, and electronics. These firms, including Loral and Alliant Techsystems (formerly Honeywell), vary greatly in size. A subcontractor might be a large firm (e.g., Avco), a subsidiary of a major defense contractor such as General Electric Aerospace, or a government organization such as an Army arsenal that supplies gun tubes to a prime contractor as government-furnished equipment.

A survey of prime defense contractors by the Air Force Association indicated that their respondents each purchased subcomponents from an average of more than 1,300 subcontractors and vendors, both domestic and foreign. The DDG-51 Aegis destroyer program depended on more than 500 equipment vendors, and one of these vendors, GE, relied in turn on more than 1,200 suppliers.[7] Subcontractors conduct extensive R&D related to components. Over time, they have developed considerable expertise in critical technologies and survive by that expertise. They are, therefore, more concerned than the prime contractors about technical data rights and any attempt by the government to gain access to commercially developed technology that might be embedded in their defense products. They are less international in outlook and argue that they have been hurt by the growing trend of prime contractors to transfer technology offshore and to source abroad (see box 3-A).

Suppliers

The bottom tier of the pyramid is composed of suppliers of parts and materials, including electronics packages, integrated circuits, batteries, and bearings. Many of these firms produce "dual-use" equipment and supplies, such as fasteners and materials, that are essential to both military and civilian applications. As a group, supplier firms are

[7] Air Force Association and USNI Military Data Base, *Lifeline in Danger: An Assessment of the United States Defense Industrial Base* (Arlington, VA: The Aerospace Education Foundation, 1988), p. 65; and Naval Sea Systems Command, *United States Shipbuilding Industry,* briefing papers, July 1990.

OTA DEFENSE INDUSTRY SURVEY

Box 3-A—Differences Between Primes and Subtiers

The survey revealed a number of differences in approach to dealing with reduced defense budgets between large prime contractors and smaller subtier fins.

International

- **primes** tend to support international sales, talk about the global nature of the defense technology and industrial base, and report that they source widely abroad. They are generally skeptical about tracking foreign dependency and sources of items.
- Subtiers are more supportive of Buy-American provisions, argue that even R&D should be oriented toward U.S. firms rather than abroad, complain about the negative effects of offset requirements, and express greater concern about loss of technology to foreign competitors.

Diversification

- **Primes** hope to diversify in defense work as well as non-defense. They generally see defense business expansion (possibly through diversification) as a requirement to maintain stock value in the face of a reduced defense budget. Diversification into civilian areas is generally approached through acquisition.
- Subtiers note a threat from primes moving into technical areas previously left to smaller, more specialized firms. Subtiers often have few resources to diversify into civilian work and stress the difficulty of making the transition, especially in a recession. In order to diversify, they tend to pursue teaming arrangements with other fires rather than acquisitions.

Commitment to Defense

- **Primes** generally express a continued commitment to defense. However, firms with a solid base of non-defense business note the difficulty of doing business with DoD and appear to be somewhat less committed to defense work.
- Subtiers' responses are mixed. Several hope to leave the defense sector, and some already have done so. They contend that the cost of doing business with DoD is far too high in light of potential returns.

Government Action

- **Primes** generally oppose government intervention and advocate letting the market decide which firms will survive the downsizing of the base.
- Subtiers see more need for intervention to protect them from international competition and from U.S. primes moving into their business sector during downsizing.

more diversified and are linked directly to the broader national industrial base.

Foreign Sources

The DTIB extends beyond the borders of the United States to include subcontractors and suppliers from Canada and other countries. Most of the foreign contracts listed in table 3-2 are for services and fuel to support U.S. forces overseas, but many key components and some weapon systems are sou.reed abroad. In addition, international exchanges of technology take place through commercial licensing agreements and through government-sponsored or private industrial collaboration. Although a few cooperative programs such as the codevelopment of the FSX fighter with Japan have attracted much attention and criticism, the military services manage a host of other intergovernmental exchanges of technology relating to propellants, explosives, airframe design, and other areas-almost all without controversy. Company-to-company collaborations are also increasing. Firms collaborate across borders to gain access to foreign markets and technology, or to meet foreign governments' insistence on offset arrange-

Table 3-2—Department of Defense Foreign Contractors

Rank[a]	Parent company	Parent location	Fiscal 1989 awards ($ 000s)	Market share (percent)
1	Federal Republic of Germany[b]	Bonn, Germany	$350,498	0.2%
2	Royal Dutch Petroleum	The Hague, Netherlands	304,543	0.2
3	SNECMA[c]	Paris, France	258,650	0.2
4	Canadian Commercial Corp.[d]	Ottawa, Canada	253,478	0.2
5	European Utilities Cos.[e]	—	173,258	0.1
6	MIP Instandsetzungsbetrieb	Germany	166,329	0.1
7	Philips Gloeilampenfabrieken	Eindhoven, Netherlands	135,064	0.1
8	CAE Industries	Toronto, Canada	125,287	0.1
9	Nisshin Service	Japan	109,619	0.1
10	Bahrain National Oil	Bahrain	101,043	0.1
11	British Aerospace	Bristol, United Kingdom	100,113	0.1
12	Kuwait National Petroleum	Safat, Kuwait	96,720	0.1
13	N.J. Vardinoyannis Group	Athens, Greece	88,880	0.1
14	Selm Servizi Elettrici Montedi	Milan, Italy	85,005	0.1
15	Imperial Chemical Industries	London, United Kingdom	83,061	0.1
16	Daimler-Benz	Stuttgart, Germany	71,822	0.1
17	FN Fabrique Nationale De Herst	Herstal, Belgium	58,379	0.1
18	Okinawa Electric Power	Okinawa, Japan	53,477	0.1
19	Greenland Contractors	Greenland	46,964	0.1
20	General Electric OLC	London, United Kingdom	42,671	0.1
21	Bell Canada Enterprises	Montreal, Canada	42,619	0.1
22	Aral AG	—	40,180	0.1
23	Compania Espaniola De Petroleos	—	34,545	0.1
24	Netherland Ministry of Defense	Netherlands	32,604	0.1
25	Rafael Armanents Development	Haifa, Israel	32,570	0.1

a Rankings are based on R&D, service, and production prime contracts of $25,000 or more received by foreign entities. Market shares are of all Department of Defense contracts.
b The Federal German Government acts as a middleman for contracts involving U.S. bases in Germany.
c SNECMA'S contract awards are from CFM International, a joint venture with General Electric of Fairfield, Conn.
d canadian Commercial Corp. is a Canadian government agency that processes DoD contracts for Canadian companies.
e European Utilities Companies represents the aggregate of utilities contracts for U.S. bases in Europe.
SNECMA = National Company for the Design and Construction of Aircraft Engines
SOURCE: James Kitfield, "Stepping Back From Reform," Government Executive, vol. 22, No. 8, August 1990, p. 26.

ments, which may involve coproduction and technology transfer.[8]

Ownership Perspective

A second policy perspective is provided by categorizing according to ownership the various companies and organizations that make up the DTIB. The majority of the base is privately owned and operated, although the government may own some of the equipment at particular facilities. A matter of some concern is the increasing foreign ownership of defense firms. While still very small, it could grow as a result of the need for additional capital.

There is also considerable public ownership in the defense industry. Currently, about one-third of the aircraft industry's facilities are government-owned, as are almost all of the fina1 assembly operations for artillery and tank munitions.[9] While DoD relies primarily on private industry to support defense production, it is U.S. Government policy, based on the Defense Industrial Reserve Act (50 U.S.C. 451), to maintain "a minimum essential nucleus (industrial reserve) of government-owned plants and equipment to be used in an emergency."[10] This government-owned portion of the base has shrunk in recent years but may become relatively more important in the wake of significant reductions in defense budgets and the resulting loss of commercial capacity.

[8] U.S. Congress, Office of Technology Assessment, *Arming Our Allies: Cooperation and Competition in Defense Technology*, OTA-ISC-449 (Washington, DC: U.S. Government printing Office, May 1990), pp. 9-18.

[9] Gansler, op. cit., footnote 5, p. 240.

[10] Office of the Secretary of Defense, "GOCO Policy Statement" Aug. 22, 1989, p. 1.

Private Sector

Before World War II, private business was not extensively involved in defense manufacturing, with the exception of the aviation industry. Business was brought into defense work because of the need for rapid expansion of weapons production and the belief that the private sector is more innovative and efficient than the government sector. The involvement of private enterprise moved to the forefront issues of fairness, access, and profits. Because defense contracting is public work for the common national good, large profits are politically unacceptable, and business has always been justifiably cautious about taking large risks under such conditions. During World War II, the U.S. Government minimized business risk by building defense plants, paying for equipment and tooling, and asking the private sector to run them. The same was true during the initial cold war mobilization, when the U.S. Government paid for almost all the equipment and facilities needed by the private sector, obviating the need for much capital.

That situation has changed over time. Costs of equipment and facilities were increasingly fma.need by business, while changes in tax laws reduced fins' working capital. Congressional concern over instances of fraud, waste, and abuse in contracting in the 1980's resulted in numerous new laws and regulations that often reduced productivity as much as they prevented crime. Thus, despite the rhetoric, the private sector of the defense industry does not conduct business in a free enterprise system. Instead, as the Defense Science Board noted, the defense industry

> . . . is characterized at the prime contractor level by a single buyer (the government) and relatively few suppliers. Exercising its monopsony power, the government has created a regulated industry, similar to a public utility.[11]

The implications for the defense industry of both private ownership and government monopsony (single-buyer) power-creating business risk while limiting potential profits--continue to be insufficiently appreciated in policy development.

Government-Owned/Government-Operated

During and immediately after World War II, there was a large and diverse array of government-owned/government-operated (GOGO) defense-industrial facilities, ranging from naval shipyards to coffee roasting plants. Beginning in the Eisenhower Administration, most of these facilities were closed or sold off. The remaining GOGOs are oriented toward the production of specialized military systems that have no counterpart in the civilian sector, or the repair and maintenance of existing systems. For example, the Army arsenal at Watervliet, New York, manufactures gun tubes for U.S. artillery. The Army tank rebuild and overhaul facility in Anniston, Alabama, serves chiefly as a repair facility, but like virtually all DoD depot-level repair facilities it has a substantial manufacturing capability that includes unique machinery and welding facilities.

In the R&D area, the government also has some unique government-owned/government-operated laboratories and test facilities. Some of these installations (e.g., China Lake Naval Surface Weapons Laboratory, the Air Force's Wright Laboratories, and the Army's Harry Diamond Laboratories) provide a Service capability for evaluating private R&D development as well as conducting research of their own; others, such as the Department of Energy's Nuclear Test Site and NASA's Langley Wind Tunnel, provide a unique national capability.

The size of the government-owned base is currently under review, including studies on the consolidation of both R&D and industrial facilities.[12] The Services argue that the government facilities are already being reduced to a bare minimum and that further reductions should be undertaken with great caution. Since major cuts in defense spending are likely to affect the various GOGOs in different ways, it is important how the cuts are made. For example, reduction in overall procurement and stretch-out of programs might result in the Services' doing more in-house manufacturing in addition to repair. In a

[11] Office of the Under Secretary of Defense for Acquisition, *The Defense Industrial and Technology Base,* vo1. I (Washington DC: December 1988), p. 12.

[12] The Army's Vision 2000 Report addressed the consolidation of both laboratories and logistics support. The Navy is consolidating its laboratory system, while the Air Force is consolidating its logistics and system commands. The Air Force and Navy appear to be ahead of the Army in many of these efforts. A joint DoD effort is considering a consolidation of functions between Services (aircraft engines to a single Service, for example) and changes in defense laboratories. See also Michael E. Davey, *Defense Laboratories: Proposals for Closure and Consolidation (Washington DC: Congressional* Research Services, 1991).

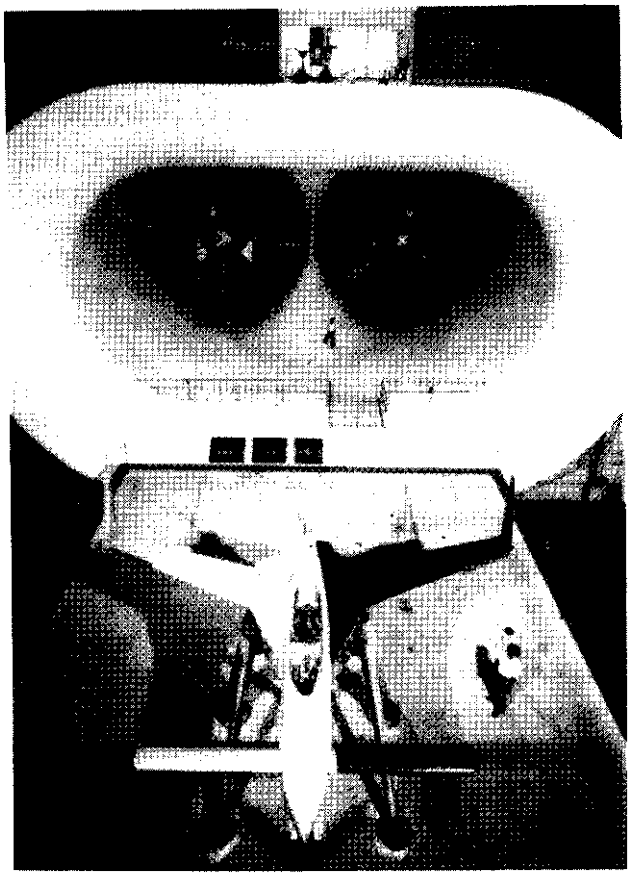


Photo credit: NASA

NASA Langley Wind Tunnel in Langley, VA, is a government-owned, government-operated (GOGO) test facility that provides a unique national capability.

period of reduced procurement, however, maintenance and repair work can help maintain the viability of private firms that will be needed to develop and manufacture the next generation of weapon systems. Allocation of maintenance contracts should therefore take into account the tradeoff between the need to preserve capabilities in the private sector and the need for a secure and responsive Service maintenance base. This tradeoff is discussed in greater detail in chapter 5.

Government-Owned/Contractor-Operated

In addition to the GOGOs, there are government-owned/contractor-operated (GOCO) facilities active in the R&D, production, and maintenance components of the defense technology and industrial base. While DoD has reduced the number of GOCO facilities, three major groups remain: Army-owned ammunition plants, Service-owned manufacturing facilities, and the nuclear weapons R&D and production complex run by the Department of Energy (DOE). In 1989 the Services owned 63 GOCOs with an initial acquisition cost of more than $64 billion.

Contractors run the Army ammunition plants or maintain them in an inactive status. Future force reductions will result in more of these plants being placed in reserve or closed altogether, although demand for ammunition will be affected by policy decisions on troop strength, readiness, and sustainability, and assumptions about the length of warning time preceding a major conflict. Given sufficient warning (24 to 36 months), new munitions plants could be built from the ground up to support a conflict against a major opponent. Thus, the ammunition production complex might be sized solely to deal with lesser regional conflicts.

Some major weapons systems are produced by private companies in government-owned facilities. For example, the F-16 is produced at Air Force Plant No. 4 in Fort Worth, Texas, while the M1A1 tank is manufactured at the Army Tank Plant in Lima, Ohio, and the Army Detroit Arsenal Tank Plant in Warren, Michigan. While the Army considers many of its facilities essential and wants to maintain ownership, the Air Force is prepared to sell its GOCOs. Interest among potential buyers for these government facilities has been depressed, however, by the adverse fiscal environment for defense programs and the liability associated with cleaning up hazardous wastes.

The U.S. nuclear weapons complex consists of National Laboratories (Los Alamos, Livermore, and Sandia) operated by the University of California and Sandia Corp. (a subsidiary of AT&T), and production facilities operated by commercial contractors, who work under close government supervision and control. The National Laboratories are involved not only in the design of nuclear weapons, but also in production and maintenance activities associated with ensuring weapon reliability. Since technical know-how critical to the manufacture of nuclear weapons belongs to the government, the nuclear weapons complex functions like an arsenal system, and many of the critical technologies for the production of nuclear warheads are maintained at a single site. The current nuclear weapons complex still includes some facilities opened during World War II and many of 1950s vintage, and it would make sense to consolidate the complex in response

Photo credit: General Dynamics

Air Force Plant No. 4 in Fort Worth, TX, is a government-owned, contractor-operated (GOCO) manufacturing facility.

to both reduced East-West tensions and the need for the modernization of facilities. Because of severe environmental contamination,[13] however, the costs of essential site cleanup and consolidation will be considerable, requiring large upfront expenditures before any savings could be derived.[14]

Defense Industrial Sector Perspective

The DTIB can also be divided according to industrial sectors, such as aerospace, shipbuilding, communications, electronics, munitions, and armament. Sectoral analysis is important because the sectors differ markedly in the way they do business and may be affected differently by government policies. The mass production of ammunition is unlike the single-item production of warships, and the problem of maintainingg adequate surge ammunition production between wars differs from the problem of keeping a shipyard open between submarine orders. The sectors also vary greatly in the engineering content of their work, the relative state of U.S. and comparable foreign technology, and integration within the broader civil industrial base. All of these factors should be taken into account in developing policies for the overall DTIB and for each industrial sector in particular.

A 1987 study by the Logistics Management Institute identified 215 industries responsible for 95 percent of defense production, including many industries not normally considered in analyses of the DTIB.[15] According to the study, defense production accounted for 10 percent or more of total U.S. output in 61 industries, and 25 percent or more in 21 industries (see table 3-3). The 40 industries in which defense production accounted for 10 to 25 percent of total output were mainly "supplier" industries: fasteners, ball and roller bearings, and industrial controls. It is in these subtier-level industries that the dependence of defense production on the larger civilian industrial base is most evident, indicating

[13]The environmental problems associated with the nuclear weapons complex are discussed in detail in: Office of Technology Assessment, *Complex Cleanup: The Environmental Legacy of Nuclear Weapons Production, OTA-O-484 (Washington DC:* U.S. Government Printing Office, January 1991).

[14]Department of Energy, *Nuclear Weapons Complex Reconfiguration Study*, Washington, DC, January 1991.

[15]Donna J.S. Peterson, Nicholas R. Chacht, and Paul R. McLenon, *Identifying Industrial Base Deficiencies* (Bethesda, MD: Logistics Management Institute, December 1987).

Table 3-3-Defense Share of Selected U.S. Industries

Standard Industrial Category (SIC) code	Industry name	DoD purchases ($ millions)	DoD purchases as percent of industry sales
3483	Ammunition, except small arms	$3,733	84.5%
3731	Shipbuilding & repair	8,111	79.0
3489	Ordnance & accessories	2,298	72.2
3761	Guided missiles, space vehicles	8,678	71.9
3721	Aircraft	17,104	55.3
3728	Aircraft equipment	11,542	54.3
3795	Tanks & tank components	2,445	52.1
3662	Radio &TV communication equipment	32,610	50.9
3724	Aircraft engines & engine parts	7,174	50.7
3339	Primary nonferrous metals	786	49.3
3825	Electronic measuring instruments	6,517	48.8
3676	Electronic resistors	605	42.1
3482	Small arms ammunition	399	40.4
2892	Explosives	416	39.7
3463	Nonferrous forgings	504	36.7
3675	Electronic capacitors	480	35.7
3811	Engineering & scientific instruments	1,618	34.6
3677	Electronic coils & transistors	431	30.9
3537	Industrial trucks & tractors	1,086	29.5
3674	Semiconductors & related items	4,065	27.6
3678	Electronic connectors	901	25.1

SOURCE: Donna J.S. Peterson, Nicholas R. Chacht, and Paul R. McLenon, *Identifying Industrial Base Deficiencies* (Bethesda, MD: Logistics Management Institute, 1987).

the importance to national security of a healthy, competitive, and technologically advanced manufacturing sector.

The integration with the civil sector at these lower subtier levels is complex. For example, there is considerable integration in areas such as bearings and fasteners, in which DoD accounted for 12.1 and 15.4 percent of production respectively in 1986. Yet defense production is also specialized in ways that make it difficult for DoD to retain selected industrial capabilities between procurement cycles. Superprecision bearings are only 6 to 7 percent of the domestic bearing production, but the military consumes 60 to 70 percent of that total.[16]

Functional Area Perspective

A final useful perspective on the DTIB is provided by dividing it according to functional areas:

- research, development, and engineering;
- production; and
- maintenance and repair.

These functional areas generally follow the weapon system life cycle from concept and design, through development and deployment, into operation, and ending with retirement.

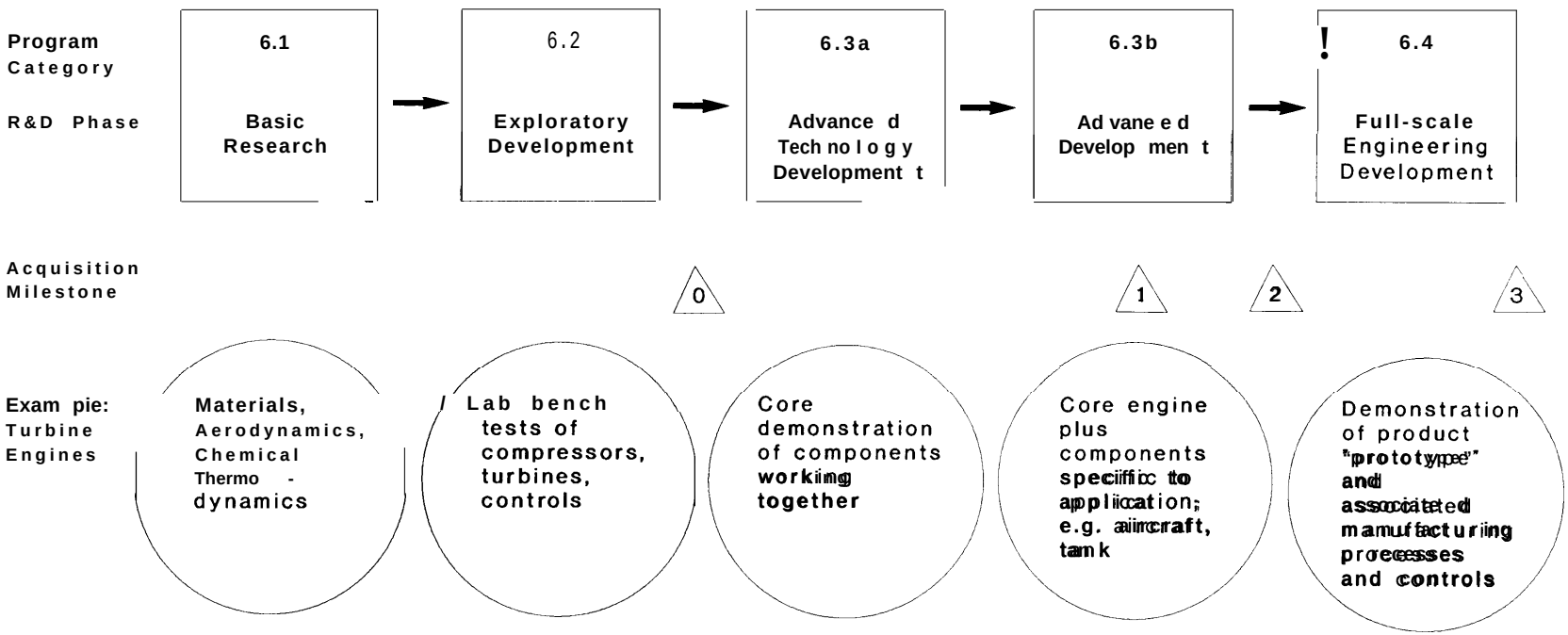
Research, Development & Engineering (RD&E)

The RD&E component of the defense technology and industrial base is located primarily in private industry but, as previously noted, also includes government laboratories and test facilities run by the Departments of Defense, Energy, Commerce, and NASA, and university laboratories conducting research relevant to defense. DoD research and development is composed of several budget categories in order of increasing technological maturity (see figure 3-4): 6.1 (basic research), 6.2 (exploratory development), 6.3A (advanced technology development), 6.3B (advanced development), and 6.4 (full-scale engineering development).[17] Figure 3-5 shows the funding breakdown. As a very rough rule, universities tend to concentrate on basic research, Service laboratories on applied research, and industry on development and engineering. For example, in fiscal year 1990, DoD's total obligation for basic

[16] Joint Bearing Working Group of the Joint Group on the Industrial Base, *Joint Logistics Commanders Bearing Study*, June 18, 1986, p. 5.

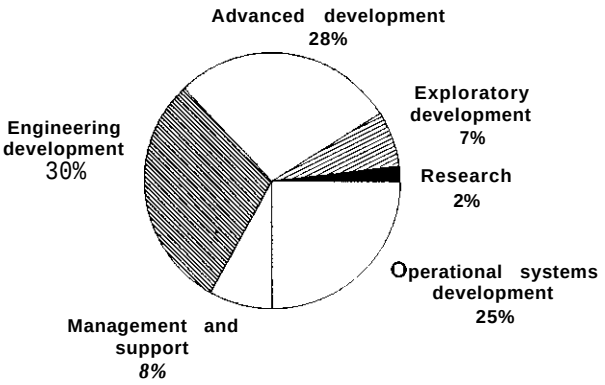
[17] U.S. Congress, Office of Technology Assessment, The *Defense Technology Base: Introduction and Overview*, OTA-ISC-374 (Washington, DC: U.S. Government Printing Office, March 1988), pp. 34-35.

Figure 3-4-Department of Defense Research and Development Process



SOURCE: James Moldenhauer, *Identification and prioritization of 6.2 Technologies Demonstration* (Pasadena, CA: Jet Propulsion Laboratory, 1986), pp. 1-2; and Office of Technology Assessment.

Figure 3-5—Allocation of Research and Development Funding by Function, Fiscal Year 1990



SOURCE: U.S. Department of Defense, Office of the Comptroller, *RDT&E Programs (R-1), Fiscal Year 1992 and 1993* (Washington, DC: Department of Defense, Feb. 4, 1991), p. II.

research (category 6.1) was $964 million, of which $551 million was spent in universities, $286 million in DoD-operated laboratories, and only $87 million in industry laboratories.[18] In contrast, of the funds spent on advanced development (categories 6.3A and higher), universities received only $264 million, government laboratories $9 billion, and industry $25 billion. Figure 3-6 shows funding and work breakout.

The research phase involves investigating new technologies that have a variety of applications; when a specific application is in sight, much development and engineering work is still required to incorporate the technology into a product. The purpose of the exploratory and advanced development stages is to obtain information about the design and engineering of a new system so that a decision can be made to enter production with adequate confidence about schedule, performance, and cost. Almost all of engineering and development is performed by private-sector contractors, who have the greatest experience in the practical application of knowledge to the production of weapons and components and expect to manufacture a particular weapon system directly related to the R&D. While this private component of the base is critical to the U.S. Government's defense responsibilities, it is also the most difficult to maintain during a period of declining defense spending.

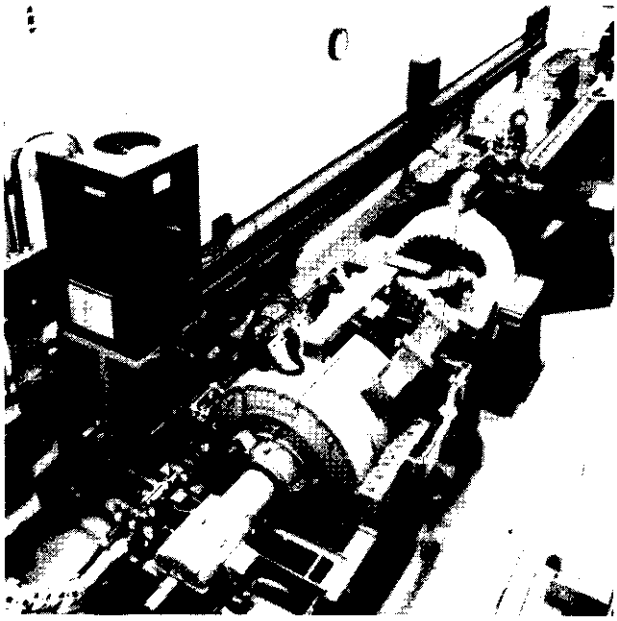


Photo credit: U.S. Department of Defense

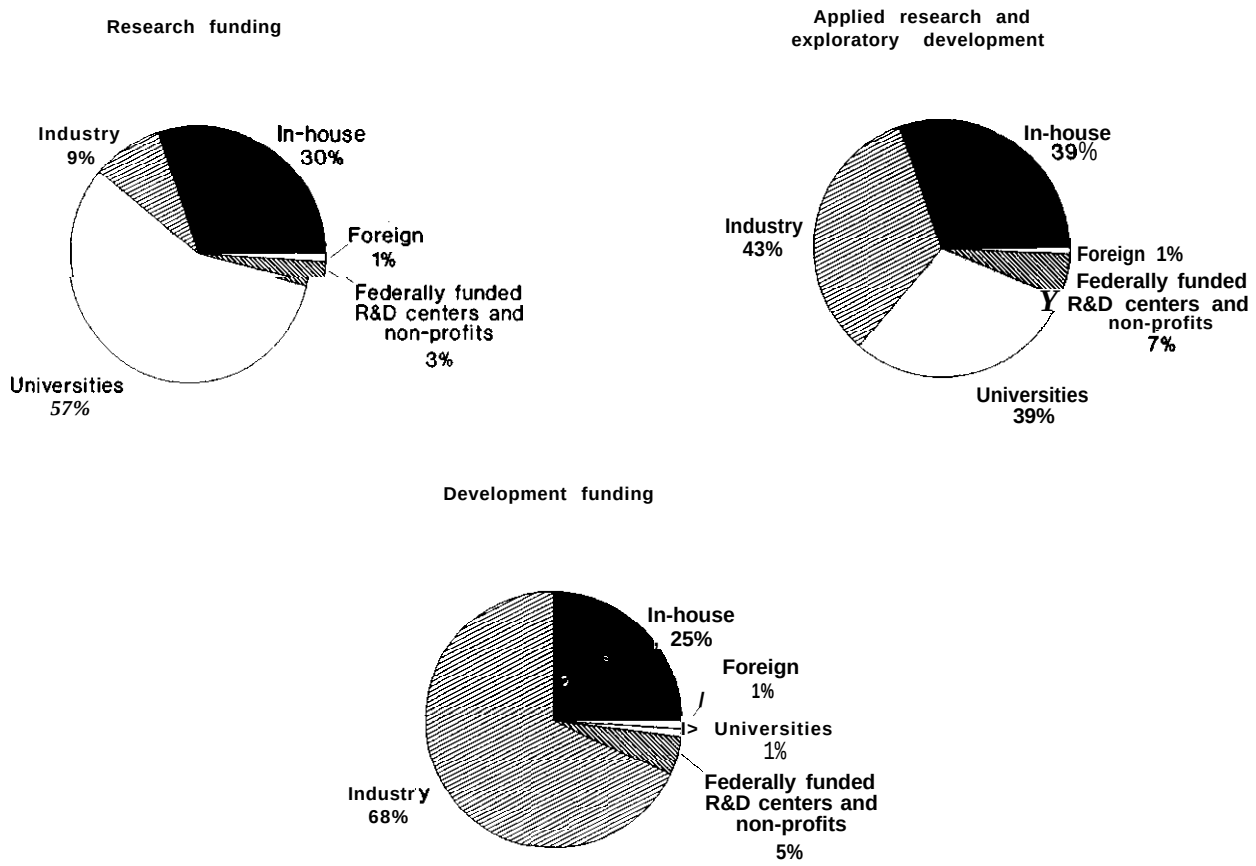
Prototype of an electromagnetic cannon undergoes testing at the Picatinny Arsenal in New Jersey, an R&D facility run by the U.S. Army.

Corporate research and development is funded either from direct DoD contracts or from company profits generated through sales of goods and services. Many R&D efforts are supported from both sources of funds. For example, while the government may provide a company a contract for the development of a system, the company may also contribute substantial amounts of its own money, which can be justified if the development leads to a profitable production contract.

Defense contractors currently defray some negotiated fraction of R&D expenses through "independent research and development' (IR&D) charges against ongoing contracts; that is, companies can charge some of their R&D as an allowable expense, similar to overhead. In fiscal year 1989, government-allowed IR&D charges totaled $2.2 billion. IR&D is conducted under the supervision of DoD, which must approve the general research areas and amounts but exerts little detailed control beyond review and audit once approval has been given. The companies

[18] National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1988, 1989, and 1990*, vol. 38, NSF 90-306 (Washington, DC: National Science Foundation 1990), p. 35 and 57. Breakouts do not add up to the total because some categories, e.g., nonprofit institutions, are not listed.

Figure 3-6-Allocation of Research and Development Funding by Performer, Fiscal Year 1990



SOURCE: National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1988, 7989. and 7990,* vol. *38,* NSF 90-308. Detailed Statistical Tables (Washington, DC, 1990), tables 14, 21, and 28.

propose the areas in which to work and keep the commercial rights to developments. Significant design work associated with a specific request for proposal can also be included in a company's bid and proposal (B&P) efforts for future contracts and also recovered as an overhead expense. In 1989, industry recovered $1.3 billion in B&P overhead charges.[19]

There has been some controversy about the IR&D program over the years. Critics argue that IR&D funds are used for research that the companies would probably undertake in any case, and that IR&D creates an added hurdle to market entry for firms that do not have DoD production contracts and hence are not eligible for the funds. Proponents of IR&D counter that since government procurement procedures limit profit, companies need a mechanism to fired R&D. The proponents also contend that the current IR&D approach benefits DoD by allowing companies to stay current in critical areas of defense technology, encouraging technical innovations, and giving government scientists and engineers valuable insights into ongoing industrial research. Other programs, such as the Small Business Innovative Research Grants, are meant to compensate for initial lack of access to IR&D funds by firms entering the defense market.

Of course, if research and development costs are not recoverable as IR&D, nothing prevents companies from paying for some R&D out of their gross profits. Indeed, under freed-price contracts, the actual accounting category does not affect a com-

[19]Information provided by the office of the Secretary of Defense (Research and Advanced Technology), April 1991.

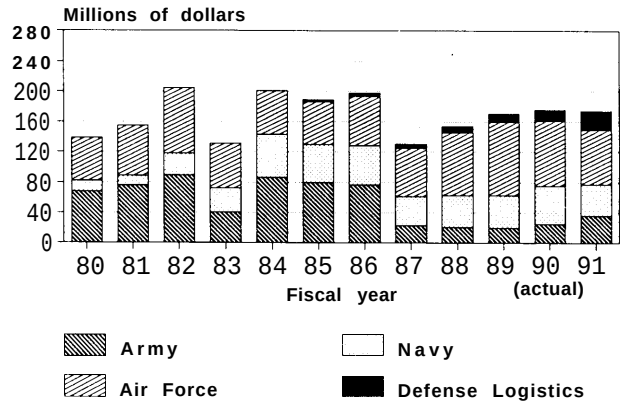
pany's profit because the charges either come out of profit or go into overhead, reducing profit by the same amount. Some firms, especially specialized subtier companies that depend for their livelihood on one technology, are wary of government-sponsored R&D because of potential conflicts over government rights to technical data. These firms prefer, therefore, to support their own R&D out of profits.

Private industry's decisions about research investment are strongly influenced by financial considerations. Since profits come largely from produced weapons, there is a general preference for R&D with a fairly predictable near-term return on investment and hence for product development rather than more basic research. Most firms concentrate on improving existing products and components, or developing new products most certain of gaining acceptance.

In addition to DoD-funded R&D contracted out to the private sector, in fiscal year 1990 over $11 billion was spent in-house by the research, development, and test facilities operated by the individual military Services. The size and missions of Service laboratories vary greatly. Some Service laboratories do basic research, but most focus on application-specific work and may also carry out prototype development. Each Service has a different style and emphasis: Navy laboratories do considerable in-house R&D, including basic research at the 6.1 level; Army laboratories generally focus on research at the 6.2 and 6.3 levels; and Air Force laboratories are organized by technology and emphasize the development of expertise to contract effectively with industry rather than performing extensive in-house research. The Services are currently responding to cutbacks by consolidating their laboratories to preserve in the surviving facilities the minimum number of personnel needed for good research. Test facilities such as those at China Lake and Nellis Air Force Base are particularly crucial because they involve a large capital investment and hence are unlikely to be replicated by the private sector.

The Office of the Secretary of Defense (OSD) does not operate any research laboratories, but it does have the Defense Advanced Research Projects Agency (DARPA), whose mission is to support "high-risk, high-payoff' research. DARPA establishes priorities and funds research carried out either in government or industry laboratories and managed

Figure 3-7-Funding of Manufacturing Technology (MANTECH) Program, 1980-91



SOURCE: Office of Technology Assessment, 1991, based on information supplied by the U.S. Department of Defense.

in collaboration with the Services. Although DARPA's charter has caused it to concentrate on the early stages of research, it has also begun to support selected projects to more advanced stages of development to demonstrate proof-of-concept. Such demonstrations are intended to make the Services more likely to apply the results of DARPA-funded research. While DARPA projects cut across Service boundaries, the agency does not have the resources to support a comprehensive technology program alone, nor does it have the explicit role of filling the gaps between Service research programs.

DoD also has access to 10 Federally Funded Research and Development Centers (FFRDCs). These nonprofit institutions include: the Institute for Defense Analyses, the Rand Defense Research Institute, the Logistics Management Institute, the Massachusetts Institute of Technology's Lincoln Laboratory, Mitre Corp., and Aerospace Corp. They provide research and analytical support to OSD and the Services and in fiscal year 1990 had finding in excess of $1.5 billion.

Most military R&D is product rather than process related. Nevertheless, a considerable amount of manufacturing process R&D occurs as firms learn how to manufacture a system. Since this cost is part of overall procurement, however, it is not funded as R&D. This loophole may be particularly important for subtier producers of critical subsystems, who may receive a fixed-price contract from a prime to deliver a particular product.

Box 3-B—Department of Defense Manufacturing Technology Program

U.S. military support for improvements in manufacturing technology can be traced back at least as far as the 19th century, when the Army supported manufacture of interchangeable parts for muskets. Since the Second World War, the military has become increasingly active in manufacturing technology, a prominent example being the Air Force's support of numerically controlled machining. Manufacturing Technology, or MANTECH, has been a formal DoD program to advance defense manufacturing since 1977.

The purpose of MANTECH programs is to improve productivity and responsiveness, with the expectation that these efforts will ultimately reduce defense procurement costs. MANTECH programs support a broad range of manufacturing technologies. For example, the Defense Logistics Agency funds programs to automate the manufacture of uniforms, the Navy to improve shipbuilding technology, the Air Force to lower costs of engine repair, and the Army to speed the inspection of ammunition.

MANTECH and similar programs are needed because defense manufacturers have few incentives to improve productivity under cost-based procurement. In normal commercial manufacturing a company has incentives to improve productivity because profits can be increased by reducing manufacturing costs. In contrast, the price of government contracts are typically based on cost, so that any reduction in cost results in a lower price for the government. Companies benefit indirectly from lower costs by improving their chances of getting the next contract, but not directly by obtaining higher profits. Since the government is the main beneficiary of productivity improvements, it ends up having to pay explicitly for at least some of them.

In general, support for the MANTECH program is stronger from Congress than it is from the Department of Defense (DoD). For example, for the 1991 budget, Congress added $150 million to DoD's $265 million request. Nor has Congress been completely satisfied with DoD's management of the MANTECH program. One result has been Congress' mandate in the 1991 defense appropriation act for a DoD Manufacturing Technology Plan, which is still being developed.

MANTECH is tiny compared to defense procurement programs and is only apart of DoD's efforts to improve manufacturing technology. Much learning is involved whenever a new item is manufactured; for example, a great deal of the technology involved in using composite materials is associated with manufacturing them and incorporating them into products. DoD also supports other manufacturing technology programs. The Defense Advanced Research Projects Agency's SEMATECH program, designed to improve micro-chip manufacturing, is probably the best known. The Strategic Defense Initiative Office also funds research efforts such as improved manufacturing of precision optics. Other sources of funds, such as Independent Research and Development (IR&D), are not earmarked specifically for manufacturing technology but may be used for this purpose.

Measuring the results and effectiveness of MANTECH is difficult because of the program's broad goals. Return on investment can be calculated for a particular project, but MANTECH projects are supposed to have wide applicability. Despite DoD newsletters, technical publications, conferences, and databases, however, there are frequent complaints that the benefits of MANTECH are not adequately diffused throughout industry.

The Services and OSD explicitly fund research on manufacturing process technologies through the Manufacturing Technology (MANTECH) program (see figure 3-7 and box 3-B). Since 1986, the Air Force has most heavily funded MANTECH and the Navy somewhat less so. Prior to that year the Army placed heavy emphasis on MANTECH, but it moved to terminate the program on the grounds that it was too small to accomplish its stated objectives. Although the Army subsequently reinstated its MANTECH program, Army officials favor devoting more resources to manufacturing technology development by providing funds for this purpose in weapon-system production contracts. The 1991 Defense Authorization Act increased MANTECH funding and directed OSD to develop a more coordinated program.

DARPA has also supported manufacturing process R&D through its former Defense Manufacturing Office (DMO), which was established to improve manufacturing know-how, reduce the cost of end-items, and create a production capacity for critical items where one did not exist. Like all DANA programs, DMO-funded R&D was contracted out to industry, government, and university laboratories, and collaboration was encouraged. The office was eliminated in April 1991 and some of its functions transferred to other offices. DMO's best known effort, SEMATECH, a consortium of U.S. electron-

ics firms with the goal of improving semiconductor manufacturing technologies, is now managed by DARPA's Electronic Systems Technology Office.

Defense contractors have few financial incentives to improve manufacturing efficiency. Since the Federal Government is the sole buyer and limits a fro's profits, a defense firm (unlike its commercial counterpart) cannot easily increase its profit margin by reducing manufacturing costs and selling at the old market price. Using its audit authority, the government has available actual costs as the basis for next year's contract negotiations. Because profit is calculated as a percentage of cost, the more efficient the contractor becomes, the less profit it makes.

Congress may want to investigate in more detail how to encourage the manufacturing R&D that is naturally embedded in weapon system production, as well as corporate investments in improved productivity. There are indications that perverse incentives created by the current acquisition process impose more important constraints on manufacturing productivity than any lack of know-how. These constraints are examined in greater detail in the discussion of trends in the base in chapter 4 and in the discussion of policy options in chapter 5.

Other government agencies play important roles in defense R&D. Three DOE laboratories, Lawrence Livermore, Los Alamos, and Sandia, conduct both defense and non-defense research and have primary responsibility for the scientific understanding, design, development, testing, and "surveillance" of nuclear warheads. (The latter term refers to continued testing and quality assurance, which are necessary because of the unstable nature of nuclear materials.) Currently, nuclear weapons responsibilities account for about 40 percent of the work of the three laboratories.

DOE Laboratories also have a secondary but important role in research on advanced conventional weapons and military support tasks, such as communications, intelligence, and arms control verification. These missions accounted for 16 percent of total weapons laboratory funding in 1990, and represented the lion's share of DOE's "work-for-others.

Some of the DOE laboratories are currently involved in consortia seeking to develop innovative manufacturing capabilities for the Strategic Defense

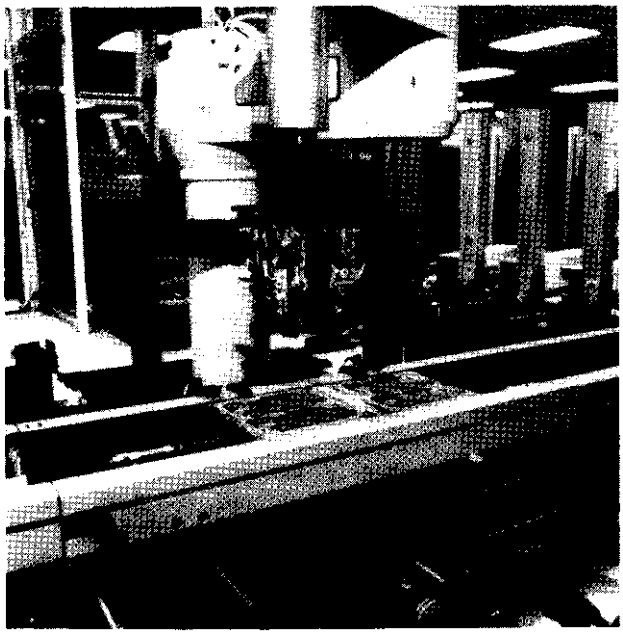


Photo credit: General Dynamics

Robot assembles electronic circuit boards for the Army's SINCGARS radio system at the automated General Dynamics plant in Tallahassee, FL.

Initiative. A Manufacturing Operations Development and Integration Laboratory (MODIL) specializing in survivable optics is located at Oak Ridge National Laboratory, while a second MODIL at Sandia National Laboratory is devoted to advanced infrared sensors and signal processing. These MODILs draw together government, industry, and university participants to develop and demonstrate new production and automation processes for specific technologies.

Other research by the national laboratories in non-defense fields (energy, environment, etc.) helps to maintain a pool of scientific and engineering talent and knowledge that could be helpful for meeting future military needs. Indeed, one expected benefit of mixing defense and nondefense work at the same laboratories is that mutually beneficial cross-fertilization will occur.

The Department of Commerce's National Institute of Standards and Technology (NIST) specializes in measurement technology (metrology) and performs some research and testing for DoD, including long-ten-n basic research. In fiscal year 1991, DoD-funded work performed by NIST amounted to just under $60 million. Of particular importance to industrial base issues is that NIST sets standards for

Table 3-4-Defense Procurement Funding (Budgetary Authority) for Fiscal Years 1990-93

	Procurement funding ($ millions)				Total percent change 1990-93
	FY1990 (actual)	FY1991 (estimate)	FY1992 (estimate)	FY1993 (estimate)	
Army					
Aircraft	3,703	1,080	1,667	1,247	–66
Missiles	2,463	2,044	1,106	1,342	-46
Weapons/tracked vehicles	2,495	1,903	839	574	–77
Ammunition	1,861	1,248	1,250	1,195	-36
Other procurement	3,532	2,457	3,164	3,254	-8
Navy					
Aircraft	9,158	6,150	7,217	6,953	–24
Weapons	5,278	5,623	4,531	4,755	–lo
Shipbuilding and conversion	11,210	9,789	8,759	8,298	–26
Other procurement	7,599	5,520	6,459	6,521	–14
Marines					
Total procurement	1,162	650	1,010	651	–44
Air Force					
Aircraft	15,414	9,322	10,916	13,457	-13
Missile	6,371	5,498	5,842	6,777	+6
Other	8,491	7,582	8,058	8,869	+4
Defense agencies					
Total procurement	1,351	2,433	2,112	2,201	+63
National Guard & Reserves	988	2,464	NA	NA	NA
Defense Production Act	50	50	NA	NA	NA
Chemical agents and munitions	88	101	—	—	—
	81,214	63,914	60,818	66,094	-19

NA-Not available.

SOURCE: U.S. Budget for fiscal year 1992.

both civil and military producers, for example in automated manufacturing.[20]

Production

The production component of the DTIB,1ike the R&D component, is made up primarily of private firms but also includes both government-owned/government-operated and government-owned/contractor-operated facilities. Defense procurement funds authorized for fiscal year 1990 were $81.2 billion[21] directed toward a wide range of production programs (see table 3-4), and roughly another $23 billion in procurement through the central supply and maintenance spending in the operations and maintenance accounts. Procurement budget authority has been falling in constant dollars since fiscal year 1986. Despite several years of continued high outlays of funds as previously ordered systems are built, defense firms and the financial markets have already begun adjusting to planned reductions in defense spending in the 1990s.

The production component of the DTIB has been important during the cold war not only for the weapon systems it has produced, but because it has been key to maintaining the overall health of the base. The expectation of profitable production runs has kept companies in the defense business, and production has helped pay for corporate R&D. As noted earlier, IR&D funding is tied directly to procurement. Further, contractors may spend their own money on research for decades in anticipation of a future production run that will result in improved profits for the firm. Production, then, has long been the "engine" of the DTIB. For this reason, the expected reduction in production contracts is viewed with much concern.

The actual number of firms in the defense production base is difficult to determine precisely. In March 1989, the Pentagon reported that somewhat over 9,000 production facilities had been identified as planned emergency producers for surge or mobili-

[20]Data provided by the National Institute of Standards and Technology, January 1991.

[21]This figure does not include the tens of billions of dollars in the operation and maintenance accounts for supplies and materials and equipment.

zation.[22] Yet such "planned producers" represent only a small fraction of the overall defense production base. Much of this base is, as noted earlier, composed of manufacturing firms that supply components and parts to firms having direct contracts with the Department of Defense. These subcontractors in turn purchase parts from lower tier suppliers.

Production planning requires a tradeoff between efficient peacetime production of weapons and wartime responsiveness. The production component has also been most heavily affected by many of the defense acquisition rules. Critics contend that these rules, mandating methods of manufacturing, auditing, special testing, and so forth, have increasingly isolated producers of defense goods from the broader industrial base.

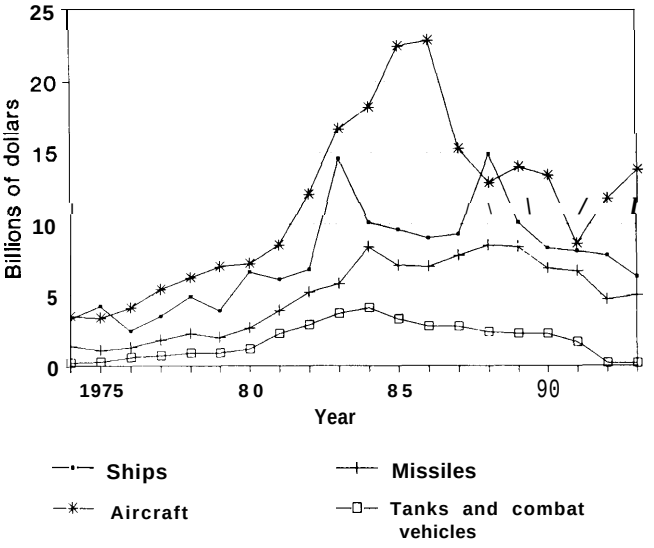
The procurement reductions since 1986 have had a negative effect on almost all programs (see figure 3-8). Aviation has been particularly hard hit and a number of other programs are scheduled to be terminated or greatly reduced. As a result, production rates will continue to show a strong downward trend. Few new major programs are expected over the next 5 years other than the Army's Light Helicopter and the Air Force's Advanced Tactical Fighter. The effects on firms will be significant, since the defense industry currently possesses enormous overcapacity at the prime contractor level.

Studies over the last decade have also indicated a decline in the number of subtier defense suppliers. These findings have given rise to two sets of concerns:

- that the remaining defense suppliers will have inadequate capacity to respond to a surge or mobilization requirement; and
- that the declining number of suppliers will result ultimately in a total loss of domestic capacity and critical skills in key sectors.

The degree to which either of these concerns is valid in the c-merit situation is a matter of debate. A major unknown is the Nation's future requirement for surge or mobilization. Another unknown is the number of firms that are capable of supporting U.S. defense needs but choose not to do business with the government.

Figure 3-8--Procurement of Major Weapon Systems, Fiscal Years 1974-93 (currant $)



SOURCE: Raymond J. Hall, "Total Quantities and Costs of Major Weapon Systems Procured, FY 1974-93" (Washington, DC: Congressional Budget Off"me, 1991), pp. 1-2.

Maintenance and Repair

The maintenance and repair component of the DTIB consists of government facilities such as Naval Shipyards, Naval Aviation Depots, Air Logistics Centers, and Army Arsenals and Depots (see table 3-5), as well as private firms that maintain and repair equipment either at their own facilities or in the field. Maintenance and repair, always a critical factor in supporting military forces, will be increasingly important in a period in which equipment is retained for extended periods.[23]

DoD's in-house maintenance and repair facilities contain unique rebuild, overhaul, and manufacturing capabilities. While organic maintenance capabilities attached to operating forces can be expected to decline in rough proportion to reductions in force levels, the potential effect on depot-level facilities is less predictable. Over the short term (5 to 10 years), retirement of older systems associated with force reductions may greatly diminish maintenance requirements. After that point, however, equipment will probably be retained longer and upgraded rather than replaced. Thus, in the long run (10 years or

[22] U.S. Department of Defense, Office of Industrial Base Assessment, *A Guide for Industrial Mobilization,* March 1989, PP. 1-2.

[23] Studies indicate that 50 percent of the total cost of a weapon system are attributed to the operations and maintenance costs over tie life of the deployed systems. Not only does this make maintenance and repair capabilities important, but it should also increase the importance of maintainability and reliability as design factors in weapons systems.

Table 3-5-Principal Maintenance and Repair Facilities

Army
Anniston Army Depot
Corpus Christi Army Depot
Letterkenny Army Depot
Lexington Bluegrass Army Depot
Red River Army Depot
Sacramento Army Depot
Tobyhanna Army Depot
Tooele Army Depot
Air Force
Oklahoma City Air Logistics Center, Tinker AFB
Ogden Air Logistics Center, Hill AFB
San Antonio Air Logistics Center, Kelly AFB
Sacramento Air Logistics Center, McClellan AFB
Warner-Robins Air Logistics Center, Robins AFB
Aerospace Guidance and Metrology Center, Newark AFB
Wright-Patterson AFB
Navy
Norfolk Naval Aviation Depot
Cherry Point Naval Aviation Depot
Jacksonville Naval Aviation Depot
Pensacola Naval Aviation Depot
North Island Naval Aviation Depot
Alameda Naval Aviation Depot
Navy Ordnance Station, Indianhead
Norfolk Naval Shipyard
Philadelphia Naval Shipyard
Portsmouth Naval Shipyard
Charleston Naval Shipyard
Long Beach Naval Shipyard
Puget Sound Naval Shipyard
Mare Island Naval Shipyard
Pearl Harbor Naval Shipyard

SOURCE: Office of Technology Assessment, 1991.

more) DoD maintenance facilities may receive more work despite lower force levels. The ongoing consolidation and streamlining of government facilities must therefore maintain critical skills for the future even while reducing the current workforce.

In addition to GOGO maintenance facilities, private contractors do substantial repair and overhaul work for all of the military services. Private fins, facing the downturn in new procurement, see repair, overhaul, and upgrades as a means to maintain their manufacturing capabilities and stay in business. Although the Services reserve a critical minimum amount of work for in-house facilities to ensure that core capabilities are retained and can be made available in a responsive manner, DoD plans to contract work above this minimum on a competitive basis between Service facilities and private fins.

MANAGEMENT OF THE BASE

After World War II, several key pieces of legislation were passed to retain an armaments production and mobilization base for future crises. The Strategic and Critical Stockpiling Act of 1946 established the national strategic stockpile of raw materials. The National Security Act of 1947 contained provisions for the creation of a National Security Resources Board to advise the President on military, industrial, and civilian mobilization and on programs for the effective wartime use of U.S. natural and industrial resources,[24] and the retention of the Munitions Board to coordinate industrial base activities within DoD.[25] The Armed Forces Procurement Act of 1947 provided a means for the Defense Department to build an industrial mobilization base by taking national security interests into account when awarding defense contracts. The Industrial Mobilization Plan of 1947 formed the basis for industrial preparedness planning and created the physical plant program for the DTIB.[26] This plan envisioned the mobilization of the Nation's resources as a fundamental aspect of national security and considered peacetime investment in mobilization capacity. Finally, the National Industrial Reserve Act of 1948 enabled the Secretary of Defense to husband certain industrial capabilities for emergency defense uses.[27]

Responsiveness

The flurry of legislation enacted at the close of the 1940s under the rubric of mobilization planning established the legal basis for the DTIB that exists today. In response to the outbreak of war in Korea and concern over the possibility of escalation,

[24] *The National Security Act of 1947*, Title I, sec. 103.

[25] Ibid., sec. 213.

[26] Ibid., pp. 9-11. Annex 47 of the 1947 plan detailed the objectives of the plant survey and allocation program: 1) to determine where essential military items can be obtained; 2) to eliminate competition among procurement agencies for output of a single plant; 3) to acquaint industry with its task in wartime and to encourage industrial planning for rapid expansion; 4) to promote orderly distribution of the initial production load of war requirements; 5) to maintain a current record of competent producers and their capacities; 6) to determine what required items cannot be provided by conversion of private industry in order to establish requirements for construction of new facilities; and 7) to minimize requirements for new construction by proper utilization of existing facilities.

[27] Roderick L. Vawter, *Industrial Mobilization: The Relevant History (Industrial College of the Armed Forces Study in Mobilization and Defense Management* Washington, DC: National Defense University Press, 1983), pp. 8-9.

President Truman declared a national emergency and ordered a mobilization effort far in excess of the immediate requirements of the Korean conflict. The Defense Production Act of 1950 provided the authority to expand overall national industrial production capacity and to manage the base during the conflict. Various portions of the Act remained in effect until its expiration in October 1990; a reauthorization of the Act is currently being debated.

Emergency preparedness functions are controlled by Title 50 of the U.S. Code, Presidential directives, and Executive orders. Under Title 10, U.S. Code, Chapter 148, "Defense Industrial Base," the major responsibility for defense-industrial responsiveness planning belongs to the Department of Defense. DoD manages the industrial base program through a series of production base analyses (PBAs), which support industrial preparedness planning for force regeneration over a wide range of crises and emergency situations. This process complements the strategic planning system employed by the U.S. Joint Chiefs of Staff, who develop mobilization requirements on the basis of critical items lists prepared by U.S. military commanders throughout the world.

A key to meeting the Nation's potential wartime requirements in the 1990s and beyond will be to determine the role of the DTIB in deterrence and response to warning. The national security community has sought a range of options to deal with crisis-options that could signal determination, provide flexibility, and, ultimately, deter conflict.[28] Starting in the mid- 1980s, defense analysts proposed the notion of incremental response to crisis or war based on the formal military Defense Alert Condition (DEFCON) scheme. This approach later evolved into the concept of Graduated Mobilization Response (GMR), which "provides a system for developing and implementing mobilization actions . . . responsive to a wide range of national security threats and ambiguous and specific warning indicators. "[29] GMR actions are designed to enhance deterrence, mitigate the risk of a crisis, and reduce significantly the lead time associated with mobilization should the crisis intensity.

Within the Department of Defense, GMR is viewed as both a near-term mobilization planning tool and as a hedge against the long-term reconstitution of Soviet military power. Testifying before the Senate Committee on Foreign Relations, Under Secretary of Defense for Policy Paul Wolfowitz commented:[30]

> We must also be prepared to respond over a much longer period of warning to any future Soviet attempt to reconstitute its strategic theater capability. With this in view, crisis management capabilities and graduated mobilization responses to assure continuing deterrence will become relatively more important than in the past.

Peacetime Acquisition

General government procurement policy is contained in Titles 40 and 41 of the U.S. Code, while defense procurement policy is contained in Title 10 (Armed Forces). These statues have been translated into regulations known as the Federal Acquisition Regulations (FAR), which govern contracting procedures, and supporting DoD and Service directives.

As a result of the Military Reform Act of 1986 (the Goldwater-Nichols Act), the Department of Defense established the position of Under Secretary of Defense for Acquisition (USD(A)), responsible for all DoD industrial and technology base programs except the Strategic Defense Initiative Organization. The Defense Management Review conducted by Secretary of Defense Cheney noted that the USD(A)'S authority on acquisition extends to "directing the Secretaries of the Military Departments on the manner in which acquisition responsibilities are executed by their Departments. ' '[31]

The Goldwater-Nichols Act further required the individual Armed Services to appoint Service Acquisition Executives, who manage the weapon procurement activities of subordinate Program Executive Officers (PEOs). The PEOs, in turn, oversee Program Managers for each major system. The Service Acquisition Executives also participate in the Defense Acquisition Board, which reviews procurement milestones for major weapon system programs and makes recommendations to the Secretary of Defense regarding continuation and required

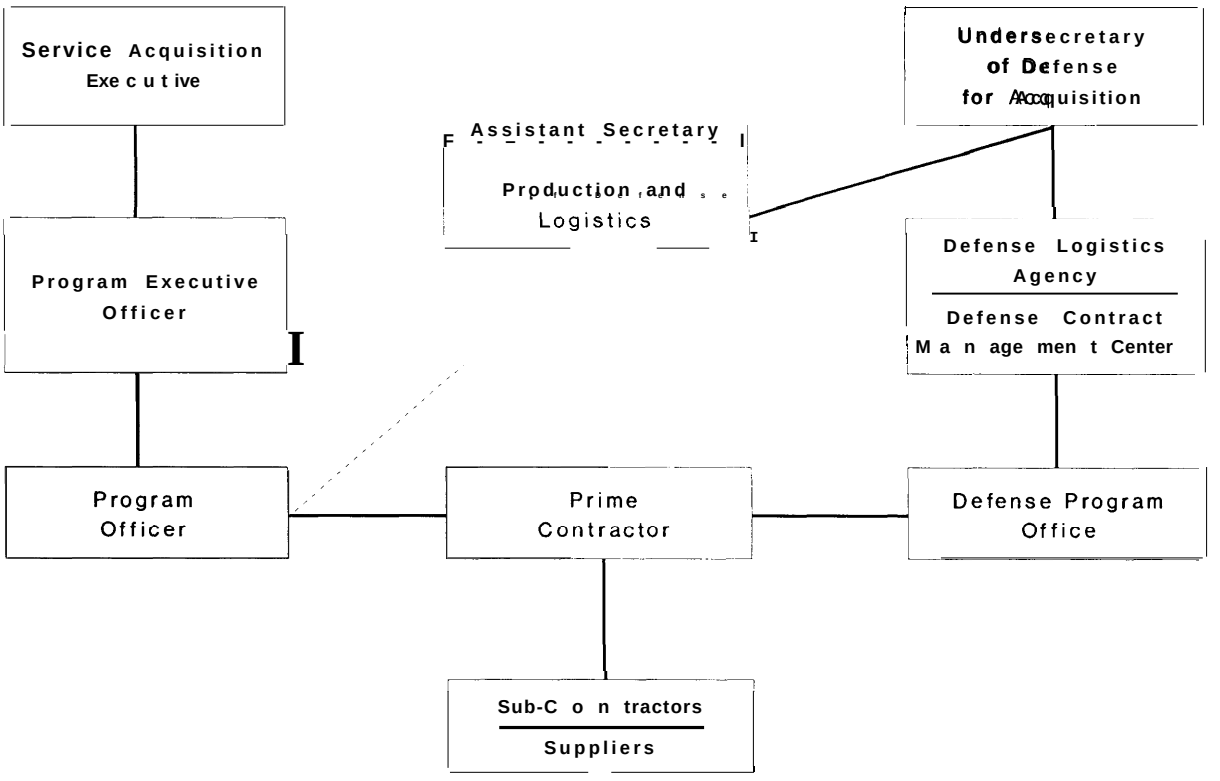
[28] Frank Carlucci, National Security Council Memo 1063/1, "National Security Emergency Preparedness priorities, " Sept. 15, 1987.

[29] 44 CFR Part 334, "&adwted Mobilization Response, " Jan. 19, 1990.

[30] Paul Wolfowitz, "Statement Before the Senate Committee on Foreign Relations," April 1990.

[31] Secretary of Defense Richard Cheney, *Defense Management Report to the President*, July 1989, p. 3.

Figure 3-9-Management Structure of a Typical Weapon Acquisition Program



SOURCE: U.S. Department of Defense briefing, April 1991,

levels of funding. The management structure of a typical weapon acquisition program is illustrated in figure 3-9. This structure is said to allow oversight over program cost and progress by both the Services and OSD.

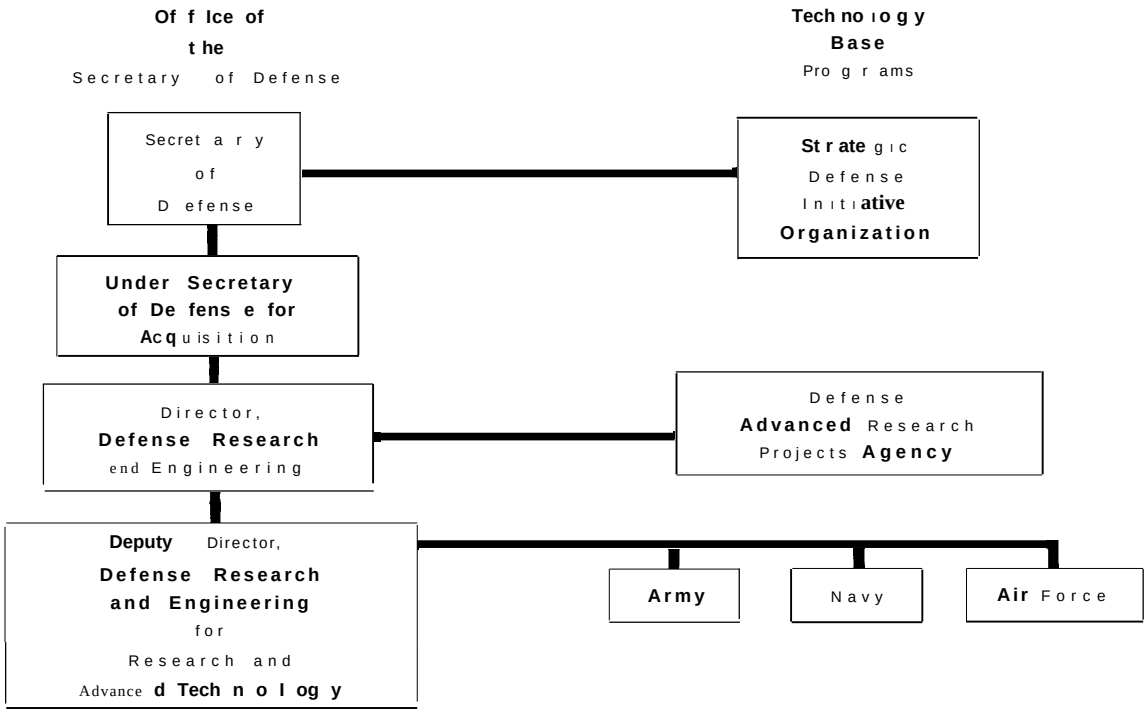
At present, management of defense R&D is dominated by the individual Services. Each Service not only runs its own laboratories but sets its own research priorities and goals, on the grounds that it is best placed to determine its technology strategy and funding levels.[32] The drawback of this approach is that the Services' technology base strategies are geared to maximize their respective military missions, with little coordination among them in the interest of overall national security needs. As the defense laboratory system shrinks, coordination at a high level may be required to avoid both redundancy and gaps in coverage.

In particular, some critics contend that the Nation's overall security interests would be better served by stronger guidance and control of technology programs from a central OSD source.[33] While OSD's Defense Guidance document does provide some technology planning guidance, it has been criticized as superficial and has had little impact on the direction of Service technology efforts. Furthermore, the Services, DARPA, and the Strategic Defense Initiative Organization (SDIO) report to different levels of the OSD bureaucracy, making an overall R&D strategy virtually impossible to develop or implement (see figure 3-10). Although the Service Chiefs of Research have recently begun to coordinate their basic research programs, a reorganiza-

[32]See, for example, the Air Force's *FY 1990 Technology Area Plans*, the Army's *Technology Base Master Plan*, and the Navy's *Exploratory Development (6.2) Investment Strategy.*

[33]Frederick Riddell et al. (eds.), *Report of the Task Force for Improved Coordination Of the DoD Science and Technology program* (Alexandria, VA: Institute for Defense Analyses, Report R-345, August 1988), p. 3.

Figure 3-10-Department of Defense Management Structure for Research and Development



SOURCE: U.S. Congress, Office of Technology Assessment, *Holding the Edge: Maintaining the Defense Technology Base,* OTA-ISC-420 (Washington, DC: U.S. Government Printing Office, April 1989), p. 21.

tion of DoD's research management structure may be necessary to achieve greater efficiency.

Logistics, maintenance, and repair are essentially handled as Service functions. As previously noted, however, the consolidation of some of these functions across Services is being undertaken as a cost-saving measure.

In recent years, the legislative branch has exerted influence over the management of the DTIB, both directly (e.g., the Goldwater-Nichols Act) and indirectly through appropriations and hearings. The massive increase in defense spending in the 1980s, and the perception of pervasive "fraud, waste, and abuse" that accompanied some spending scandals, caused Congress to increase its oversight.[34] As a result, DoD is currently monitored by 30 committees, 77 subcommittees, and 4 panels in the process of budgeting, authorizing, appropriating, overseeing, and investing defense resources each year.[35] Critics contend that the redundancy and complexity of the congressional oversight process, and the extensive reporting requirements, impose a burden on DoD that constrains its ability to manage. They further argue that the yearly budget cycle that dominates procurement makes it extremely difficult to conduct longer range planning and inhibits industry investment in improved manufacturing productivity.

SUMMARY

A comprehensive view of the DTIB is possible only by combining several different perspectives, the major ones having been outlined in this chapter. Although one can talk of the DTIB as a coherent

[34] J. Ronald Fox with James L. Field, *The Defense Management Challenge: Weapons Acquisition* (Boston, MA: Harvard Business School Press, 1988), pp. 72-84. Fox believes that this resulted in micromanagement as evident in the numbers of hearings held, committees and staffs involved, details of legislation written, and the number of reports required. "The 1985 budget request contained 1,890 separate line entries for procurement and 897 program requests for R&D. A joint Senate-House conference committee eventually authorized 92.5 percent and 94.4 percent of the Budget Authority requested by the Administration for procurement and R&D, respectively. Nevertheless, the HASC and SASC together changed. ..23.3 percent of the procurement line entries, and. . . 35.3 percent of all R&D programs." He also noted that "in 1985, the Pentagon was able to identify 458 congressional reporting requirements stemming from prior years' defense authorization and appropriation bills and their accompanying reports."

[35] *Defense Management Report to the President,* footnote 31, p. 24.

entity, it is clearly a complex mixture of government and private ownership, large and small fins, R&D- and production-oriented organizations, and domestic and foreign sources. Moreover, the structure of the base is in constant flux. The private/public ownership mix is changing, and the importance of particular industrial sectors will shift as new types of weapons are developed. As a result, no single perspective can describe more than one or two aspects of the base. Distinctions based on one perspective, such as between public and private ownership, may be outweighed by other factors such as the size of the firm.

While the complexity of the DTIB makes it difficult to formulate universal policies, good management practice argues against trying to develop individualized measures for each defense-industrial sector and firm. The challenge that the complex structure of the base poses for Congress is to develop policies broad enough to be manageable, yet sufficiently tailored to be effective.

Chapter 4

Trends and Problems in the Base

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Chapter 4
Trends and Problems in the Base

INTRODUCTION

The defense technology and industrial base (DTIB) has expanded and contracted three times since the end of World War II: the initial cold war mobilization in the early 1950s, the Vietnam War, and the peacetime defense build-up of the early 1980's, which began to contract in 1987.

Some trends in the current DTIB are listed in table 4-1. The R&D element of the base has been criticized as losing its overall competitive edge. Although U.S. weapons performed well in Operation Desert Storm, critics argue that these weapons were the products of earlier research (some in the 1950's and 1960's) and question whether the United States will continue to enjoy a weapons performance edge in the future. Nevertheless, it is important to consider future defense R&D requirements in the context of realistic threats, which, in the next decade, are likely to be relatively less demanding than in the recent past.

Current production capacity at the prime-contractor level exceeds both peacetime production requirements and most expected surge requirements. There are, however, long lead times at the subtier producer levels, and the production element has been criticized for its isolation from the broader civilian base and the resulting increased costs of weapons. Finally, all elements of the DTIB are becoming more international, raising concerns over potential vulnerabilities arising from excessive dependence on foreign sources.

GENERAL TRENDS

The DTIB shares many of the problems of the civilian technology and industrial base, including the high cost of capital, which reduces the ability to make needed investments, and low rates of increase in productivity. Defense contractors argue that they face a host of additional problems specific to the defense industry. In the 1980's these problems included fixed-price contracts on risky development projects, overly demanding military specifications, government demands for rights to proprietary data, instability in program finding, government-imposed limits on profits, and burdensome auditing requirements (see box 4-A). All these factors have tended to isolate the defense base from the broader civilian base. Further, changes in U.S. Government procurement rules during this period reduced recovery rates of independent research and development (IR&D) and bid and proposal (B&P) expenses, delayed progress payments, and increased company responsibility for purchasing new tools and test equipment. These changes required firms to have increasing amounts of capital on hand simply to stay in the defense business. Government pressures for business to help finance costly (and risky) development projects such as the Air Force's Advanced Tactical Fighter and the Navy's A-12 attack aircraft also contributed to the need for capital.

Beginning in 1986, cuts in defense spending depressed defense fins' stock prices and made equity financing increasingly unattractive or impossible, forcing companies to borrow to finance capital investment and production. Major defense firms also took on future debt as a result of aggressive bidding for fixed-price development contracts.[1] By the end of the 1980's, nearly all of the major defense contractors were considered poor business risks by the investment community. A review of the 5-year performance of major defense stocks relative to the Standard & Poor index (figure 4-1) shows that they performed far worse than the market average. As the decade closed, reduced procurements of all major weapon systems left the primes with both surplus production capacity and a lack of capital needed to undertake new weapons developments.

Table 4-l—Trends in the Current Base

- Extensive but declining R&D capability
- Continuing surplus production capacity in primes
- Declining number of subtier suppliers
- Continued limited access to civilian technology
- increasing costs of production
- Consolidating maintenance and repair capability
- increasing globalization of all three elements of the base

SOURCE: Office of Technology Assessment, 1991.

[1]Philip Finnegan, "Mounting Debt Threatens Industry," *Defense News*, vol. 5, No. 17, Apr. 23, 1990.

Box 4-A—How Government Auditing Requirements Isolate the Defense Industry

Government-imposed accounting practice tends to isolate the defense industry from the rest of the economy. While some real technical barriers prevent complete integration—military products sometimes require unique characteristics or processes-technical differences alone cannot explain the great degree to which military and civilian production is separated. With few exceptions, companies that do both military and commercial work set up special government-products divisions to do the defense work, even when the military and civilian technology is similar enough that economies of scale would accrue by keeping production under one roof.

Defense industry executives claim that work is separated primarily because of the government auditing requirements needed to calculate prices. Without a market to set prices through supply and demand, the government has sought to establish prices of military materiel by calculating costs and adding a percentage profit. (This approach also meets political requirements to limit profits on public contracts to "reasonable" levels.) Companies with DoD contracts must keep track of costs in a manner specified by the government, and must allow the government access to these cost records.

The combination of accounting practice and government access forces companies to separate government and commercial work, for several reasons. First, government accounting practice does not conform to modem commercial standards of accounting. For example, ledger entries and cancelled checks without invoices may not be adequate records of costs for government contracts. Information required by government accounting standards may not be useful to a commercial operation, or it may be judged too expensive to collect. In general, government contracts require far greater detail in allocating costs than do commercial management information systems, and errors in accounting on government contracts can bring criminal charges against business executives, causing them to devote inordinate amounts of effort to matters of no commercial consequence. Commercial firms cannot achieve consistency by adopting government standards because the added cost of government accounting procedures must be borne ultimately by the customers, placing the firm at a commercial price disadvantage relative to firms that do no government work. Moreover, the auditing burden is passed along with subcontracts.

Firms must not only collect cost information but open their books to U.S. Government auditors. Title 10 of the U.S. Code, section 2313 states that "an authorized representative" of the government "is entitled. . .to inspect the plant and audit the books and records" of contractors and subcontractors carrying out cost-based contracts. For 3 years after final payment, the government 'shall have the right to examine any books, documents, papers, or records of the contractor, or any of his subcontractors, that directly pertain to, and involve transactions relating to, the contract or subcontract.' These rights of inspection extend to negotiated fixed-price and competitively bid contracts and when the product has been sold on the commercial market. Thus, even in cases where competition should, in theory, assure the government a fair—if not the lowest—price, costs are audited to insure that profits are reasonable. The only exception to the auditing requirement is when contracts are awarded strictly on the basis of price.[1] This exception actually undermines efforts to award contracts based on best value rather than lowest cost. Section 2306(f)(2) expands governmental inspection rights to data regarding negotiation and pricing of a contract.

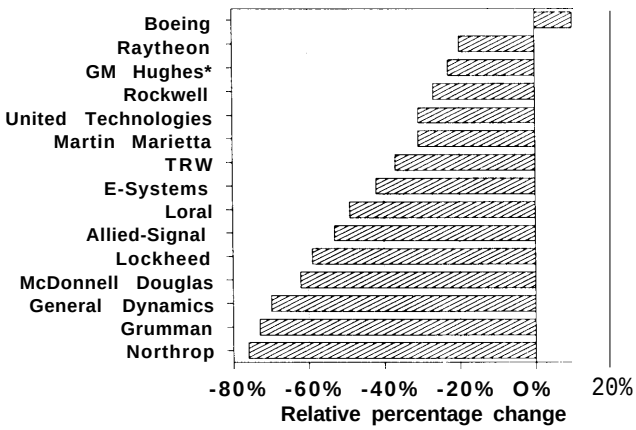
Court decisions have established the government's right to examine company accounting records covered by these regulations for the sole purpose of collecting information, even if the aim is not cost verification.[2] If a company thoroughly integrated its civil and military production, then virtually no company information would be excluded from such government audits. In the end, most companies choose to set up a separate government-products division rather than try to untangle overhead and other charges between commercial and government work or to allow government inspectors access to their commercial books.

[1] 4 CFR section 331.20(f)(2).

[2] *Smithkline Corp.* v. *Staats* 668F.2d 201 (3d. CIR.) *cert. denied*, 461 U.S. 913 (1981). established that the government could have access to cost information even if it was desired for research on contracting procedures.

One result of these problems is the declining number of suppliers willing or able to perform defense work. Small subtier firms have, for a variety of reasons, even less flexibility than primes or large subcontractors in adapting to changes in procurement laws and reduced defense spending. For example, subtiers have less liquid capital on hand to keep them in business during major downturns in the defense market, and they are less capable of dealing with the burdens of defense-acquisition regulations such as auditing requirements and military specifications. The potential loss of proprietary data rights

Figure 4-l—Five-Year Stock Price Performance of Major Defense Firms Relative to S&P 500, Dec. 31, 1984-Dec. 31, 1989



*4- year performance

SOURCE: Paine Webber Inc.

is seen as a direct threat to survival by small, specialized firms in all technical areas but particularly in the software field.

The subtiers also have been affected adversely by strategies employed by prime contractors to deal with cuts in defense spending. For example, when prime contractors make overseas sales, the purchasers often demand offsets, in which the seller agrees to let the buyer manufacture parts or components of the weapon system or some unrelated product as a condition of the sale. According to the Defense Science Board, "Not only do such offsets result in reduced subtier profitability and cash flow, but they also require the transfer of data to a future competitor.' For example, when General Dynamics sold F-16s to the Netherlands, it required Menasco Texas, a producer of aircraft landing gear, to teach a Dutch firm how to make the product; the Dutch firm now competes with Menasco.[3] Subtiers also contend they are forced by primes to accept a disproportionate share of program cost and risk.[4] Further, subtier firms are under growing competitive pressure from large defense contractors that are expanding their defense business base to improve their market position. Several small firms surveyed by OTA argued that the diversification of large firms into technical niches now occupied by subtiers would result in loss of business and reduced quality for the government customer.

Subtier firms are not optimistic about their ability to adapt successfully to a downsized DTIB. Many of the smaller firms surveyed by OTA are trying to move out of defense work, and some reported they had already done so. Those planning to remain in the field foresee an environment in which suppliers will attempt to survive by underbidding to win contracts, even if the result is poor performance and cost overruns, and by curtailing IR&D, training, and other long-term investments just to keep the doors open. One firm summed up the situation by predicting that the industry will behave like a pack of dogs trying to subsist on a food supply adequate for half its number. Many will die horrible deaths, and the survivors will be weak and unhealthy.

While the transition to a downsized DTIB maybe particularly difficult for smaller firms serving niche markets, from a national perspective the supplier base will have to shrink. The challenge will be to maintain sufficient capability and competition to promote price discipline and technical innovation in this important element of the base. These objectives might be accomplished if large prime contractors move component production in-house, or if small firms diversify into the civil sector. In order to motivate diversified subtiers to remain in the defense sector, it will be necessary to make defense work more attractive through changes in acquisition laws, particularly as they relate to technical data rights claimed by the Government. Strategies for the transition are discussed in greater detail in chapter 5.

SPECIFIC ISSUES

In addition to these general conditions and trends in the current DTIB, there are several specific issues that have a direct effect on the nature and composition of the base:

Disincentives for Manufacturing Investment

The procurement regulations imposed by the Federal Government discourage corporate investment in manufacturing technology for a number of reasons. First, regulations often specify production

[2]Office of the Under Secretary of Defense for Acquisition *The Defense Industrial and Technology Base, vol. II: Subgroups Appendices (Washington* DC: December 1988), p. 137.

[3]Eileen White, "Tool of Trade," *Wall Street Journal*, Sept. 10, *1987, p.* A1.

[4]Office of the Under Secretary of Defense for Acquisition, op. cit., footnote 2, pp. 136-137.

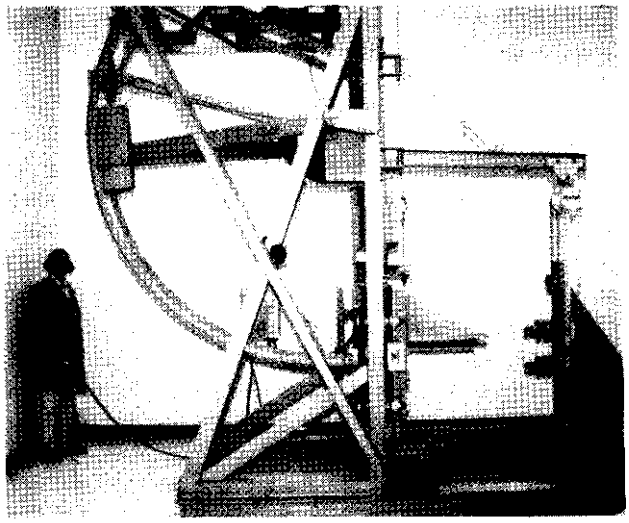


Photo credit: General Dynamics

Field radios, built according to military specifications and procedures mandated by the government, must be shock-tested with this hammer.

procedures and tests, so that firms cannot make manufacturing innovations without explicit contract authority. While authorization is possible, it can be so costly and time-consuming that firms avoid making modifications that could improve productivity. Second, as discussed in chapter 3, limits on contractor profits reduce incentives for firms to invest in greater production efficiency. Third, the requirement to compete for future short-term production contracts means that a firm may not recover an investment in improved manufacturing technology if the resulting immediate costs keep it from winning a future contract. Fourth, the general uncertainty in defense programs and spending levels provides strong incentives to seek short-term profits.

In this environment, some firms have sought to become a competitive second source by bidding on a production contract after the development has been carried out by another firm. If the developer is attempting to recover company-funded R&D expenses, the second source will be able to produce at lower cost, greater profit, or both. The very success of this strategy suggests that the current procurement system gives rise to perverse incentives, since winning a development contract should not penalize a firm in the subsequent competition for the production contract. Many of these perverse incentives will have to be removed as the Nation moves to a smaller DTIB.

Inappropriate Competition

Congress and the Nation have long evinced a deep faith in competition to improve efficiency and control costs. Some defense analysts support this view, arguing, for example, that dual-sourcing has yielded better designs and quality, lower production costs, and reduced maintenance costs.[5] But critics contend that while competition is good in theory, as currently practiced by the Department of Defense (DoD), it has raised costs, inhibited productivity investments, and slowed innovation. Some contend that more competition is not necessary and that the system would function better with fewer, but more qualified, competitors. Further, in the area of R&D, teaming and cooperation may be more beneficial than a purely competitive approach.

Congress' belief in the virtues of competition is embodied in the Competition in Contracting Act (CICA), Public Law 98-369, Title VII, July 18, 1984, 98 Stat. 1175, which requires "full and open competition' in Federal acquisition programs. The meaning of "full and open competition" rests ultimately on the definition of a responsible offeror. Title 41 of the U.S. Code, Section 403, defines "responsible source' as a prospective contractor that has adequate financial resources, facilities, organization, and technical skills to carry out the contract, as well as a satisfactory performance history and record of integrity and business ethics.

Both the general and defense-specific procurement statutes also enumerate several exceptions under which a Federal agency may limit the number of potential bidders. Such noncompetitive bidding procedures may be invoked when:

1. the needed property or services are available from only one "responsible" source or a limited number of sources;
2. the agency's need is of such "unusual or compelling urgency" that it would suffer injury unless it limits the number of bidders;
3. the contract must be awarded to a particular source in order to maintain a vital industrial or R&D capability;
4. an international treaty or agreement mandates noncompetitive procedures;

[5] Jacques S. Gansler, Affording *Defense* (Cambridge, MA: MIT Press, 1989), pp. 185-188.

5. a statute requires that the procurement be made from a specified source;
6. wide disclosure of the agency's needs would compromise national security; or
7. the Secretary of Defense (or other agency head) determines that it is necessary "in the public interest" to use noncompetitive procedures in a given case, and notifies Congress of this determination at least 30 days before contract award.

The statutes also state, however, that a Federal agency may only award a contract using noncompetitive procedures after the contracting officer has justified the use of the exemption in writing and certified its accuracy. Explicit approval from procurement authorities must then be obtained, at a bureaucratic level determined by the size of the contract. The competition rules are further enforced through a bid-protest mechanism. In general, the incentive structure of the defense procurement bureaucracy encourages conservatism in pursuing noncompetitive exemptions that would be justified under the statute. This is because applying for an exemption is time-consuming, can trigger a bid-protest proceeding and hence a costly delay in starting the program, and can potentially involve the responsible contracting office in litigation. Yet the office runs no risk by failing to apply for an exemption when it is warranted.

In the view of both industry and government, CICA has been a double-edged sword. While the Act has increased contracting opportunities by opening up formerly sole-source programs to competitive procurement, it has had numerous unintended harmful effects. The OTA survey revealed that while most firms favor the idea of competition and do not seek the repeal of CICA, they believe the Act has been applied in an inflexible and counterproductive manner. In particular, government agencies have generally interpreted the Act as requiring competition under all circumstances, strictly on the basis of price. By technically leveling all competitors and then awarding to the lowest priced bidder, CICA has tended to remove sound business judgment from the procurement process. In the OTA survey, industry made a number of recommendations for change (see box 4-B).

Photo credit: U.S. Department of Defense

Modern military equipment from a variety of suppliers is increasingly sold in international arms markets, such as these Israeli products displayed at the Paris Air Show.

Increasing Globalization of the Defense Base

The internationalization of the DTIB is part of the evolution toward a global economic system. As the Defense Science Board has observed: "Globalization not only means dependence on foreign sources for raw materials but also for manufactured products .... [M]ore and more, defense systems require foreign manufactured components and assembly." G Almost all U.S. weapon systems contain component parts from foreign sources, predominantly incorporating "dual-use" technologies with both military and civilian applications, such as microelectronic chips, composite materials, and flat-panel displays. The use of foreign sources may not be large in dollar terms, but it often involves key components. Although there are no reported cases of the United States' failing to receive components from allied suppliers in wartime, U.S. firms have claimed that lack of access to certain key components has delayed production of civilian products in peacetime. In response, the Defense Science Board has argued that the United States must have *assured access* to technologies it defines as critical.

Changing R&D Priorities

DoD's current plans call for holding funding for research and exploratory development relatively

[6]Office of the Under Secretary of Defense for Acquisition *The Defense Industrial and Technology Base, vol.* 1, October 1988, p. 11.

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Box 4-B—Problems With the Competition in Contracting Act (CICA)

Surveyed firms argued that CICA as implemented has had the following adverse consequences:

- *Fiscal Damage-CICA* has generated "artificial" competition for its own sake, without evaluating suppliers on their true merits or giving the Department of Defense (DoD) the most cost-effective solution. By basing evaluations strictly on price, without due consideration of quality or past performance, the Act has enabled unqualified firms to ''buy in" at the expense of quality producers. CICA has also opened the door to bidding abuses. In particular, low-overhead, "build-to-print" companies have used aggressive pricing techniques to win production contracts after other firms complete the development work. Once the government has accepted an unrealistically low bid, it may later be forced either to modify the contract when the firm cannot meet its terms or seek an alternative contractor. For example, one company reported that DoD had dropped it in favor of a competitor who made a lower bid, only to return when the latter was unable to deliver. By that time, however, the first contractor had been hurt financially by the loss of the original contract.
- *Eroding Technology Base--C1CA* has reduced industry investment in R&D and eroded the Nation's defense technology base, for a number of reasons. Fret, CICA has caused firms to expend additional resources on bid & proposal (B&P) for programs where they could have been justified as sole-source. This increase in B&P costs has lowered the firms' investment in independent research and development (IR&D), Second, fostering competition through dual-sourcing has been a major disincentive to invest in technology development. Since all innovations will ultimately be made available to a second source, firms are generally unwilling to make investments in new technology that the government will then transfer to a competitor. Third, the government has held competitions for production runs that are too small to maintain corporate R&D capabilities or to cover new manufacturing investments. This practice has reduced R&D and inhibited productivity improvements. Fourth, the government practice of purchasing a significant portion of military spare parts from low-cost parts suppliers has had a negative effect on contractors who maintain design and development staffs. By depriving the developer of satisfactory rates of return on its initial engineering investment, this policy also inhibits future incentives to invest in R&D and reduces the long-term capability to manufacture components and parts. The net result of such actions by individual firms is the erosion of the defense technology base.
- Reduced Eficiency--By requiring a new competition for components and subsystems, CICA has inhibited the development of long-term relationships between primes and subcontractors. As a result, it has limited the introduction of improved management techniques [Just In Time (JIT) and Total Quality Management (TQM)]. Industry argues that the procurement community, in its efforts to increase competition, has sometimes spent more money creating new competitors for a program than it could have reasonably expected to save through increased competition. Moreover, problems caused by enforced competition at the subcontractor level must ultimately be borne by the prime. Finally, mandatory dual-sourcing is the wrong policy for a shrinking defense market. Since declining budgets cannot support multiple sources for all goods, spreading future contracts among many competing suppliers may not allow any one firm enough business to remain healthy.

The firms surveyed argued that "effective competition" should replace ''full and open competition' as the goal in procurement Accordingly, they suggested that CICA and the regulations derived from it be changed to make clear that competition is merely one tool in the policy toolbox, to be used when necessary, reasonable, and practicable. The firms made the following specific recommendations:

- Modify CICA to allow the government to procure under a "best value' rather than lowest price standard, so that the many factors affecting total cost-effectiveness can be considered.
- Enable a contractor to recoup nonrecurring R&D costs before a competitor is allowed to bid to manufacture the product of the R&D.
- Limit competition to preselected qualified producers who have performed well on past contracts or meet clear rules established for admitting newcomers.
- Interpret CICA to encourage long-term, predictable relationships between primes and suppliers.

OTA DEFENSE INDUSTRY SURVEY

Box 4-C—Industry Views on Research and Development

All surveyed industry executives recognized the current close link between R&D and production and expressed concern about the expected decline in tiding. A minority suggested dealing with this problem by adjusting production to minimize disruption to R&D. For example, smaller procurements could be stretched out over long, slow production runs to allow steadier, albeit lower, financial support for design teams. Alternately, the current approach-of rapidly ramping up production, meeting deployment requirements quickly, and then ramping down--could be modified to include planning from the outset for frequent upgrades of deployed systems. At the very least, when government contracts are awarded, the quality and cost of the research and engineering performed by the production house should be considered in evaluating competing bids. Otherwise, those firms that neglect long-term research will always underbid those that fund research, to the eventual detriment of the Nation's defense technology base.

The majority view of the surveyed firms is that fundamental changes are required in the government approach to funding and directing military R&D. If the government wants to maintain R&D in spite of reduced procurement levels, then R&D must be made profitable in its own right. Currently, the few research contracts not aimed at specific development programs, while welcome, make an insignificant contribution to overall R&D requirements. Surveyed firms believe that government laboratories will protect their own budgets at the expense of industry capabilities, exacerbating the separation of research and production. To the extent such a shift occurs, however, the firms argued strongly that the results of R&D by government laboratories must be made widely available.

Many respondents see value in maintaining technological capability through vigorous, government-funded prototyping. Without the urgency created by the Soviet threat, the weapon development process could be slower and more deliberate. Ideas could be tested more thoroughly before entering production, and small-scale production runs could allow field testing before committing to large-scale production. Other respondents suggest that despite the lack of new weapon platforms, innovation can be maintained by upgrading existing weapons.

Many small firms are built around a single specialized skill or technology. Such firms survive only by protecting their proprietary technical data and many therefore refuse government R&D funding, which could compromise their competitive edge by requiring the transfer of company data to other manufacturers. Any future plan for direct government funding of R&D will have to address the concerns of these specialized firms.

At the same time, almost all surveyed firms are wary of developing technology to "put on the shelf" because of the problems associated with moving from development to production. New development tools, such as computer-aided design and concurrent engineering, may reduce these problems in the future. Uncertainties about manufacturing might also be resolved by occasionally pursuing limited production runs and by increasing the importance of producibility as one of the criteria by which a new design is evaluated.

constant. Because the defense industry's investment in R&D is linked to procurement, however, overall funding may decline as a result of reduced recovery of IR&D and as firms spend less of their profits on research. In addition, the transformation of the international security environment is expected to slow the pace of defense R&D and to lengthen weapon procurement cycles. Firms anticipate more investment in new components that can be retrofitted to existing platforms, rather than replacements for the platforms themselves (see box 4-C).

R&D organizations recognize that the diminution of the Soviet threat will result in an increase in the relative importance of threats in other parts of the world, and are considering a shift in R&D priorities. For example, the United States is currently the world leader in strategic antisubmarine warfare (ASW) technologies directed toward detecting large Soviet nuclear submarines in the open ocean. As the immediacy of the Soviet strategic threat declines, the Navy may want to restructure its ASW research effort to place greater emphasis on detecting small electric submarines in shallow water.

Photo credit: Litton Industries, Ingalls Shipbuilding Division

The shipyard at Pascagoula, MS. Trends in U.S. shipbuilding are toward fewer new keels in the yards and a sharply reduced supplier base.

Diminishing Industrial Capabilities

Many key defense sectors are shrinking rapidly to only a few or single producers. Shipbuilding is one sector that has experienced a major decline over the past two decades: the number of shipyards capable of building large ships fell from 37 in 1982 to 20 in 1990. Today, there is essentially no commercial shipbuilding in the United States, and private shipyards are totally dependent on U.S. Government contracts for survival.[7] Armored vehicle production has also been reduced to only a few sources. Although many components of these weapon systems could be procured from the commercial sector, the end-items cannot.

Management Inertia

The Defense Management Review (DMR) undertaken by Secretary of Defense Cheney addressed acquisition practices and procedures, as well as defense planning, government-industry accountability, and personnel and organization. The Review resulted in a number of recommendations for acquisition reform, many of which still have not been implemented. For example, while the DMR called for more stability in funding and noted the savings that might accrue from multiyear contracting, the OTA survey and subsequent industry interviews found almost no improvement in this area.

The DMR also called for reducing reporting requirements and regulations that inhibit "sound procurement policies such as 'best value' competitive practices and the buying of commercially-available products. . and that impose unnecessary reports and reviews on program offices and contractors."[8] Again, the OTA survey and interviews revealed continuing problems in all these areas.

The national management of the DTIB is currently inadequate to deal with the challenges of the transition to a downsized base. Management problems that raise the costs of developing and producing new weapon systems have been identified many times, but consensus on dealing with these problems does not yet exist. As a result, these well-identified problems persist.

CURRENT GOVERNMENT AND INDUSTRY STRATEGIES

The OTA assessment team has not identified any overall government strategy to manage the changes in the DTIB and ensure that a viable base will exist in the future. There are, however, a variety of uncoordinated strategies being pursued by the Office of the Secretary of Defense (OSD), the Services, and Congress. Secretary of Defense Cheney's Defense Management Review noted that steps are being taken to revamp some of the regulations that increase costs, reduce efficiency, and thus isolate defense production from the commercial sector. In addition, the Department of Defense's Joint Depot Consolidation Plan is designed to save money by rationalizing maintenance and overhaul work in Service depots. The Services are also in the process of consolidating research and development facilities. In recent months, the Air Force has been studying ways to maintain aviation design capabilities, and the Army has commissioned studies on its future DTIB needs. Finally, as a result of congressional prodding, OSD is revamping the Manufacturing Technology (MANTECH) program.

Concern over the perceived problems in the technology base of both defense and civilian sectors has led to a number of recent initiatives. One has been the identification of key national defense technologies. For example, the 1989 Defense Authorization Act requires the Secretary of Defense to

> . . . submit to the Committees on Armed Services of the Senate and the House of Representatives an annual plan for developing the technologies considered by the Secretary of Defense and Secretary of Energy to be the technologies most critical to ensuring the long-term qualitative superiority of United States weapons systems.[9]

This effort was supplemented by a report on supporting industries, which was published in response to requirements in the 1990 Defense Authorization Act. Other "critical technologies" lists have been requested by Congress and subsequently published by the Department of Commerce and the

[7] Naval Sea Systems Command, Corporate Operations Directorate, *United States Shipbuilding Industry,* briefing papers, July 1990.

[8] Secretary of Defense Dick Cheney, *Defense Management Report to the President,* Department of Defense, July 1989, PP. 11-12.

[9] Department of Defense, *Critical Technologies Plan,* prepared for the Committees on Armed Services, U.S. Congress (Washington, DC: Office of the Secretary of Defense, Mar. 15, 1990), p. 1.

Table 4-2—Comparison of National Critical Technologies With Department of Commerce Emerging Technologies and Department of Defense Critical Technologies

National Critical Technologies	Commerce Emerging Technologies[a]	Defense Critical Technologies[b]
Materials		
. Materials synthesis and processing	. Advanced materials	. Composite materials
. Electronic and photonlc materials	. Advanced semiconductor devices . Superconductors	. Semiconductor materials and microelectronic circuits • Superconductors
. Ceramics • Composites • High-performance metals and alloys	• Advanced materials	• Composite materials
Manufacturing		
• Flexible computer-integrated manufacturing	. Flexible computer-integrated manufacturing	
. Intelligent processing equipment • Micro- and nanofabrication • Systems management technologies	• Artificial intelligence	• Machine intelligence and robotics
information and communications		
• Software • Microelectronics and optoelectronics	• High-performance computing • Advanced semiconductor devices • Optoelectronics	• Software producibility • Semiconductor materials and microelectronic circuits • Photonics
• High-performance computing and networking	• High-performance computing	• Parallel computer architectures • Data fusion
• High-definition imaging and displays • Sensors and signal processing	• Digital imaging • Sensor technology	• Signal processing • Passive sensors • Sensitive radars • Machine intelligence and robotics
• Data storage and peripherals • Computer simulation and modeling	• High-density data storage • High-performance computing	• Photonics • Simulation and modeling • Computational fluid dynamics
Biotechnology and life sciences		
. Applied molecular biology • Medical technology	• Biotechnology . Medical devices and diagnostics	• Biotechnology materials and processes
Aeronautics and space transportation		
• Aeronautics • Surface transportation technologies		• Air-breathing propulsion
Energy and environment		
• Energy technologies • Pollution minimization, remediation, and waste management		
		• No National Critical Technologies counterpart: High-energy-density materials, Hypervelocity projectiles, Pulsed power, Signature control, Weapon system environment.

a U.S., Department of Commerce, Emerging *Techno/ogies:A survey of Technical/ and Economic Opportunities*, spring 1990.
b us. Department of Defense, *Critical Technologies Plan*, Mar.15, 1990.

SOURCE: Executive Office of the President, Office of Science and Technology Policy, *Report of the National Critical Technologies Pane/*, March 1991.

White House Office of Science and Technology Policy (see table 4-2). To date, however, these efforts have been generally criticized as failing to provide an investment strategy for the future.

In the absence of a coherent government strategy for the DTIB, defense contractors are taking a number of steps to adapt to the new environment. The main strategies are outlined below.

Consolidation

Firms are attempting to become leaner and more efficient through consolidation efforts that include laying off workers, using temporary workers and consultants, reducing floor space, selling excess assets, and cutting back on both R&D investments and capital expenditures for military programs. Some have brought component manufacturing in-

house. While such actions can have a positive short-term effect on costs, they can have a negative long-term effort on R&D and manufacturing skills.

Concentration on Defense Work

Some firms are focusing on defense work, which despite the downturn is likely to amount to about $100 billion in defense R&D and weapon procurement (including equipment purchased from industry for operation and maintenance). Industry executives argue, however, that maintaining a constant share of a diminishing market will make their firms unattractive investments. These firms must therefore expand their share of the reduced defense business either by increasing relative market share of current defense products or by moving into other defense product lines. Firms that survive using this strategy will be more diversified within the defense sector. They will have also eliminated many of their direct rivals and may increasingly become sole-source "arsenals" for key weapon systems.

Diversification

An alternative strategy being followed by some firms is diversification outside the defense market by acquiring new capabilities or redirecting current ones. Indeed, some business analysts argue that DoD procurement should, in the future, favor diversified firms over nondiversified fins. These analysts argue that only a diversified firm will be "strong enough to turn down a poor defense contract' and thus avoid repeating some of the severe financial mistakes related to freed-price development contracts. Another diversification strategy is to engage in joint ventures and teaming arrangements. By pooling financial resources, technology, and skilled labor, two or more firms can enter a market where a single firm could not compete on its own.

There are, however, problems with diversification. Well-known "horror stories" include the largely unsuccessful attempts by aerospace firms like Grumman and Boeing Vertol to enter the mass transportation market in the 1970's. But there are also examples of successful diversification: Rockwell International and Raytheon have greatly reduced their dependence on defense contracts since the early 1980's. To the extent that firms offset defense cutbacks with growth in commercial sales involving similar technologies, they can mitigate the adverse effects on overall military production capabilities of declining DoD procurement. Diversification could therefore support a strategy of increased civil/military integration. Recent legislation seeks to ease diversification into commercial markets by allocating $200 million from the defense budget for conversion of defense industries to civil production.

Arms Exports

Another corporate strategy for adjusting to defense budgets is to expand internationally by seeking foreign investment and market access, forming strategic alliances with foreign partners, and participating in multinational codevelopment and coproduction programs. Foreign sales could maintain warm production lines for major weapon systems, aid U.S. defense industrial responsiveness, and help pay for additional research and development. Nevertheless, this strategy faces a number of important challenges, including export controls (see box 4-D) and an increasingly soft international arms market. Not only has the end of the cold war significantly reduced domestic markets of the major producing countries, but the Third World arms market has declined as well. In constant-dollar terms, Third World arms sales fell by one-half between 1982 and

Box 4-D—Export Control Laws

Export controls are governed by the Arms Export Control Act of 1976, which regulates the transfer of military equipment and technologies, and the Export Administration Act of 1979 (as amended), which controls the export of those dual-use technologies that could significantly enhance the military capabilities of a potential adversary.

Defense Exports

Two types of exports of defense equipment are regulated by the Arms Export Control Act: Foreign Military Sales (FMS) and direct commercial sales. Under the FMS process, a U.S. defense contractor sells the equipment

Continued on next page

Box 4-D—Export Control Laws-Continued

to the U.S. Government, which then delivers it. Since the U.S. Government serves as an intermediary, the company need not apply for a separate export license, but it must ask the same price it would charge the government for a domestic sale and comply with all U.S. military specifications.

U.S. defense contractors generally prefer direct commercial sales because they provide greater flexibility and profit. The firm can charge what the market will bear and the equipment does not have to meet U.S. military specifications. Nevertheless, direct sales require obtaining an export license, which is a complex and time-consuming process. Although FMS sales remain the primary mechanism for arms transfers, since 1983 there has been a steep increase in direct commercial sales.

Role of the Congress

The State Department must report annually all license requests for the export of major defense equipment costing $7 million or more, or any other defense articles or services over $25 million, at least 30 days before the license is issued. Congress may also request a report on the capabilities of the weapon being exported.[1] This notification process is designed to ensure that Congress can block a proposed sale if it chooses to do so.

Congress has prohibited arms transfers to some countries, restricted re-exports to third parties, and earmarked more than 90 percent of Foreign Military Financing (FMF) of foreign arms sales, thereby reducing the ability of the executive branch to make grant funding available to other countries.[2] At the same time, Congress has exercised relatively little control over the FMS program, giving the executive branch considerable latitude in arms sales and transfers of defense technology, and it does not review proposed commercial sales in detail. In the wake of Operation Desert Storm, however, Congress may seek greater restrictions on conventional arms sales.

Exports of Dual-Use Technologies

U.S. export-control policy involves balancing two competing interests: giving U.S. companies a freehand in competing for foreign markets, and reducing the threat to U.S. security from the export of militarily relevant goods and technologies. The United States controls exports of dual-use technologies under the Export Administration Act and coordinates its policies with allies through the Paris-based Coordinating Committee for Multilateral Export Controls (COCOM).[3] In a process begun in June 1990 and completed in May 1991, COCOM replaced its previous industrial control list with a much shorter 'core list' by decontrolling many items and reducing controls on others.

In some cases, the United States controls items that the other COCOM countries do not. An example is so-called West-West' licensing requirements: the need to obtain licenses for technology exports to allies and other non-Communist countries. Such licenses are designed to prevent the diversion to the Soviet Union, China, and their allies of technologies sold to customers in Western countries. In addition, the United States is the only COCOM member to require a reexport license before foreign goods containing controlled U.S. components can be sold to third countries.

These unilateral export controls result in considerable expense, delay, and uncertainty for U.S. firms, and may cause them to lose out to foreign competitors that are not similarly constrained. According to a recent report by the National Academy of Sciences (NAS), the negative economic effects of export controls have resulted almost entirely from the unilateral aspects of U.S. policy.[4] Yet except in rare cases, unilateral U.S. controls do not significantly affect the availability of dual-use technologies to the proscribed countries. The NAS report recommends that such controls be eliminated except in those relatively few cases where unilateral action can be effective.

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[1] Paul V. Hammond et al., *The Reluctant Supplier: U.S. Decisionmaking for Arms Sales* (Cambridge, MA: Oelgeschlager, Gunn & Hain, 1983), p. 95.

[2] U.S. Congress, Office of Technology Assessment *Global Arms Trade,* OTA-ISC-460 (Washington, DC: U.S Government Printing Office, June 1991), p. 20.

[3] COCOM controls exports of dual-use technologies to the Soviet Union, China, and their allies. Nonproliferation of technologies for unconventional weapons (e.g., nuclear, chemical, biological, and Wtic missiles)—which the Soviet Union and China already possess-is addressed in other forurns.

[4] National Academy of Sciences, *Finding Common Ground: U.S. Export Controls in a Changed Global Environment* (Washington, DC: National Academy Press, 1991), pp. 19-20.

1989.[10] At the same time, there is growing competition from both traditional arms exporters and emerging defense industries, such as those of Brazil and China.[11]

SUMMARY

The current trends in the DTIB are considered to be largely unfavorable because of:

1. regulatory controls that have increased the cost of conducting defense business and discouraged many firms from participating in defense efforts, and
2. the lack of any overall strategy enabling both private firms and government organizations to prepare for the future.

In the absence of a DTIB strategy, and under the pressures of current regulatory practices, firms are taking actions simply to survive rather than to position themselves for future business. Chapter 5 addresses some of the issues entailed in developing such a strategy. It outlines desirable characteristics of a future DTIB and the strategic choices and tactical decisions involved in the transition.

[10] R. Grimmett, "Trends in Conventional Arms Transfers to the Third World by Major Suppliers, 1982-89," Congressional Research Service, June 1990.

[11] Michael T. Klare, ''Growing Firepower in the Third World,'' *Bulletin of the Atomic Scientists*, vol. 46, No. 4, May 1990, pp. 9-13.

Chapter 5

Framing the Debate

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Chapter 5
Framing the Debate

The preceding chapters have examined the future U.S. military needs that must be supported by the defense technology and industrial base (DTIB) and the structure, condition, and trends of the current base. With this background, we can now consider the transition to the future base and the implications of alternative policies. This chapter identifies some desirable characteristics of the future DTIB and explores the strategic choices and tactical decisions involved in moving to and maintaining the future base.

FUTURE U.S. FORCES

Future U.S. forces, as described in chapter 2, are likely to be smaller, engaged in areas other than Europe, less forward-based, and sufficiently mobile to support operations from the continental United States (table 5-l). With smaller active forces, the U.S. military will also become more dependent on the mobilization and long-term reconstitution of forces to counter either a renewed Soviet threat or a new "great power' threat.

U.S. national security planners will continue to stress high-performance weapons. The Nation has traditionally been reluctant to expose its forces to unnecessary battlefield risks, and probably only in the case of a direct threat to national survival would the American public tolerate high U.S. casualties. For this reason, the United States has opted since World War II for superior weapon performance over raw numbers. Despite the diminished Soviet threat, the Persian Gulf War demonstrated the utility of high-performance weapons in attacking critical targets and reducing U.S. casualties, strengthening the long-held U.S. preference for superior weapons to counter any adversary.

Nuclear weapons will remain a fundamental element of the U.S. military deterrent, although the number and composition of these weapons will change in response to changes in the Soviet Union, arms control treaties, and the emergence of new nuclear-weapons states over the next decade. Although the Biological Weapons Convention was signed in 1972 and negotiations are currently under way to eliminate chemical weapons, biological- and chemical-warfare agents are a growing threat to U.S. forces operating in the Third World and may require the development of improved defenses.

Table 5-l-Characteristics of Future U.S. Forces

- Smaller active and ready reserve forces
- Less forward basing, greater strategic mobility
- Continuing weapons performance advantage
- Substantial nuclear capability
- Chemical and biological defense capabilities
- Greater dependence on mobilization

SOURCE: Office of Technology Assessment, 1991.

DESIRABLE CHARACTERISTICS OF THE FUTURE BASE

The future DTIB will still need to meet the two objectives outlined earlier in this report:

1. affordable development and peacetime acquisition of high-performance weapons, and
2. the responsive production of weapons and supporting equipment in crisis or war.

These objectives, the force structures and operations outlined above, and projected fiscal constraints suggest some desirable characteristics of the future DTIB that are summarized in table 5-2.

Preserving an advanced research and development capability is the highest priority over the next decade. While production funding will still greatly exceed R&D funding, there should be a relative shift in funding priorities. The ongoing need to deploy high-performance weapons and to guard against technological surprise necessitates a robust R&D capability. The R&D component of the base will continue to consist of some combination of private and government organizations, but a fundamental

Table 5-2—Desirable Characteristics of Future Base

- Advanced research and development capability
- Ready access to civilian technology
- Continuous design and prototyping capability
- Limited, efficient peacetime engineering and production capabilities in key defense sectors
- Responsive production of ammunition, spares, and consumables for theater conflict
- Healthy, mobilizable civilian production capacity
- Robust maintenance and overhaul capability
- Good, integrated management

SOURCE: Office of Technology Assessment, 1991. Characteristics are not necessarily listed in order of priority.

question will be the allocation of resources between these elements, as well as the overall level of R&D funding.

In the current DTIB, the R&D emphasis is on systems development for production. In the future, the emphasis will be on technology demonstration, prototyping, and *potential* production. Since the reduced Soviet threat will allow for slower deployment of new weapon systems and more deliberate development schedules, the Nation can afford to invest relatively more in research (budget categories 6.1 and 6.2). Moreover, the deployment of fewer new weapon systems and platforms will increase the relative importance of upgrades and component changes in existing systems. The challenge for DTIB planners will be to maintain an R&D capability that hedges against technological surprise while concentrating on evolutionary developments.

The future defense base will need ready *access to civilian technology in as* many areas as possible, particularly sectors such as electronics and telecommunications where innovation is driven increasingly by civilian applications rather than military requirements. Given the isolation of defense technology from the civil base described in chapter 4, increased civil-military integration will require changing current acquisition laws that make civilian integration difficult.[1]

The future DTIB will also require a *continuous design and prototyping capability, in* contrast to the current intermittent development of prototypes, which is largely oriented toward production. The continuous development process might lead to a dead-end or proceed to fabrication of prototypes, full-scale engineering development, and limited production, as illustrated earlier in figure 3-4. Maintaining a capability for design and development will be particularly difficult when far fewer new types of weapons are produced. The reduction in procurement funds is already having a direct effect on maintaining design teams. Not only will reduced procurement levels limit the resources available for design and prototype work, but researchers and engineers may not wish to develop systems that are never deployed. As discussed later in this chapter, however, a properly managed competitive prototyping strategy can:

1. preserve design teams;
2. develop new concepts and materials;
3. help maintain manufacturing processes; and
4. if limited production and fielding occurs, allow test of operational concepts.

Individual prototypes may be more expensive than production items, but the use of a prototyping approach might save funds over an entire program while preserving competitive design and production capabilities.

Although an emphasis on prototyping carries the risk of erosion of manufacturing skills, and the reduced expectation of future profits from production may reduce incentives to innovate, future fiscal constraints will force the Nation to make hard choices that include such risks. The challenge to DTIB management is how to maintain innovation and cost control in an environment in which the current develop-to-produce approach is no longer viable. A continuous prototyping strategy would sustain R&D between procurement cycles, while the combination of retrofits, upgrades, limited production for operational field testing, and force modernization would help maintain essential manufacturing skills.

When prototyping reveals important new performance dimensions that provide a decisive operational advantage (such as stealth technology), force modernization can be pursued using realistic production rates extended over long periods. This approach would preserve *limited, efficient peacetime engineering and production capabilities in* key defense sectors such as aerospace and armored vehicles. While these capabilities would be more limited than the current peacetime production base, they would yield sufficient materiel to supply deployed forces and would provide the foundation for DTIB expansion to meet a reconstituted threat.

If future war-reserve stockpiles of ammunition and other consumables are reduced in size in proportion to the reduction to smaller active forces, *industrial responsiveness will assume* relatively greater importance for both small and medium-sized contingencies. It has been reported, for example, that over 25 percent of the U.S. stockpile of Tomahawk conventional land attack missiles was fired in the

[1] Jeff Bingaman, Jacques Gansler, and Robert Kupperman, *Integrating Commercial and Military Technologies for National Strength: An Agenda for Change* (Washington, DC: Center for Strategic & International Studies, March 1991), pp. 85-95.

Photo credit: U.S. Department of Defense

The Tomahawk cruise missile proved effective in the Persian Gulf War, but more than 25 percent of the inventory was consumed.

frost week of war with Iraq,[2] and other munitions such as the Maverick antitank missile were also consumed at high rates. While these rates could be sustained from the war reserve stocks amassed to counter a conventional Soviet threat in Europe, they might not have been sustainable with stocks sized to support a smaller active force.

Thus, in the future, a dedicated, rapidly responsive production capability will be needed to produce selected items such as munitions, spare parts, and other battlefield consumables. The size and responsiveness of this portion of the base would be related to the size of war-reserve stocks, and it would differ from the current capability in that ***surge requirements would be funded explicitly for selected items.*** Such an approach would necessitate a realistic assessment by regional military commanders of requirements for theater conflict and the determination of clear priorities.

Because warning time of large-scale conventional aggression would be on a scale of years, the United States can afford to lower its military readiness against a reconstituted threat and to rely for much of its materiel on a *healthy, mobilizable civilian production capacity.* This mobilizable base consists of civilian plants and workers that could be transferred to defense production in an emergency, expanding on the core elements of the DTIB involved in peacetime procurement. As a result, there would be diminished concern with detailed defense-industrial preparedness for a major conflict and greater emphasis on the general health and composition of the larger industrial base. Developments in flexible manufacturing could also enhance the value of the mobilizable civilian base by allowing defense and civilian production on the same lines. Even so, taking full advantage of civilian production capacity would require changes in weapons design and greater emphasis on dual-use technologies.

The future DTIB will require a *robust maintenance and overhaul capability* **that can** support fielded systems over an extended deployment life. Over the coming decades, there will be a shift from the urgent manufacturing and deployment of new systems typical of the cold war era to increased emphasis on the maintenance, remanufacturing, and upgrading of deployed systems. The maintenance base must be sufficiently responsive to support theater conflicts. If properly managed, it could also provide one means of preserving the Nation's defense production potential.

Finally, the DTIB must have good, integrated management to achieve its objectives in a fiscally constrained environment, avoiding both micromanagement and neglect. The test of good management is whether the DTIB adequately meets the goals of affordable peacetime acquisition and wartime responsiveness. Current base management does not pass that test.

In sum, the future DTIB should be flexible, research-intensive, integrated whenever possible

[2] Stanley W. Kandebo, "U.S. Fires Over 25% of its Conventional Land Attack Tomahawks in the First Week of War," *Aviation Week & Space Technology,* vol. 134, No. 4, Jan. 28, 1991, pp. 29-30.

with civilian technology and industry, and should retain its orientation toward high-performance weapons. By integrating defense production more closely with a healthy civilian industrial base, U.S. economic strength can help to deter military adventurism on the part of potential adversaries.

STRATEGIC CHOICES FOR THE FUTURE BASE

A number of strategies have been proposed within the defense community to meet future U.S. defense technology and industrial needs. Some of these strategies were originally suggested to deal with problems identified in the current base, while others are new. All of them stress broad policy choices, such as the degree of the Nation's defense-industrial autonomy, the appropriate extent of competition for defense contracts, the degree of integration of defense and civilian industry, and the amount of government intervention in the base.

At the Federal Government level, resource allocation involves choices between competing national priorities. Decisionmakers must choose among allocating money for defense or for competing social needs such as health care, the old dichotomy of "guns versus butter." The trend outlined in earlier chapters of this assessment, and already in evidence, is for major reductions in defense spending and relative increases for other national needs. Having decided on the allocation of resources, decisionmakers must then structure the use of defense dollars by developing an overall strategy for the various U.S. Government agencies with national-security responsibilities.

The following sections consider three broad strategic choices that will continue to be central to the debate over defense-industrial management:

1. the degree of international interdependence versus national autonomy,
2. the degree of reliance on the civil sector and a market approach for production versus a regulated arsenal approach, and
3. the allocation of resources between deployed weapons versus the potential to develop and produce new weapons when needed.

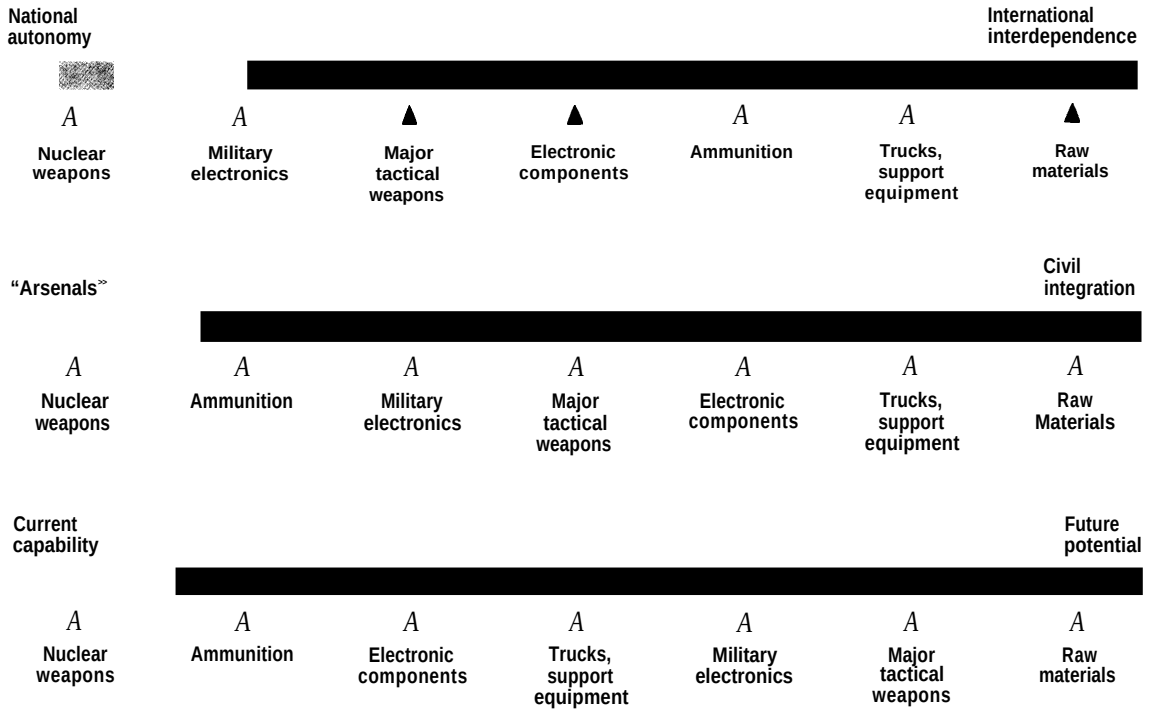
In practice, the Nation will not pursue any one strategic choice to the complete exclusion of the other. Instead, the various defense industrial sectors are positioned along a continuum according to a weighing of the risks and benefits of applying a particular strategy (see figure 5-l). On the national autonomy/international-interdependence spectrum, for example, the Nation seeks greatest autonomy in the design and production of nuclear warheads, long-range missiles, ships, aircraft, and tanks, and is more willing to accept interdependence in electronic components, machined parts, and raw materials. In the case of the civil-integration/arsenal spectrum, nuclear weapons and tank final assembly lend themselves to arsenal production, whereas machined parts, electronic components, and raw materials are produced more efficiently by the civil sector. On the deployed/potential spectrum, the declining large-scale military threat allows the United States to focus on the potential to respond to a reconstituted threat through ongoing development and prototyping of major weapon systems such as tanks and high-performance aircraft. In this way, the Nation can maintain a core capability that can be expanded if necessary, while producing sufficient equipment to meet more likely theater threats. The three strategic choices are also interrelated. For example, greater reliance on the civil sector would result inevitably in more international interdependence because of the increasing globalization of civilian technology.

Congress will play an important role in making and implementing these strategic choices. Deciding whether the Nation should emphasize its own defense-industrial capabilities ("Buy American") or become more interdependent with allies will require an examination of the implications of both strategies. Increased reliance on the civil base implies new approaches to procurement, in particular decisions about financial accountability. Shifting to an arsenal system (including designated sole-source producers in the private sector) will also require a review of procurement laws that promote wide competition for government contracts.

International Interdependence v. National Autonomy

If the United States is weak in a military technology defined as "critical," the purchase of a weapon system or component from the best available foreign source creates a conundrum, since in making the purchase the United States improves its short-term military capabilities but may weaken its

Figure 5-1—DTIB Strategic Choices



SOURCE: Office of Technology Assessment, 1991.

long-term defense technological potential. Many people who are concerned about the health of the DTIB and U.S. international industrial competitiveness favor adopting a 'Buy American' strategy that would concentrate the Nation's limited future defense-procurement contracts on U.S. firms. They contend that foreign-sourcing could erode the DTIB as domestic firms go out of business, making it more difficult to shift resources from the civil to the defense sectors. Moreover, foreign-sourcing could impair the Nation's defense capability if foreign firms are less responsive to U.S. defense needs than are domestic producers. Proponents of a strategy of national autonomy argue that procuring most or all defense materiel from U.S. sources would:

1. reduce the risk of supply cutoffs during a crisis,
2. free domestic suppliers of services and equipment from the threat of unfair foreign competition, and
3. increase the demand for U.S. defense products, thus potentially increasing U.S. industrial productivity through larger production runs and more funding for technology development.

Since most military systems are already purchased from U.S. prime contractors, this strategy would have its greatest effect on subtier industries such as optics, fasteners, bearings, and electronics.[3] However, the key national-security consideration is not

[3] H.R. 4s6, introduced in the 101st Cong., shows one possible pa@ it limited "to domestic manufacturing and assembly sources those existing or new weapons, parts, or components which the President determines are critical," and directed the President to consider "the extent to which domestic sources for the materials or services being procured can meet defense needs for 6 months following any declaration of war by the Congress. . ."

total foreign content but foreign vulnerability related to critical technologies or products.[4]

The alternative strategic choice would allow increased interdependence with allies. This strategy acknowledges both the ongoing globalization of the technology and industrial base and the increasing cost of developing new weapons systems. The 1988 Defense Science Board (DSB) summer study on the DTIB argued that the advent of industrial globalization implied "an interdependence of allied nations for the technologies and even the components of defense systems.' The DSB also noted that

> The days of Fortress America are past. We are, and will remain dependent on foreign resources for critical components of our weapons systems. We cannot eliminate foreign dependency in this era of globalized defense industry. We can and must eliminate the apparent loss of leadership in key defense technologies.[6]

Given the constraints on U.S. defense spending, the Nation may wish to concentrate on developing and manufacturing high-performance weapon systems while exploiting foreign sources for some of its requirements in other areas, such as small arms, unguided bombs, and artillery rounds.

As production and markets become increasingly international, tracking foreign content becomes increasingly difficult and costly. A manufacturer may use thousands of parts, from bolts to integrated circuits, from a variety of sources. Although measuring the average foreign content of U.S. weapons is difficult, most attempts reveal that it is low, almost certainly less than 10 percent. Final assembly of end-products for U.S. forces will probably remain limited to domestic prime contractors. Thus, as previously noted, the strategic choice between autonomy and interdependence will have its most profound effects at the subtier levels.

Proponents of international interdependence contend that it will:

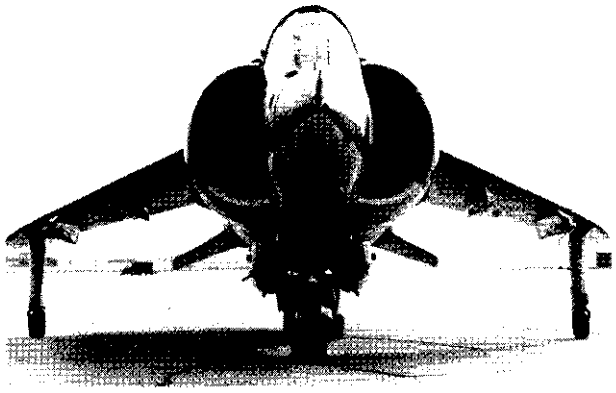


Photo credit: U.S. Department of Defense

***The* British Harrier jet, capable of vertical takeoff and landing, is just one example of valuable foreign technology available from allies.**

1. create a more competitive environment, ultimately decreasing the price of military products;[7]
2. facilitate standardization and interoperability of weapons with allies; and
3. assure access to the best technologies as new scientific developments take place-around the world.

Collaboration with allies has given the United States such defense technologies as the British Harrier VTOL (vertical takeoff and landing) fighter and Chobham composite armor, and the German 120 mm gun for the Ml tank.

The Nation may wish to preserve selected critical technologies for reasons of national security or industrial competitiveness. This goal might be achieved through protectionism or active intervention to make U.S. sources internationally competitive. The challenge for policymakers is to develop a definition of which technologies are truly critical, and to establish priorities for promoting them with limited resources. The three current critical technology lists (table 4-2) have been criticized as too broad to provide any real guidance.

[4]Martin Libicki, Jack Nunn, and Bill Taylor, *u.S. IndustrialBase Dependency/Vulnerability* (Mobilization Concepts Development Center, November 1987), pp. 1-15.

[5]Office of the under Secretary of Defense for Acquisition, *Final Report of the Defense Science Board 1988 Summer Study on the Defense Industrial and Technology Base* (Washington, DC: October 1988), p. 1.

[6]Ibid.

[7]F or example, DOD has argued that the 5-year cost of legislation man&~ the purchase of moo@ chain from U.S. firms was almost $7 million for fiscal years 1986 through 1990. Report to the United States Congress by the Secretary of Defense, *The Impact of Buy American Restrictions Affecting Defense Procurement* (Washington DC: U.S. Department of Defense, July 1989), p. A-65.

An additional consideration is that future cooperation with allies may be driven in part by the need for stronger controls on the worldwide proliferation of weapons and defense industrial capabilities. A recent OTA report on the international arms trade examined the dilemma of the United States and its allies in choosing between arms exports to maintain a viable defense production base, and export controls to reduce the flow of modem weapons and technology to potential trouble spots.[8] The study argued that the globalization of the arms industry and the trends in defense technology suggest that unilateral action to reduce the proliferation of modem weapons and technology is bound to fail.[9] If so, then closer defense industrial cooperation with sophisticated partners such as the European allies and Japan would provide access to new technologies, while improving allied coordination for controlling the export of sensitive technologies.

Whether such an arms-export control regime could be effective is unclear, however, since the United States, Europe, and Japan do not control all of the important weapons technology. Other countries have both military technology and the incentives to export it: Brazil and the People's Republic of China need foreign exchange, while Taiwan and Israel may need political support. It might also be exceedingly difficult to rationalize production among allies on the basis of national specialization. The Europeans have long argued that the United States subsidizes its commercial aviation industry through military programs, and would be unlikely to forfeit to U.S. industry the development and production of high-performance aerospace equipment such as fighter aircraft or cruise missiles.

One benefit of greater defense procurement from allies is that the United States might be able to exploit its leverage as the largest defense market to set better terms for offsets and other trade practices that currently concern DTIB planners. But any increased reliance on foreign sources will depend on congressional actions to repeal many of the current legislative restrictions on the offshore procurement, maintenance, and repair of U.S. weapon systems,[10] and a change in Congress' overall approach to interdependence.

Arsenal System v. Civilian Integration

Chapters 3 and 4 examined the increasing isolation of the DTIB from the civilian industrial base, a trend that has been blamed for the increasing costs of weapons systems and the declining productivity in the defense sector.[11] Indeed, many observers argue that the current situation is the worst of all possible worlds: the Nation lacks the control and protection of a government-owned arsenal system but does not get the innovation and flexibility potentially available from private industry. Thus, some advocate a return to an arsenal system, while others prescribe a greater integration with the civilian economy.

Future defense production requirements will be too limited to support the current system of multiple competing defense firms. Before World War II and the subsequent cold war with the Soviet Union, the United States maintained the DTIB through a system of government arsenals and close association with a small number of commercial producers. A modified "arsenal system, " composed of a combination of government-owned facilities and sole-source private firms, might allow efficient development and manufacturing of military-unique equipment. Such a strategy would concentrate on establishing and maintaining a limited number of expert sources of weapons and equipment and would restrict competition for Department of Defense (DoD) contracts to those firms and public facilities with recognized skills. The French defense industry is one example of an arsenal system, while the current U.S. nuclear weapons complex is another. The competitive prototyping approach discussed below might be a way to maintain the beneficial aspects of competition in this environment.

Proponents of the modified arsenal strategy argue that it would allow the Nation to:

[8] U.S. Congress, Office of Technology Assessment, *Global Arms Trade: Commerce in Advanced Military Technology and Weapons*, OTA-ISC-460 (Washington, DC: U.S. Government Printing Office, June 1991), pp. 3-31.

[9] Ibid.

[10] For example, the Byrnes-Tollefson Amendment prohibits foreign construction of any vessel for the U.S. Navy.

[11] The Packard Commission and two Defense Science Board Studies, 1) Office of the Under Secretary of Defense for Acquisition, *Use of Commercial Components in Military Equipment* (Washington DC, January 1987); and 2) Office of the Under Secretary of Defense for Acquisition, *Use of Commerical Components in Military Equipment* (Washington, DC, 1989), all noted the trends and argued for increased use of commercial products, changes in military specifications, and changes in acquisition procedures.

1. develop and conserve needed expertise that could then be expanded in a crisis,
2. improve the efficiency of bid and proposal for contracts, and
3. increase the stability of production.

Implementation of the arsenal strategy would require major changes in current procurement laws and in the philosophy of weapons acquisition. Promotion of competition would have to be reexamined but could still be maintained. Congress would also need to consider different ways of controlling costs and fostering innovation without the current "full and open competition," perhaps through the "effective competition" approach advocated in some recent studies.[12]

The alternative choice is to place greater reliance on integration with the civilian sector, buying civilian parts off the shelf and using more civilian technology and procedures. Proponents of increased reliance on the civilian industrial base argue that it would:

1. lower costs of weapon system development and production,
2. result in an improved mobilization capability against a reconstituted major threat, and
3. make improved technology available to defense in areas where civilian technology now leads military technology.

Eliminating unnecessary military specifications and streamlining procurement rules could result in lower costs for parts purchased directly from commercial suppliers, and might attract many more companies back into defense work.[13] Current military specifications are frequently criticized for being excessively demanding. Even when the desired performance is comparable to that of available civilian components, the specifications are different, precluding the use of civilian components in defense systems. In some cases, military requirements are distinct from civilian requirements and may warrant higher levels of performance, but military specifications often go further by describing the manufacturing *process,* down to the type of solder and flux. These process specifications tend to isolate military systems from civilian technology. Cost accounting and auditing standards also create barriers to the use of civilian products.

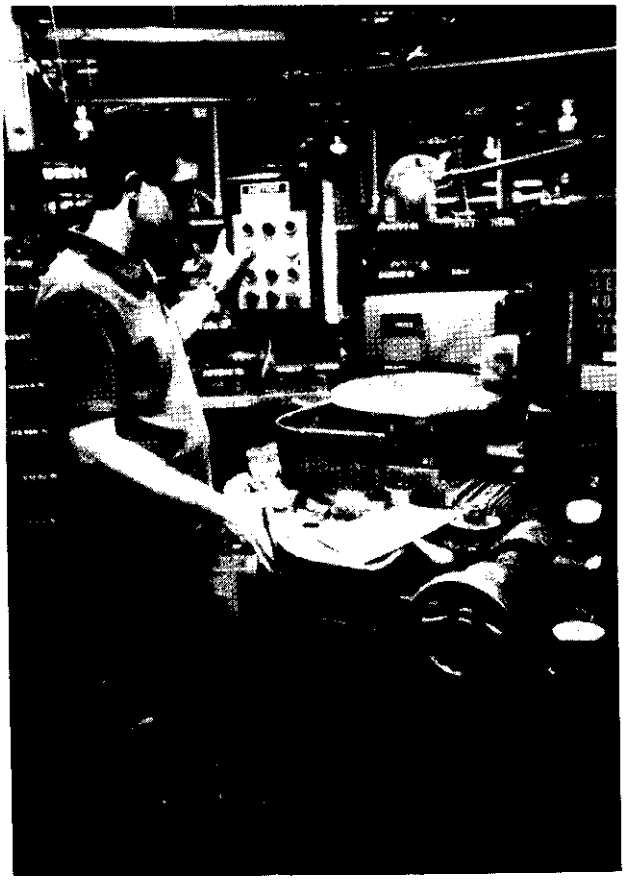


Photo credit: Eaton Corp.

The pinion gears and axles produced by this factory assembly line go into both commercial and Army trucks, an example of civil-military integration.

Additional problems with increasing reliance on the civilian base might include a reduced performance edge of U.S. weapons over those of potential adversaries, since-depending on export controls—they might have access to the same technology. Moreover, commercial parts might not be capable of performing with high reliability under severe combat conditions. The choice of an arsenal system or civil integration will also be highly dependent on the industrial sector in question. As figure 5-1 indicates, nuclear weapons will always be built in arsenals. With reduced procurement levels, armored vehicles

[12] Bingaman et al., op. cit., footnote 1, pp. 49-50.

[13] The DSB argued that many firms had left defense business because of procurement procedures and risks that were too high for the potential returns. The CSIS study, Bingaman et al., op. cit. footnote 1, pp. 71-95, follows the themes of the DSB studies and points out specific ways to overcome many of the problems.

and aircraft might be built in arsenals as well, but electronic components and a host of other components might be better sourced from the civil sector.

A recent OTA report found that foreign defense firms are generally more diversified into civilian markets than are large U.S. defense contractors. The foreign firm are also more integrated between civilian and military products. This structure appears to help these firms weather fluctuations in defense spending.[14]

To allow rational choices between the arsenal system and civil integration, Congress would need to review current procurement laws and make changes in those laws dealing with access and accountability. Current laws mandating free and open competition preclude the use of arsenals (including sole-source commercial producers) where they may be appropriate, and laws dealing with accountability impede greater use of the civil sector. While current contracting procedures theoretically allow use of commercial items and enable contractors to make changes in production processes, they provide few incentives to make such changes.[15] (See box 5-A.)

Current v. Potential Capability

Another important strategic choice facing the Nation is the allocation of resources between maintaining current military capability and future military potential. With the perception of a sharply reduced immediate threat and expected large reductions in the defense procurement budget, the present allocation of resources is being reexamined. Decisions must be made between active and reserve forces, between buying ammunition war reserves and maintaining reserve ammunition production capacity, between procuring current weapons or spending on research to develop future weapons, and ultimately between spending on the military and other national needs.

While it may be necessary in a fiscally constrained environment to retain only the *potential* for manufacturing enough sophisticated platforms, such as the most advanced aircraft and armored vehicles needed to fight a major conflict, there is still a requirement to have sufficient fielded weapons, including aircraft and tanks, to support theater warfare contingencies. These deployed weapons would be a product of the limited peacetime defense production base discussed earlier. They would be upgraded with new components as necessary until a new technological breakthrough or aging of the fleet prompted modernization.

The approach of maintaining future military potential in the face of sharply reduced defense budget is currently termed a "research strategy." Such a strategy covers a range of possibilities. In the simplest terms, it means spending proportionally more on R&D and less on production. But increasingly radical approaches are also imaginable (see figure 5-2). Alternative A, shown in the figure, envisions building a limited number of demonstration models with hard tooling[16] on an actual production line to prove manufacturing concepts and allow field testing. After limited production, the line would be shut down. Alternative B calls for the production of demonstration models with soft tooling, without proceeding to develop an actual production line. Alternatively, prototypes could be built to prove the feasibility of a new technical concept. For example, between the World Wars, the U.S. Army built prototypes of several different tanks and guns but procured only a few. The designs, however, were the basis for models produced during World War II.[17]

In alternative C, the most extreme case of a research strategy, no prototype would be built. Instead, designers would develop components and use computer-aided design techniques to test concepts and develop technical data packages that could

[14] U.S. Congress, Office of Technology Assessment, *Global Arms Trade: Commerce in Advanced Military Technology and Weapons*, op. *cit.*, footnote 8, pp. 69-78.

[15] For example, contractors can currently recommend production changes to improve productivity, but such recommendations must go through several DoD command levels. If accepted, they may not result in any direct return to the contractor, who may lose the contract to another source.

[16] There is no sharp line between "hard" and "soft" tooling, but in general, hard tooling consists of stamps and dies designed to serve for a long production run of one particular part, while soft tooling is less durable and specialized, and may even be improvised, but is adequate for making only a few items.

[17] See, for example, Richard M. Orgorkiewicz, *Armor* (New York, NY: Frederick A. Praeger, 1960); and R.P. Hunnicut, *Firepower* (Novato, CA: Presido Press, 1988). Also, a prototype of the M1918 4.7 inch antiaircraft artillery gun that was built after the World Wal I Armistice, but not put in inventory, was the basis of the 120 mm AA gun produced in 1943. U.S. Army Air Defense School, *Air Defense: An Historical Analysis*, vol. 1 (Fort Bliss, TX, June 1%5), p. 48.

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OTA DEFENSE INDUSTRY SURVEY

Box 5-A-Civil-Military Integration

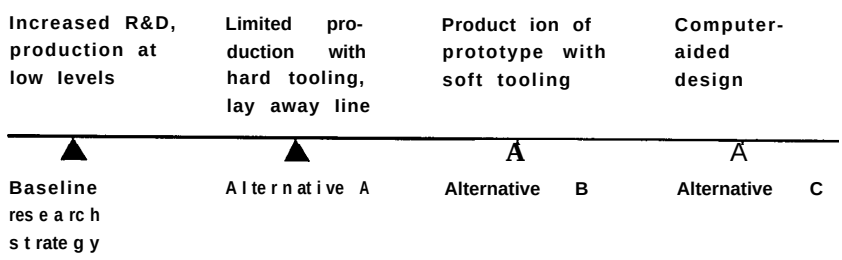
Defense contractors surveyed by **OTA contend that civil-military integration should be pursued on a case-by-case basis. Greater use of commercial technology makes sense in areas such as electronics and aerospace, where defense and civil requirements are often similar, but not in military-unique fields such as missile propellants and gun tubes. When the use of commercial technologies is appropriate, many firms believe that such use could usually provide** a particular capability at lower risk and **cost,** while expanding the mobilization potential of the civilian industrial base. The surveyed firms also believe that greater use of commercial buying practices would yield major benefits. **For example, while commercial firms use competition to lower costs, they are not afraid to single-source, often forming long-term partnerships with qualified suppliers to control prices. Commercial films also use simple purchase-order systems and have sought to minimize requirements for documentation and source selection.**

In general, defense firms have had difficulty breaking into commercial markets because of high overhead costs and a lack of understanding of commercial business, Defense **contractors also note they must make capital investments in special** processes, test equipment, and tooling to meet government requirements that are rarely useful commercially. Conversely, heavily commercial firms tend to view government business as unpredictable, low-profit, burdened with onerous regulations, and carrying the potential for loss of proprietary information.

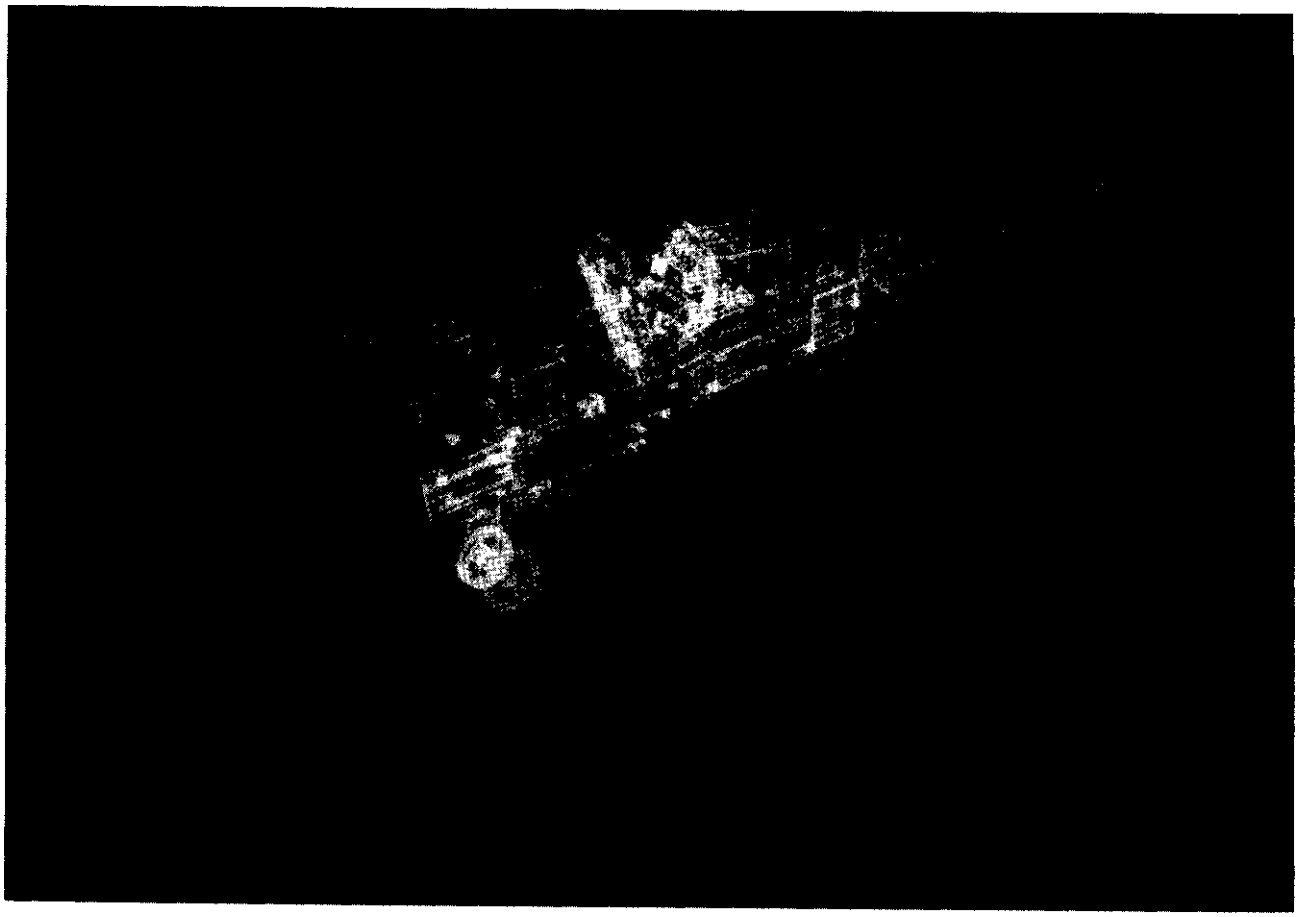
The surveyed defense firms contend that government policies are the primary obstacle to civil-military integration. Restructuring procurement rules to accomodate **commercial practice i8 not an easy task when faced with the myriad test and certification requirements currently in place.** Strict government regulations, payment **policies, auditing, and oversight rules constrain the industry's ability to perform military and Commercial work in the same factories. Other institutional obstacles to civil-military integration include overly rigid performance and manufacturing specifications, which tend to suppress innovation; mandatory Competition; cost-accounting rules and certification requirements; and set-asides for subcontracts to small and Disadvantaged Business (SDB). While such set-asides reflect valid social concerns, larger companies argue that they hamper effective and efficient acquisition and make it difficult to develop and maintain long-term business relationships with suppliers.**

According to the surveyed firms, achieving greater civil-military integration will require a complete overhaul of government acquisition policy. First the Department of Defense must be more willing to tailor its requirements to what is commercially available. Second, auditing procedures must be changed to permit use of identical parts and components in military and commercial products produced by the same firm. Third, defense procurement practices should become more similar to commercial ones. Finally, government should support R&D on dual-use technologies with both defense and civil applications, and make seed money available through loans or grants for civil initiatives by defense firms.

Figure 5-2—Alternative Research Strategies



SOURCE: Office of Technology Assessment, 1991.



Ph credi Lockheed Corp.

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subsequently be produced when needed. While this type of "research **strategy" is** many years from being **a** practical reality, manufacturing technology is moving in **that direction.** Computer-aided design, computer simulation of operational environments, a design philosophy emphasizing high reliability and ease of maintenance, and automated flexible manufacturing would all make this type of research strategy a more practical alternative.

Each of the research strategy alternatives has certain limitations. Moving along the spectrum from production to pure research lowers costs but increases risk and uncertainty. For example, skeptics argue that without actually working out the manufacturing process, it is impossible to foresee all the roadblocks standing between an idea and the actual production run. Thus, while building prototypes could reduce unforeseen problems with systems integration, building one or two prototypes would reveal little about serial or large-scale production, operational use, maintenance, and reliability.

Moreover, the operational potential of many past weapon systems was not fully appreciated until enough of them had been deployed to allow military commanders to experiment with them in field exercises or on the battlefield. A process that generates a continuous flow of hypothetical weapons would never allow military commanders to develop optimal tactics for using them, nor would it allow the military bureaucracy to assimilate new weapon systems prior to a major conflict.

With the reduced expectation of future profits from production, companies will have less incentive to support research and development. Interviews with industry representatives frequently reveal the intention to reduce research spending in response to current planned cutbacks in procurement, in part

because of the reduced opportunity to recover independent research and development (IR&D) expenses. For this reason, the Federal Government will need to support defense research and development directly, rather than indirectly through production. Such funding could be accomplished by covering the full cost of private-sector R&D contracted by the government, and by moving critical capabilities into arsenals or government laboratories where the technological know-how might be kept alive in the absence of procurement. Such arsenals Could be government-owned and operated, or government-owned but managed by expert firms operating with sole-source contracts. Whatever the approach, one key to a successful research strategy is the ability to separate R&D financing from the expectation of a profitable production contract.

TACTICAL DECISIONS

Each of the strategies outlined above would be tailored to meet the varied perspectives of the DTIB outlined in chapter 3: industrial sector, tier, ownership, and functional area (R&D, production, or maintenance). The following sections discuss tactical decisions involved in achieving the desirable characteristics of the future base (outlined earlier in table 5-2). These decisions will occur within the context of the broad strategies just discussed and will also be affected strongly by the four DTIB perspectives.

Advanced R&D Capability

The advanced R&D capability of the DTIB is embodied in the dedicated defense base and the larger civilian base, and is increasingly global in character. Maintaining this capability in the face of declining procurement will require:

1. the retention and replacement of skilled R&D personnel;
2. the identification of core competencies; and
3. the development of new ways to discipline, guide, and evaluate R&D within a streamlined defense R&D establishment.

Human Resources

The most important single component of an advanced R&D capability in the base is *people*. Across the board, managers at laboratories, private firms, and within DoD identified human resources as the key to the Nation's defense R&D capability. They also noted that retaining quality personnel in the face of the expected budget downturn creates severe challenges. One immediate problem is that laying off workers yields quick savings for a firm or agency struggling for survival, but may endanger its long-term design and manufacturing capabilities.

Strategies for attracting and retaining good research and development personnel include higher pay, a challenging work environment, and job security. Over the longer term, interesting and challenging work is the most important motivation. Thus, while downsizing the base, it will be necessary to maintain meaningful work for defense R&D personnel, possibly through research grants and programs not directly tied to production. Moreover, maintaining a core of personnel dedicated to defense R&D in the peacetime DTIB is insufficient for preserving an advanced research capability. The Nation also requires access to civilian technology and to the R&D personnel employed in the larger mobilizable civilian base. For this reason, it will be necessary to monitor and maintain R&D capabilities in dual-use areas such as aerospace, electronics, and advanced materials, all of which are critical to designing the next generation of military systems. Appendix B suggests some new approaches to data collection that might improve the Nation's understanding of its industrial capabilities.

Facilities are less critical than people, but given the complex and costly equipment required for R&D, they are still important. With reduced budgets, many facilities may be closed. The military Services are consolidating their research laboratories with the intention of creating better overall capabilities while cutting long-term costs. Yet many of the consolidation plans require upfront costs that make them more expensive in the short term. This funding dilemma is particularly critical with respect to the Department of Energy laboratories, but it has also affected the Army's plan for consolidating its R&D facilities. If the Nation is to maintain viable defense R&D capabilities in the future, however, it will have to pay the upfront costs associated with such consolidation. Further, some facilities will have to be closed, and community losses accepted.

Core Competencies

The publication by executive branch agencies of three different "critical technology lists" over the past 3 years (outlined in table 4-2) indicates a growing desire to identify and prioritize technologies for which the Nation must maintain a domestic

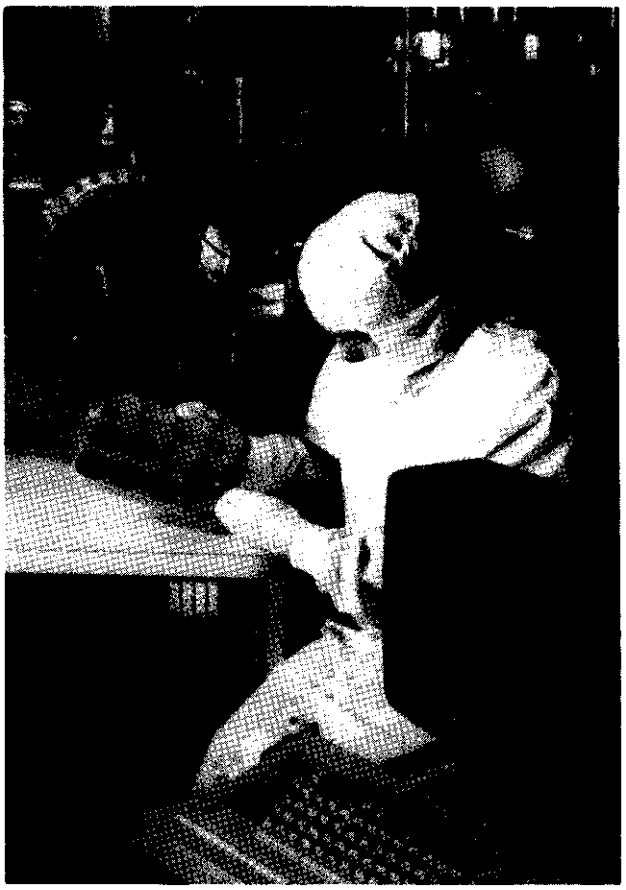


Photo credit: Lockheed/Sanders Microelectronics Center

A technician manufactures microwave circuit substrates in a dean room. Attracting and maintaining skilled personnel are key to preserving a viable defense technology base.

knowledge base in the face of growing resource constraints and international competition. The general nature of the technologies listed and differences among the three lists suggest the difficulty of deciding which technologies are truly critical to the Nation's economic health and military security. Nevertheless, examples of technologies that currently appear to meet every definition of 'critical" include electronics, propulsion, advanced materials, and software. Identifying such core competencies will assist the United States in adequately funding a small number of truly vital areas of R&D with limited resources.

In addition, cutbacks in R&D spending may require greater specialization in defense technology. Over the short term, across-the-board cuts in R&D funding are easiest because they "spread the pain" and thus are bureaucratically more acceptable. Many research organizations have found, however, that since R&D projects often require a minimum level of support to accomplish anything at all, it is preferable to cut entire programs rather than to reduce funding across the board. The Nation may therefore be forced to concentrate its defense R&D efforts in those sectors that are both of critical importance to military systems and not available elsewhere.

For example, it may be necessary to abandon defense electronics R&D in those areas where the civil sector can be depended on to improve performance, such as higher speed and smaller size, and concentrate on those areas where no civilian R&D is taking place, such as hardening against nuclear effects or developing dedicated circuitry for electronic warfare. As a result, the Nation will need to place greater emphasis on civilian R&D. Similar arguments hold with respect to foreign-sourced technology. The Nation may have to focus its R&D efforts on those technologies deemed to be critical, while placing greater reliance on allies and international industry in other areas.

A basic question is the degree to which important defense technologies are maintained in government facilities or in the private sector. The lion's share of defense R&D is currently conducted by private industry. Service laboratories visited by OTA typically contract out three-quarters of their R&D work to private firms.[18] While the government laboratories want to retain in-house talent, they recognize the importance of keeping skilled researchers in the private sector because it is defense contractors that actually apply technology to weapon systems. Ultimately, however, the biggest cuts in defense R&D personnel will be made in the private sector.

The globalization of science and technology makes new discoveries abroad increasingly likely, either in the laboratories of foreign countries or the foreign-based subsidiaries of U.S. multinational corporations. Maintaining cooperative scientific programs with allies assures access to new developments with potential military applications. Nevertheless, excessive dependence on allies is not desirable. While it would be too costly and practically impossible to stay ahead in all areas of defense technology, the United States must strive to retain

[18] Roughly half of the in-house money is spent on research and half on contract administration.

world-class competence in critical sectors. International cooperation can promote that competence, but only if the United States benefits as much from cooperation as its partners. For this reason, the Nation must ensure that future international cooperative programs provide for reciprocal flows of technology, and that mechanisms exist to transfer dual-use technologies developed through international civilian R&D efforts to U.S. defense applications.

Service laboratories are knowledgeable about civilian developments in their technical areas. But in order to take maximurn advantage of the possibilities in this area, DoD should improve its existing capability for assessing and evaluating international developments in both civilian and military technology for their potential to fulfill U.S. defense needs.

Guiding and Evaluating R&D

Although the U.S. Government runs some outstanding laboratories, most defense R&D will continue to be in the private sector, with greater emphasis on single sources. If the government wants to preserve a robust R&D capability, it will have to find ways to maintain funding at levels now considered high relative to the overall defense budget, to make funding less dependent on production, and to communicate this long-term commitment to industry. One approach might be to transfer more resources from production to defense R&D. Although the administration's 1992 budget proposal would increase total R&D funding, most of the increase is in advanced technology development (6.3A) and engineering development (6.4) of systems slated for production, such as the Advanced Tactical Fighter and Light Helicopter-that is, a continuation of past policy. A different approach would be to mandate fewer weapon development programs and to insist on greater interservice commonality, such as a single advanced attack aircraft for the Navy and the Air Force instead of a different one for each Service. This approach might result in longer production runs and hence lower unit costs. While joint Service procurement efforts do not have a happy history (note the F-111), there is no fundamental reason why they should not work.

Related civilian research in dual-use technology will also be of benefit for defense, although the size of the payoff will depend on the technology in question. For example, there may be important ''spin-ens'—transfers of technology from the civilian sector to defense—in areas of microelectronics, displays, and software production. Nevertheless, civilian technology has little relevance to important military technologies such as stealth, many areas of defense electronics, and nuclear hardening.

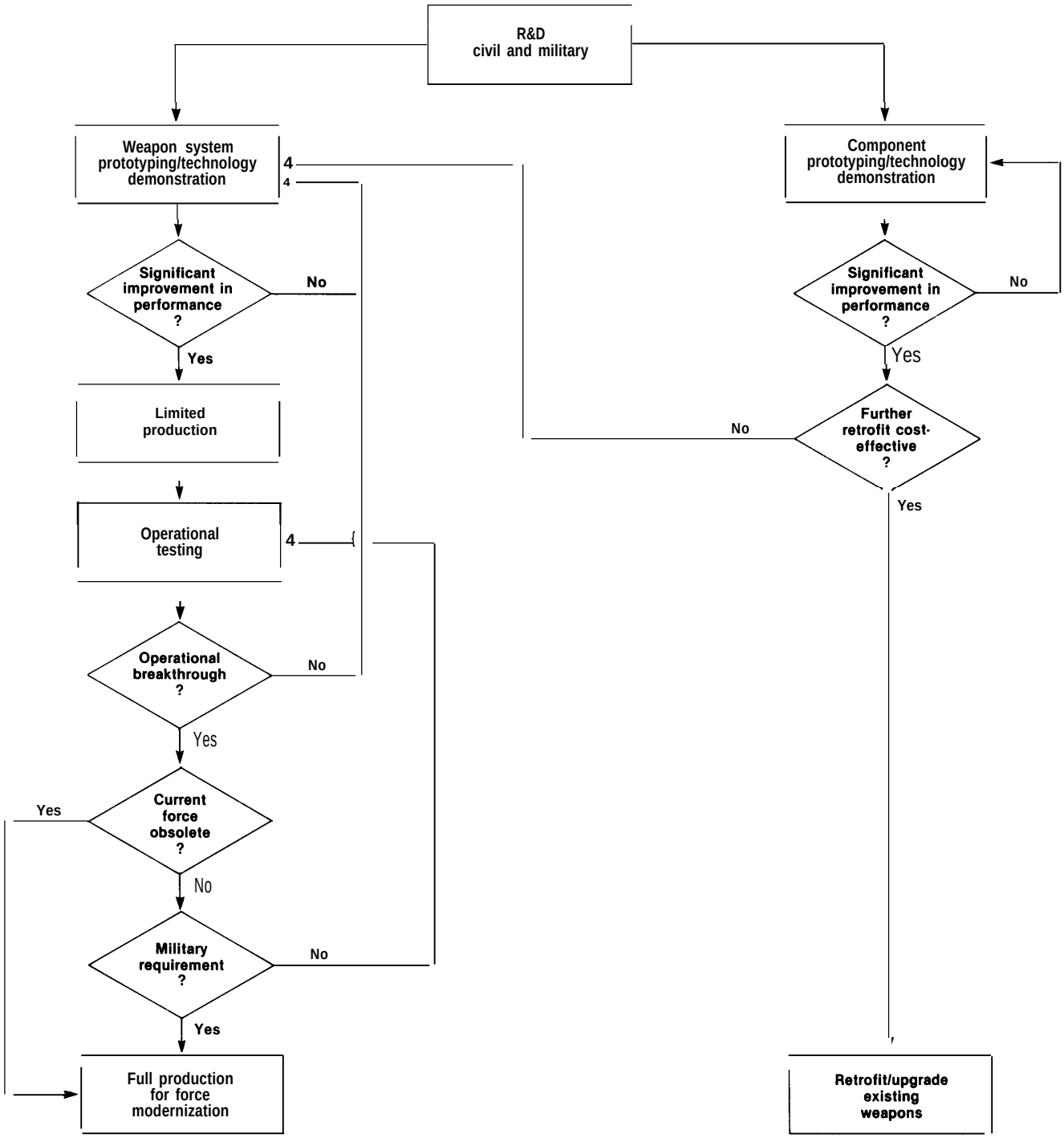
Competition in R&D is one means to promote innovation and impose discipline for greater cost efficiency. But while competition must continue in defense R&D, during a period of austere funding it must be structured differently. Rather than competing laboratories, there might be competing design teams at the same laboratory. Similarly, in the private sector, a few lean design teams with associated manufacturing capability-along the lines of the Lockheed Skunk Works-could be maintained for each major type of weapon system or technology. And instead of domestic competition among U.S. fins, there might be international competition, with the United States relying on a single domestic source in competition with other world-class producers.

Since World War II, defense R&D has concentrated on weapon performance rather than manufacturing, reliability, and product maintenance. When the United States faced a numerically superior and technically sophisticated enemy, it made sense to emphasize battlefield performance. With the reduced military threat, however, it is now possible to trade some of this performance for improved reliability, lower-cost manufacturing, and reduced maintenance. Doing so will require changing the incentive structures to make other design goals as important as performance in the overall development process.

Design and Prototyping

A key element of the future DTIB will be a continuous design and prototyping capability that can operate with reduced R&D spending and in the face of curtailed production. The extent to which designs are carried through to manufacture will depend on whether there is a technological development that provides a significant operational performance advantage. Some prototypes will lead to force modernization, while others will simply advance the state of knowledge within the defense technology base. Figure 5-3 outlines a "dual-track" approach, with the development and prototyping of new systems on one track and the development and prototyping of components for upgrading current systems on the other. This dual-track approach

Figure 5-3-Dual-Track Prototyping Strategy



SOURCE: Office of Technology Assessment, 1991.

would ensure that fielded systems are kept up-to-date and would help maintain the skills of both design and manufacturing teams. The retrofits and upgrades could also preserve the capability to produce components and parts, which would be manufactured either by subtier firms or by prime contractors. For example, the F-4 Phantom fighter, the B-52 bomber, and the AIM-9 Sidewinder missile have all undergone extensive modifications and upgrades.

Like R&D in general, the capability to design and develop new systems rests largely with people, namely the design and engineering teams essential for the development of modern weapon systems. These teams vary in size according to the complexity of the system and the stage of development. For example, design teams for a modern fighter aircraft can grow from a half dozen people in the initial conceptual design phase to a few hundred to a thousand engineers with a variety of skills during prototype development and testing. The size of design teams also varies considerably by firm and can apparently be kept small without undue harm to design quality. In fact, there maybe real advantages to a small team. One of Kelly Johnson's basic operating rules for the Lockheed Skunk Works was: "The number of people having a connection with the project must be restricted in an almost vicious manner. Use a small number of good people. . . .'

The idea of maintaining a design and prototyping capability that is not directly linked to production has been criticized as impractical partly because good design teams are unlikely to continue to work without seeing any tangible results, and partly because the design process needs an occasional ''reality check. ' In fact, these are not insurmountable obstacles. Scale prototypes can test technological innovations, keep design teams interested, and allow them to be ready when new requirements arise. For example, gas turbine engines, because of their long development-cycle times, necessarily have to be improved without regard to specific eventual applications. Compared to production, these prototype programs can be relatively inexpensive: the Joint Turbine Engine Advanced Gas Generator demonstrator cost the government $60 million over 4 years, with additional industry contributions of $30 million. Further, as figure 5-3 notes, a limited number of prototypes of new systems would sometimes be built and tested, and if promising, would be followed by limited production

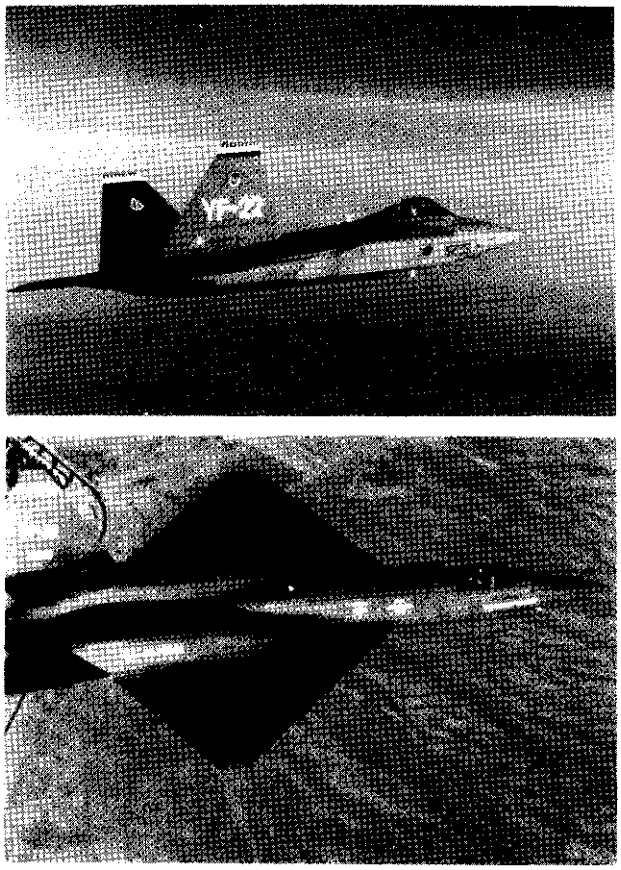


Photo credit: Lockheed Corp. and Northrop Corp.

Two industrial teams competed for the Air Force's Advanced Tactical Fighter contract. Competitive prototyping could maintain important design skills, although not all prototypes would be carried into production.

of sufficient units to test operational concepts (e.g., enough aircraft for a squadron or enough tanks for a battalion). If the new system provided an operational advantage, then force modernization could occur. A good example of this process is the development and production of the F-117 stealth fighter.

Responsive Production

While the current defense production base exhibits considerable overcapacity with respect to current peacetime production requirements and is sufficiently responsive to meet most requirements short of a ''reconstituted' Soviet threat, that condition is unlikely to last long. The base is shrinking rapidly with the closing of production lines for major systems such as tanks, fighter aircraft, and electronic systems, and their supporting spare parts (see ch. 4). The transition strategy must therefore identify the

critical items of defense equipment that might be required for future short-notice contingencies and preserve the manufacturing capacity to meet those needs.

Since much of the defense production effort is in subtier firms, maintaining industrial responsiveness will entail either preserving critical subtier capabilities or allowing vertical integration to occur as primes bring more subcontracting in-house, possibly by not requiring the second-sourcing of spare parts production. The transition to a small responsive base of the type envisioned will require: 1) identifying critical areas of defense production, 2) setting priorities, and 3) funding a surge capacity in the identified areas.

Identifying Critical Areas

Realistic short-warning threats now appear limited to regional conflicts outside Europe. Under these conditions, surge production capacity can be limited to those munitions, spare parts, and consumables that theater commanders view as critical to war fighting. Some examples of immediate-response requirements for Operation Desert Shield/Storm are shown in table 5-3. In addition, there is a need for the capability to modify fielded systems rapidly as combat experience reveals operational shortcomings. Much of this responsive element will probably have to be maintained in a dedicated defense base, although some products, such as clothing and food, have sufficient commonality with the civilian production to allow for greater use of the civilian base, as occurred during Desert Shield/Storm.

The degree of foreign dependence that the Nation can accept in meeting identified surge requirements will be a contentious issue, and one that should be addressed directly. U.S. law cannot compel priority production of items by foreign manufacturers outside North America. Nevertheless, DoD could hedge against defense production bottlenecks in a crisis by stockpiling foreign-sourced parts. Since the responsive base will be devoted primarily to supporting military equipment already in the field, some degree of foreign vulnerability maybe unavoidable but can be minimized by developing multiple foreign suppliers. Limiting the size of the responsive element of the base will also facilitate establishing DTIB data requirements, which are essential to base management (see app. B).

Table 5-3-Desert Shield/Storm Immediate Response Requirements

- Rations
- Chemical suits
- Atropine injectors
- Desert uniforms and boots
- E-3 electronic pods
- Waste disposal units
- 25mm Bushmaster ammunition
- 120mm tank ammunition
- Missile shipping containers

SOURCE: Office of Technology Assessment, 1991.

Setting Priorities

Maintaining a selective surge capability will require better planning than in the recent past, when the task of trying to surge all weapon systems was perceived as unrealistic and thus resulted in little action or funding. Indeed, the key to having a responsive base is to determine which items require a surge capability and to fund that capability. Industrial preparedness planning requires a coherent management approach, such as Graduated Mobilization Response (see ch. 3), and must be coordinated with realistic war reserve stocks to ensure rapid response in a crisis.

Production lines for selected surge items would be kept open with low levels of production. Since peacetime production rates of these items are likely to be too low to support second-sourcing, the Nation would have to move toward greater reliance on single sources with additional surge capacity. When meeting surge requirements, civilian goods such as clothing, fasteners and subcomponents, and services such as maintenance and food service should be used whenever possible. Thus, preserving a rapid-response industrial capacity may require substantial changes in the defense-procurement statutes and regulations to allow greater use of the commercial industrial base and sole-sources.

Funding for Surge

Having identified the limited number of items to be included in the responsive element of the base, the Nation must fired the capability to surge. This funding should be considered as essential to national security as funding for troop exercises or any other training or contingency planning. Surge simulations and exercises will also be necessary.

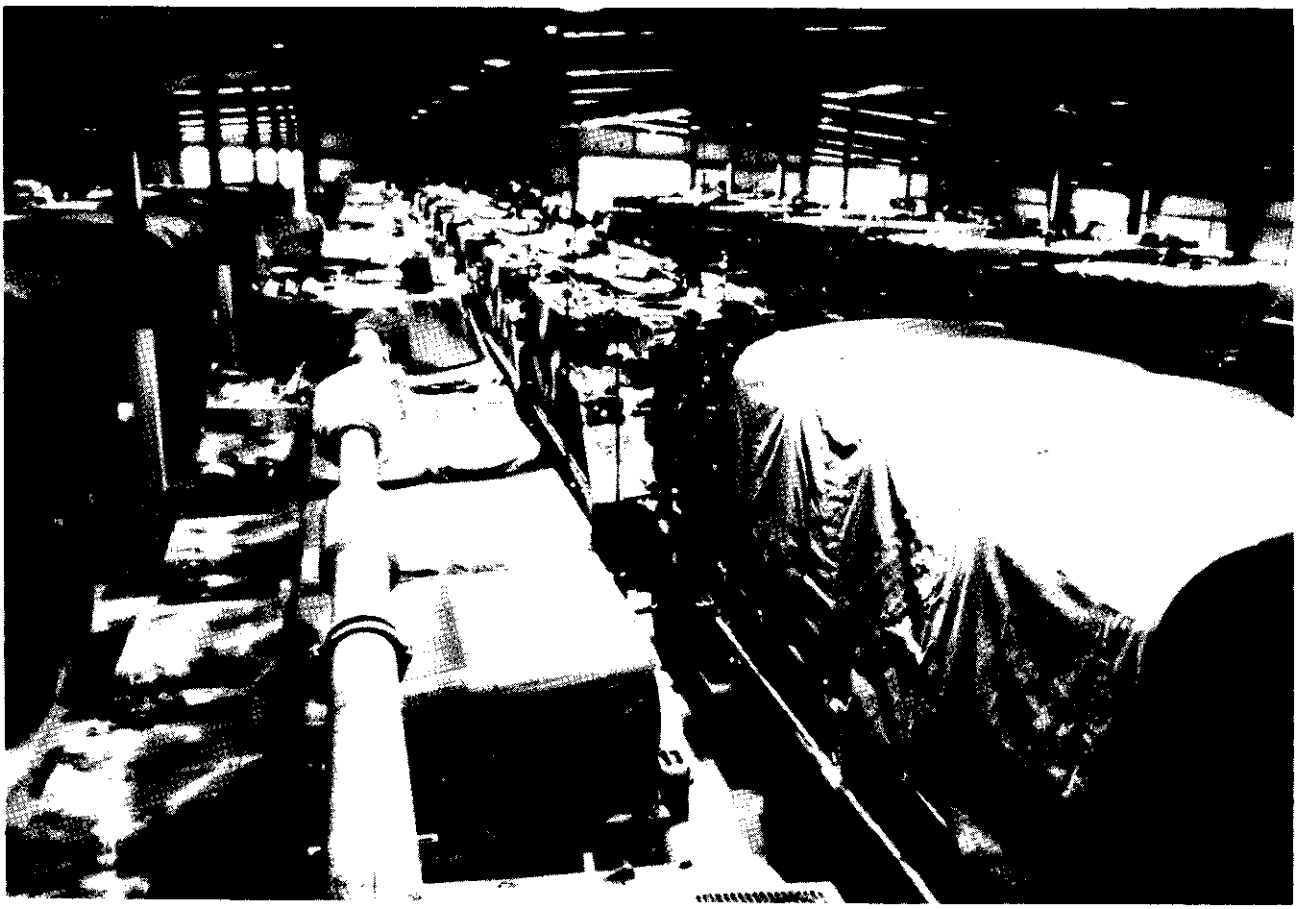


Photo credit: U.S. Department of Defense

Prepositioned equipment for a U.S. division lies in storage in Europe. The new security environment will require a reappraisal of war reserve requirements.

Mobilizable Production Base

While *the* responsive portion of the DTIB enables the Nation to cope with less challenging but more likely theater-level contingencies, producing military equipment in peacetime at affordable prices requires access to a larger industrial base--part dedicated to defense production and part remaining in the civil sector. This mobilizable component of the production base also provides a hedge against a reconstituted Soviet threat or any other great-power threat that could arise over a period of years. It comprises defense contractors whose products—tanks, ships, and fighter aircraft-would not be surged in lesser contingencies, civilian factories and workers that could be transferred to defense production, and some foreign suppliers. Since rapid responsiveness is not a requirement, the defense plants in the mobilizable component of the base should be sized for small, *realistic* production runs to support the peacetime modernization of forces (see box 5-B). In addition, reliance on a mobilizable civilian base implies the maintenance of a robust civilian manufacturing sector in electronics, machine tools, and heavy vehicles that is capable of converting to defense production in an emergency.

Recent developments in manufacturing technology have led to much interest in the so-called "factory of the future." This concept envisions a manufacturing process that:

1. surveys customer needs,
2. evaluates alternative designs for meeting those needs,
3. selects the best design with respect to ease of manufacturing and product reliability, and
4. manufactures and delivers the product.

Box 5-B—How Production Planning Affects Costs

Discussions of downsizing the defense industrial base often focus on maintaining critical manufacturing capabilities. The worry is that as production levels of weapons decline, unit costs will go up, and that there maybe some minimum volume at which production will cease to be economically viable. What, in fact, is the relationship between unit cost and levels of production?

Industrial production can be characterized by the number of items built. The extreme is one-of-a-kind production, such as the Hubble Space Telescope or the Eiffel Tower. The opposite extreme is mass production of millions of identical items, such as light bulbs or memory chips. Between these two extremes lies "serial" production of limited numbers of similar items. Although artillery rounds and small arms ammunition are mass-produced, most modem weapon systems are serially produced. Indeed, even ''large' production runs of defense systems are modest by the standards of most industries. Armored vehicles are bought by the thousands, fighter aircraft by the hundreds, and small warships by the dozen. Nor are production *rates* high. For example, in 1989, the United States procured on a monthly basis one F-14 fighter, two Harriers, three F-15s, seven F-18s, and fifteen F-16s. Thus, cutting the total number in half does not entail changing from mass production to serial production, but rather from serial production to smaller serial production.

Manufacturers generally like large production runs because unit costs tend to decline overtime. As more items are built, workers learn new skills, management improves, and early mistakes are avoided, resulting in a' 'learning curve" of increasingly efficient production. Learning curves are measured in terms of a "progress ratio," or the ratio of the cost of the second lot of items to the cost of a first lot of equal size. For a wide range of products, from electronics to aircraft, the progress ratio is roughly 80 percent, with almost all cases falling between 70 and 90 percent. Moreover, studies have shown that the variation in progress ratios is greater between firms in a single industry than between two different industries. This observation suggests that company organization and management are key to efficient production.[1]

In addition to learning, other effects reduce unit costs in large production runs. Some "fixed" costs, such as research and development or initial tooling, are independent of the size of the eventual production run. As these costs are spread over more units, a smaller share is allocated to each item, lowering average unit costs. The converse is also true: if fewer items are produced, unit costs will rise. Finally, as more units are produced and markets become larger, commercial firms often make capital investments to increase production efficiency. Yet this strategy entails the risk that if the expected rise in demand does not materialize, unit costs will increase.

In addition to the total *number* of units produced, unit costs are affected by the planned *rate* of production. On the one hand, if an expensive piece of manufacturing equipment must be purchased, it is generally cheaper to manufacture items with one machine rather than with two machines operating in parallel at twice the rate. On the other hand, a short production run with a rapid return on investment will minimize the cost of borrowing money for the initial research and development, equipment, and training. Given any set of conditions, one can calculate an optimal rate of production to minimize unit costs.

Once manufacturing facilities have been built, however, deviations from the planned rate of production will increase unit costs. If production drops below the planned rate, overhead costs must be spread over fewer units. Conversely, if production rises above the planned rate, unit costs will rise because of the need for multiple shifts, overtime, and delayed equipment maintenance. In sum, there are three separate but related production factors that affect unit costs:

1. total numbers produced,
2. planned production rate, and
3. deviations from the planned production rate.

While defense-industrial analysts have expressed concern that smaller production runs will greatly increase unit costs, deviations from planned production rates are at least as important. As a result, the increased costs of smaller production runs can beat least partly offset by more realistic planned production rates and more predictable funding.

[1] Linda Argote and Dennis Epple, ''Learning Curves in Manufacturing,'' *Science,* vol. 247, No. 4945, Feb. *23, 1990, Pp.* 920-924.

Photo credit: FMC Corp.

Careful planning can allow efficient peacetime production of major weapon systems like the Bradley Infantry Fighting Vehicle, providing the core around which civilian industry could mobilize in time of war.

While totally integrated future factories will make extensive use of automation and computer-aided design and manufacturing, the concept relies less on computers and robots than on a new philosophical approach that emphasizes flexibility in meeting a wide variety of customer demands. Greater flexibility in manufacturing would allow for more integration of civilian and defense production. For example, it may eventually become possible to exploit the inherent flexibility of 'dual-use' factories to manufacture military components that have no direct civilian counterparts. With the help of a small cadre of personnel in the dedicated defense base, dual-use factories would be capable of shifting from civil production to the manufacture of weapons in an emergency. Nevertheless, such truly flexible manufacturing systems remain distant.

To harness the Nation's total industrial strength against a reconstituted threat and to exploit future flexible manufacturing, weapons design might be determined more by commercially available technologies than by the desire to optimize military performance. Moreover, since the mobilizable component of the defense base is embedded in the larger civilian base, the strategy for transition to the future DTIB will be shaped by concerns over the declining international competitiveness of the U.S. civilian industrial base.[19] Many of the steps necessary to strengthen this broader base are outside the purview of the Department of Defense and the other national-security agencies of the Federal Government. If DoD is to make more effective use of the civilian industrial base, however, it will require better data about the commercial availability of dual-use products so it can define those industrial sectors in which civilian and defense production can be integrated most effectively.

Also essential is a major review of the defense acquisition laws to identify changes that can promote greater integration of the civilian and defense industrial bases .20 Laws that warrant review include those that mandate government auditing and ac-

[19] This concern prompted the DOD report by the Under Secretary of Defense for Acquisition, *Bolstering Defense Industrial Competitiveness* (Washington, DC: U.S. Department of Defense, July 1988), and several Defense Science Board studies. Civilian studies of the issue include: Office of Technology Assessment, *Making Things Better: Competing in Manufacturing* (Washington, DC: U.S. Government Printing Office, March 1990), and the report by the MIT Commission on Industrial Productivity, *Made in America* (Cambridge, MA: MIT Press, 1989).

[20] Jeff Bingaman et al. (eds.), op. cit., footnote 1.

counting procedures, and give the government rights to technical data, particularly in the case of subtier firms whose survival depends on specialized dual-use technology.

Maintaining the ability to make national security use of the mobilizable production base will not necessarily entail more government intervention, but it will require planning and better tracking of the changing capabilities of the base. The United States will need to invest in establishing and updating databases that monitor the Nation's industrial resources, and the Departments of Defense and Commerce should assign more staff to follow defense-industrial issues. This data-gathering effort must be comprehensive while avoiding excessive intrusion into proprietary areas. In those cases where DoD considers it essential to maintain a domestic capability to manufacture particular defense items, the government may have to invest in creating or maintaining a U.S. source; in less critical cases, the decision may be made to source abroad. It is likely that the mobilizable production base will place greater reliance on interdependence with allies than the responsive base.

Maintenance and Overhaul

As noted earlier, the maintenance and overhaul component of the base will likely be confronted with limited requirements in the near term (5 to 10 years) and increasing requirements after that period as systems are retained in inventory. The size of the increase will also depend on the effort devoted to designing improved maintainability into new systems. Investing in this area could keep maintenance requirements low by historic standards.

An important question facing defense-base planners for the transition period is whether maintenance should be performed by Service depots or by the private sector. Traditionally, maintenance and overhaul have been a responsibility of the military Services, but a growing number of manufacturing fins, faced with the prospect of fewer production contracts, are becoming interested in maintenance, remanufacture, and retrofit work. At the same time, Service depot consolidation is either planned or taking place. The military Services argue that in-house maintenance facilities provide greater flexibility and responsiveness in supporting overall force readiness. Further, the Services are wary of over-reliance on private firms that have shown little interest in maintenance and repair work until the recent budget decline, and may not wish to stay in the business when economic conditions improve.

While the Services argue that there is a need for an in-service depot capability and that some minimum core of business is also essential for maintaining competency, they appear willing to compete with private industry for work above this minimum. Maintenance, overhaul, and upgrade contracts might be critical to maintaining a private-sector design and production capability for some weapon systems, such as armored vehicles. Nevertheless, Congress may wish to pay particular attention to maintenance during the transition so that government capabilities are not lost because of promises by private firms that never materialize.

Good, Integrated Management

Despite the volumes of recommendations for improving the management of the DTIB and the numerous management reorganizations that have taken place over the last decade, few people argue that the current base is well managed. Many of the problems identified in the current DTIB result from national rather than Department of Defense actions. For example, the inability to make long-term manufacturing plans is critically affected by unpredictability in program funding, which has often fluctuated independent of changes in the threat. One way of addressing this problem is the proposal for a multiyear defense budget, which has so far failed to be adopted by Congress.

One of the most important current issues is the extent to which the government should intervene to manage the transition to the future DTIB. As noted in chapter 3, this is a controversial issue, but one that must be resolved if the Nation is to move successfully to the new base. Several defense procurement laws and regulations were developed over the past decade, a period of rapidly increasing defense budgets, to provide wide access to government funds through mandated competition and to ensure accountability in the use of those funds through extensive auditing procedures. Many of these statutes now appear inappropriate for dealing with the transition to a downsized DTIB, regardless of which structure ultimately is chosen.

For example, Congress will want to consider the negative effects of the Competition in Contracting Act as currently implemented (see ch. 4). Both DoD

and Congress should also review many of the legally mandated contracting procedures that make it unnecessarily costly and difficult for firms to bid on defense contracts. Revised versions of these statutes might place less emphasis on access and competition, and more on efficiency and quality of procurement and the preservation of core competencies and long lead-time capabilities. Some reviews of the defense acquisition regulations are already under way.

Management of the DTIB will depend on skilled and experienced personnel. These skills are often lacking in the current system because of short tenure and inexperience on the part of many political appointees, uniformed military, and congressional staff. The military services have recently made changes to professionalize their acquisition corps. Alternatively, some defense analysts have recommended the creation of a professional civilian acquisition corps similar to those in France, Germany, and other European countries. Although this approach offers some advantages, the French experience in the Gulf War revealed its limitations. In particular, French procurement has often been driven more by industrial interests, such as arms exports, than by the military requirements of the French armed forces.

Management of the future DTIB would also benefit from revamping the complex organizational structure of the Federal procurement bureaucracy, as well as improving the relationship between government and business. The latter objective would be promoted by removing some of the criminal sanctions from the procurement laws. Above all, the Nation should develop a broad defense technology and industrial strategy. While the individual services have developed technology strategies and DoD has prepared an initial "critical technologies" plan, there is a need for a comprehensive approach that better links procurement and defense-industrial policies with operational military plans and overall national security strategy.

SUMMARY

This chapter has laid out some desirable characteristics of the future DTIB and has discussed the potential benefits and risks associated with the broad strategic choices and tactical decisions necessary to achieve those characteristics. The identified characteristics and strategies were developed on the basis of discussions with government officials, defense industry personnel, and other interested observers, and provide a framework for congressional debate over the nature of the future DTIB.

The present transition period will be critical to the health of the future base. Without careful planning, the Nation could retain the wrong capabilities (old ammunition plants with little future utility, firms without weapons-development capabilities) because of a failure to understand the revolutionary changes in the security environment or an inability to make hard choices that might result in facilities being closed in particular areas.

The Nation has a rare opportunity to revamp the DTIB that will support U.S. national security well into the 21st century. OTA's analysis suggests that the transition will entail an emphasis on research and development rather than production, but a broadened approach to R&D that includes improvements in manufacturing or ''process' technologies as an important goal. The future DTIB will also require continuous prototyping and limited production to maintain competition while preserving and improving manufacturing skills, and it must be more fully integrated with the civil sector. Regardless of the final characteristics chosen and the strategies followed, the emphasis must not be on maintaining the structures and facilities of the past, but on developing an efficient and flexible DTIB that can meet the security demands of an uncertain future.

Appendixes

Appendix A

The North American Defense Industrial Base: Canadian and Mexican Contributions

Introduction

Since the beginning of World War II, Canada and the United States have engaged in extensive defense industrial cooperation that has resulted in the partial integration of their defense bases. With sharp cuts in defense spending in both countries, however, this partnership faces major challenges. Will the two countries intensify their collaboration or turn instead to greater protectionism? In planning for the future U.S. defense technology and industrial base (DTIB), Congress will want to consider Canada's contribution to U.S. defense procurement and wartime preparedness, as well as the political and economic consequences of various policy options affecting the Canadian portion of the base. There is also a need to consider the implications for the DTIB of growing U.S. economic integration with Mexico, including the production and assembly of defense products and the potential relocation of some subtier industries across the border.

The concept of a North American Defense Industrial Base (NADIB) was never a clear U.S. policy objective but has evolved on an ad-hoc basis over the past four decades. In the early 1960s, Canada agreed to buy its major weapon systems from the United States if three conditions were met:

1. the absence of a domestic production capability for the system in question,
2. a price that was "not prohibitive," and
3. tariff-free access by Canadian component suppliers and subcontractors to the U.S. defense market.

Since then, U.S.-Canadian defense industrial collaboration has developed according to guidelines laid down in numerous agreements negotiated by the two governments as specific needs arose. Collectively known as the Defense Development and Defense Production Sharing Arrangements (DD/DPSA), these accords have created a degree of interdependence between the U.S. and Canadian defense industries. In 1990, direct sales of Canadian defense goods to the U.S. Department of Defense were nearly Can$450 million, while subcontracting by Canadian firms to U.S. prime contractors rounded out the total to about Can$l billion.[1]

Over the past decade, U.S. defense contractors have also begun to perform production and assembly work in Mexico, taking advantage of the special customs arrangements established under the Mexican Government's *maquiladora* (assembly plant) program to benefit from the low labor costs available across the border. As the United States, Canada, and Mexico move toward the creation of a continental free-trade zone, trade in dual-use and defense products among the three countries is likely to increase. In that context, a North American industrial base, and an associated expanded NADIB, may ultimately emerge.

At present, however, the NADIB is still far from being fully integrated. U.S.-Canada defense trade has long been constrained by protectionist legislation in both countries, as well as by the small size of Canada's defense industry. Moreover, the prospect of significant cuts in U.S. defense spending and declining arms sales to Western Europe may increase domestic pressures to protect the U.S. defense market, injecting new tensions into the U.S.-Canada relationship.

This appendix surveys the structure of the Canadian defense **industry and its contribution to the NADIB, the history of U.S. defense-industrial cooperation with Canada, the developing partnership with Mexico, and the effect on these relationships of shrinking defense budgets and markets. The appendix concludes with a discussion of whether expanded defense-industrial cooperation with Canada and Mexico could help the United States maintain a downsized yet cost-effective defense technology and industrial base.**

The Canadian Defense Industry

The Canadian defense industrial base is much smaller and more fragmented than that of the United States, and is also more diversified into the civilian sector. The Canadian aerospace industry, for example, depends on defense business for only 30 percent of its revenue, compared to more than 60 percent for similar industries in Japan, Europe, and the United States.[2]

Since the early 1960s, Canada has pursued a strategy of purchasing almost all of its major platforms and weapon systems from foreign sources (mainly the United States[3])

[1]Data provided by Canadian Embassy, Washington, DC.

[2]David Hughes, "Canadian Aerospace Industry Prepares for Rising Competition, Falling Defense Sales," *Aviation Week & Space Technology, vol. 134, No.* 11, Mar. 18, 1991, p. 68.

[3]In 1987, Canada acquired Can$1.7 billion in defense equipment from the United States, or 77 percent of the total Can$2.2 billion defense procurement budget. Source: Max Reid, Counselor for Defence Programs, Canadian Embassy, Washington DC.

while developing and manufacturing high-quality defense subsystems and components in selected areas where Canada possesses technological strengths. Within the context of this acquisition strategy, the Canadian Government has sought to secure domestic or multiple foreign sources for "critical" items of defense equipment and to maintain a defense-industrial base capable of producing the consumables of war(e.g., ammunition and spare parts) and repairing and overhauling foreign-sourced weapons.

The Canadian defense industry employs between 80,000 and 90,000 people. Although the industry accounts for less than 1 percent of Canada's total GNP, employment, and exports, it dominates a few industrial sectors. More than 65 percent of employment in shipbuilding, for example, is tied to defense contracts.[4] Since the Canadian defense procurement budget is small (about US$2.2 billion in 1990), the industry relies heavily on export markets. In 1988, 30 percent of sales in the aerospace and defense electronics fields were domestic, 49 percent were to the United States, and 21 percent to the rest of the world.[5]

Of roughly 1,000 potential suppliers of defense products, about 250 firms are active producers, all of them in the private sector. Only a few are large corporations with annual sales of more than $100 million; most are relatively small suppliers or subcontractors employing between 25 and 50 people. Like Canadian industry generally, the defense industry is concentrated geographically: the large majority of electronics and aerospace firms are located in the provinces of Ontario and Quebec, and shipbuilding is based primarily in the Atlantic region. The secession of Quebec from the rest of Canada might have a serious effect on the Canadian defense industrial base if Quebec insisted on full sovereignty, which is only a remote possibility. Even so, the aerospace industry is unlikely to leave Quebec, and the industrial ties developed over 50 years between Quebec and the United States would continue.

Canada produces only a few stand-alone defense systems, including remotely piloted vehicles, the Swiss-designed Light Armored Vehicle (LAV), and the Canadian Patrol Frigate. Most Canadian defense companies are specialized in the production of electronic subsystems, munitions, and precision-machined parts and components (e.g., aircraft wing assemblies) for export to U.S. and European prime contractors. Aerospace equipment and electronics account for 70 percent of total defense sales, followed by shipbuilding, wheeled armored vehicles, and munitions. Areas in which the Canadian defense industry

Photo credit: Canadair, Surveillance *Systems Division*

The CL-227 Sentinel unmanned airborne surveillance system, manufactured by Canadair in Montreal, performs battlefield reconnaissance under remote control. It has a top speed of 130 knots, and an endurance of up to *4* hours.

is **on the technological leading edge include small gas-turbine engines, reconnaissance drones, avionics, flight simulators, structural components for aircraft, military communications equipment, acoustic antisubmarine warfare systems, remote sensing, ballistic computers and fire-control systems, and equipment suitable for use under Arctic conditions. (Table A-1 lists the U.S. defense contracts awarded to the Canadian industry from 1987 to 1989.)**

Leading Canadian-owned defense contractors include Spar Aerospace (developer of the Space Shuttle robot arm), CAE-Link (a leader in simulation technology), and Indal Technologies (which produces shipboard helicopter recovery systems). Nevertheless, many of the largest Canadian defense contractors are foreign-owned. About 54 percent of the industry is in U.S. hands, while another 10 percent is European-owned, primarily by British corporations.[6] Seven of the top 10 Canadian firms (by sales) in the aerospace and defense electronics sectors are U.S.-owned, including Boeing's De Havilland Division, McDonnell Douglas Canada, Litton Systems Canada, RCA Canada, Raytheon Canada, Garrett Canada, and Pratt & Whitney Canada. These subsidiaries enjoy varying degrees of autonomy from their U.S. parents. For example, Pratt & Whitney, with 9,500 employees, is the largest aerospace concern in Canada; it has an all-

[4] James Fergusson, *Canadian Defence Trade and Europe: Methodological Concerns and Empirical Evidence,* Centre for Studies in Defence Resources Management, Solicited Research Report #4 (Kingston, Canada: National Defence College, fall 1990), p. 18.

[5] David Leyton-Brown, "The Impact of European Market Integration on Canadian-American Defence Industrial Cooperation," Centre for Studies in Defence Resources Management, Solicited Research Report ##5 (Kingston, Canada: National Defence College, fall 1990), p. 2.

[6] Ibid.

Table A-1—U.S. Defense Contracts Awarded to Canadian Companies, 1987-1989 (millions of Canadian dollars)

Company	Year	Contractor	Value	Product
Canadian Marconi	1987	us.^Air' Force	0.5	Demonstration: Microwave Landing System Avionics
Canadian Marconi		U.S. Air Force	NA	Airborne Microwave Landing System Receiver
Canadian Marconi		U.S. Army	NA	CMA-2016 Helicopter Flight Computer System
Hermes		U.S. Navy	11.0	AN/SSQ-53B Sonobuoy
Menasco		McDonnell Douglas	2.7	C-1 7 Nosewheel and Steering System
Indal Technologies		U.S. Navy	10.0	Shipboard Helicopter Recovery System (RAST)
Garrett		U.S. Air Force/Canada	4.0	Study of Next Gen. Environmental Control System
Leigh instruments		U.S./Spain/Canada	9.4(est)	Recording/Radio Communication Systems for F-18
Adanac	1988	U.S. Navy	9.0	Program Management System--Antisubmarine Warfare
Adanac		U.S. Navy	12.0	Shipboard Helicopter Recovery System (BEAR TRAPS)
Canadian Marconi		Sikorsky	9.0	Helicopter Cockpit Display Systems
CAE-Link		U.S. Army	60.0(est)	Blackhawk/Chinook Helicopter Simulator
Northern Telecom		U.S. Air Force	147.0	Integrated Digital Telecommunications Systems
Hermes		U.S. Navy	10.0	AN/SSQ-62B Sonobuoys
Astra Pyrotechnics		U.S. Dept. of Defense	1.6	Signal Cartridges
Spar Aerospace		U.S. Navy	NA	AN-SAR-8 Shipboard Infra-Red System
Hawker Siddley		Textron-Lycanning	6.1 (est)	ALF502R Jet Pipes and TF40 Engines
Canadian International	1989	U.S. Dept. Defense	2.4	DEW Line Transmission Systems
Computing Devices		U.S. Navy	NA	Antisubmarine Warfare Interface Convertor Units
Computing Devices		U.S. Navy	NA	Unmanned Air Vehicles (with Teledyne Corp.)
Canadian Marconi		Lockheed	3.2	Next-Generation U.S. Navy Microwave Landing System
Canadian Marconi		Lockheed	3.2	Microwave Landing System for P-7A
Canadian Marconi		U.S. Army	58.0	AN/GRC-226(V) Radio Sets
Canadian Marconi		U.S. Air Force	1.2	Airborne Navigational Equipment
Dowty		U.S. Lockheed	200.0	P-7A Landing Gear
Donlee Precision		U.S. Navy	1.5	Jet Turbine Shafts
Litton Systems		Kerry Electronics	1.0	LED Switches-Boeing Military Aircraft
Oerlikon		U.S. Army	NA	Air Defense and Anti-Tank System (ADATS)
Heroux		U.S. Air Force	2.5	Landing Gear for CSA/B, C-130, KC-135R
Bristol		U.S. Air Force	4.6	F-5 Horizontal Stabilizers

NA = Not available

SOURCE: James Fergusson, Canadian *Defense Trade and Europe:* Methodological Concerns *and Empirical Evidence*, Center for Studies in Defense Resources Management, Solicited Research Report #4 (Kingston, Canada: National Defence College, fall 1990), table Viii.

Canadian board of directors and behaves more like a Canadian firm than a foreign subsidiary.

Canada's current defense industrial base has both strengths and weaknesses. Its strengths include a relatively new industrial plant compared with those of other Western countries, close proximity to the United States, a relatively secure location (compared to Europe), a local supply of strategic raw materials, and access to foreign technology through U.S. and European ownership. The small size of the base also makes it relatively manageable from the standpoint of the Canadian Government, although the base has been shaped by its dependence on foreign military and technological requirements.[7] Weaknesses of the Canadian base include the small size of the domestic defense market, overconcentration in certain market niches, and the Canadian Government's modest support for defense R&D, which could render the industry's niche markets vulnerable to foreign competition.[8]

During the early 1980s, the Canadian Government invested considerable resources in rebuilding or expanding key elements of the domestic defense industrial base, with the goal of restoring a selective capability for the design and production of weapon systems. The Canadian Government also invested in the defense industry to promote high-technology innovation, regional industrial development, and skilled employment. This revitalized defense base includes naval shipbuilding and naval electronics subsystems for the Canadian Patrol Frigate program; the integration of production facilities for military trucks, utility vehicles, and light armored vehicles; the capability to manufacture small arms such as the M-16; the phased development of a light to medium helicopter industry; continued expansion of the design

[7] R.B. Byers et al., *Canada and Defence Industrial Preparedness: Options and Prospects* (North York, Ontario: York University Centre for International and Strategic Studies, April 1987), p. 120.

[8] Only about 5 percent of the US$2.2 billion Canadian defense budget is devoted to R&D. In 1989, the Canadian defense industry invested US$637 million in R&D, as well as US$449 million in plant and equipment. Source: David Hughes, "Canadian Aerospace Industry Prepares for Rising Competition" op. cit., footnote 2, p. 68.

and production of small gas-turbine engines; and a significant improvement in ability of the defense industry to undertake large-scale integration projects.[9]

Nevertheless, the plummeting domestic defense requirements caused by the end of the cold war, combined with softening export markets, have raised concerns that the Canadian Government's substantial investment in the defense industry may be wasted. Few new programs are being launched to replace ongoing weapons programs, and many Canadian defense contractors are already increasing their share of nondefense work. The aerospace industry is expected to reduce the military portion of its sales from 30 to 20 percent of the total. 10 As defense firms turn increasingly to the civil sector, Canada is losing critical elements of its defense industrial base. For example, Canadian Marconi Co. (CMC) recently closed its manufacturing facility in Montreal for military-standard printed circuit boards, eliminating Canada's only domestic source of these vital components.[11]

The U.S.-Canada Relationship

With the exception of the late 1970s, when Canada acquired the German *Leopard I tank*, defense trade with the United States has dwarfed that with any other country. In 1989, for example, the United States accounted for 84.7 percent of Canadian defense imports and 80 percent of Canadian defense exports.[12] Canada is also a major supplier of strategic raw materials used in U.S. defense production: of the 35 critical materials not available domestically, Canada provides 23. Finally, the Canadian defense industrial base is heavily integrated into the U.S. base at the subtier level. Thus, according to Canadian analyst David Leyton-Brown: "Without access to the U.S. market, it seems fair to say that there would not be a Canadian defence industry. '[13] Although the volume of Canadian participation in U.S. defense contracts is relatively modest, amounting to about US$800 million in 1990, or only 0.5 percent of the total Department of Defense (DoD) procurement budget, this figure does not include the large volume of cross-border trade in dual-use components.

U.S.-Canada defense cooperation began during World War II, when Canadian industry manufactured large quantities of warships, guns, and aircraft.[14] The two governments pooled their industrial resources to reduce duplication and enhance the effectiveness of the allied war effort. In 1940, Prime Minister Mackenzie King and President Franklin Roosevelt met at Ogdensburg, NY, and signed an agreement establishing a senior advisory group on North American security called the Permanent Joint Board on Defense. The following year, the two leaders issued the Hyde Park Declaration, which directed each country to buy military goods from the other on the basis of complementarily, competitive advantage, and specialization. During World War II alone, the U.S. and Canada procured from each other equipment worth a total of $8.65 billion (in 1990 U.S. dollars).

With post-war demobilization, the Canadian defense industrial base began to erode. Although defense production expanded briefly during the Korean War, NATO's short-war nuclear strategy had little need for defense industrial mobilization. A further watershed in Canadian defense-industrial policy came in 1959, when the Canadian Government canceled the production of an advanced all-weather interceptor called the *AVROArrow. The* most ambitious defense R&D effort in Canadian history, the program succumbed to cost overruns, numerous design changes, the excessive technical demands of the Royal Canadian Air Force, the lack of export potential, and poor government planning.[15] Because of the small size Of the domestic defense market, the Canadian Government concluded that it could no longer afford to develop advanced weapon systems and platforms unless it became a major arms exporter, which would have conflicted with its foreign-policy goals.

Canadian defense officials responded to this situation by offering to purchase most major weapon systems from the United States, in return for duty-free access to the U.S. market for Canadian producers of defense-related parts, components, and subsystems. Washington also granted Canadian subcontractors the opportunity to compete for U.S. defense contracts on the same basis as American firms.[16] This ***quid pro quo*** **was** implemented through a series of negotiated memoranda of understanding and

[9] Lt.Gen. A.J.G.D. de Chastelain, "The Need for Sustainment," *Canadian Defence Quarterly,* June 1989, p. 19.

[10] David Hughes, op. cit., footnote 2, p. 68.

[11] "Survival At All Costs: Canadian Industry Is Rapidly Reshaping Itself To Combat Declining Defence Markets," *Jane's Defense Weekly,* Oct. 20, 1990, p. 775.

[12] Data compiled by the Canadian Department of External Affairs. See Fergusson, op. cit., footnote 4, tables VII and XVII.

[13] Leyton-Brown, op. Cit., footnote 5, pp. 23.

[14] During World War II, Canadian industry produced over 17,000 aircraft, 38,000 tanks and armored vehicles, over 800,000 wheeled vehicles, and 480 naval ships, although it relied heavily on the United States and Great Britain for technical data packages and key subsystems such as aircraft engines. See de Chastelain, op. cit., footnote 9, p. 15.

[15] "The Canadian Defence Industrial Base: The Policy Environment," *Canadian Defence Industry Guide 1990/91* (Toronto: Baxter Publishing, 1990), p. 6.

[16] William Johnston, "Canadian Defence Industrial Policy and Practice: A History," *Canadian Defence Quarterly,* June 1989, p. 25.

letters of agreement that came to be known collectively as the Defense Production Sharing Arrangements (DPSA). The accords had the effect of exempting Canadian defense products from U.S. Buy American tariffs, as well as U.S. duties on Canadian defense goods produced under subcontracts for U.S. prime contractors.

The DPSA agreements laid out five fundamental objectives for U.S.-Canada defense-industrial cooperation:

1. greater integration of military production between the two countries,
2. improved standardization of military equipment,
3. wider dispersal of production facilities,
4. establishment of supplemental sources of supply for wartime mobilization, and
5. a greater flow of defense supplies and equipment between the two countries.[17]

A June 1963 supplement to the DPSA also called for the maintenance, over the long term, of a' 'rough balance" in reciprocal defense procurement at increasing levels.[18]

The two governments recognized that for the production-sharing arrangement to remain viable, the Canadian defense industry would need to retain an indigenous development capability. For this reason, the DPSA was supplemented by the Defense Development Sharing Arrangement (DDSA). This agreement provides for the use of Canadian-developed technology where it can meet U.S. defense requirements; in such cases, both countries share in funding the development work, with the United States contributing not less than 25 percent of the cost of an R&D project. An example of a successful DDSA project is the AN/GRC-103 tactical radio, developed by Canadian Marconi, which is now standard equipment in the U.S. and Canadian armed forces.

The DD/DPSA accords continue to provide the framework for peacetime defense-industrial cooperation between the U.S. and Canadian defense establishments. This relationship is managed by a bilateral Steering Committee that meets on an annual basis and is co-chaired by the U.S. Deputy Under Secretary of Defense for International Programs and the Canadian Assistant Deputy Foreign Minister for International Trade and Development. The Steering Committee is supported by several subcommittees and working groups. Unfortunately, the large number of participating agencies from both governments has often made it difficult for the Steering Committee to develop clear directives and guidelines.

Types of Defense Trade

There are two types of U.S.-Canada defense trade: 1) government-mediated contracts issued to Canadian industry by the U.S. Department of Defense (DoD), and 2) commercial subcontracts negotiated directly between U.S. and Canadian firms.

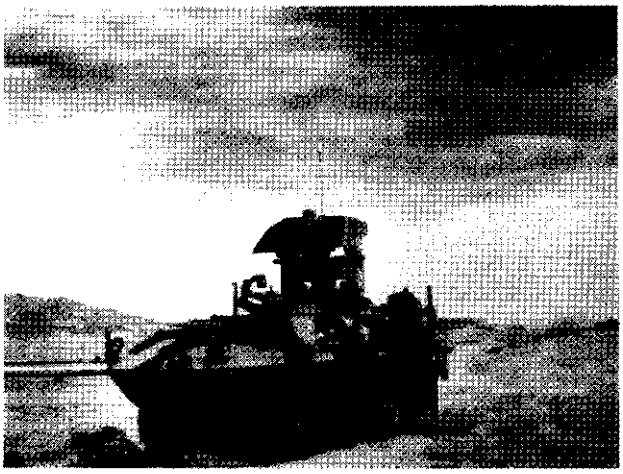


Photo credit: GM Canada

The Light Armored Vehicle (L./W), manufactured by General Motors Canada, was procured as a non-developmental item by the U.S. Marine Corps and used in Kuwait. The Marines have bought five versions; the antitank version is shown here.

The first category involves bids by Canadian companies on contract tenders from DoD. In order to facilitate participation by Canadian firms in U.S. defense contracts, the Canadian Government established an entity called the Canadian Commercial Corp. (CCC), which acts as a conduit for contracts between Canadian defense contractors and DoD. The CCC obtains Requests for Proposal from the Ottawa office of the Defense Contract Administration (part of the U.S. Defense Logistics Agency). The CCC then solicits bids from Canadian contractors and submits them to DoD. When a Canadian bid is successful, the Pentagon negotiates with the CCC, which issues a contract to the Canadian firm. This back-to-back contract meets all the terms and conditions of the U.S. contract while allowing the Canadian company to meet the labor and environmental laws of Canada.

Under the bilateral arrangements, the Canadian Government undertakes to ensure quality control, certifies price and delivery, and assumes contract liability should a Canadian company fail to fulfill a contract. The CCC also audits Canadian companies that receive U.S. contracts according to uniform auditing standards and rules worked out with DoD. The advantage of this system for Canadian companies is that they can operate under Canadian law and use their normal business practices without having to learn the intricacies of the U.S. defense

[17]Byers et al., op. cit., footnote 7, p. 106.

[18]Fergusson, op. cit., footnote 4, p. 38.

procurement system. U.S. prime contractors also benefit from the Canadian Government's pledge that subcontracts awarded to Canadian companies will be fulfilled U.S. subcontractors complain, however, that the Canadian Government's guarantee gives Canadian firms an unfair competitive advantage in bidding for DoD contracts.

The second type of U.S.-Canadian defense trade involves a large volume of direct cross-border supply and subcontracting relationships between U.S. and Canadian firms. After Canada tightened its export controls on goods of U.S. origin, there was no longer a need to require permits for cross-border transfers of dual-use products. As a result, this type of defense trade is not handled through government agencies such the Defense Logistics Agency or the CCC. Instead, company-to-company defense trade is simply aggregated into the general trade figures, and there is no easy way to disaggregate it.[19] The Canadian Embassy in Washington estimates that roughly 60 to 65 percent of all U.S.-Canada defense trade is in the form of commercial contracts between Canadian suppliers and U.S. primes or subcontractors. While the Canadian Embassy attempts to monitor this trade, it lacks the resources to do so completely.

Fragmentary data suggest that because of the high level of integration between the two economies at the subtier level, as well as the flow of goods between parent companies and subsidiaries, there is a much higher level of cross-border trade in parts and components between U.S. and Canadian firms than the official defense-trade statistics would suggest. Certain suppliers provide "dual-use" goods (e.g., structural components or fasteners) that have no clear defense application until they are actually incorporated into a weapon system. Moreover, Canadian firms producing subsystems for U.S. prime contractors often procure parts from U.S. subtier suppliers. According to one estimate, 56 percent of all materials and supplies incorporated into Canadian defense products come from U.S. industry sources.[20] This estimate suggests that participation by Canadian firms in U.S. defense contracts provides expanded business opportunities for U.S. subtier suppliers, although the exact magnitude of this multiplier effect cannot be determined.

Obstacles to Defense Trade

In theory, **the mutual benefits provided by the DD/DPSA regime should have resulted in a highly integrated North American Defense Industrial Base, with extensive access by Canadian firms to the U.S. market and a rough balance in defense trade between the two countries. Despite some notable achievements, however, Canadian-American defense trade has experienced persistent problems.**

First, the long-term balance in defense trade promised in 1963 has not been achieved. During the Vietnam War, Canadian defense sales to the United States surged dramatically. Between 1%5 and 1971, Canada had a positive defense-trade balance with the United States of nearly US$500 million. This major imbalance came at a time when U.S.-Canadian political relations were strained by Ottawa's official criticism of the war. In response, U.S. officials concerned with the balance-of-payments deficit joined forces with protectionists and conservatives in Congress to pass a series of laws restricting U.S. defense purchases from Canada.[21] Rising U.S. protectionism in turn convinced the Trudeau government to seek greater trade and political links with Western Europe, including the purchase of the German *Leopard I* tank and an Italian 127mm naval gun for Canada's four *Tribal-class* destroyers.[22]

In 1975, the defense-trade balance shifted in favor of the United States when a major reequipment of the Canadian forces resulted in orders for 18 Lockheed CP-140 *Aurora* maritime reconnaissance aircraft and 138 McDonnell Douglas CF-18 ***Hornet*** **fighters.[23] Over the past decade, the United States has consistently recorded a defense-trade surplus (see figure A-1) because Canadian purchases of major U.S. weapon systems are still being paid off. In 1989, for example, Canadian defense imports from the United States were 1.4 times greater in value than Canadian defense exports to U.S. customers.[24] Increased defense sales to the United States remain an important Canadian policy objective.**

The U.S.-Canada Free Trade Agreement (FTA), which entered into force on January 1, 1989, explicitly excludes pure defense products such as combat systems, although it does cover government procurement of dual-use items.

[19] Fergusson, op. cit., footnote 4, p. 8.

[20] Canadian Embassy, *Canada-U.S. Defence Economic Cooperation* (Washington, DC, June 8, 1989), p. 9.

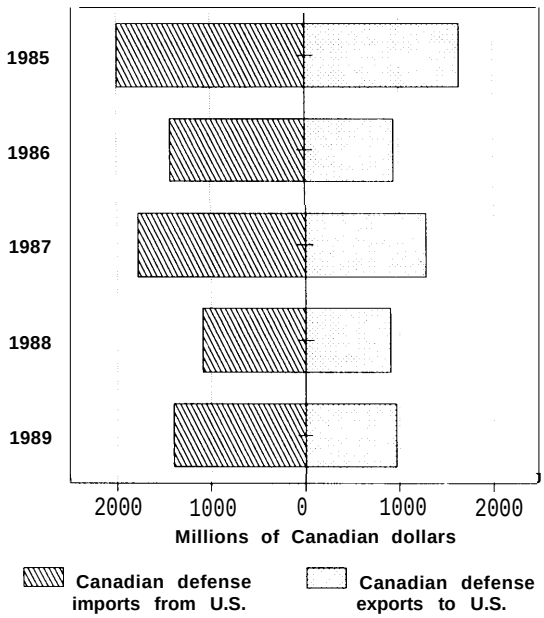
[21] Center for Strategic and International Studies, *Partners i„ Defense: U.S.-Canadian Cooperation in Meeting the Security Challenges of the 1990s*, October 1990, p. 9.

[22] At that time, the Leopard I represented the latest technology. The U.S. M-1 tank was still in advanced engineering development, and production models would not have been available in the period requested by the Canadian Armed Forces. Moreover, the Leopard I could be supported in Europe, where all of Canada's heavy armor was deployed. These purchases have remained anomalies, however, since all of Canada's other tracked armored vehicles and military aircraft have been purchased from the United States.

[23] Johnston, op. cit., footnote 16, p. 26.

[24] Canadian Embassy, op. cit., footnote 20, p. 6.

Figure A-1--Canada-U.S. Defense Trade Under the DD/DPSA Agreement, 1985-1989



SOURCE: James Fergusson, *Canadian Defence Trade and Europe: Methodological Concerns and Empirical Evidence,* Center for Studies in Defence Resources Management, Solicited Research Report #4 (Kingston, Canada: National Defence College, Fall 1990), Table VI.

The rationale for excluding most defense products from the FTA was that they were already covered by the DD/DPSA agreements and represented a relatively small trade volume compared to most commercial sectors. Because the DD/DPSA agreements do not have treaty status, however, they are vulnerable to protectionist laws and nontariff barriers imposed by each country.

A variety of protectionist U.S. laws affect Canadian defense contractors, including U.S.-owned subsidiaries based in Canada. These statutes include the recurring amendments to the annual Defense Appropriations Act, which are incorporated into the Defense Federal Acquisition Regulation Supplement (DFARS). For example, the Berry Amendment prohibits the Department of Defense from procuring food, clothing, fibers, and tools from foreign sources; the Bayh Amendment restricts foreign R&D contracting; and the Byrnes-Tollefson Amendment rules out foreign construction of any naval vessel. (This law has even been applied to block the sale by a Canadian company of small *Zodiac* motorboats to the U.S. Navy.) The Small Business Act requires that some procurement contracts be set aside in whole or in part for small or disadvantaged U.S. companies, thereby precluding Canadian participation. Finally, U.S. public law imposes constraints on the cross-border flow of defense-related information, and U.S. National Disclosure Policy specifies areas of sensitive defense technology that cannot be disclosed to foreign countries, including Canada. These various nontariff barriers are estimated to prevent Canadian firms from bidding on some $65 billion in U.S. defense contracts for which they would otherwise be eligible.[25]

The Canadian Government also imposes restrictions on cross-border defense trade. Tariffs are levied on U.S. defense goods that enter Canada, either under direct sales or government-sponsored Foreign Military Sales (FMS) contracts.[26] Moreover, depending on the technology and the importance of the product, Canada generally favors domestic suppliers. Only when procurement from Canadian sources is uneconomical or impractical does the government turn to outside sources of supply.

Another obstacle to U.S.-Canada defense industrial cooperation has been Canada's insistence on offsets in its acquisition of major weapons systems.[27] Beginning with the purchase of the CP-140 *Aurora* maritime reconnaissance aircraft from Lockheed in **1975, the Canadian Government instituted a policy that foreign contractors competing for a Major Crown Project (worth more than Can$100 million) are expected to offer benefits to Canadian industry, such as technology transfer and production-sharing arrangements. This policy was shaped to a large extent by Ottawa's desire to use large military procurement programs to foster industrial expansion in the less-developed provinces, to enhance the overall international competitiveness of Canadian industry, and as a payback to the domestic economy for large outlays of taxpayers' money for foreign-sourced equipment.**

In addition to barriers created by legislation and industrial-benefits policy, U.S.-Canada defense trade has been hampered by ignorance on the part of government and industry officials about the bilateral defense-industrial relationship. Canadian Embassy officials contend that they must often intervene to inform DoD contracting officers that under the DD/DPSA agreements, Canadian companies are to be treated differently than other foreign firms.

Joint Industrial Preparedness Planning

A memorandum of understanding (MOU) signed in 1970 gave Canadian firms the opportunity to participate

[25]Interview with Michael Slack, a defense analyst at the Centre for International and Strategic Studies, York University, Ontario, Canada.

[26]Canadian customs regulations permit the refund of duties only for U.S. components used for the manufacture of Canadian goods that are then reexported in new condition. Nevertheless, under the Free Trade Agreement, these tariffs will be phased out over a 10-year period ending in 1999.

[27]According to such arrangements, the seller of defense equipment provides the purchasing country with subcontracts, production sharing, technology, and other direct benefits to the Canadian economy that help offset the cost of the contract.

in the U.S. Industrial Preparedness Planning program (IPPP), in which manufacturers commit themselves to respond to a U.S. demand for surge or mobilization production in wartime. About 86 Canadian firms are currently considered as "planned producers" for specialized components, assemblies, and parts. Participation in the IPPP program guarantees Canadian firms the opportunity to bid on any U.S. defense contract over $10,000 on an equal footing with U.S. firms, and also limits the percentage of the contract that can be set aside for U.S. small business. These measures help ensure that the participating Canadian firms could contribute effectively to U.S. surge production in an emergency.

In 1985, President Reagan and Prime Minister Mulroney reaffirmed their commitment to the DD/DPSA agreements and pledged to reduce the legislative and administrative barriers to cross-border defense trade. The first tangible step in the direction of enhanced cooperation came in March 1987, when the United States and Canada established a joint North American Defense Industrial Base Organization (NADIBO). This body has no direct role in peacetime weapons acquisition. Instead, NADIBO is an emergency surge/mobilization planning organization that gathers information, performs analyses, maintains a large database, and coordinates the activities of several Federal departments and agencies with an interest in defense industrial preparedness. There are two plenary meetings a year: a spring planning session that brings together industrial-base planners from the two governments, and a fall workshop to which industry representatives are invited.

Through NADIBO, the two governments have focused primarily on joint industrial preparedness planning (lPP) as a means of identifying deficiencies and bringing about corrective actions aimed at strengthening the North American Defense Industrial Base. For example, an Ammunition Task Force has discussed the ammunition supply problem and possible joint solutions. NADIBO also organized a joint task force on surge production of precision-guided munitions (PGMs) to determine whether Canadian firms could manufacture components for which the United States was already dependent on offshore sources of supply. Of the 284 critical items assessed in the study, an actual or potential Canadian production capability was identified for 239 (or 84 percent) of the required components and raw materials. A similar analysis of the M1A1 Abrams tank revealed that the necessary production technology existed in Canada for all but one of the 129 subsystems.[28]

Despite such joint planning efforts, however, NADIBO's effectiveness has been limited by its lack of executive authority and financial resources, and the participation of a large number of government agencies with divergent interests. As a result, the organization has been unable to generate the clear directives and guidelines needed to coordinate the activities of procurement managers and industrial-base planners. According to Col. Clement Lavoie, head of the Canadian Directorate of Defence Industrial Resources, joint production base analyses have had little real impact because "IPP is not always at the forefront of decisionmaking in the materiel acquisition process.' '[29]

Both Canada and the United States face the challenge of restructuring their defense industries to meet the expected requirements of their armed forces at significantly lower levels of defense spending. Because Canadian defense companies now export 70 percent of sales, mainly to the United States, impending cuts in U.S. defense spending will have a significant impact on the Canadian defense industrial base. In addition, the economic integration of the European Community by the end of 1992 may displace North American defense contractors from parts of the European market, while U.S. prime contractors that do make military sales to Europe will increasingly be required to negotiate offsets involving subcontracts to European firms rather than Canadian ones. As a result, Canadian defense companies can expect to face increased economic competition from both U.S. and European firms in the vital U.S. defense market, as well as growing protectionism designed to reserve more of that market for U.S. industry.

U.S. Defense Production in Mexico

The third largest U.S. trade partner, with bilateral commerce worth $52 billion in 1989, Mexico has long been an attractive location for U.S. industry because of its extremely low labor costs. In 1965, in an effort to relieve unemployment near the U.S. border, the Mexican Government established special customs treatment and liberal foreign-investment regulations for foreign assembly plants operating on Mexican territory. These assembly plants, known as *maquiladoras,* may be 100-percent foreign-owned and managed. They can import into Mexico duty-free the raw materials, machinery, parts, and other components used in the assembly or manufacture of products, which must then be exported back to their country of origin or to a third country. Since U.S. customs regulations provide for duty-free reentry into the United States of goods assembled in another country from components of U.S. origin, duty must be paid only on those components not of U.S. origin and the value added by assembly or manufacture in Mexico.

[28] Supply and Services Canada, *The Defence Industrial Base Review 1987* (Ottawa: SuPply and Services Canada, 1987), P. 10.

[29] Col. Clement E. Lavoie, "U.S./Canada Armament Cooperation and the North American Defense IndustrialBase—A Challenge for the 1990s" (Washington DC: Industrial College of the Armed Forces, Fort McNair, 1990), p. 13.

In 1982, a major devaluation of the Mexican peso **with respect to the dollar** made production of **labor-intensive goods in Mexico highly attractive, resulting in a tripling of the size of the duty-free assembly program between 1982 and 1988. Today, some 1,795 *maquiladoras* annually** generate more than $12 billion in products and over $2 billion of value-added income for Mexico. The majority are foreign-owned, primarily by U.S. companies but also by firms from Japan, Sweden, France, Canada, Taiwan, Hong Kong, and Korea.[30]

Several U.S. defense contractors have established *maquiladoras in the* border area for the production of wiring harnesses and PC boards for missiles, radars, aircraft, and telecommunications equipment, including Emerson Space, GE Aerospace, Stuart-Warner, General Dynamics, TRW, and Westinghouse. Some more diversified defense contractors, such as Rockwell International, use Mexican assembly plants for commercial rather than defense business: Rockwell's four plants produce controllers for machine tools and data modems for fax machines.[31] Still, the plants owned by U.S. prime contractors may only be the tip of the iceberg. Numerous second-and third-tier suppliers of defense components may also operate ***maquiladoras*, although such dual-use production is difficult to track**

The governments of the United States and Mexico are currently negotiating a free trade agreement that would eliminate restrictions on the flow of goods, services, and investment between the two countries. A North American free-trade zone encompassing the United States, Canada, and Mexico would constitute the world's largest market, with annual production totaling more than $6 trillion and almost 370 million consumers. U.S. objectives in the negotiations with Mexico include a reduction of tariffs to zero over a period of years, the elimination of most nontariff barriers on goods and services, an open investment climate, and full protection of intellectual property rights.[32] The proposed agreement has become highly controversial in Congress: advocates contend that it would stimulate economic growth and increase net employment on both sides of the border, thereby promoting political stability in Mexico; opponents counter that it could cause severe job losses in the United States, accelerate the decline of ailing U.S. manufacturing industries, and lead to severe industrial pollution along the U.S.-Mexican border.

If negotiated, a free trade agreement with Mexico would accelerate the current integration of the U.S. and Mexican industrial bases.[33] Both the U.S. and Canadian governments are concerned, however, that a U. S.-Mexican free trade agreement might enable third countries to use Mexico as a staging area for a new surge of exports to North America, performing minimal assembly work in Mexico in order to gain duty-free access to U.S. and Canadian markets. In order to rule out this possibility, the United States plans to negotiate strict rules of origin that will reserve preferential market access to the signatory countries. Furthermore, whether or not defense trade is explicitly included in a U.S.-Mexico free trade agreement, dual-use components and subsystems assembled in Mexico could be exported to the United States or Canada and then, under the provisions of the U.S.-Canadian DD/DPSA agreements, transshipped duty-free across the U.S.-Canada border. It may therefore be necessary to amend the DD/DPSA to cover such contingencies.

Policy Considerations

An important issue facing Congress is whether to promote the further integration of the U.S. and Canadian defense industries and the emerging Mexican defense industrial base. Such integration involves tradeoffs between the overall U.S. national interest in efficient weapons procurement and industrial mobilization capacity and the interests of local communities in the United States that are economically dependent on defense production. The issue of NADIB integration is also part of the larger debate over whether the Nation should place greater reliance on U.S. domestic firms or on defense-industrial interdependence with allies.

Canada is unique among U.S. allies in that it is both a leading purchaser of major U.S. weapon systems and a key supplier of subsystems, components, and materials to the U.S. defense industry. Although the Canadian defense industrial base is small, it can supply DoD and U.S. prime contractors with some products of higher quality and lower price than competing U.S. firms. Moreover, since Canada relies extensively on U.S. weapon systems, there is a large overlap in requirements between the two countries. At the same time, there is little direct competition for export sales, which complicates cooperation with the major European allies. Further, the existence of a second, technologically sophisticated defense industry on the North American continent gives the United States a valuable source of surge and mobilization capacity in crisis or war.

The objective of greater NADIB integration would be to rationalize defense production within the North American continent by enabling both countries to specialize in the areas where they are most proficient. Congress could help achieve this goal by removing some or all of the

[30] Committee for the Promotion of Investment in Mexico, An *Overview of the Maquiladora Industry in Mexico* (mimeo), January 1990, p. 3.

[31] Telephone interview with Ray Garcia, Rockwell hlt-tied.

[32] U.S. Department of State, Bureau of Public Affairs, "US-Mexico Free Trade Agreement," *gist*, December 1990.

[33] See Clark W. Reynolds, "Integrating the U.S. and Mexican Economies," *Business Mexico*, vol. 7, No. 4, December 1990, pp. 11-15,69.

existing legislative and policy barriers to free trade in defense and dual-use products between the two countries and by appropriating funds for the codevelopment and coproduction of defense equipment by U.S. and Canadian firms. The repeal of U.S. protectionist legislation might be made conditional on Ottawa's willingness to drop its offset requirements.

Such congressional action would need to be supplemented with additional measures by the executive branch. For example, the U.S. and Canadian defense departments might seek improved coordination in defense R&D policy and a more liberal policy on cross-border transfers of technology so that the research of both countries could be utilized more efficiently. Joint U.S.-Canadian industrial preparedness planning might also be expanded.

Greater NADIB integration would offer political, economic, and military/strategic benefits for the United States and Canada. First, both countries could benefit from the exchange of technological know-how in areas of complementary advantage. Second, because of geographical proximity and the high degree of commonality in the critical defense items employed by the U.S. and Canadian armed forces, security of wartime supply for both countries could be enhanced. Third, gaining access to some of the Canadian defense products now excluded from the U.S. market by protectionist legislation could enable DoD to obtain items of superior quality or reduced cost.

Greater NADIB integration would entail some drawbacks, however. First, at a time of shrinking defense budgets, awarding defense contracts to companies across the border would be politically difficult for either government if domestic firms are hurt. Second, there are clear political limits to integration. Canada and the United States are both sovereign nations with their own interests, foreign policies, and public laws, which would have to be respected in any bilateral arrangements.

Opponents of greater NADIB integration argue that Congress should seek to minimize the adverse effects on the U.S. economy of defense-spending cuts by adopting a "Buy American" policy that would close the U.S. defense market to Canadian firms. Such protectionist measures would enable U.S. companies to preserve a larger share of a shrinking defense market, ensuring that taxpayer money allocated to defense is reinvested in the U.S. economy and American jobs. Nevertheless, a unilateral cutback in defense industrial cooperation with Canada would have a negative effect on overall U. S.-Canada relations. Conceivably, it could provoke retaliatory actions by the Canadian Parliament, such as the refusal to purchase major U.S. weapons systems in the future or even calls for the repeal of the Free Trade Agreement.

Increased defense-industrial integration with Mexico would also have benefits and costs. On the plus side, relocation of labor-intensive manufacturing and assembly operations to Mexico could enable U.S. defense contractors to lower their labor input expenses and thereby reduce overall procurement costs to DoD. On the minus side, some U.S. manufacturers (particularly at the subtier level) will have difficulty competing and may thus be forced out of the defense business. Further, greater reliance on Mexican assemblers might entail some risk to security of wartime supply.

As a practical matter, however, the shift of some defense manufacturing and assembly work to plants based in Mexico would probably have little adverse effect on the ability of the U.S. defense industry to mobilize in a crisis. Because of stringent military specifications and restrictions on classified work manufacturing and assembly in Mexico is likely to remain limited to labor-intensive production of noncritical dual-use items, such as subassemblies and subcomponents.

Appendix B
Industrial Base Models and Databases

Introduction

Access **to** accurate and timely information and analysis on the defense technology and industrial base (DTIB) will be essential to manage the transition to a downsized yet efficient base. Although the various Services and defense agencies have constructed databases and models aimed at fulfilling their specific missions, these efforts have been uncoordinated. As a result, it is difficult to obtain a broad overview of the national defense-industrial capabilities and requirements in particular sectors (e.g., electronics). Moreover, while the quality of available data may be good at lower levels, the data are not presented in a form or at a level of aggregation useful to national decisionmakers.

In addressing this problem, it will first be necessary to decide what types of information and models are needed for national DTIB policymaking and how much the Nation is willing to pay for this analytical capability. Since the majority of analysts working on this problem agree that it would be costly and time-consuming to collect and enter large amounts of information into a single integrated DTIB database, it would be preferable to find ways of coordinating the existing databases and to make better use of current industrial base models than to develop any major new capabilities. While networking among databases is now technically possible, such an approach would require major procedural changes.

This appendix reviews the major DTIB models and databases for defense manufacturing data, outlines some steps for improving overall database and modeling capabilities, and considers future approaches for providing key decisionmakers with accurate and timely industrial-base information. Many of these issues were examined in detail at a North American Defense Industrial Base Organization (NADIBO) Industrial Base Data Workshop.[1] To gain further insights into the issue of defense industrial database and model needs and current capabilities, OTA sponsored a l-day workshop on DTIB information requirements and capabilities. Participating in the OTA workshop were analysts involved in model development, senior officials from the Department of Defense (DoD), the Department of Commerce, and the Federal Emergency Management Agency (FEMA), and congressional staff members.[2]

Current Models and Databases

Individual military organizations and commands have developed a number of computer models and databases to support DTIB decisionmaking and to keep track of vendors involved in the acquisition of particular systems (see table B-l). Some of the recent models, including the Joint Chiefs of Staff's Joint Industrial Mobilization Planning Process (JIMPP), FEMA's Resolution of Capacity Shortfalls (ROCS), and the Office of the Secretary of Defense's Defense Industrial Network (DINET), incorporate a hierarchy of submodels of industrial sectors and subsectors, along with databases, making it possible to assess the ability of selected industrial sectors to meet the military demands for a specific crisis or wartime scenario. Collecting and updating the data needed to keep these systems current is difficult and costly, and in many cases has not been adequately supported.

The JIMPP model developed for the Joint Chiefs of Staff has been constructed to deal with DTIB issues both at the level of industrial sectors and individual firms. It is the most ambitious and sophisticated of all of the models shown in table B-1 in its ability to deal with the defense industrial requirements of a given scenario. JIMPP has been used to support DoD mobilization exercises and analysis of the national stockpile. Its principal drawback is the lack of accurate data on the ability of specific industries to produce goods during an emergency. The ROCS model is currently being expanded and made more flexible. This upgrade will make the output of ROCS more comparable to those of JIMPP and allow closer coordination between FEMA and the Joint Chiefs of Staff on industrial mobilization matters.[3]

DINET differs from the others shown in table B-1 in that it is not a model and embodies no analysis or simulation. Instead it is a collection of numerous databases on suppliers and procurement activities and can be queried to extract information about a wide range of topics concerning the base. DINET has recently been revamped to provide a more complete picture of the current DTIB. It is now structured to answer questions related to: acquisitions, mergers, and takeovers; dependencies on single and foreign sources; the effects of government policies on the industrial base; surge and mobilization in crisis and war; U.S. ability to respond to and recover from natural disasters; and critical defense-

[1] North American Defense Industrial Base Organization, *Strengthening Defense Manufacturing Data: Proceedings of Industrial Base Data Technical Workshop* (Dayton, OH, Apr. 18-20, 1990).

[2] Workshop participants are listed at the front of this report.

[3] FEMA also has a new industrial base model called the Integrated Civilian Industrial Mobilization Planning Process (ICIMPP), but that model was not evaluated during the OTA workshop.

Table B-l—Models and Databases Currently in Use for Evaluating the DTIB

Model Acronym	Full name of model	Type	Proponent/User	Developer
DID	Defense Industrial Demand Model	macro	Department of Commerce, Office of Policy Analyses	in-house
DINET	Defense Industrial Network	set of databases	Office of the Undersecretary of Defense (Acquisition), Office of Industrial Base Assessment (DoD)	Systems Research and Analyses Corp. and in-house
EDIO	Energy Disaggregate Input/Output Model	macro	Department of Commerce, Office of Policy Analyses	in-house
IMAP	Industrial Mobilization Analytical Process	macro, multiple	Army Material Command, Industrial Engineering Activity	General Research Corp.
JIMPP	Joint Industrial Mobilization Planning Process	macro/micro, multiple	Joint Chiefs of Staff-J4	Institute for Defense Analyses
MAX DSS	Maximum Army Expansion Decision Support System	micro, multiple	Army Material Command, Industrial Engineering Activity	in-house
NAVEASY	Navy Economic Analysis System	macro/micro	NavSea Shipbuilding Support Office	in-house
NIIS	National Infrastructure Information System	general, multiple	Federal Emergency Management Agency	in-house
ROCS	Resolution of Capacity Shortfalls	macro	Federal Emergency Management Agency	in-house
STIM	Systems Dynamic Model For Testing Industrial Mobilization	macro/micro, general	Army Material Command, Industrial Engineering Activity	General Research Corp.
TASCFORM-MOBE	Technique to Assess Comparative Force Mobilization	micro/macro	Office of the Secretary of Defense, Program Analyses and Evaluation, and Office of the Undersecretary of Defense (Acquisition)	The Analytic Sciences Corp.
TASCMAIN	Technique for Assessing the Capability to Mobilize American Industry	macro, multiple	Office of the Secretary of Defense	The Analytic Sciences Corp.

SOURCE: OTA Defense Industrial Base Database Workshop, 1990.

related technologies. Nevertheless, DINET is not currently capable of providing a comprehensive view of the manufacturing subtiers or the ability of the base to respond to emergency requirements.

Problems With Current Models and Databases

Officials attending the OTA workshop expressed dissatisfaction with available models, data, and collection plans. Some specific problems were noted:

- **Most of the current models are not linked to one another, limiting their usefulness beyond those specific problems for which they were designed.**
- **All DTIB models are short of data because data collection efforts are generally underfunded and are not standardized.**
- **There are major differences in the methodology and rigor with which industrial preparedness data are collected and validated. Each Service and model developer independently collects and evaluates its own data according to its own procedures, including** questionnaires, interviews, solicitations, and other methods.

From a technical standpoint, there is no reason why the models and databases cannot be linked and the data standardized. But in order for such integration to occur, the organizations that possess the models and data would have to cooperate. Currently, most of these organizations see few incentives to do so. As issues become more global and cross departmental boundaries, however, cooperation becomes more essential.

Solving the Problems

At the **OTA workshop, participants made the following observations and recommendations.**

Senior decisionmakers need to specify what types of DTIB information they need. The types of information required by officials varies depending on their level and responsibilities. For example, in a crisis the Secretary of Defense would be interested in the overall ability of the DTIB to respond and support overall U.S. military objectives. This broad question would then be broken down into specific questions about the production of U.S.

weapon systems, critical components, and the extent and projected duration of the crisis. Program managers and contractors also require an indication of the priority of weapon systems for surge and mobilization in the particular contingency.

Because DTIB information requirements can be large, there is a need to develop priorities on what types of data are essential to gather and maintain. Several methods for identifying weapon system development and procurement priorities have been established within DoD. For example, the Commanders-in-Chief's Critical Items List (CINC-CIL) identifies those weapon systems that the CINCs determine are essential for achieving their wartime missions. The Master Urgency List (MUL) prepared by the Office of the Secretary of Defense (OSD), sets overall priorities for procurement. The Weapon Systems Essentiality Code is used by the Defense Logistics Agency to ensure maximum supply support for high priority weapons in the field. Finally, the Key Asset Protection Plan (KAPP), maintained by U.S. Forces Command, contains the names and addresses of contractor facilities that the Services and Defense Agencies view as essential for defense production and thus should be protected by U.S. military forces against sabotage. These various indicators of priority are by no means exhaustive, nor may they be the best for industrial base planners to use in developing data collection plans. OSD, in conjunction with the CINCs and the other defense agencies, should therefore perform a thorough analysis of these various systems to determine their relevance for defense industrial responsiveness in a crisis, as well as peacetime development of weapon systems and other DTIB requirements.

To date, a high-level commitment to obtaining data on the DTIB has been lacking. A good example is that the most recent input/output table of the U.S. economy published by the Census Bureau describes the economy as it existed in 1977, making it of historical interest but of little practical value to DTIB planners. Moreover, while the Census Bureau collects extensive corporate data that could be used to answer many DTIB questions, under Title 14 of the U.S. Code requiring the protection of proprietary data, the Census Bureau is prohibited from making this information available to other U.S. Government agencies for analytical purposes. Solutions to the problem of obsolete data include: more funding for data gathering, greater reliance on the Commerce Department to provide analytical support, and a proprietary information security system.

Current DTIB databases and models concentrate on prime contractors for weapon systems and major subcontractors. Monitoring the health of subtier suppliers is difficult and has been neglected in current databases. Since many of these firms provide important spec ialized technology, however, keeping track of selected capabilities is important. Several participants in the OTA workshop argued that it would be too costly to establish and maintain a complete database on subtier suppliers of parts and subsystems, and that such data should be gathered only for critical items. This observation again points to the importance of developing priorities for data collection.

Participants in the OTA workshop concluded that DoD organizations and Canada (as part of the North American Defense Industrial Base) should collectively adopt a standard weapon system coding scheme to support analyses, acquisition decisions, and industrial preparedness planning. Most current data have been collected without the use of any standard definitions or formats, making it difficult to know the mcaning of a given data element and virtually impossible to cross-reference information in different databases. The result is a "Tower of Babel" of databases that cannot communicate with one another. The lack of a common identification scheme also limits DoD's ability to assess the capabilities of subtier suppliers. If the Joint Chiefs of Staff employed a coding scheme to identify equipment for the CINCs' Critical Items List, it would significantly improve the information available for DTIB assessments.

Mechanisms must also be created for improved coordination among databases. Much of the DTIB information required by decisionmakers is already contained in a variety of databases developed and maintained by the individual Services, the Defense Logistics Agency, the Office of the Secretary of Defense, and the Joint Chiefs of Staff. Technology currently exists for networking databases installed indifferent types of computers. Since each database has a "dictionary" describing the data it contains, it should be possible to interlink these dictionaries to permit cross-referencing among databases. Thus, instead of creating a new centralized database at enormous cost, data from existing dispersed databases could be exchanged in a coordinated fashion.

Summary

Achieving either of the **DTIB objectives of responding to crisis or producing affordable weapons in peacetime requires information and analytical modeling support. OTA workshop participants indicated that models and databases exist at various levels to support many of DoD's information requirements. There is a need for high-level officials to determine what types of DTIB data are essential for decisionmaking and to support data collection and maintenance. Any new effort should make use of existing models and databases rather than starting over.**

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