Chapter 1

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INTRODUCTION

The transformation of the global security environment is causing sweeping changes in the U.S. defense technology and industrial base (DTIB). The collapse of the Soviet military threat, which drove U.S. defense planning and spending for 40 years, combined with the urgency of domestic problems and the spiraling budget deficit, have generated pressures to reduce the defense budget by a third to a half over the next decade. Yet the Persian Gulf War illustrated the continuing need for an effective U.S. military establishment, supported by a smaller but still robust DTIB.

Cuts in funding for defense research, development, production, and maintenance could impair the ability of the base to meet future national security needs unless the cuts are accompanied by changes in how the base is structured. As a result, the Nation needs to develop a comprehensive strategy for managing the downsizing of the DTIB while preserving the core capabilities essential for the development, production, and maintenance of major weapons and defense equipment. The broad outline of such a strategy was examined in an earlier OTA report, *Redesigning Defense (See* box l-A.), and in three background papers.[1] ***The*** previous report described some desirable characteristics of the future DTIB, which are listed in table 1-1. This report elaborates on the findings of the earlier OTA publications and examines in greater detail the specific policy choices involved in restructuring the DTIB over the next decade.

Implications of Defense Budget Cuts

Both the administration and Congress appear to be preparing for major, long-term reductions in defense spending. The administration's fiscal year 1993 Department of Defense (DoD) budget request is for $267.6 billion in budget authority and $272.8 billion in outlays—a 7-percent reduction after inflation from the fiscal year 1992 spending level. The DoD projects that by 1997, budget authority will fall below $240 billion in constant 1992 dollars. (See table 1-2.)[2] Many members of Congress have proposed even deeper cuts.[3] By the end of the decade, the defense budget could well be between $180 and $220 billion in 1992 dollars. Even these projected cuts may be conservative given the continuing decline of the immediate military threat, the growing Federal budget deficit, and competing social priorities.[4]

Reductions in defense spending are likely to affect procurement accounts more than other budget areas. The fiscal year 1993 budget request, for example, put a cap on B-2 bomber production at 20, terminated the SSN-21 Seawolf attack submarine with the lead boat, shifted the focus of the Army Comanche helicopter program from full production to building prototypes and developing subsystems, and terminated or reduced a host of other weapons.[5] A recent Congressional Budget Office report concluded that future budget cuts would leave little room for new weapon programs in the near term.[6] Further, DoD funding for procurement is likely to be constrained by competing demands. For example, the House Armed Services Committee noted in its fiscal year 1990 authorization report that compli-

[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); *Redesigning Defense: Planning the Transition to the Future U.S. Defense industrial Base,* OTA-ISC-500 (Washington, DC: U.S. Government Printing Office, July 1991); *American Military Power: Future Needs, Future* Choices, OTA-BP-ISC-80 (Washington, DC: U.S. Government Printing Office, October 1991); *Lessons in Restructuring Defense Industry:* The *French* Experience, OTA-BP-ISC-96 (Washington, DC: U.S. Government Printing Office, June 1992).

[2] Secretary of Defense Dick Cheney, *Report of the Secretary of Defense to the President and Congress* (Washington, DC: U.S. Government Printing Office, February 1992), p. 21.

[3] Eric Schmitt, "Move to Shift $15 Billion from Military Gains Support in House," New *York Times,* p. A12, reports that Congressman Les Aspin has proposed a $91 billion cut from the budget by 1997.

[4] OTA's assessment of opportunities for economic conversion has recently been published in a report that addresses many of the problems of economic adjustment. U.S. Congress, Office of Technology Assessment, *After The Cold War: Living with Lower Defense Spending,* OTA-ITE-524 (Washington, DC: U.S. Government Printing Office, February 1992).

[5] Cheney, op. cit., footnote 2, p. 25. These proposals are all being hotly debated, particularly the termination of the Seawolf.

[6] Congressional Staff Memorandum, *Implications of Additional Reductions in Defense Spending,* Congressional Budget Office, October 1991.

Box l-A— OTA's Redesigning Defense *Report*

Redesigning Defense described the defense technology and industrial base (DTIB) and current pressures to reduce it, and developed a framework for debating the size and structure of the future base. The report postulated some desirable characteristics of a future base, described the broad strategic choices that the Nation faces regarding the future base, and outlined tactical decisions that could be made to support the transition to the future base. The report's key findings are outlined below.

Definition of the DTIB-The defense technology and industrial base is defined as the combination of people, institutions, technological know-how, and facilities used to design, develop, manufacture, and mnaintain the weapons and supporting defense equipment needed to meet U.S. national security objectives.

The DTIB consists of three broad elements—research and development (R&D), production, and maintenance. Each of these has a private and a public component. The DTIB can also be divided into tiers —prime contractors, subcontractors, and parts and raw-material suppliers-and into different industrial sectors. While the DTIB is often discussed as if it were an independent entity, it is really interwoven with the Nation's civilian technology and industrial base and, increasingly, with the global economy.

Current Base Conditions-The report noted that although the DTIB has produced some outstanding weapons, as demonstrated in the Persian Gulf War, it has serious weaknesses that limit its ability to support future national defense needs for peacetime production and crisis response. Other studies have documented the problems of the high cost of weapon systems, growing dependence on foreign sources for critical components, and the Shrinkl"n g number of defense subcontractors.

Desirable Characteristics of the Future Base-To avoid a weakened and potentially crippled DTIB, it is important to set goals for the future base. OTA suggested a list of desirable characteristics for a future DTIB as a guide for planning. These characteristics are outlined in table 1-1 of the text.

Broad Strategic Choices-The Nation needs a long-term strategy for identifying and maintaining critical facilities, technological know-how, and people needed to develop, manufacture, and maintain future systems. The Nation faces some broad strategic choices that will shape the future DTIB. Ad hoc decisions, made in lieu of a strategy, will result in a weak DTIB that will undermine the Nation's defense.

Autonomy v. Interdependence- 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 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 advances.

Arsenal System v. Civil Integration-A second choice relates the internal structure of the future base. On one hand, the Nation can rely on "arsenals," i.e., government or privately-owned, sole-source producers of particular military systems. On the other hand, the Nation can modify military requirements to allow much greater use of technologies in the civilian sector. In the absence of deliberate choices, the DTIB is likely to evolve towards an arsenal structure, since current procurement laws impede civil-military integration and shrinking production will lower the number of private defense contractors, thereby reducing competition,

Current Capability v. Future Potential—A third choice concerns the allocation of resources between current military capability and future military potential. Although some deployed capability is needed for future theater conflicts, the greatly reduced threat of a major global conflict allows a shift of funding away from production toward research and development.

Tactical Decisions-Besides the broad strategic choices mentioned above, the Nation needs to make tactical decisions to ensure that the future DTIB has the characteristics, outlined above, that are needed for a strong defense. These tactical decisions concern:

. Guiding and evaluating research and development
. Protecting core competencies
* Developing human resources
. Identifying critical manufacturing areas
• Setting manufacturing priorities
. Funding surge and mobilization planning

Redesigning Defense's description of desirable characteristics and the Nation's strategic a and tactical decisions were the starting point for the current report. They were modified and extended as this second report developed.

Table l-l—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.

ance with environmental legislation will cost the DoD $5 to $10 billion over the next 5 years.[7]

A recent DoD report on the defense industrial base noted, in something of an understatement, that ''the consequences of DoD budget reductions will be one of the most important issues facing defense contractors in the 1990s. ”[8] Individual defense firms will need to restructure, and some face challenges to their survival. The government portion of the DTIB must also restructure as government-operated arsenals, depots, and laboratories are faced with the new national security and fiscal realities.

The DoD has asserted that its budget request reflects a new approach to defense acquisition, featuring:[9]

- heavy emphasis on government-sponsored R&D to maintain America's technology base;
- more reliance on prototyping, advancing to full production only after thorough testing and demonstration of a "critical' requirement;
- greater attention to the producibility of new systems and to manufacturing processes; and
- more reliance on upgrading and inserting new capabilities into existing platforms.

The DoD proposals embody many of the desirable DTIB characteristics discussed in *Redesigning Defense. (See* table 1-1 and box l-A.) But while these policies represent the DoD's first real response to the challenges of the post cold war era, they are not sufficient to ensure an effective future base. OTA's analysis indicates that a more detailed and integrated plan of action will be necessary if DoD initiatives are to result in a strong and healthy DTIB. What is missing from the current approach is an announced strategy and an implementation plan (including budget considerations) that links these and other policies to ensure the ability of the DTIB to meet the Nation's future national security needs. Such an integrated approach is suggested later in this chapter.

Table 1-2—Department of Defense Budget Authority (billions of dollars)

Year	Current $	Constant $	Real growth %
1985	286.8	375.6	
1986	281.4	359.1	-4.4
1987	279.5	345.7	-3.8
1988	283.8	338.5	-2.1
1989	290.8	333.7	-1.4
1990a	291.0	324.1	-2.9
1991[a]	276.0	292.9	-9.6
1992[a]	277.5[b]	287.8[b]	–1 .8
1993	267.6	267.6	-7.0
FY 1985-1993 real change:			-28.8
1994	267.8	258.0	-3.6
1995	269.9	250.4	-2.9
1996	270.4	241.8	-3.4
1997	274.6	237.5	-1.8
FY 1985-1997 real change:			-36.8

a Excludes cost of Operation DESERT SHIELD/STORM. This is consistent with the 1990 Budget Enforcement Act, which exempted DESERT SHIELD/STORM spending on an emergency basis from negotiated budget ceilings set by the Executive Branch and Congress. According to the DoD, the net U.S. cost for this operation should not exceed $5.9 billion after all foreign contributions are received.

b Enacted in FY 1992 DoD Appropriations Act, The FY 1992 figure in this year's budget request ($270.9 billion) differs because it reflects proposed environmental supplemental appropriations and proposed rescission of already appropriated funds.

SOURCE: Report of the Secretary of Defense to the President and Congress, February 1992.

ORGANIZATION OF THIS REPORT

This report consists of six chapters and one appendix. Using the desirable DTIB characteristics described in *Redesigning Defense* as a starting point, the chapters analyze detailed policies for achieving those characteristics, This chapter summarizes key findings and policy issues. Chapter 2 addresses alternatives for maintaining an advanced research and development (R&D) capability. Chapter 3 discusses OTA's "prototyping-plus" strategy and

[7] House Armed Services Committee, *FY 1990 Authorization Report.*

[8] Under Secretary of Defense (Acquisition) Assistant Secretary of Defense (Production and Logistics), *Report to Congress on the Defense Industrial Base,* November 1991, p. 4-1.

[9] Ibid.

its implications. Chapter 4 describes how a future production base might manufacture quality military equipment at an affordable price in peacetime and also meet the surge and mobilization requirements of a future crisis or war. Chapter 5 discusses policy alternatives for ensuring a robust maintenance capability. Chapter 6 considers the management of a future restructured base. The appendix summarizes plans of selected allied nations to deal with changes in their defense industrial bases.

The findings of the assessment are divided into general observations that apply to most or all of the DTIB, and more specific findings relating to one or a few parts of the base. The general findings also include a discussion of three issues that cut across all the elements of the base.

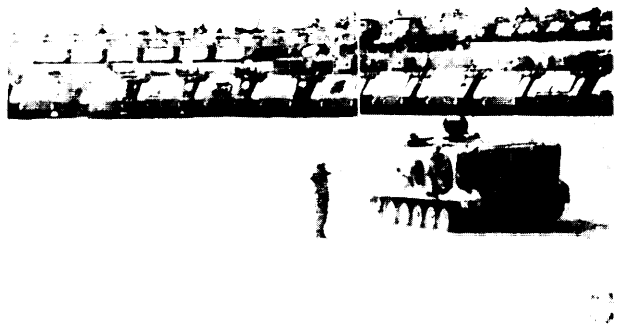


Photo credit: DoD

***The* reduced security threat of tile near future can be met largely with existing inventories of weapons.**

GENERAL FINDINGS

The capacity of the current U.S. DTIB to provide defense goods and services exceeds foreseeable national security requirements. This overcapacity is largely a result of the reduced military threat and the large inventory of military materiel on hand. However, the current base has potential production bottlenecks and shortfalls to quantity production that will be exacerbated as some producers are forced out of the defense business by cuts in funding. Reductions in capacity must therefore be undertaken with care.

Powerful military, economic, and political interests support downsizing the DTIB in a manner that allows the maximum number of current firms and organizations to survive, albeit reduced in size. Such a "proportional downsizing" would not best support the Nation's future defense needs. What is required is not just a smaller DTIB, but a restructured base with a new allocation of resources among its three main elements—R&D, production, and maintenance. The waning major military threat and large inventories of advanced weapons and equipment demand a relative shift of resources toward R&D, as has begun in recent defense budgets. The production and maintenance bases, while still important, will bear proportionally larger budget reductions.

The elements of the future DTIB must be better integrated. There must also be an integrated management approach that aims to achieve the best use of resources for the DTIB as a whole. In the past, DTIB managers have focused on achieving individual goals within their own organizations, with little attention given to the effects of these policies on the entire base. For example, R&D costs were made to appear artificially low by shifting some of the true cost of R&D to production. Government managers have **also** sought to control production costs through "spare parts breakout" (i.e., contracting production of' spare parts to a firm other than the original equipment manufacturer) and the use of second sources. The se policies, however, have reduced the funds available for full-service contractors to maintain R&D teams and facilities.

If the DTIB is to provide high-quality weapons at an affordable price in peacetime and to respond with increased production in crisis or war, it must be restructured to exploit the synergies arising from a closer integration of R&D, production, and maintenance. For example, R&D **can** be directed more toward improving production processes, and contractors can manufacture multiple products on a single production line that also upgrades older equipment. While rigid centralization is not an appropriate way to manage the future DTIB, it will be essential to develop an integrated management approach that gives priority to the needs of the entire base over those of its parts. Such an integrated approach may require reorganizing DoD oversight at the levels of the Office of the Secretary of Defense (OSD) and the individual Services to ensure an integrated approach to managing R&D, production, and maintenance. Managers a: all levels may also need incentives to take a broader view of the base. R&D managers, for example, right be evaluated in

part on their ability to promote the development of systems that can be manufactured more easily.

There may be a similar need to reorganize Congress' committee structure to improve communication among the various committees monitoring defense R&D, production, and maintenance. The structural changes in the DTIB described in this report will require a concomitant shift in thinking about what constitutes national security and the role of science and industry in maintaining it. This new paradigm will rest on a willingness to purchase knowledge rather than hardware in many cases. While standing forces are the currency of national power in a hot or cold war, military potential in the form of economic and technological strength is more important during periods of reduced military threats. Just as the Nation commits resources in peacetime to maintain divisions, air wings, and carrier battle groups against future contingencies, it must commit resources to preserve a strong DTIB.

The "pipeline" model of acquisition, which shapes current procurement policy and focuses on products rather than manufacturing processes, will be counterproductive in the future. Instead, flexibility in development and manufacturing will be essential. The automatic link between development and production could be broken so that the basic criterion for management success is not to produce a new system against all odds, but to develop new capabilities that only sometimes take the form of new hardware.

The current debate over maintaining a warm production base is incorrectly framed; the real issue is how to maintain a "warm capability. " Such a capability can provide for the future development and production of new systems. Changing the terms of the debate in this way would provide the opportunity to identify the defense industrial sectors in which R&D alone is sufficient, those in which warm production lines must be preserved, and those in which other alternatives may exist,

Legislative and regulatory barriers impede civil-military integration. Current laws on defense acquisition aim to give a maximum number of companies access to public funds, while also ensuring maximum public accountability in the use of those funds. A negative effect of this approach has been to impose different regulatory and accounting rules for civil and defense activities, forcing firms to isolate their defense work from their civilian work. As the DTIB shrinks, this approach might be reexamined. Critics argue that greater integration between civil and military production would actually improve access by increasing the number of firms willing to do business with the DoD. This increase would in turn provide greater opportunities for competition and reduce the need for extraordinary government actions to ensure accountability. Although several DoD programs have sought to transfer more oversight responsibility to defense firms, these programs have often failed because of a lack of long-term support from the DoD acquisition community.

Since the DoD is unlikely to beat the forefront of all defense-relevant product and process technologies, it should establish priorities for which technologies it wishes to pursue. Defense-relevant technologies are increasingly developed in the civil sector and by other countries. The DoD needs to track these developments and to take advantage of them.

Cross-Cutting Issues

Some issues confront policymakers with common challenges across the DTIB. Three of these crosscutting *issues—human resources, facilities,* and *technology*---will be key to whether the United States has a strong DTIB in the 21st century.

Human Resources

People are the single most important ingredient of the DTIB. They provide the knowledge to conceive of and build new systems, devise and improve manufacturing processes, and manage the base. To retain a healthy DTIB, the Nation must therefore retain high-quality technicaI and managerial personnel, encourage them to improve their skills, and attract new people. Even more important than individuals are teams with special know-how that is passed down over decades, such as aircraft design teams and missile production groups, The continuity of such teams is critical to technical advancement and the Nation's future military capabilities. Yet private companies and government organizations are slashing personnel and training programs to remain competitive or simply to survive economically.

The objectives of a future DTIB human-resources policy should not be to retain the

maximum number of people currently employed in the defense industry but to ensure that individuals and teams with essential skills are preserved, and to help those who leave the DTIB to maintain relevant skills in the civil sector. The strategy for preserving skills (both individual and team) depends on the industrial sector. Electronics skills, for example, can be maintained in the civilian base with little government intervention. In contrast, since submarine production and munitions design are not performed in the civilian base, specific actions will be needed to preserve know-how in these areas.

Facilities

The cold war mobilized a significant portion of private industry and expanded the government's military research, production, and maintenance facilities. The end of the cold war requires the demobilization of many private and government facilities. Facilities can be replaced more easily than people, but some facilities are unique and not easily replicated once closed, including large dry docks, aerospace test facilities, special laboratories, and maintenance hangars. Nevertheless, the limitations on new production and maintenance work will make it costly for the Nation to maintain duplicate facilities. It will therefore be necessary to decide when to consolidate to a single facility, when to maintain more than one, when to rely on allied capabilities, and when to close a unique facility and adopt an entirely different approach to meeting a national security need.

The objective of a facilities strategy should not be to maintain current capacity, but to ensure the proper mix and size of future DTIB facilities. How this is done will vary by industrial sector and technology. The government may have to intervene to preserve militarily unique facilities for tank assembly, nuclear submarines, and ammunition. Technologies and industrial sectors with more civil applications (e.g., electronics, fasteners, and clothing) can probably be maintained entirely in the civil sector. Even so, this approach would require changes in DoD acquisition policy such as eliminating overly rigid military specifications and designing military systems to allow use of commercial components. Critical and unique facilities might be preserved either by allowing them to be used profitably in the private sector or by converting them into government-owned, contractor-operated (GOCO) facilities or government-owned, government-operated (GOGO) facilities. OTA's analysis suggests that many critical facilities can be maintained by encouraging greater civil-military integration or by concentrating activities at a few select facilities.

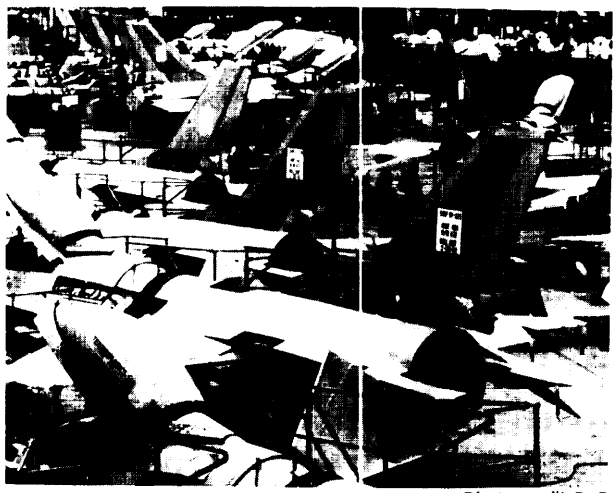


Photo credit: DoD

Production facilities built to meet the needs of the cold war are in excess of current requirements.

Technology

Advanced technology remains critical to the Nation's military strength. But the narrow focus on battlefield performance during the cold war should give way to a broader approach that takes account of defense manufacturing and maintenance issues and economic security. The cold war spurred an outpouring of U.S. technological innovations aimed at outperforming a quantitatively superior enemy on the battlefield and building a strategic nuclear deterrent. In the future, military innovation might be sustained with relatively less funding and reorganized to take advantage of scientific and technological advances in the U.S. civil sector and abroad. Policymakers will also need to identified technologies with the potential to solve national security problems (the aim of the congressionally mandated Critical Technology Plans) and make a long-term commitment to fur ding their development.

National Choices

In a general sense, the chief defense-management challenge of the next decade will be to maintain the U.S. advantage in defense-related technology and to produce high-quality military hardware on a much smaller defense budget. There are different ways of

Photo credit: Lockheed/Sanders

A technician prepares gallium arsenide semiconductor wafers for a final manufacturing step. Such technologies will be crucial to future military capability.

organizing the future DTIB to achieve these goals. The alternative policies involve strategic choices, as described in the earlier OTA report *Redesigning Defense. (See* box l-A.) Further analysis by OTA has led to refinement of these strategic choices, as indicated by the decision tree in figure 1-1. The strategic choices at each fork in the tree are not absolute but merely suggest general tendencies. For example, the United States might emphasize R&D and prototyping for most weapons systems, while still keeping some items in production at any given time to modernize selected portions of its forces.

The first choice for the Nation is between current and future military capabilities. To the extent the United States faces an immediate military threat, the DoD will need to allocate funds for current capabilities. If the immediate threat is reduced, however, the DoD has the option to shift funds to the development of military potential. The administration's fiscal year 1993 budget proposal made a tentative move in this direction by calling for a small real increase in R&D funding, a 13-percent decrease in procurement, and the cancellation of several production programs.

Subsequent choices are:

1. between dual-use and militarily unique technologies (both product and process);
2. between private and public ownership;
3. between competitive procurement and single sourcing; and
4. between reliance on domestic and international sources.

The decision tree outlines some of the reasons for making each of these choices.

For much of the military materiel required by the DoD, OTA's analysis suggests that for reasons of cost, total capacity, and potential for innovation, the path defined by chosing dual-use technologies, private ownership, and competitive acquisition is preferable to alternate paths. Nevertheless, in some cases other paths may be necessary because of unique military performance requirements or manufacturing processes (e.g., for production of ammunition and nuclear submarines), or technology security (e.g., for nuclear weapons).

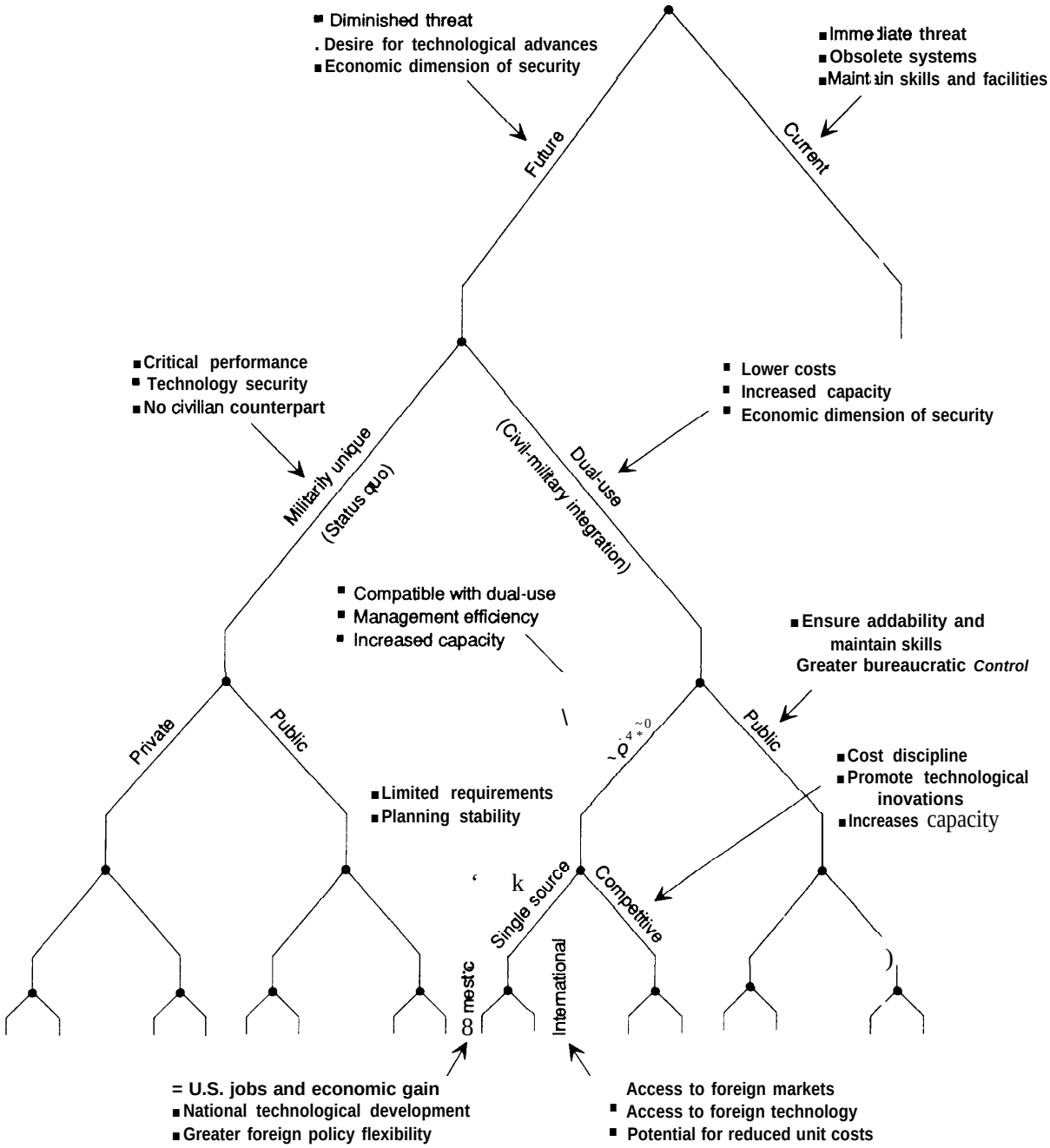
Following the dual-use/private/competitive path would require a number of changes in current U.S. laws and regulations, including the adoption of accounting and manufacturing practices that do not isolate defense from civil production, a change in the profit/risk ratio for private-sector defense work, and an emphasis on flexible performance specifications rather than rigid military specifications for products and manufacturing processes.

Finally, there is a choice between national autonomy and international cooperation. OTA's analysis confined that this choice is important but is subordinate in most cases to other choices. In the new security environment, the government will need to ensure that the benefits of international arms collaboration, sales and purchases are weighed against the potential drawbacks.

SPECIFIC FINDINGS

The discussion below focuses on the desirable characteristics of the future DTIB (see table 1-1) and the policies for achieving them. It is important to keep in mind that these characteristics should be viewed as an integrated set. Policies developed for the R&D and maintenance **elements**, for example,

Figure I-l—Strategic Choices for the Future DTIB



SOURCE: Office of Technology Assessment, 1992

will affect the health of the production base. A discussion of the integrated future base follows a description of the R&D, production, and maintenance elements.

Research and Development

Redesigning Defense stressed the importance to future national security of an advanced R&D capability that can 1) maintain qualitative weapon performance superiority against potential adversaries; 2) create opportunities for innovation and hedge against technological breakthroughs by opponents; and 3) support the Nation's overall economic strength, which is ultimately the source of its military strength.

An advanced defense R&D capability includes world-class personnel (individuals and teams); cutting-edge research that guards against technological surprise; robust efforts in critical technologies; a balance between the near-term technology needs of each Service and long-term U.S. defense needs; strong links to manufacturing, so that proposed weapon systems are producible; and integration with civilian R&D, even in the absence of a national consensus on directed federal support for civil technology programs.

Both the Administration and Congress have expressed a desire to support defense R&D. The DoD's current budget request contains a shift in relative emphasis toward R&D. Over the long term, however, the military R&D base will almost certainly shrink. Funding is expected to drop in real terms from around $40 billion today to $25 to $27 billion (in 1992 dollars) by 2001. Moreover, the DoD will have to pay explicitly for defense R&D rather than follow the past practice of funding it partially through production,

Without offsetting actions, funding reductions will result in disproportionate cuts in defense R&D performed by private industry. Direct R&D contracts to industry will decline, and lower procurement budgets will also reduce companies' willingness to invest their own money in R&D. DoD support for research in colleges and universities could also decline as the defense budget shrinks. As a result of these trends, the DoD will not have the benefits of some leading-edge research by industry and universities that it has enjoyed in the past. The DoD will also have less of a chance to familiarize the next generation of scientists and engineers with the Nation's defense needs. A national DTIB strategy should compensate for this trend by providing proportionately more direct support for private-sector R&D than in the past, and by maintaining funding of university basic research.

Present Service plans to consolidate R&D activities do not adequately meet the need for a major restructuring of the defense R&D base. A defense R&D base that is smaller and has a new mission will also need a different organizational structure. Current and proposed plans to consolidate the Services' ungainly complex of laboratories and centers were developed before the demise of the Soviet Union. Such plans are therefore unlikely to create the integrated structure that the R&D element of the future DTIB will require. If R&D funding is not shifted to the private sector, the Service laboratories and the Federally Funded Research and Development Centers will have to shoulder much of the responsibility for research and innovation now performed by private companies. If, however, policymakers do shift R&D funding to the private sector, far more Service consolidation will be required. In any event, a smaller DTIB will necessitate greater coordination and consolidation among the Services' R&D efforts and between the Services and the private sector.

The DoD must make greater efforts to exploit civilian technology. Yet without regulatory changes, current performers of military R&D will have no incentive to improve their links to civil R&D. Three areas deserve attention. First, current rules governing independent research and development (R&D) impose barriers between military and civil R&D activities within companies. Second, current rules allowing the government full rights to corporate technical data developed with government funding discourage specialized subtier fins-a primary source of innovation in defense systems—from developing technologies for both civil and military use. Third, reduced funding will preclude the DoD from maintaining world leadership in all defense-relevant technologies, increasing the need for the United States to benefit from R&D efforts in other countries. Yet current import and export restrictions inhibit interchange between defense and nondefense sectors and prevent the DoD from drawing on technology developed abroad, even by U.S.-based multinational firms.

Current policy places too little emphasis on improving manufacturing technologies. The DoD's effort to develop a Manufacturing Technology Plan warrants support as a way to address the current imbalance between process and product technologies. A remedy will require a new focus on manufacturing technologies by the Service laboratories and the private sector.

Prototyping-Plus

Many people now advocate prototyping in some form to maintain technology innovation during a period when fewer new weapon systems are under development.[10] A DoD acquisition Strategy that combines greater use of prototyping and limited production, along with changes in manufacturing and maintenance, might help to preserve critical design and manufacturing capabilities. As currently practiced, however, defense prototyping is narrowly focused on performance and does not usually incorporate manufacturing and maintenance considerations. As a result, it does not enable defense contractors to move efficiently into production when needed.

This report assesses a prototyping strategy that combines prototyping with limited production. Termed prototyping-plus, it would seek to promote innovation and maintain America's technological edge and its ability to deploy new generations of the most advanced military systems. Prototyping-plus would involve the continuous development and limited, intermittent production of technology demonstrators and prototypes for operational testing during the periods between full production programs. By always having some prototype programs under way, the Nation would be in a better position to move the most advanced available systems into production. At the same time, it could maintain a robust weapon design and development capability that could respond flexibly to the uncertainties of the new security environment.

A prototyping-plus strategy is an important part of an overall plan to restructure the DTIB and should break the nearly automatic link between development and production in the current acquisition pipeline. The strategy should be rooted in an understanding; of which defense-related design and manufacturing capabilities must be preserved in the absence of ongoing production. Nevertheless, prototyping-plus is not a "research-only' strategy. It includes future force modernization with advanced weapons as needed, after the development and testing of Alternative concepts. Some prototyping efforts would aim to develop improved subsystems for upgrading current platforms. Others would focus on developing new platform configurations for potential deployment in the event of a breakthrough in performance (e.g., stealth), the need to replace obsolescent equipment, or the emergence of a large-scale military threat.

Industry has raised a number of objections to pursuing a prototyping strategy. First, some firm contend that while prototypic: could preserve design teams, it would involve too few production workers to maintain manufacturing skills. Prototyping-plus, however, calls for the limited production of operational prototypes. Recent trends in manufacturing, such as greater use of co concurrent engineering and flexible manufacturing systems, increase the potential to produce limited numbers of prototypes for field testing and to preserve key manufacturing skills without quantity production. The challenge for the future will be to use the construction of a small number of prototypes to identify and correct manufacturing problems associated with quantity production.

A second criticism of a prototyping strategy is that since profits for defense contractors today come from production and not R&D, a prototyping strategy could not keep defense firms in business. This is a valid point, and in the future, prototyping activities will have to be filly funded by the government.[11] Moreover, defense contractors will not rely exclusively on prototype development for their livelihood. Instead, they might derive their income from several concurrent activities, including the low-rate production of new weapon systems; the retrofit, overhaul, and maintenance of deployed military systems; R&D; and prototyping.

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10 The administration, for example, has announced that it will *make* much more use of prototyping. Congressman Les Aspin, Chairman of the House Armed *Services Committee, has* proposed a prototyping strategy tbat he has termed "rollover-plus." OTA proposec a prototyping strategy in *Redesigning Defense.*

11 Firms *Would not, however,* be precluded from paying for their own prototyping if they believed they had an idea that would 'sell, ' but the incentives to do so might be low.

A third criticism of pursuing a prototyping strategy is that it would have a negative effect on the subcontractors and suppliers at the lower tiers of the DTIB. This objection has some merit because the volume of parts required for prototyping may be too small to keep many subtier firms in business. But new production will not cease entirely in all systems. Subtier firms will build components for continuing (but much reduced) new production, and supply parts for upgrades and retrofits of fielded systems. Many subtiers also have a diversified product line that includes nondefense markets. As a result, the number of subcontractors and suppliers at risk from a prototyping-plus strategy may be small. In some cases, key technologies may have to be acquired by prime contractors or preserved in government facilities. In addition, subtier firms will likely be consolidated into a smaller number of diversified suppliers more closely linked to primes. This restructuring will require changes in acquisition laws and regulations that currently inhibit rather than promote such long-term associations.

Implementing a prototyping-plus strategy would require more integrated DoD management and the reform of defense-procurement laws and regulations. It would also demand a change in mindset by both government and industry from the current focus on producing hardware to a new emphasis on acquiring new technology and know-how as the basis for the Nation's future military potential. A prototyping-plus strategy can help maintain the key design and manufacturing personnel required to develop the next generation of systems. But it should be a part of an overall DTIB strategy that includes continued manufacturing and a viable structure for maintaining and upgrading fielded equipment.

Efficient, Responsive, Mobilizable Production

Redesigning Defense noted that a continued strong production base is essential and suggested three desirable characteristics for future defense production:

1. it should produce weapons and military equipment efficiently in peacetime,
2. it should be responsive to a regional crisis or war perhaps through increased production ("surge"), and
3. it should be capable of greatly expanding production (''mobilization") in a timely fashion if a large global military threat emerges.

The policies needed to achieve these different characteristics may be in conflict and require tradeoffs. For example, reducing excess manufacturing capacity to promote efficient peacetime production may limit the ability of the base to meet surge requirements in wartime.

The current defense production base has considerable overcapacity when measured against anticipated military requirements. The overall procurement budget may drop by two-thirds (in real terms) from its peak in the mid-1980s. Such shrinkage requires a major restructuring of the production base. *Redesigning Defense* concluded that if this restructuring takes place haphazardly, it could create gaps in critical defense industrial sectors. The government could adopt policies to smooth the transition to a smaller but sounder production base. Alternatives for achieving the desirable characteristics of efficiency, responsiveness, and mobilizability are examined in chapter 4 and briefly summarized below,

Efficiency

Efficient production is defined as manufacturing quality products at an affordable cost. However, for the future DTIB, retaining a manufacturing skill base is also a major stated goal. An efficient defense production base must streamline individual businesses and consolidate industrial sectors. These processes are currently under way. But unplanned restructuring of the base in response to market forces risks the loss of critical production capabilities, as manufacturers shed important base capabilities such as R&D staffs and training programs. Policymakers might act to facilitate the consolidation of the production base into a few strong, quality producers rather than retaining many weak firms. To do this, they would need to identify critical producers, modify contracting practices, and change competition rules. (See table 1-3.) In the case of militarily unique sectors, such as nuclear submarines and gun tubes, it may be necessary to support a private or public arsenal to maintain a capability that might otherwise disappear.

The government should ensure that an essential capability continues to exist in the DTIB, but it might be indifferent as to whether a particular

Table I-3—Policies to Assure Efficient Peacetime Production

Base Structure
- Identify critical producers at the supplier, subcontractor, and prime contractor levels.
- Intervene in the market if necessary to save and strengthen these critical producers through sole-source production, upgrade, spare part, or repair contracts; by removing barriers to mergers and monopoly; or by creating a private or public arsenal.
- Allow consolidation of subtier producers to support innovative, dependable, quality producers.
- Move aggressively toward increased civil-military integration of the base.

Procurement Reforms
- Substitute "best value" or some similar formulation for "lowest bid" as the criterion for contract awards.
- Reexamine the rules on the protection of proprietary data rights.
- Continue the trend towards greater commercial product buys and greater reliance on commercial business practices.
- Reduce costly paperwork, data, and oversight requirements that have been created by law or by the procurement culture.
- Rationalize military specifications to emphasize final quality and performance overproduction process and use only where necessary.

Aquisition Strategy
- Mandate increased commonality and modularity in systems.
- Increase joint procurement, possibly by moving to "purple suit" procurement, specialized Service procurement, or a civilian acquisition corps.
- Fund the stockpiling or production of items not produced domestically but considered too important to continue sourcing abroad.
- Support low-rate production in critical industries through predictable, multiyear contracts.
- Fund manufacturing skills directly through scholarships, manufacturing technology apprenticeships, the creation of training centers, or indirectly through procurement and incentives.
- Support manufacturing technology developments where appropriate.

international Activities
- Reduce barriers to foreign military sales.
- Support international development and production ventures as a source of technology transfer to the United States.
- Continue to purchase essential supplies and components abroad and determine whether increased reliance on allies is in the national interest.
- Source critical foreign components from multiple countries to avoid cutoff.
- Adopt international specifications and standards where appropriate.

SOURCE: Office of Technology Assessment, 1992.

company continues to produce defense goods and services. The survival of a particular firm or organization need not drive DoD production policy in the long run. Government policies are therefore best targeted toward maintaining capabilities rather than particular companies or government organizations.

Planned low rates of production (unlike the unplanned production stretchouts that have characterized the cold war) can provide U.S. forces with a steady flow of materiel while preserving manufacturing skills, facilities, and equipment that might otherwise atrophy. A DTIB strategy that includes low-rate production will need to establish production rates at an appropriate level: one that preserves the manufacturing complex (primes and subs, private and public facilities) and provides predictable funding so that producers can make major organizational and capital-investment decisions with confidence.

Defense production during the cold war was characterized by plans to equip U.S. forces rapidly with new weapon systems by means of high production rates. In practice, however, budget constraints often lowered actual production rates, resulting in higher unit costs. More realistic future production planning will save money, although it will also reduce surge capacity

The DoD could supplement low-rate production with prototyping of follow -on systems, spare-parts production, and upgrade and maintenance work. Industrial sectors could be further consolidated so that several related products are built in the same factory (e.g., a variety of armored vehicles or aircraft), a practice common in subtier companies and in some prime contractors. The advent of flexible manufacturing techniques and organization will make this last option more practical over time.

Peacetime production efficiency will be enhanced by lowering barriers between defense and civilian production. These barirers—including special accounting requirements for defense products and stringent military specifications and standards—were created to safeguard public funds and ensure quality. But they also increase defense acquisition costs, place extra burdens on defense companies seeking to diversify into the civil sector, deter leading-edge commercial firms from participating in defense work, and obstruct the flow of technology between the two sectors. A radica1 solution would be

to absorb the defense production base into the civil base, leaving only a few militarily unique products to be built in arsenals. At a minimum, the DoD could continue its efforts to procure more products off-the-shelf and to reduce excessive oversight and specifications through management reforms that shift more responsibility to producers.

Foreign sales of American military hardware can help maintain defense manufacturing and advance U.S. foreign policy objectives. They also carry significant risks. While foreign military sales can maintain U.S. production lines and support allies, sales to unstable or potentially aggressive countries can create new security threats. Collaborative programs with allies help share R&D costs and enable the United States to gain access to foreign technologies. But arms sales often involve ''offset' arrangements that give the purchasing country a share of the development and production work, or transfer technologies that can accelerate the proliferation of advanced weapons and may eventually undermine U.S. competitiveness.[12] purchasing systems, components, and supplies abroad is already a fact of life in an increasingly global economy. But the benefits of lower costs need to be weighed against any risks to security of supply.

Finally, peacetime production efficiency can be enhanced through manufacturing innovations, including a reliance on common subsystems and parts. Manufacturers, given the right incentives, can increase efficiency by incorporating new ideas in management, organization, technology application, procedures, and training. Commonality in product subsystems and procurement practices among the Services, if pursued vigorously, would simplify logistics and lower costs,

Responsiveness

A responsive production base is one that is able to react to a crisis or war that is smaller and less demanding than a "total' war demanding national mobilization. A response to regional threats might be accomplished through some combination of surge production of key items, stockpiles, or reliance on allies. Each of these three alternatives has strengths and weaknesses. Planning to surge production of materiel when needed avoids the costs of manufacturing and stockpiling. But it entails

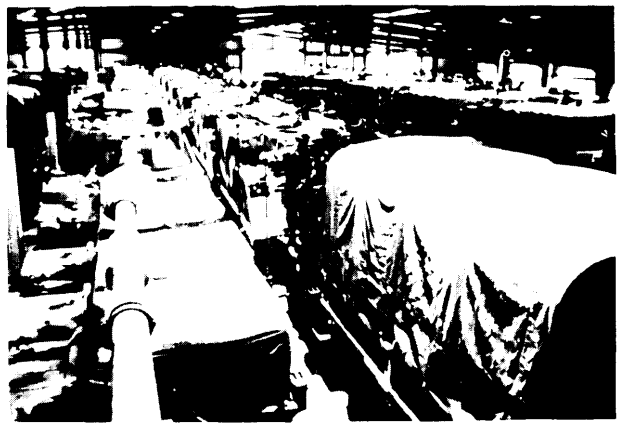


Photo credit: DoD

Substantial U.S. military materiel has been prepositioned abroad. Requirements for future conflicts must be met with a combination of production surge capability and stockpiling.

investment in excess production capacity and thus lowers the efficiency of the peacetime production base. Stockpiled military materiel has the advantage of being available on demand, but it carries manufacturing and storage costs, and it may become obsolete before it is needed. Foreign purchases may cost less but may be susceptible to cutoff or unacceptably long delivery times in crisis or war, and may hinder U.S. development of defense technologies. Moreover, most U.S. allies have small defense industrial bases and are consolidating them. Thus, they may need their own entire output if they are combatants alongside the United States in some future conflict.

The United States might best focus its surge planning primarily on consumables (e.g., munitions, food, fuel, and spare parts) for intervention in regional conflicts. For the foreseeable future, the U.S. military will probably not require a surge capacity for major weapon platforms and should not fund such a capability.

Mobilization

Responding to a major new military threat on the order of the former Soviet Union would require a mobilization of the Nation's industrial base, as occurred during World War II. Even though the likelihood of a major attack on the United States and its allies is extremely low, the large planned cuts in U.S. active forces would increase the need to

12 U.S. Congress, offic of Technology Assessment, *Global Arms Trade: Commerce in Advanced Military Technology and Weapons,* OTA-ISC-461 (Washington, DC: U.S. Government Printing Office, Jun 1991).

mobilize if a large-scale military threat emerges in the future. The dedicated defense base would serve as the core of any mobilization effort, supplemented by the domestic civilian production base, war reserve stockpiles, and allied industry.

As a result, there might be greater emphasis on mobilization preparedness planning and maintaining essential DTIB capabilities. This task will require a good understanding of the broader national industrial base and realistic estimates of available warning time. Mobilization plans should be reassessed and exercised periodically. Low-rate production, prototyping-plus, and other strategies designed to retain defense manufacturing skills are also central to mobilization preparedness. Policies that foster increased integration of the defense and civilian production bases will aid any future mobilization.

A Robust Maintenance Capability

Depot maintenance, the overhaul of military equipment in specialized facilities as opposed to routine repairs in the field, is critical to the readiness of future U.S. forces. The U.S. defense maintenance base is large ($13 billion in fiscal year 1991). It includes an organic, ''in-Service' component operated by the different Services that currently performs between 60 to 70 percent of the depot maintenance work. A private-sector component does the remainder of the work and also supplies billions of dollars' worth of spare parts, which are included in the $13 billion. The Nation needs a plan to preserve the maintenance base through the present turbulent period of force reductions, and to restructure it to support smaller numbers of more sophisticated and reliable systems. The most important choices affecting the future maintenance base are:

1. the extent of consolidation,
2. ownership and control of the base (private v. public),
3. emphasis on efficiency v. wartime responsiveness, and
4. the extent to which maintenance can be integrated into the future manufacturing base.

In-Service maintenance facilities were modernized during the 1980s, and there is general agreement that current capacity exceeds realistic future requirements. New DoD initiatives implemented as a result of the 1989 Defense Management Report are streamlining and consolidating the government maintenance base, but there is disagreement about its future structure. The Services generally seek to retain in-Service capabilities, while industry seeks to promote a greater role for the private sector.

Future depot maintenance requirements will differ from those of the past 40 years. Initially, the United States will retire many of its older weapons in response to the waning military threat, reducing the average age of equipment in the field and decreasing the near-term maintenance workload. Over time, however, the lower rate of new weapons production will increase the average age of deployed equipment and make upgrading more important. Future systems will be more sophisticated but also more reliable, changing the nature of the maintenance task and reducing maintenance requirements.

The ongoing consolidation of in-Service depot maintenance (including single sites for each technology and significant reductions in workforce) is a major achievement by past standards, but is still insufficient to meet the needs of the new security environment. Performance of maintenance tasks across Service lines remains limited. Moreover, despite reductions in manpower and consolidation of workload, the maintenance base contains almost the same number of major facilities as existed to support a defense establishment prepared for war with the former Soviet Union. While the drive for peacetime eficiency must be tempered by the need for responsiveness in a major future crisis, the foreseeable demand for wartime maintenance support has greatly diminished with the end of the cold war.

Private industry has the capability to do more depot maintenance work and is eager to assume this role. Proponents of transferring more maintenance work to private firms note that they already possess an inherent maintenance> capability by virtue of having manufactured the equipment. Further, manufacturers typically provide depot maintenance support until a system has been deployed in sufficient quantity to permit standardization of maintenance procedures by the military user. Since the manufacturing firm has already developed test equipment and trained personnel, there is an additional cost (depending on the particular system) in developing a separate Service maintenance capability. Proponents also argue that private firms are more efficient than government depots.

Photo credit: Lockheed Aeronautical Systems

A private company maintains ejection seats and other components for the T-33 jet trainer built in the 1950s. As production funding declines, private industry is increasingly interested in maintenance work.

Those who favor retaining Service maintenance capabilities contend that shifting maintenance to private fms would reduce Service flexibility, increase the risk of inadequate responsiveness in wartime, and leave the DoD vulnerable to cost escalation. Yet there is no clear evidence that private firms cannot be responsive or that private-sector costs cannot be controlled. Nor is there clear evidence that private firms are inherently more efficient than Service depots. Accordingly, there is a need for more study of the proper private-public mix in the future maintenance base.

During the downturn in production, maintenance might play an important role in supporting manufacturing capabilities in industrial sectors where there is an overlap in processes, equipment, and skills required for manufacturing and maintenance. In many cases, maintenance and upgrades could be carried out in the same factories as new manufacturing. Some industries, however, have little overlap between manufacturing and maintenance. In such cases, combining maintenance and manufacturing would require restructuring the production process to take advantage of synergies between manufacturing and maintenance on the factory floor.

Congressional actions have made the rationalization of the depot maintenance base more difficult. legislation limiting competition, directing work to particular facilities, and mandating job protection have all constrained the DoD's ability to operate the maintenance base efficiently. Properly sizing the future maintenance base will require a broader view of overall DTIB requirements and decisions designed to support the integrated base rather than its individual parts.

Good, Integrated Management

Good, integrated management is fundamental to the successful operation of the future DTIB. Such management must anticipate future needs and take action to ensure that the base can meet them at an affordable cost. Good management does not imply any particular amount of direct government intervention in the DTIB, but it does allow for intervention if needed to ensure the survival of a critical technology or industrial capability.

Future DTIB management could be integrated with respect to the three functional elements of the base (R&D, production, and maintenance), the three Services, the Executive Branch and Congress, and government and industry. Peacetime procurement could also be integrated with crisis and war planning. Integration among the R&D, production, and maintenance elements of the base would ensure that managers understand how these three elements interact and make decisions optimized for the entire base rather than an individual element or subelement. Integration of DTIB planning within the DoD and the Services can eliminate redundancies in Service capabilities (e.g., laboratories and depots) and Service-specific contractors. Several DoD initiatives are addressing these issues, but there is still much resistance to closing and consolidating facilities. The difficulty of consolidating the current base would be eased through better coordination among the Executive Branch, Congress, and private industry, since DTIB management is ultimately a national, rather than a DoD, responsibility.

Photo credit: Defense Systems Management College

The Defense Systems Management College trains government acquisition personnel responsible for billions of dollars of purchases a year.

The immediate management challenge is to plan rationally for the major shrinkage and restructuring of the DTIB. Three strategies for approaching the transition to a smaller base are discussed in chapter 6. The Nation could employ:

1, a free-market strategy that relies on market forces to decide which defense contractors and government facilities will survive,
2. an activist strategy in which the U.S. government attempts to manage the change by identifying critical firms and facilities and ensuring their survival, or
3. a mixed strategy that allows market mechanisms to operate when possible but uses government intervention to preserve critical defense industrial capabilities that might otherwise be lost.

Applying exclusively a free-market approach to DTIB management is likely to result in a weakened and inefficient base as firms shed capabilities to remain competitive. Yet the DTIB is too complex to allow detailed centralized control. Thus, an optimal approach might combine centralized planning with decentralized execution. For 40 years, the DTIB has been an increasingly regulated market with a single government buyer, so that free-market forces are unlikely to operate efficiently. Because the DTIB is part of the larger national industrial base, however, it can potentially take advantage of market forces within the larger base. Modifyng acquisition laws to open up the DTIB to a larger number" of companies would enhance the effects of market forces. But if policymakers choose to retain the current acquisition system, more government intervention may be needed to ensure that crucial elements of the base are preserved.

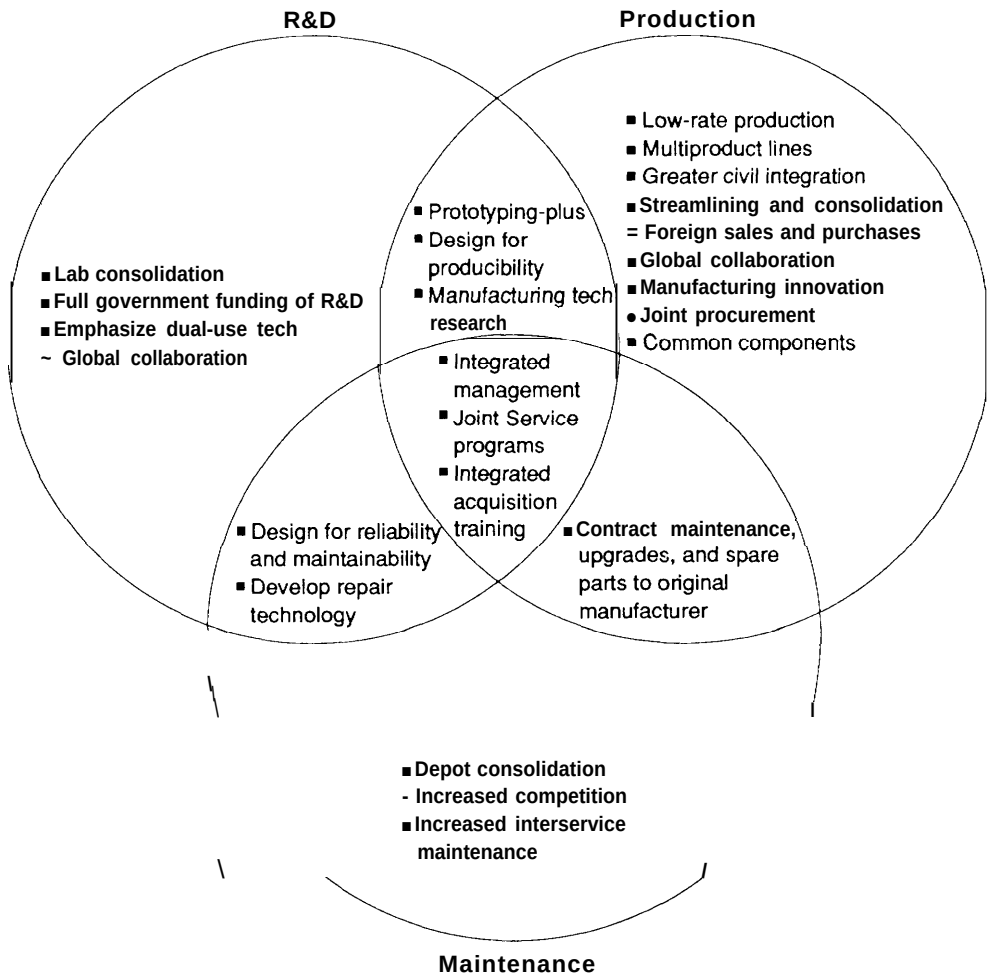
Laws, regulations, and bureaucratic behavior inhibit DTIB managers from making greater use of the civilian technology and industrial base. Future base managers will need to be more creative in using the entire range of potential technology and industrial resources, including civil and foreign fins, rather than concentrating on dedicated defense producers. Key to successful management of the future base will be the purchase of commercial products, the use of civilian production facilities, and the adoption of commercial operating procedures. Achieving such civil ad military integration will require less day-to-day DoD and Service control over technology and industria1 assets and an increased ability to make use c f the wide array of goods and services existing in the civilian sector.

THE FUTURE INTEGRATED BASE

The previous sections described desirable characteristics of the future DTIB and suggested some alternative strategies for achieving each. These characteristics cannot be viewed in isolation, but must work together for the future base to be healthy and meet the Nation's security needs.

OTA's analysis suggests that, given the likely reductions in defense budgets, minor changes in the structure and operation of the DTIB will not suffice to provide the Nation an effective future military capability. One of the principal findings of this assessment is that the base can be restructured to exploit the inherent synergies that can result from

Figure 1-2—The Future Integrated DTIB



SOURCE: Office of Technology Assessment, 1992

closer integration of the R&D, production, and maintenance elements.

The interrelationships among the three functional elements of the future DTIB-R&D, production, and maintenance—are portrayed in figure 1-2. Although these elements are largely managed separately in the current base, the figure suggests that the three elements could be structured and managed in an integrated reamer to yield greater efficiencies. For example, R&D could be directed not just to creating new products but to making the manufacture and maintenance of those products as simple as possible. Similarly, carrying out production and maintenance activities in the same factories would facilitate low-rate production.

Integration could also be carried across Service lines and between defense and civilian industry. The DoD could enforce joint Service use of common equipment (for example, air-defense systems) and ultimately eliminate all barriers between the civilian and military technology and industrial bases. It could move to a centralized acquisition corps separate from the Services, perhaps along the lines of the French model. A fully integrated industry might handle R&D, production, and maintenance, with very little of the base remaining under government ownership. Such a radical restructuring of the DTIB would require a substantial change in the attitudes of both government and industry.

Chapters 2 to 6 consider ways to exploit the synergies among activities, including prototyping-plus, low-rate production of selected military equip-

ment, restructuring of assembly lines to be more diversified and flexible, increased civil-military integration, and more competition in all three elements of the base. Yet if each of these alternatives were pursued in isolation, it would have only a modest impact and might even be detrimental to the base as a whole. For example, critics have argued that prototyping alone cannot maintain an effective manufacturing capability and would not be profitable enough to keep defense firms in business; that low-rate production of new systems would fail to provide an adequate economic return, result in high unit costs, and lead to failures among subtier producers; and that shifting more maintenance work to the private sector would reduce the responsiveness of the base to military requirements.

None of these criticisms lacks validity. Although the options suggested in this report all entail risks, so do current DTIB policies if they are simply extended into the new era of reduced budgets. The critical question is not whether the DTIB will shrink, but how best to restructure the base to assure the Nation's future security.

The following section describes the general characteristics and management activities of a future integrated DTIB. Boxes 1-B to 1-D contain a hypothetical scenario set in the year 2010 illustrating synergies among the elements of the DTIB and the implications of alternative policy choices.

National-Level Decisions

National decisions on overall defense funding and tiding priorities are based on assessments of the military threat, as well as economic and political conditions. Once the total resources to be directed to defense have been established, DTIB managers at the national level allocate them to the various national security goals and elements of the base. These funding decisions involve the strategic choices outlined earlier in figure 1-1 and require supporting policies if they are to succeed. Examples of policies associated with each of the choices are shown in figure 1-3.

In the post-cold war era of diminished immediate military threats and reduced budgets, a healthy future DTIB requires shifting funds from current production to R&D. The policies outlined in figure 1-3 indicates that a healthy base also requires a commitment to purchase *knowledge* rather than *hardware.* As noted earlier in the discussion of figure 1-1, a shift of resources to future-oriented investments will not be universal, since some systems will need to be produced to replace obsolete equipment or to respond to an emerging threat.

A decision to emphasize dual-use technologies or civil-military integration would require the DoD and the Services to increase reliance on commercial fins, provide incentives for using non-developmental items, and stress performance criteria over rigid military specifications. These policies would require greater initiative on the part of government contracting officers than is currently allowed, and therefore better trained government acquisition personnel.

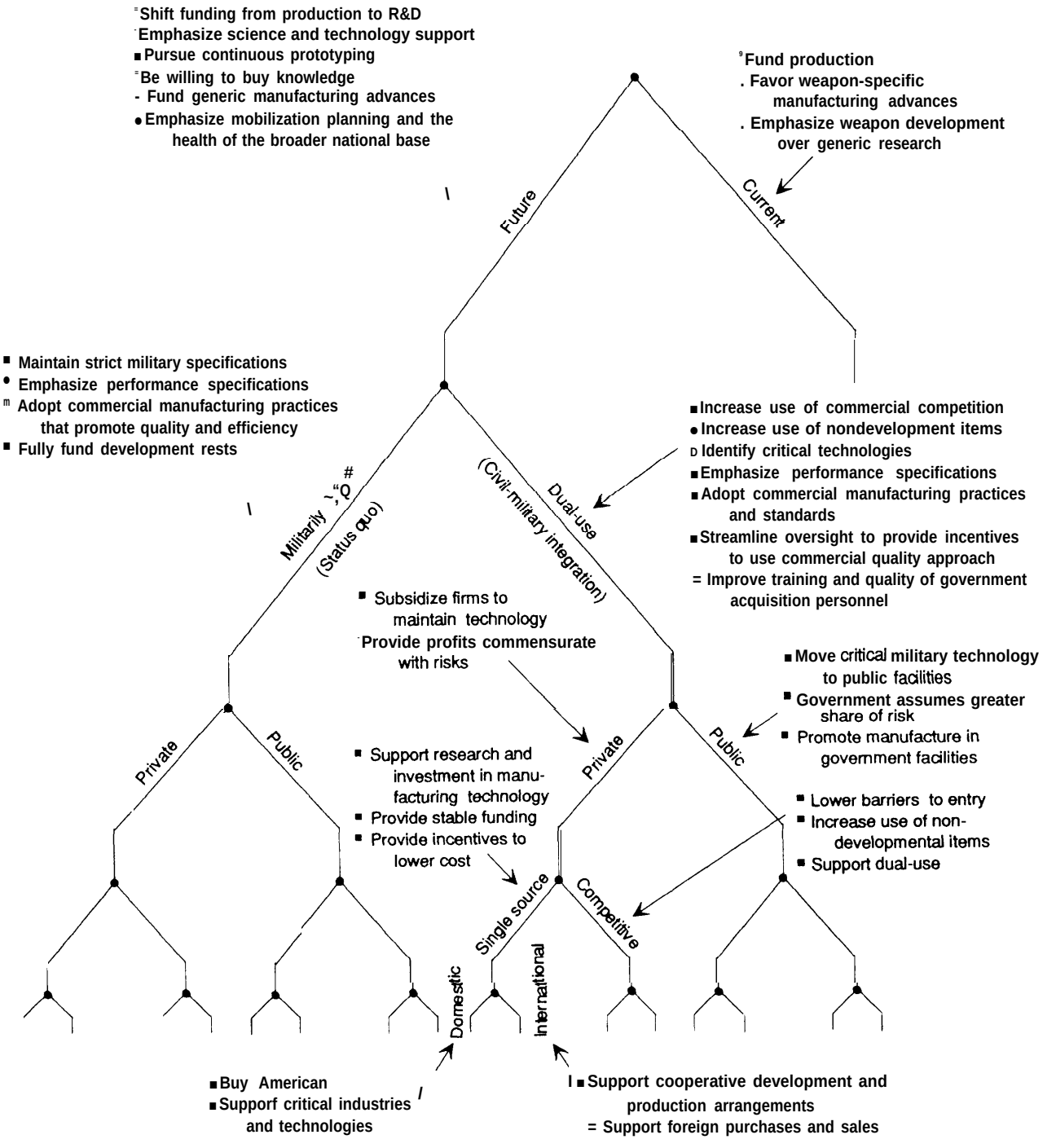
A decision to retain strong private-sector involvement in the DTIB, instead of letting most activities in the base devolve to the Services and the DoD, would require rule changes that enable industry to obtain profits commensurate with risks. Although the overall strategy stresses the private sector, the DoD may still have to maintain some critical capabilities in GOCOs or GOGOs.

The choice of single-source or competitive procurement will be driven by demand and market structure. Policies to support dual-use technologies and civil-military integration would increase the participation of commercial firms and thereby strengthen competition, While militarily unique items might also be acquired competitively, sole-source procurement may be preferable to artficial competition in those areas where civil-military integration is not feasible.

Finally, the United States has the choice of drawing on international sources of technology to enhance its own military capabilities. The ability to do so would be facilitated by negotiated international agreements that promote reciprocity in defense trade. Nevertheless, domestic sources for some critical defense-related items should be preserved. The policy questions are, ''which items?' and 'how to preserve them?' Improved databases are essential to answering these questions.

Despite significant reduction, the actual levels of future defense funding are very uncertain. All estimates indicate that as long as the United States seeks to remain a major world power-let alone the preeminent one-defense spending will remain at a fairly high level. Table 1-4 shows some possible DTIB funding allocations for the frost decade of the

Figure 1 -3—Policies Supporting Future DTIB Strategic Choices



SOURCE: Office of Technology Assessment, 1992

Table 1-4-Hypothetical Annual DTIB Funding Alternatives for 2001-2010[a]
(billions of fiscal year 1992 dollars)

Total DoD budget	Total DTIB funding	R&D	Prototyping[b]	Production	Main enance
220	88	24	9	47	8
180	72	20	10	35	7
150	61	17	11	27	6

[a] Estimates are based on cold war allocations with adjustments for changes in the nature of the military threat.
[b] As overall production declines, prototyping funding is increased to maintain technological innovation, key c esign skills and some manufacturing techniques.

SOURCE: Office of Technology Assessment, 1992.

21st century, assuming a reduced global military threat and a shift from fill-scale production toward greater use of prototyping. Assuming reasonable U.S. economic growth rates, these budgets might represent expenditures of 2 to 3 percent of the GNP.

The table suggests that even with major budget cuts, DTIB spending might be adequate to support a significant defense R&D, manufacturing, and maintenance effort. But DTIB restructuring would be needed and within these funding constraints, force modernization decisions would be made at the DoD, rather than the individual Service level.

The hypothetical scenario in boxes 1-B to 1-D reflects a policy emphasis on future over current capability, dual-use over militarily unique technology, private over public-sector facilities, competitive over sole-source procurement, and international over domestic sourcing, where international is defined as choosing the best technology regardless of source. (See box l-B.)

Industrial Sector Strategies

A national strategy to restructure the DTIB would be implemented differently in the various defense industrial sectors because the sectors differ in:

1. their degree of integration with the Nation's industrial base (e.g., electronics is more integrated than ammunition);
2. their economic health (e.g., the aircraft industry is healthier than shipbuilding); and
3. the amount of military goods and services the military buys from the sector in peacetime.

To maintain at least one source of design, development, production, and maintenance for each system and component, the government may have to compromise on weapon performance and make significant changes in acquisition laws and regulations. Indeed, in some sectors the demand maybe so limited that a single-source arsenal (public or private) may be required to preserve the technology. (See box l-C.)

DTIB managers will need to look for synergies to reduce overall costs and improve efficiencies. For example, research on common technologies may be consolidated among the Services. It will also be important to identify bottlenecks and gaps in the DTIB so that remedial action can be taken. To achieve a small but flexible defense base, managers will need a better overview of industrial capabilities and potential than has existed in the recent past.

Organizational Implications

Companies that decide to stay in the defense business may have to make significant internal changes. These include:

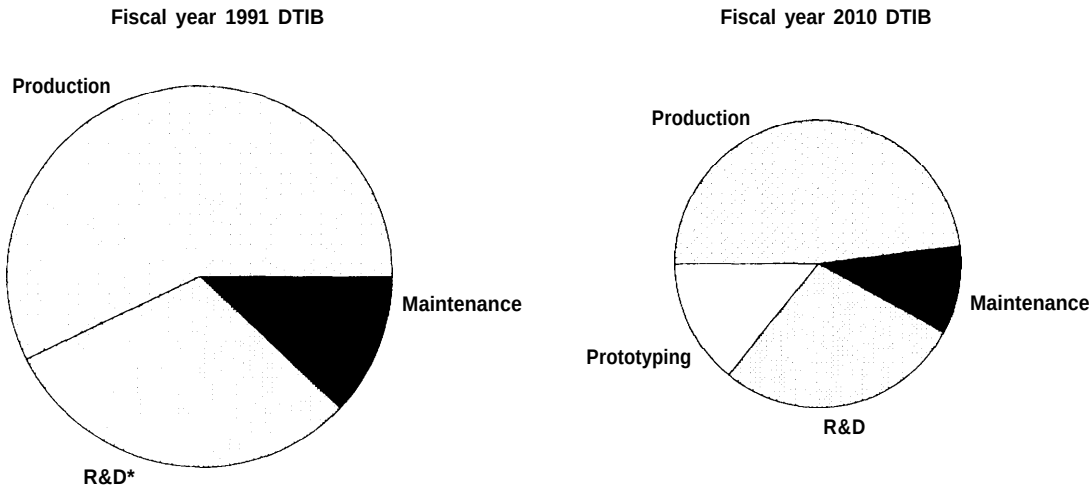
1. concentrating on a defense market niche or, alternatively, becoming a full-service defense firm with high-quality design, production, and maintenance capabilities
2. streamlining;
3. expanding horizontally or vertically into new military product lines on, alternatively, concentrating on current lines; and
4. better integrating military work with civilian work and/or expanding into the civil sector.

Any move to low-rate production suggests that firms will probably need to manufacture more than one product and engage in some maintenance activities. To give firms an incentive to move in this direction, the DoD will need to change its contracting criteria and acquisition rides, and might also fund innovations in manufacturing technology such as multiproduct assembly lines As the DTIB moves toward greater civil-military integration, the DoD may also have to modify weapon design in order to make better use of the civilian base and take advantage of commonalities in systems. (See box l-D.)

Box l-B—National Strategy in 2010

Beginning in the *1990s, the* United States undertook a major shift of resources from defense to other national priorities as a result of the reduced global military threat, fiscal problems, and the need to strengthen the economic foundation of national security, U.S. military forces have been involved in a few limited military operations over the past decade, but no major new military threat has emerged. Defense spending for 2010is$180 billion in fiscal year 1992 dollars. DTIB funding as a percentage of overall defense spending has increased in relative terms, but has fallen in absolute terms.

Allocation of DTIB Funding in **1991 and 2010**



"Prototyping is included in the fiscal year 1991 R&D funding.

SOURCE: Office of Technology Assessment.

The United States remains not only the strongest global military power, but also the one having the greatest military potential. With limited funding, the U.S. DTIB strategy emphasizes three principaI thrusts. First, DTIB spending generally emphasizes maintaining military potential rather than current capability. A prototyping strategy is being pursued across the weapons spectrum. This strategy includes a shift in emphasis from preproduction prototypes to the use of computer simulations, technology demonstrators, and low-cost prototypes to test new concepts. The $10 billion prototyping budget maintains several design teams in critical defense areas such as high-performance aircraft, ground combat vehicles, and new munitions, as well as for the myriad of subsystems and components that go into these systems. R&D is receiving a relatively large share of DTIB funding compared to 1991, and more funding has been dedicated to manufacturing and maintenance technologies.

Second, even with the emphasis on military potential, production remains the largest single component of DTIB spending at $35 billion-a drop of about 40 percent since 1991. Current production includes end-items (e.g., ships, aircraft, armored vehicles, and munitions), their embedded components (including upgrades), spare parts, and prototypes. The DoD is following a systematic approach to force modernization and continuing to replace weapon systems as they become obsolete. But, because of the limited production funding, decisions on major new weapon programs require more joint-Service analysis and cooperation to achieve national, rather than individual Service, objectives. A significant percentage of procurement funds go to upgrading older fielded weapon systems to improve their overall capabilities.

Third, the defense acquisition process and the DTIB have been restructured to make extensive use of civilian industry. For example, defense R&D administrators leverage their $20 billion budget by focusing in-house efforts on militarily unique technologies and by assimilating or adapting new civilian scientific and technical developments to meet defense needs. Weapon and component designs increasingly incorporate commercial products and processes, and military and civilian products are often manufactured side-by-side. Private firms are heavily involved in providing depot level maintenance and upgrades for deployed forces.

Box l-C—Armored Vehicles and Helicopters in 2010

Armored vehicles and helicopters remain important components of the United States' combat capability, but they are evolving over time. There are about 13,000 armored vehicles and 2,000 helicopters in the active U.S. inventory. Most are older, but some new systems have been introduced during the last 15 years.

Strategies to maintain the two sectors have both commodities and differences. Attempting to maintain a reasonably modem force (vehicles and aircraft not more than 30 years old) at current force levels requires an average production of several hundred new vehicles and more than one hundred new aircraft each year. Actual production is limited by available funding. Armored vehicle production is receiving a little less than 3.5% of the fiscal year 2010 procurement budget (about $1.23 billion in fiscal year 1992 dollars), and helicopter production, with higher priority, is receiving about 5.5% ($1.93 billion) of the procurement budget. These funds would be insufficient to maintain the current force at the unit cost levels existing in the early 1990s.

The national DTIB strategy stressing civil-military integration of the base (i.e., reducing unnecessary military specifications and purchasing components and using processes from the civil sector) has helped reduce unit costs, but not enough to maintain the desired force structure at current funding levels. The DoD is exarnining additional ways to lower unit costs, the possibility of increasing the relative share of production funding 'or these two sectors, or further reducing force levels.

System upgrading is a major component of each sector strategy. Upgrades include new electronic components with improved reliability, improved night-vision systems, fire-control electronics, and antititank missiles in both helicopters and armored vehicles. The consolidation of R&D in some critical defense technologies (e.g., optoelectronics and advanced materials) has enabled the DoD to maintain a world-class effort in these areas even with reduced R&D funding.

Prototyping is a particularly important part of the armored vehicle sector strategy. Funding is divided among computer simulations, technology demonstrators to explore new technical conceps, and the development and testing of operational prototypes. The Army continues to develop prototypes of lighter weight armored vehicles. Component prototyping efforts have been the backbone of all the weapon system upgrades that have occurred over the last decade. DoD policy emphasizes using private firms with production facilities for the design andprototyping, but some prototyping is occurring in specialized "design firms." Contracts for operational prototypes require production of these operational prototypes on standard flexible manufacturing tools, thereby favoring organizations with manufacturing capabilities or engineering firms linked to manufacturing firms. Research and development on some militarily unique technologies is being conducted in government laboratories and arsenals.

The DoD has a stated policy of maintaining more than one source for design, development, production, and maintenance for each system and component wherever feasible. To date it has been able to maintain this policy in both these sectors, but the DoD has sometimes been forced to comprornise on initial performancee criteria to increase purchases from companies developing similar equipment commercially. New armored vehicle and helicopter designs now have many more common components with other vehicles and helicopters than in the past.

New design concepts have been encouraged by DoD investments in flexible manufacturing through government manufacturing technology programs and investment incentives, and through changes in procurement rules that have cut back direct government oversight. The government has made it easier for firms to use defense production lines and machines for non-DoD work as a result, the DoD can support more than one prime contractor and several sources for many components (though some components are single sourced). Changes in acquisition procedures, and the replacement of many military specifications by international standards, have increased the number of potential producers of military equipment. Foreign sales remain an important but relatively small part of overall production.

Although both sectors have fewer defense prime contractors in 2010 than in 1991, there are more subtier firms with the potential to provide components to the defense sector. Further, the surviving defense firms remain strong and capable of developing and producing future systems.

Box I-D-Operations at Selected Defense Firms in 2010

Both private defense contractors and government facilities have been restructured to support smaller U.S. military forces. Surviving prime contractors have either consolidated their manufacturing of similar products into single, privately-owned facilities (sized to meet expected peacetime production needs and lacking excess surge capacity) or have become managers of government-owned facilities—also sized for peacetime rather than wartime production. Subtier firms usually run integrated civilian and military production lines. Consolidated armored vehicle and helicopter production facilities manufacture as many as 3 to 5 different types of armored vehicles and 2 to 3 types of helicopters. Income from low-rate production of several systems is supplemented with spare parts production, repair and overhaul work, prototyping and the continuous upgrading of older equipment. Multiyear contracts provide greater predictability of cash flow and enable the firms to make long-term investments and establish links with subcontractors and suppliers.

Developments in manufacturing technology (such as flexible or "agile" manufacturing) have aided the restructuring process, Firms are employing multidisciplinary engineering teams to develop prototypes that are built in their regular production facilities. Prime contractors have relatively more design and engineering capability than in the 1980s. Firms are less concerned with the yearly production of any single system than with maintaining adequate levels of production of several different systems over several years.

Summary

A defense establishment funded at $180 billion (fiscal year 1992 dollars) or even at $150 billion, as shown in table 1-4, will require first-rate technology and industrial support. The portion of the defense budget allocated to the DTIB may fall to the $55 to $70 billion range (fiscal year 1992 dollars). Though considerably smaller than today's DTIB spending, this level of industrial activity would remain a significant national investment. This investment can only be used effectively, however, if the DTIB is restructured successfully through the collaborative efforts of the White House, Congress, the DoD, and industry.

POLICY ISSUES FOR CONGRESS

The DTIB described in both *Redesigning Defense* and this report is complex. Although it is best understood by breaking it down into its component parts, the base can only be managed effectively if it is viewed as an integrated whole and if decision-makers take actions optimized for the entire base.

Policy issues concerning DTIB restructuring in which Congress has particular interest fall into three areas. The fist involves funding, both total DTIB funding and the funding mix within the Federal budget. The second involves organization, including restructuring the institutions in the current DTIB, integrating them with the civilian base, and improving the ability of private firms to meet future defense needs. The third involves management of the transition and improving the DoD's coordination of the critical elements. A key issue is how qualified DTIB managers can be recruited, trained, and retained.

Funding

Congress has the constitutional responsibility to provide for the Nation's defense. The decline in the Soviet military threat permits major reductions in defense spending. The administration estimates that defense spending will fall to $237.5 billion (fiscal year 1992 dollars) by 1997. This level corresponds to about 3.4 percent of the gross national product, the lowest percentage in the past 50 years. Many Members of Congress advocate even deeper cuts. Whatever the level of overall defense spending, Congress will also have to make a judgment on the appropriate level of DTIB funding within that budget.

Funding for the DTIB should reflect the fact that it is a critical component of U.S. national security. The DTIB is vital both to the ability of U.S. forces to handle regional military threats and as a hedge against a reconstituted global threat. During the cold war, the combined R&D and procurement budgets averaged about 36 percent of the DoD budget. This share fell after the Korean and Vietnam conflicts but rose by almost 10 percentage points during the military buildup of the early 1980s. The current DoD budget request envisions DTIB funding in fiscal year 1993 slightly below the cold-war average.

In the post-cold war era, with a requirement for fewer active forces and the potential for greater leverage of military forces through technology, Congress might consider giving the DTIB a relatively larger share of the defense budget than has been the case in the past. Since such funding would compete with force readiness, it would probably not be attractive to military leaders. Nevertheless, maintaining relatively high funding would provide modern weapons and support to smaller U.S. forces, assure them a technological advantage in the field, and hedge against future threats. A smaller, better-armed force is preferable to a larger, less-well-armed force.

Congress will also have to consider whether to continue funding defense R&D at a high level. An alternative would be to limit defense R&D to a relatively small number of militarily unique technologies, relying on civilian R&D, perhaps government funded, to generate dual-use technologies with defense applications. Congress should also consider whether to fund manufacturing technology through the DoD, with the possibility that side benefits will falter into the broader industrial base, or to fund such efforts in the civil base and let defense production draw on that larger commercial technology pool. If the Nation adopts a strategy for strengthening civil technology, as several recent studies have proposed, defense could also benefit.[13]

Within the overall DTIB funding level, the appropriate allocation among the R&D, production, and maintenance elements of the base is critically important. A prototyping strategy, whether implemented as proposed by the DoD or along the lines of chapter 3 of this report, would take funds away from production. Prototyping should anticipate no automatic connection between the development of a prototype and a decision to go into quantity production. Congressional debate is likely to revolve around the wisdom of spending relatively large sums of money on prototyping programs that may yield little operationally useful hardware for extended periods. Further, since companies are unlikely to invest their own funds in developing prototypes that have no immediate prospect of entering production, the government's share of the bill may appear relatively large compared with the past. Frototyping under these conditions often involves buying knowledge rather than hardware.

Despite the shift toward R&D, it will be essential to maintain production capabilities in the future. Cancellations or stretch-outs of ongoing and planned procurement programs will shrink the production base and may leave some manufacturing facilities with no production contracts for several years. As a result, Congress will have to consider funding options that maintain key manufacturing skills and facilities during a period when few new systems are produced. Greater civil-military integration, if pursued, will require legislative changes.

Funding options for future defense production include:

1. low-rate production spread over multiyear procurements,
2. intermittent production at higher production rates followed by laying away production lines,
3. funding international collaborative production programs,
4. increased foreign sales,
5. innovations in manufacturing technology,
6. designing for more commonality in systems, and
7. the use of single sources o gain economies of *scale.*

These options can leverage limited funding, but all have drawbacks. Low-rate production may increase unit costs (although the increases might be limited if facilities are kept small and the product is designed for low-rate production); intermittent production can result in the dispersal of workers during periods when there is no production; collaborative programs can involve the partial loss of technology to foreign competitors; and foreign arms sales may provide weapons to new military threats.

Government funding for production may use some mix of these approaches, combined with funding for prototyping and maintenance. Changes in manufacturing funding that encourage firms to produce multiple products may help make low-rate production a more effective tool for maintaining the production base. The DoD can encourage this shift

13 A Carnegie Commission Study, *Technology and Economic Performance,* September 1991, recommended that the Defense Advanced Research Projects Agency (DARPA) be refocused into a National Advanced Research Project Agency (NARPA) to provide stronger links between military needs and commercial industry. A subsequent report by the Hudson Institute recommended the establishment of a National Technology Agency.

by funding manufacturing advances to assist defense firms that seek to produce multiple products.

Funding for maintenance will also decline, but probably not as much as for production. Maintenance funds are currently spent mainly in the public sector. Congress will want to consider the most effective future mix of public and private maintenance depots. Increased competition is expected to lower maintenance costs, but competition is currently concentrated on work traditionally available to the private sector. Meanwhile, the government sector retains a large core of work that is not open to competition. Both the role of competition and the future size of the in-Service maintenance core should be examined in detail.

Congress will want to consider ways to retain people who are critical to the strength of the DTIB. Policy options include predictable defense funding, which can provide the basis for longer term personnel planning; support for technical education and apprenticeships that benefit both the DTIB and the broader national industrial base; support for engineering education in relevant technologies; a prototyping strategy that maintains design teams as well as innovation; and some continued defense production. The recent Defense Acquisition Workforce Improvement Act was an important step toward improving the contracting and program-management capabilities of the defense acquisition process. Corresponding steps are required to ensure the technical competence and overall management of the DTIB.

Organizational Changes

Congress will face a number of organizational changes in the DTIB. Some of these changes are internal to the traditional base, while others are external to it. The external structural changes appear to be the more important. *Redesigning Defense* concluded that the DoD faces the choice of greater integration with the civilian industrial base or maintaining a defense-unique base that will most likely devolve to a set of sole-source providers ("arsenals") in the public and private sectors. Several studies have found that increasing the integration between military and civilian technology and production will lower overall defense costs, promote technology transfer, increase available industrial capacity, and strengthen the economic dimensions of national security .14 OTA's discussions with industry and government personnel support these conclusions. The expected deep reductions in defense spending make civil-military integration all the more important.

Moving toward greater civil-military integration will, however, require Congress to make major policy changes in a number of areas. First, it will be necessary to amend the Federal procurement laws that have tended to isolate the DTIB from the broader base. *Redesigning Defense* outlined some of these laws, and chapter 4 of this report lists areas of additional concern. The DoD Advisory Panel on Streamlining and Codifying Acquisition Laws is expected to make significant recommendations in January 1993 for simplifying the acquisition laws, and Congress will want to consider these recommendations carefully.

Second, the DoD's ability to increase purchases of commercial and nondevelopmental products depends on reform of acquisition laws and modification of the military specifications that control most defense manufacturing. One approach is to accept commercial and international standards in place of military specifications. The DoD could make a concerted effort to implement standards that, in addition to serving defense needs, help make U.S. firms more competitive internationally, The inability of the United States to accept the metric system is one indication of the difficulty of implementing new standards.

Third, the shift toward greater civil-military integration may require substantial changes in defense R&D. As noted above, Congress x-night restrict funding for militarily unique R&D and shift more funds to research on dual-use technologies of both military and commercial interest, perhaps by creating a new agency for promoting technological innovation in the civil sector.

Fourth, in the absence of a shift toward greater civil-military integration, Congress will have to consider ways to assure the benefits of competition in a smaller DTIB that has fewer sources of supply. This might entail allowing more competition with allies.

[14] These studies include two Defense Science Board Reports on the use of commercial items for defense, a Defense Science Board study on the defense industrial base, and a study by the Center for Strategic and International Studies on civil-military integration.

The second broad organizational issue facing Congress concerns the internal restructuring of the DTIB. Congress will want to examine the consolidation now going on within and among the Services, in industry, and between the private and public sectors. The public-private split that is appropriate will be influenced by the degree of civil-military integration. Congress might promote more rational consolidation by supporting multi-Service procurement and increased inter-Service maintenance for equipment and supplies, and by providing firms an incentive to maintain R&D as well as production capabilities. Changes will also be needed in multiyear procurement rules and the Competition in Contracting Act to promote long-term association between prime contractors, subcontractors, and suppliers.

Management Options

The immediate task facing Congress is to ease the transition to a much smaller post-cold war DTIB. Although the administration has generally advocated letting the free market shape the DTIB, it has also expressed concern over the need to preserve some components of the base. In recent testimony, for example, Secretary of Defense Cheney specifically cited shipbuilding as a problem area.[15] Congress will need to consider the degree of intervention that is appropriate to downsize the base in **a** rational manner. Chapter 6 observes that increased civil-military integration of the base, accompanied by changes in acquisition practices, could increase free-market competition.

The best approach to restructuring appears to be a mixed strategy that fosters true competition wherever possible (enhanced by greater use of the civilian base) and limits government intervention to those cases in which there is no alternative. But such a strategy would require good information on current DTIB capabilities and future requirements. To this end, Congress might establish and fund a joint legislative-executive commission that would report to the President within 6 months concerning the current capabilities of the base and future requirements and provide some overall guidelines for the downsizing of the DTIB. There is also a need for a more systematic approach to DTIB data collection over the long term. As the future defense base becomes more integrated with the broader civil base, the DoD might not be the best agency to maintain this information, and Congress might consider alternatives such as the Department of Commerce.

Finally, Congress will wan: to consider how best to balance efficiency and accountability in the future DTIB. Although accountability y in the use of taxpayers' money is essential, the issue is how to achieve it most efficiently. Increased civil-military integration has the potential to impose market discipline on more producers, but not necessarily on manufacturers of militarily unique products where accountability will probably still require administrative oversight. Although the DoD has had numerous programs to increase contractor responsibility, the programs have largely failed because of inadequate support or lack of incentives. Congress might consider ways to improve the effectiveness of such efforts.

Ultimately, good management will depend on recruiting and retaining skilled and experienced DTIB managers. Recent steps to improve education and pay are helpful, but Congress should monitor these activities to ensure an improvement in the quality of management personnel.

SUMMARY

This report analyzes the desirable characteristics of the future DTIB described in *Redesigning Defense* and considers alternative policies for achieving them. Restructuring the DTIB will require managing the base as a whole: rather than allowing managers in the individual elements (R&D, production, and maintenance) to pursue policies optimized for their separate benefits. Achieving a strong and healthy future base will require an overall strategy that properly considers the trade-offs between investment in current capability versus military potential. Currently these trade-off~~ are being debated in terms of continuing to invest in current products versus moving funds to research and development.

If DTIB planners look beyond the next decade they will see that even in a relatively peaceful world the Nation will need an effective defense base. The DoD and Congress can plan the transition to a smaller but robust base by emphasizing military potential over current capability. Such a strategy must be applied with care and include limited production of new products to permit force modernization and avoid the erosion of manufacturing

15 "Cheney Opens Door for Steps to Preserve Industrial Base," *Aerospace Daily,* Feb. 3, 1992, p. 174.

expertise. Overall, the changes in the military threat facing the Nation provide many opportunities and challenges for Congress. The ability to transfer funds to nondefense priorities is a great opportunity. Deciding how best to spend the remaining defense dollars is a great challenge.