Chapter 5

Framing the Debate

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Framing the Debate

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

FUTURE U.S. FORCES

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

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

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

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

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

SOURCE: Office of Technology Assessment, 1991.

DESIRABLE CHARACTERISTICS OF THE FUTURE BASE

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

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

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

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

Table 5-2—Desirable Characteristics of Future Base

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

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

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

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

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

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

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

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

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

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

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

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

Photo credit: U.S. Department of Defense

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

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

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

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

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

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

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

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

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

STRATEGIC CHOICES FOR THE FUTURE BASE

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

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

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

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

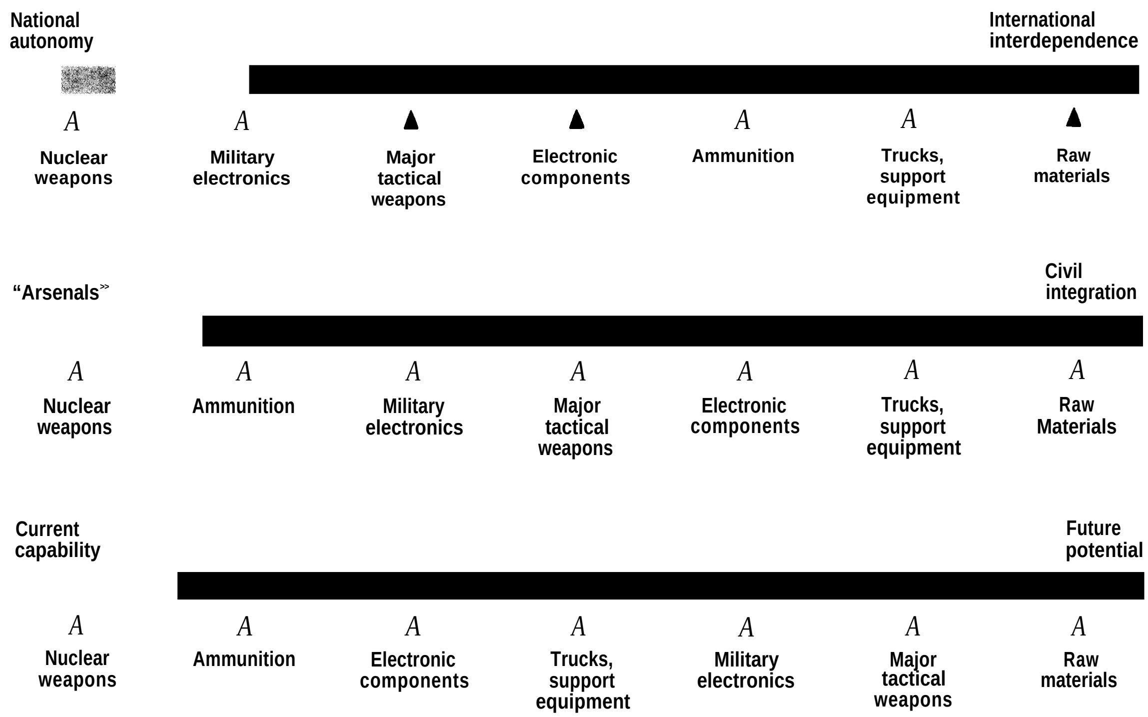
In practice, the Nation will not pursue any one strategic choice to the complete exclusion of the other. Instead, the various defense industrial sectors are positioned along a continuum according to a weighing of the risks and benefits of applying a particular strategy (see figure 5-l). On the national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

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

International Interdependence v. National Autonomy

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

Figure 5-1—DTIB Strategic Choices



SOURCE: Office of Technology Assessment, 1991.

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

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

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

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

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

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

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

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

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

Proponents of international interdependence contend that it will:

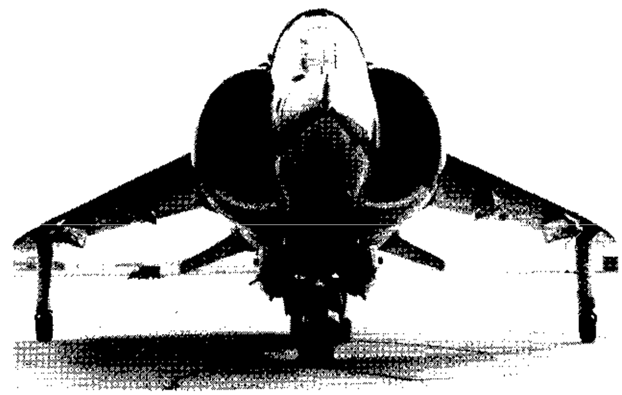


Photo credit: U.S. Department of Defense

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

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

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

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

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

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

[6] Ibid.

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

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

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

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

Arsenal System v. Civilian Integration

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

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

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

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

[9] Ibid.

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

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

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

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

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

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

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

Photo credit: Eaton Corp.

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

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

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

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

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

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

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

Current v. Potential Capability

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

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

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

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

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

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

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

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

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OTA DEFENSE INDUSTRY SURVEY

Box 5-A-Civil-Military Integration

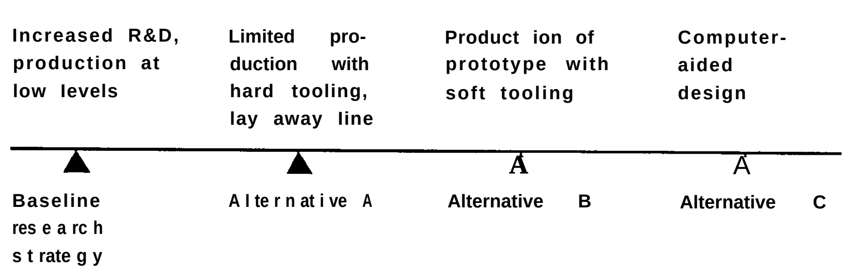
Defense contractors surveyed by OTA contend that civil-military integration should be pursued on a case-by-case basis. Greater use of commercial technology makes sense in areas such as electronics and aerospace, where defense and civil requirements are often similar, but not in military-unique fields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

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

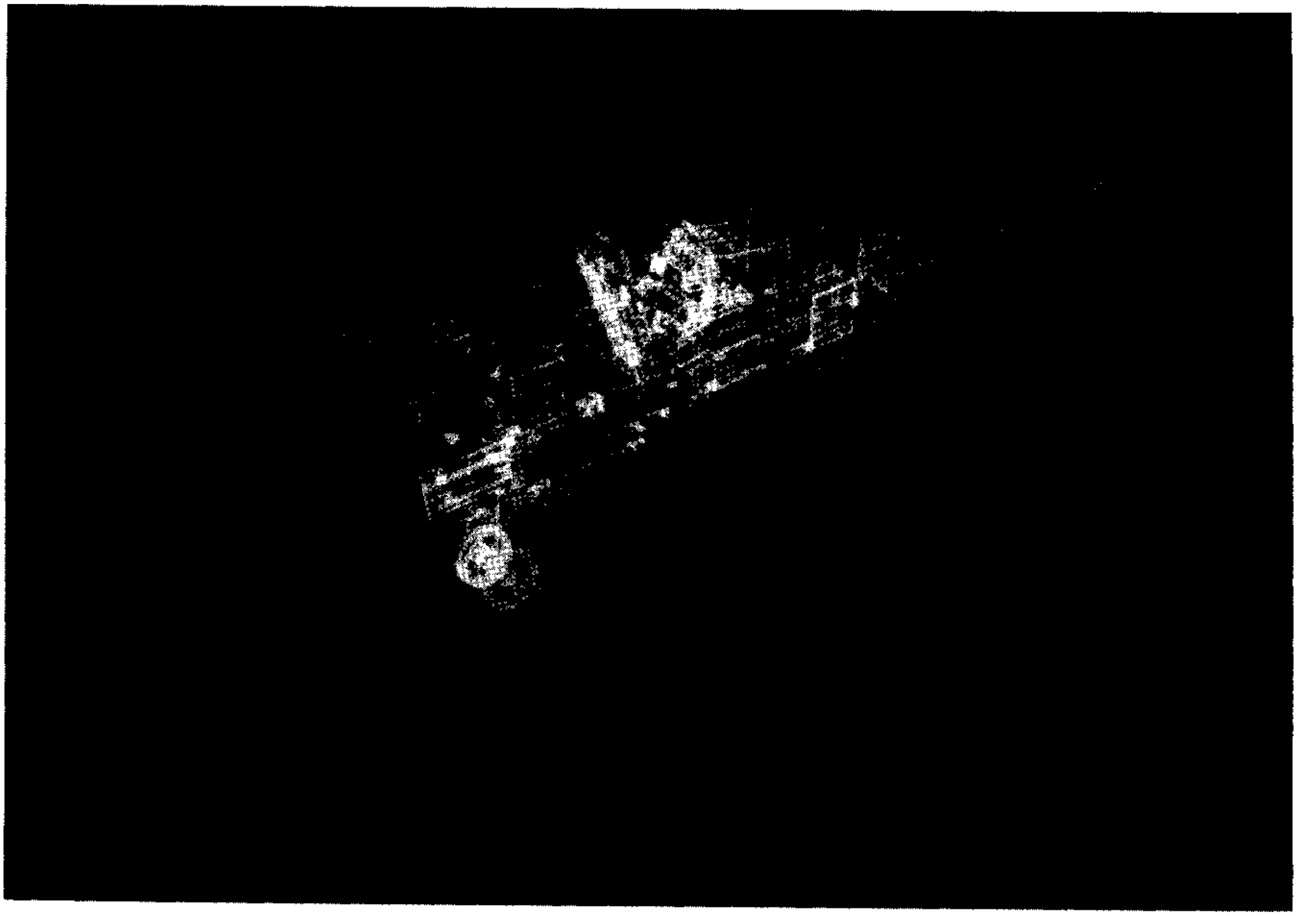
The surveyed defense firms contend that government policies are the primary obstacle to civil-military integration. Restructuring procurement rules to accomodate commercial practice i8 not an easy task when faced with the myriad test and certification requirements currently in place. Strict government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

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

Figure 5-2—Alternative Research Strategies



SOURCE: Office of Technology Assessment, 1991.



Ph credi Lockheed Corp.

D g a d comp we po m ch g ai p a w be d wi a comp me cas d ca be sed d pe compu d mach

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

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

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

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

TACTICAL DECISIONS

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

Advanced R&D Capability

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

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

Human Resources

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

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

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

Core Competencies

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

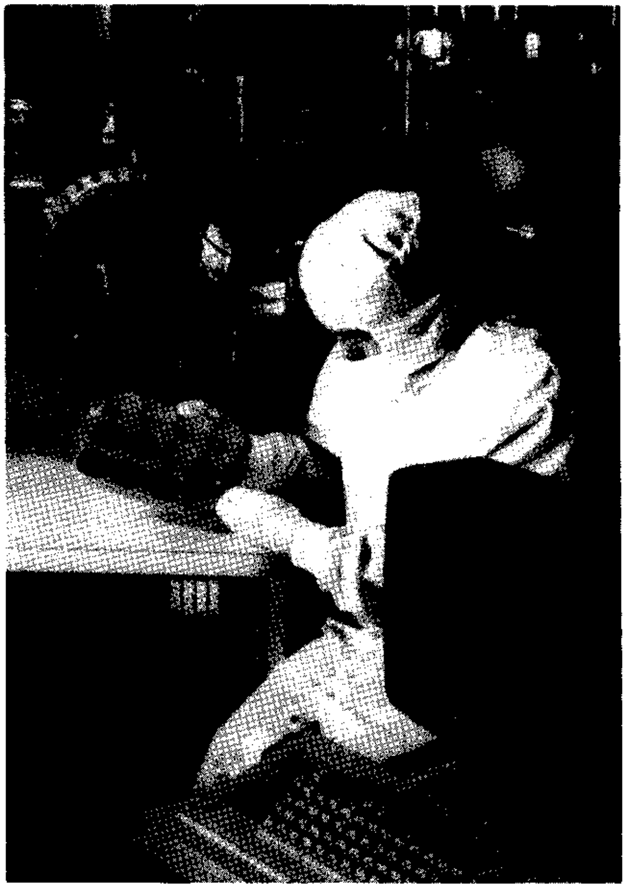


Photo credit: Lockheed/Sanders Microelectronics Center

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

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

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

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

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

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

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

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

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

Guiding and Evaluating R&D

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

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

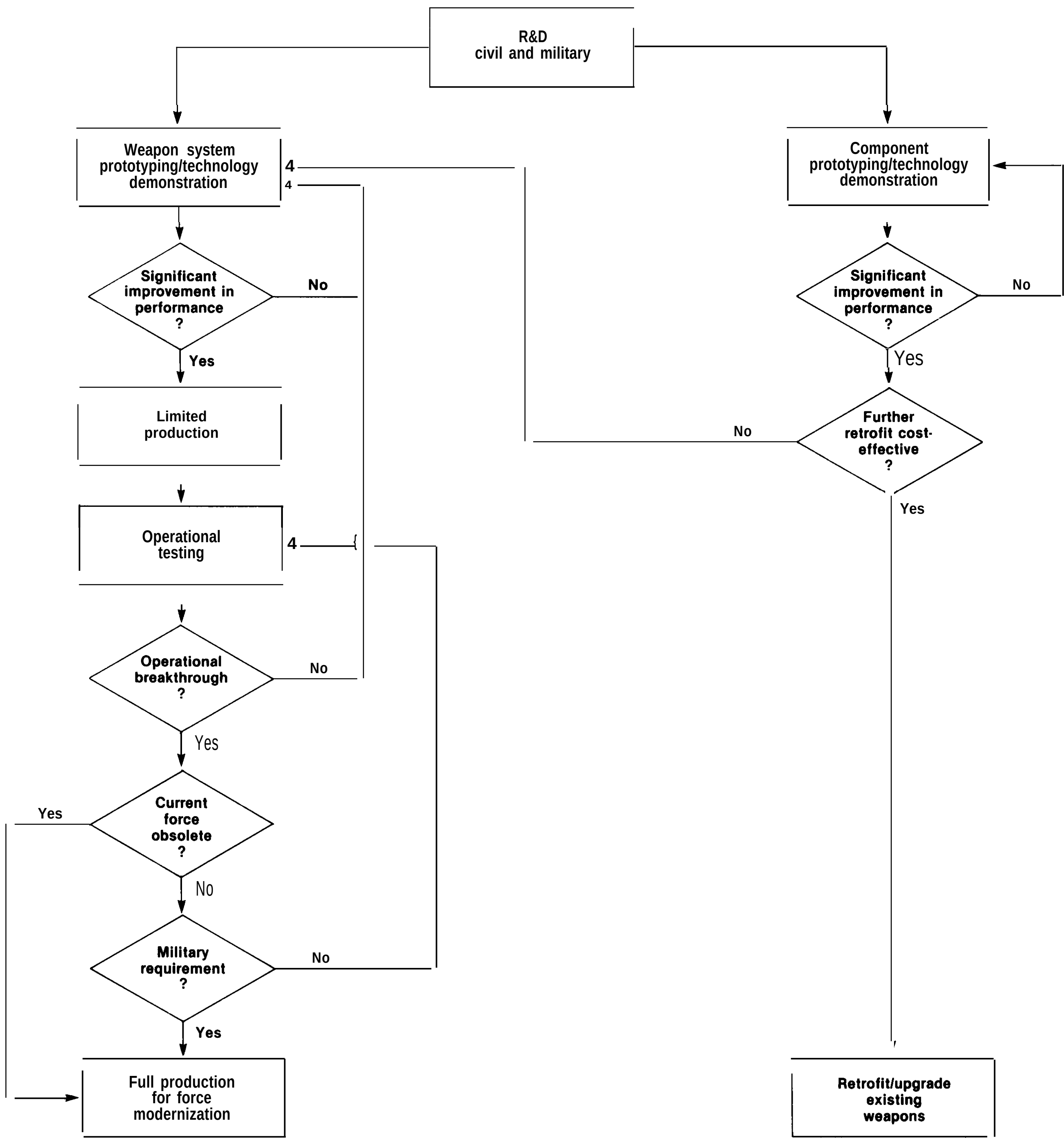
Competition in R&D is one means to promote innovation and impose discipline for greater cost efficiency. But while competition must continue in defense R&D, during a period of austere funding it must be structured differently. Rather than competing laboratories, there might be competing design teams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

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

Design and Prototyping

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

Figure 5-3-Dual-Track Prototyping Strategy



SOURCE: Office of Technology Assessment, 1991.

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

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

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

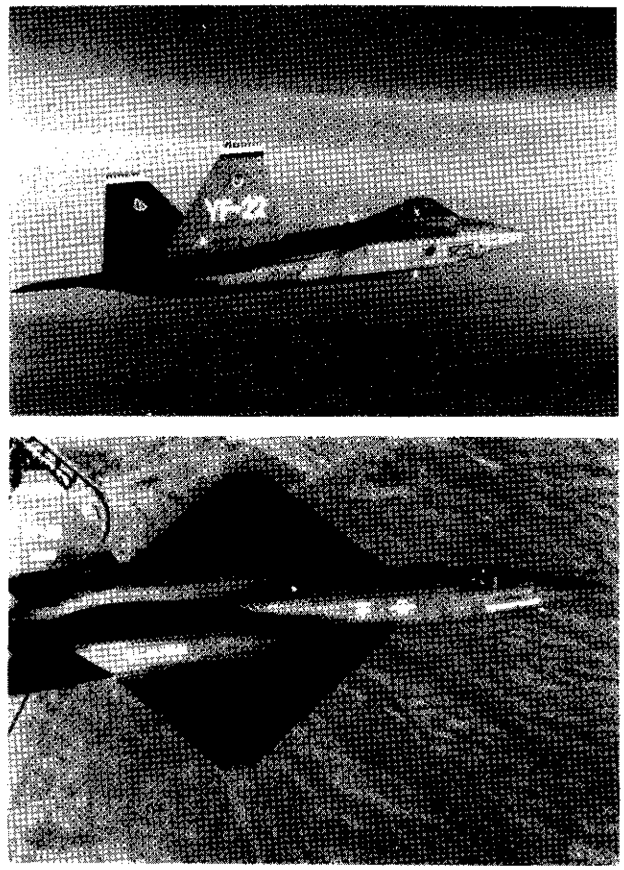


Photo credit: Lockheed Corp. and Northrop Corp.

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

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

Responsive Production

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

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

Identifying Critical Areas

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

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

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

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

SOURCE: Office of Technology Assessment, 1991.

Setting Priorities

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

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

Funding for Surge

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

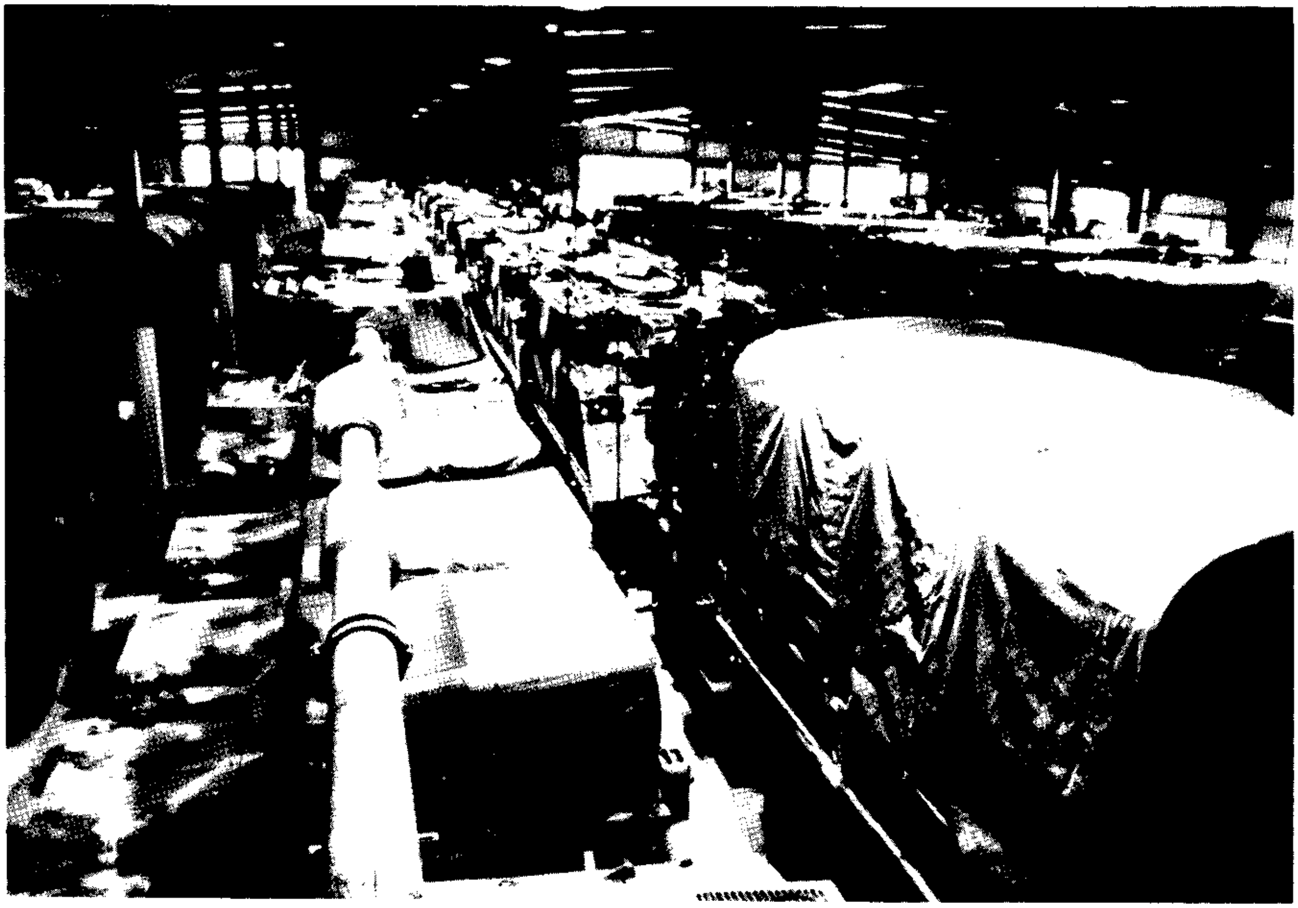


Photo credit: U.S. Department of Defense

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

Mobilizable Production Base

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

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

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

Box 5-B—How Production Planning Affects Costs

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

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

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

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

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

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

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

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

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

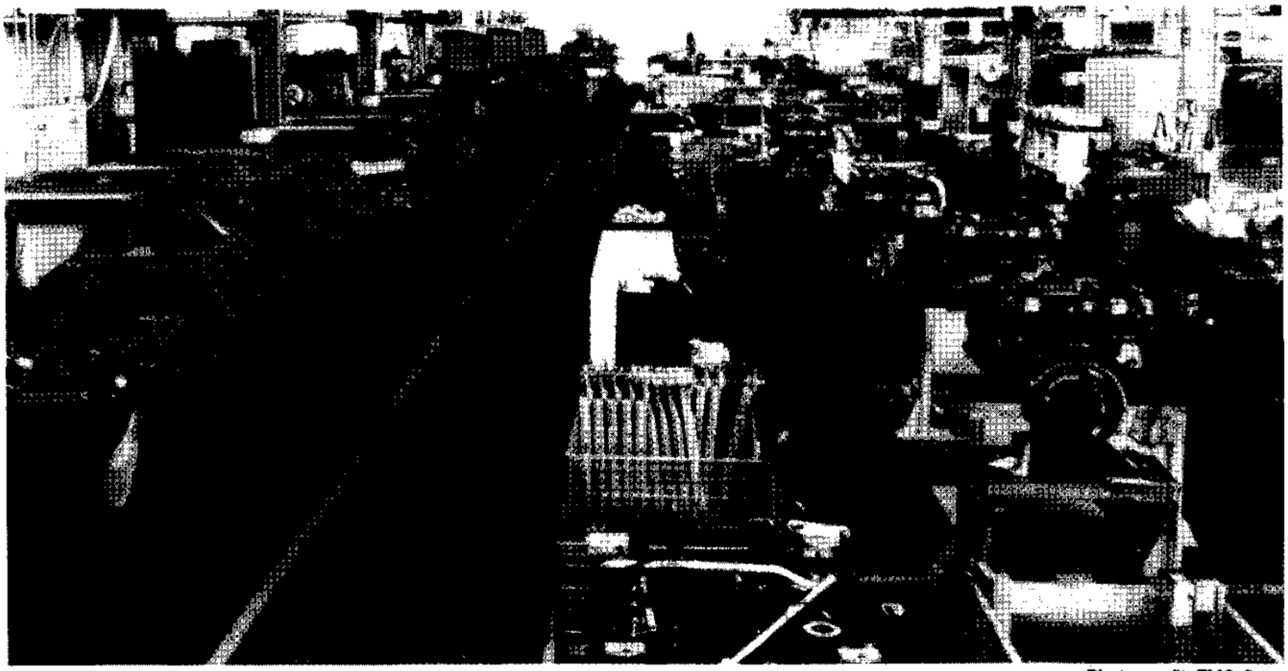

Photo credit: FMC Corp.

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

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

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

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

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

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

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

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

Maintenance and Overhaul

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

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

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

Good, Integrated Management

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

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

For example, Congress will want to consider the negative effects of the Competition in Contracting Act as currently implemented (see ch. 4). Both DoD and Congress should also review many of the legally mandated contracting procedures that make it unnecessarily costly and difficult for firms to bid on defense contracts. Revised versions of these statutes might place less emphasis on access and competition, and more on efficiency and quality of procurement and the preservation of core competencies and long lead-time capabilities. Some reviews of the defense acquisition regulations are already under way.

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

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

SUMMARY

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

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

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