Chapter 4

Efficient, Responsive, Mobilizable Production

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INTRODUCTION

By dollar expenditure, production is the single largest component of the defense technology and industrial base (DTIB). Production will probably suffer the largest defense budget cut in absolute and relative terms. Historically, this component has had three principal functions:

1. manufacturing high-quality military equipment in peacetime,
2. responding quickly but selectively to increased military requirements in crisis or war, and
3. mobilizing the national economy for large-scale hostilities. [1]

Redesigning Defense suggested that these functions remain desirable characteristics for the future smaller production base. This chapter discusses options the Administration and Congress might employ to arrive at a future production base that is efficient, responsive, and mobilizable under the conditions of significantly reduced procurement.

BACKGROUND

Defense procurement is projected to fall over 50 percent in real terms between fiscal years 1985 and 1997, Between 1990 and 1993, budget authority for aviation is projected to decline by 40 percent, shipbuilding by 59 percent, and Army tracked vehicles and weapons (excluding missiles) by 77 percent. [2] While production of some munitions and other consumables may increase temporarily to replenish stocks consumed during the Persian Gulf War, procurement of major weapon platforms will decline sharply over the next decade.

Procurement reductions of this magnitude will radically change the way defense manufacturing is conducted. These reductions might severely weaken the defense production base if they are handled without sufficient foresight. The Nation may be hard pressed to maintain future shipbuilding, aircraft manufacturing, and armored vehicle production capabilities, for example. Small companies that produce critical components for major defense systems may become economically unviable and leave the defense business or cease operations entirely. And basic material and subcomponent suppliers may decide that the defense market has grown too small and unpredictable to be worth the trouble of dealing with procurement laws and regulations, (See ch. 6.) In order to survive the cutbacks and remain competitive, businesses may jettison important capabilities (e.g., R&D facilities and staffs) and put off new productivity investments. The end result might be the unnecessary loss of skilled workers and an inadequate DTIB.

As procurement authorizations declined in the wake of the Carter-Reagan military build-up, the production base was left with significant overcapacity in most industrial sectors. Reduced production, large overhead, and sunk costs caused weapon systems to grow more expensive even as the contractor and supplier base shrank. The decreasing global competitiveness of the U.S. economy made the military more dependent on foreign suppliers in such market segments as advanced materials, electronics, and display technologies. The projected future decline in defense procurement is expected to aggravate all of these trends.

In Redesigning *Defense,* OTA **outlined three desirable characteristics** for the future defense production base:

1. limited, efficient peacetime production capabilities for high-quality materiel;
2. responsive production of ammunition, spares, and consumables for theater conflict; and
3. healthy, mobilizable civilian production capacity.

Managing the transition to such a production base while avoiding the pitfalls of recent trends will require leadership from both the Administration and Congress. If any meaningful resolution of the dilemma in defense production is to be found, it will

[1] U.S. Congress, Office of Technology Assessment, *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), p.3. Much of the introductory comments for this chapter arc taken from this report,

[2] Steven Kosiak and Paul Taibl, *Analysis of the Fiscal Year 1993 Defense Budget Request* (Washington, DC: Defense Budget Project, Mar. 11, 1992), tables 8 and 9.

be necessary to focus on the end goal-a restructured defense industry.

THE CURRENT PRODUCTION BASE

The production base is not a monolithic structure amenable to generic remedies. It is a complex conglomeration of separate ventures on multiple tiers in many industrial sectors, with varying degrees of private and public ownership, operating in an environment of increasing global economic interdependence. The defense downturn will affect individual businesses differently, and effective solutions to the problems of the future production base will depend on understanding these differences. The current production base was described in some detail in *Redesigning Defense* and is only summarized here.

Tiers of the Base

The DTIB can be divided into a series of levels or tiers. Occupying the top tier of the defense industrial base are the prime contractors,[3] often large corporations (e.g., General Dynamics) whose main task is to bring together all the necessary components for a system and integrate them into a whole (e.g., an aircraft).

The vast majority of production base companies, however, are in the subtiers.[4] The subcontractor tier of the defense production base is the most diverse in terms of size and product, and includes both industrial giants and small machine shops. A subcontractor manufactures specialized parts, components, or subsystems that are integrated into a larger subsystem or final system. In a major weapon system, several layers of subcontractors might produce hundreds or thousands of individual items. The supplier tier provides the prime contractor and subcontractors with basic pars, hardware, subcomponents, capital equipment, and materials. This tier is generally more integrated into the civilian market than the prime or subcontractor tiers, although cases of suppliers totally dedicated to defense work are not uncommon. Figure 4-1 illustrates this multilayered arrangement for the DDG-51 *Arleigh Burke* destroyer.

Each tier of the base is already being adversely affected by the downsizing of the defense production base. Prime contractors are heavily dependent on large weapon system contracts, which are increasingly scarce. Many still have sufficient working capital from production contracts that began in the 1980s, since money appropriated is only now being spent.[5] This capital will allow w some of them to reorient their business horizontally, to other markets (e.g., through acquisitions of defense and nondefense firms),[6] or vertically, by taking over the business of their subcontractors and suppliers. As current production contracts are completed, however, money will become increasingly scarce. Many prime contractors hope to expand sales of systems, repairs, spare parts, or upgrades abroad.

Larger, more diversified subcontractors should not be devastated by the termination of any single program. Most have substantial commercial dealings to help them weather defenese cutbacks or allow them to leave defense work for the civil sector while their less diversified defense competition fails. For example, Allied Signal manufactures a wide variety of aerospace power systems, guidance systems, torpedo propulsion systems, sonars, and other electronics for the Department of Defense (DoD). It also does extensive work in commercial aerospace, as well as in the automotive and material sectors.[7] Like some of the primes, larger subcontractors are often

[3] The breakdown of the base into tiers (primes, subcontractors, and suppliers) is an artificial construct used widely to simplify discussion of the base. The actual base is more complex. For example, a major corporation may serve as prime contractor on one contract while acting as subcontractor on another, or a small company that functions as a prime contractor on a small item (e.g., shoes) may have characteristics more in common with subcontractors than a major prime contractor. These distinctions will be addressed in the text where important. For a further discussion on the tier structure see ***Redesigning Defense,*** op. cit., footnote 1, pp. 4044.

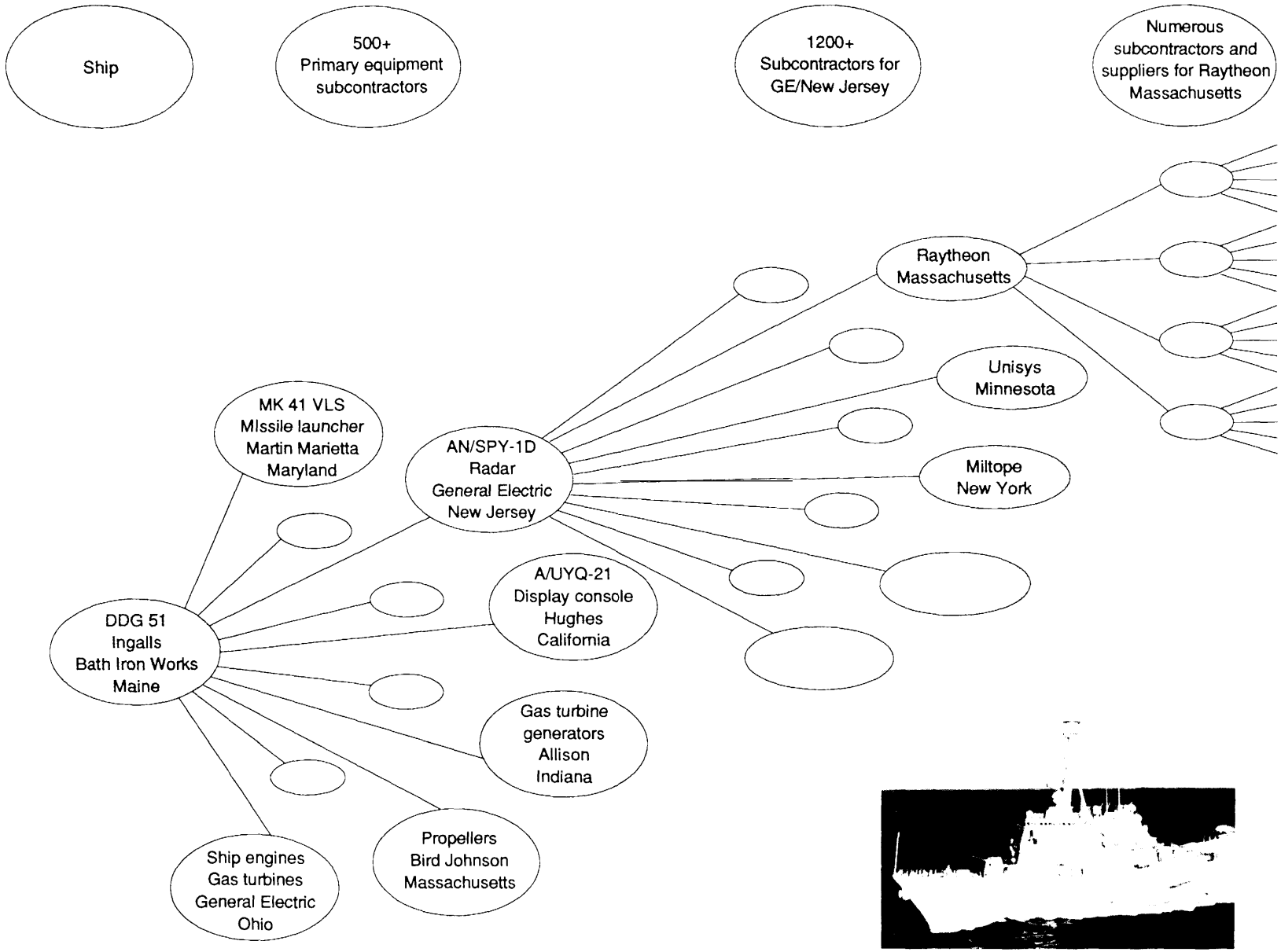
[4] Over 70 percent according to the DoD, Defense Systems Management College, *Defense Manufacturing Management: Guide for Program Managers,* 3d ed. (Washington, DC: U.S. Government Printing Office, April **1989), ch. 2,** p. **5.**

[5] Major systems take years to build. In some cases, multiple buys, authorized and contracted for in one year, will be stuted over a period of several years.

[6] These companies prefer to acquire businesses that have large back orders or good commercial prospects. (' 'Casualtics of Peace, ' ***Business*** *Week,* Jan. 13, 1992, p. 64.) For example, Hughes Aircraft plans to increase its proportion of commercial sales from 25 percent in 1988 to 50 percent by the late 1990s through investments in areas such as satellites, head-up displays, and electric drives for cars. (Caleb Baker, ''Hughes Braves Skeptics With Commercial Market Drive, " Defense *News,* vol. 6, No. 46, Nov. 25, 1991, p. 24.)

[7] ''Top 20 Government Contractors, ' *Government* ***Executive,*** vol. **23, No. 8,** August 1991, p. 119; and Dialog Information Services, Inc.

Figure 4-1—Production Tiers for the Navy's *Arleigh Burke* Guided Missile Destroyer



SOURCE: Naval Systems Command, July 1990.

Photo credit: Department of Defense

able to acquire the necessary resources to expand vertically or horizontally into other markets.

Smaller subcontractors involved in only a few programs are more immediately at risk from reduced defense procurement. The elimination, delay, or stretch-out of programs could force them out of the defense business and into either the commercial world or bankruptcy. Many of these companies have made their living through the ability to meet unique military specifications and operate according to military auditing practices. The transition to commercial markets, standards, and practices will be difficult. Some subcontractors (e.g., electronic equipment manufacturers), both small and large, see a continuing need for their products, whether they are used as components in new systems or as upgrades in older military equipment, and thus are somewhat optimistic about their future.

The future health of many defense suppliers depends on their strength in the civil sector rather than on the future course of defense procurement, because their defense market is relatively small compared to their civil market. For example, the military's share of the domestic market for DRAM (dynamic random access memory) chips, which are used in a wide array of electronic devices, is only a few percent.[8] As defense cutbacks make this portion of the market even smaller, suppliers may find the stringent specification, handling, and accounting rules of government procurement increasingly burdensome. The result may be to force the DoD toward higher unit costs, commercial standards, or the creation of dedicated government suppliers. Suppliers that are more dependent on defense spending and regulations will face a fate similar to that of the less diversified subcontractors.

Outside the domestic defense production base, but intertwined with it, is the global DTIB. The DoD and its contractors routinely purchase materials, parts, components, and finished goods from foreign manufacturers, just as other nations do from the United States. Foreign militaries are a significant market for U.S. defense products. Through foreign sales, the United States is able to reduce unit costs on weapons and equipment and keep production lines warm when domestic requirements wane. There is, however, public concern over such sales.

Foreign defense production also supplements the U.S. defense base by sharing technology and processes through cooperative ventures, thereby reducing duplication of R&D, production, and maintenance. Foreign firms also sell components and materials that are either not available on the U.S. market or are less expensive. Such trade carries risks: shared technology could undermine domestic industry and foreign supplies could be cut off. But without this cooperation, the United States might not have access to some state-of-the-art militarily unique and dual-use technologies and would have to pay the cost of pursuing them independently or not having access to them at all.

Public and Private Sectors

The current production base is divided between the private and public sectors. The United States relies primarily on private industry to provide defense materiel. Most defense work is done at privately owned facilities. However, when the initial capital investment costs of a defense program are prohibitively high or when tile government wants the option of shifting contract:; among firms without having to reinvest in new infrastructure, the government may establish a government-owned, contractor-operated (GOCO) facility. The DoD owns a number of GOCOs, including aircraft assembly facilities, propellant and explosive plant;, and tank production lines, which are run by private fins. The government also retains a few government-owned, government-operated (GOGO) facilities for assured access or to meet a requirement that the private sector is not fulfilling at a reasonable cost (e.g., large-bore gun tube production at the Watervliet U.S. Army Arsenal). Government ownership and operation provides the most direct government control over facilities and resources. Critics of GOC0s argue that private management is more efficient and innovative. Recent government policy has been to divest government holdings.

As defense procurement shrinks, it is likely that some unique subcontractors or suppliers of items critical to a weapon system will face business failure, threatening a shutdown in system production. The DoD will then have the choice of assisting the failing firm through higher prices, subsidies, or the purchase of facilities (making them GOCOs);

[8] Interview with Martin Libicki, National Defense University; and Benjamin Zycher, Kenneth A. Solomon, and L oren Yager, ''An 'Adequate Insurance' Approach to Critical Dependencies of the Department of Defense, ' R-388@ DARPA, The Rand Corp., 1991, p. 23.

stimulating other sources (foreign or domestic) of production; redesigning the relevant weapon to bypass the missing component; or establishing a public production capability (i.e., a GOGO).

Representative Industries

The current defense production base is a heterogeneous collection of industrial sectors, which will be affected by procurement reductions in different ways. The following are examples of important industrial sectors.

Defense Electronics

Defense electronics appears to be the industry segment best positioned for the restructuring of the defense industrial base that lies ahead. Defense electronics firms are generally subcontractors on major system projects, although in some areas, such as command, control, and communications, the electronics firms assume the role of prime contractor. The larger firms tend to have several defense contracts under way at any onetime. Although many electronics suppliers participate in the larger commercial electronics sector, strict military specifications and accounting procedures compel most firms to segregate civil from military production. The rapidly growing commercial electronics industry may provide companies fertile ground for horizontal expansion.[9] However, prospective commercial partners might shy away from long-term relationships with defense electronics firms for fear of being abandoned at the first upturn in defense procurement.

Defense electronic fins, while bracing themselves for cutbacks, see future opportunities as well. Even without the acquisition of major weapon systems—the bread and butter for the large prime contractors---electronic firms see upgrades of their products as inevitable because of the fast-paced development cycles in the world electronics market. Moreover, they foresee a continuing opportunity to supply electronic upgrades to foreign countries that have purchased American weapon systems in the past. In fact, new weapon system production will continue, albeit at a greatly reduced rate. When combined with upgrade and other programs, this production will eventually halt the downward trend and may even provide for moderate growth of defense spending in this sector. (See figure 4-2.) Spares and repairs are seen as less viable options for future business because of increased product reliability.

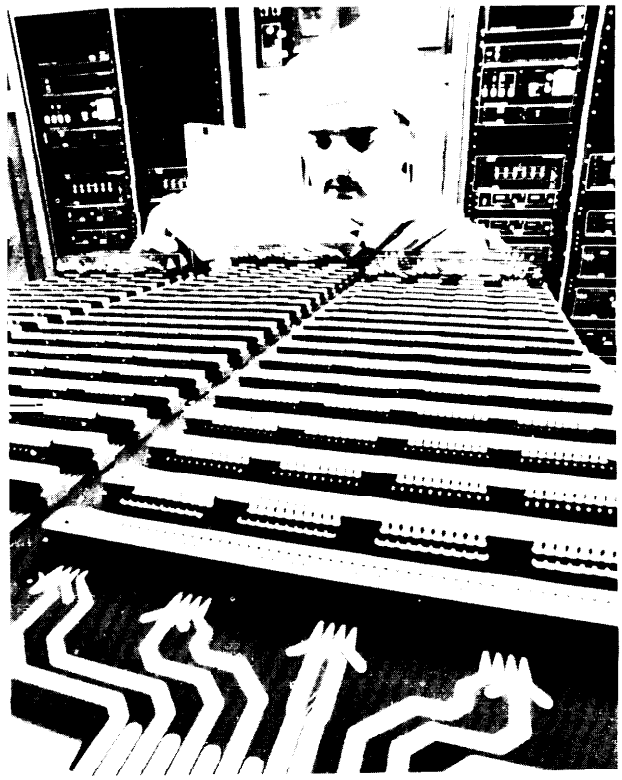


Photo credit: Lockheed Electronics Co.

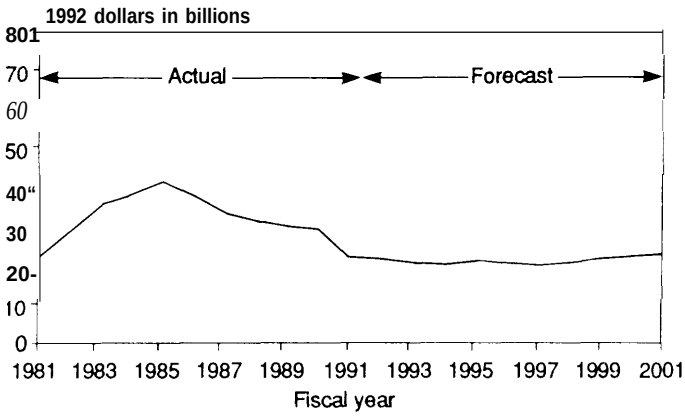
Lockheed technician tests microelectronic components to ensure they meet military quality standards.

Satellites

The satellite industry is closely related to, and often intertwined with, defense electronics, especially at subtier levels. There are only a few major prime contractors. Like defense electronics fins, these firms tend to work on several projects at once, making them less dependent on a particular project. The main difference between the sectors is that satellites are generally built in small, high-value lots of one or a few at a time. This might make the prime contractors vulnerable should funding for satellites diminish. The satellite sector is hoping for increased commercial business and NASA construction as well as continued work on Strategic Defense Initiative projects such as the "Brilliant Pebbles' anti-

[9]For example, while the DoD demand for semiconductors is likely to grow at 2 to 3 percent annually, the commercial market is expected to expand at a rate of 13 to 15 percent. (Debra Polsky, ''Chip Producers Turn Attention From Military to Boost Revenues, ' *Defense News*, June 10, 1991, p. 55.)

Figure 4-2—Projected Defense Electronics Procurement Budget Through 2001



SOURCE: Electronic Industries Association, 1991.

Photo credit: The DoD

Troops prepare to board a UH 60 Blackhawk during Operation Desert Shield.

missile system or on the development of less capable but more numerous military satellites dubbed ''light sats' or 'cheap sats. ' But there is growing concern over foreign competition.

Fixed-Wing Aircraft

The military aircraft industry anticipates program cancellations, delays, and stretch-outs. Too many companies are chasing too few contracts. Industry analysts believe that the military cannot support the current number of aircraft prime contractors and that consolidation will be unavoidable. A Rand Corp. official, for example, predicted that the number of military aircraft divisions of major U.S. airframe manufacturers will shrink from 10 to 5 or fewer in the next 3 to 5 years through mergers, changes in organizational status, or leaving the business.[10] Companies are laying off or not replacing employees, closing or selling off excess facilities, and entering into teaming arrangements with their competitors to share both the risks and rewards of new contracts. Global competition in the military and commercial aviation business is intensifying with many foreign competitors buoyed by government subsidies, and foreign sales are increasingly subject to offset agreements that transfer technology to future competitors. The Air Force's F-22 Superstar interceptor and the Navy's AX attack plane appear on track for development and production. Continued production of some current models is also scheduled.

Helicopters

The U.S. military helicopter industry includes four major prime contractors all of them divisions of major corporations. Military sales dominate U.S. production (more than 85 percent between fiscal years 1987 and 1990), but sales in the commercial sector are significant. In addition to extensive defense procurement cutbacks, the U.S. helicopter industry faces the possibility that the Army will transfer 3,000 aging helicopters into the commercial sector during the next decade.[11] Such surplus helicopters may further depress the demand for new commercial helicopters.[12] On the other hand, they may increase the demand for spare parts, upgrades, and overhauls.

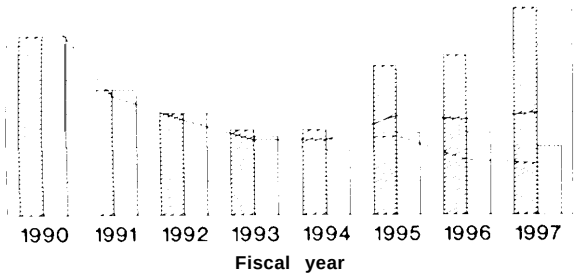
In the 1960s, U.S. Firms dominated world helicopter sales, only to be challanged in the 1980s by the emergence of aggressive foreign competitors, most of which are partially government owned or subsidized. Government support may give foreign companies an advantage over U.S. firms weakened by the reduction of military contracts, which have traditionally driven U.S. helicopter innovation. The

10 Bruce D. Smith, "Airframe Building Capability Loss Looms for Full-Service Defense Contractors, ' *Aviation Week and Space Technology*, vol. *136, No.* 11, Mar. 16, 1992, p. 41.

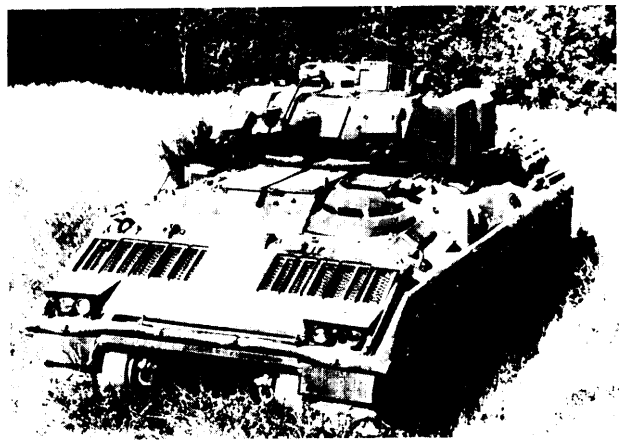
11 Leonard M. Horner, testimony before the House Armed Services Committee Panel on the Structure of the U.S. Defense Industrial Base, Nov. 1, 1991.

12 They may also undermine foreign military sales if they are passed on to allies.

Figure 4-3-impact of Comanche Procurement on Military Helicopter Funding and Production



NOTE: Figure does not include V-22 ***Osprey.***
SOURCE: DoD FY 1992-97 Program Objective Memorandum.



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future commercial helicopter market will likely be dominated by a competition to capture market share in other countries.

Projections of military helicopter production vary substantially depending on the systems built. For example, figure 4-3 illustrates the effect a decision to purchase the RAH-66 Comanche helicopter would have on procurement levels.[13] Because of the general wear and tear on helicopters, the need for repairs, upgrades, and spare parts should keep a core of subtier firms in business.

Armored Combat Vehicles

The Army is currently reviewing its plans for manufacturing armored combat vehicles. The diminished threat of large-scale conventional hostilities in Europe, the signing of the Conventional Armed Forces in Europe Treaty, the impressive performance of current armored vehicles in the Persian Gulf War, and projected budget reductions have left the Army with a large supply of advanced armored vehicles and an overcapacity for production. The Army had planned to phase out production of current combat vehicles and begin the development of a new family of six armored vehicles under the Armored Systems Modernization program. It now appears, however, that this family will be restructured around three vehicles, with the other three deferred indefinitely.

Reductions in Army procurement will have a substantial but varying impact on companies involved in producing armored vehicles. The two main armored vehicle systems, the Abrams tank and the Bradley fighting vehicle, have respectively over 1,000 and 200 subcontractors and suppliers, with relatively little overlap between the programs at the higher tiers. (See table 4-1.) The prime contractors for these systems-General Dynamics Land Systems for the Abram and FMC for the Bradley—argue that unit costs may become unaffordable unless specific levels of production are maintained.[14] The DoD has stated that procurement of these systems will cease, leaving export sales, spare parts, and R&D on follow-on systems as the main tasks for the armored vehicle sector in the 1990s. Mothballing some facilities is seen as more cost effective than continued production.[15] While the current primes have considerable expertise in devel-

13 The Resident's fiscal year 1993 budget request for the DoD emphasizes continued Comanche development and prototyping over production. Upgraded Apache and other helicopters and unmanned aerial vehicles are intended to fulfill the Comanche's role in the near term. See U.S. Congress, House Armed Services Committee, "Statement of the Secretary of Defense Dick Cheney in Connection with the FY 1993 Budget for the Department of Defense," Feb. 6, 1992.

14 The minimum economic production rate for a particular plant is determined by a number of physical and organizational factors, as well by the measures taken at the plant to reduce overcapacity. Both General Dynamics Land Systems Division and FMC have taken significant steps in recent years to reduce their overcapacity and establish lower economical production rates. Government actions, discussed later, can further lower these rates.

15 Department of Defense, *Report to Congress on the Defense Industrial Base,* November 1991, p. ES-5.

Table 4-l-Sample Products of the Armored Vehicle Production Tiers

	Subcontractors		
Prime Contractors	Subsystems	Components	Suppliers
Abrams tank	Electro-optical systems	Optical lens and mirrors	Hardware
Bradley fighting vehicle	Gas turbine engine	Gun mounts	Aluminum
	Transmission	Cannon	Steel date
	Radio	Roadwheels	Machine tools
	Navigation unit	Aluminum castings	Deple ed uranium
		Turret ring casting	
		Thermal imager & laser range finder	
		Displays	

a There are over 100 suppliers for the thermal imager and laser range finder in the Abrams tank alone.

SOURCE: Office of Technology Assessment, 1992.

oping and constructing armored vehicles, they could be replaced should the need arise, although at potentially high startup costs.

Similarly, reduced production will affect some subcontractors and suppliers more adversely than others. For example, the electronics and optics manufacturers for the Abrams tank and Bradley fighting vehicle support a number of other weapon systems and should be able to maintain at least some of their capabilities if these other programs are not cut excessively. But other subcontractors and suppliers might be forced out of business should the production of the Abrams and the Bradley be reduced too far. The failure of these firms would have serious consequences for the production of weapon systems. Like the prime contractors, however, many of these subcontractors and suppliers could be replaced by others in related lines of work, especially if the government is willing to buy from foreign manufacturers.[16] In the case of truly unique manufacturers, the government will need to take some action, such as subsidies, stockpiling, transfer of technology and government-owned equipment, or redesign.[17] As the production base Shrinks, policy-makers will face this issue again and again, in sector after sector.

Shipbuilding

The national shipbuilding industry is currently in a severe-some say terminal-slump. The bottom fell out of the commercial shipbuilding market in the 1980s. At the beginning of the decade, 69 commercial ships were either on order or under construction. By 1988 this number had fallen to zero. The order book remained blank until a single new ship was ordered in 1990.[18] If it were not for the U.S. Navy's pursuit of a 600-ship Navy, the U.S. shipbuilding industry might have completely collapsed from the lack of commercial work. (See figure 4-4.) Now, some analysts are projecting a reduction in naval forces to 400 ships or fewer, which will result in a further consolidation of the industry.

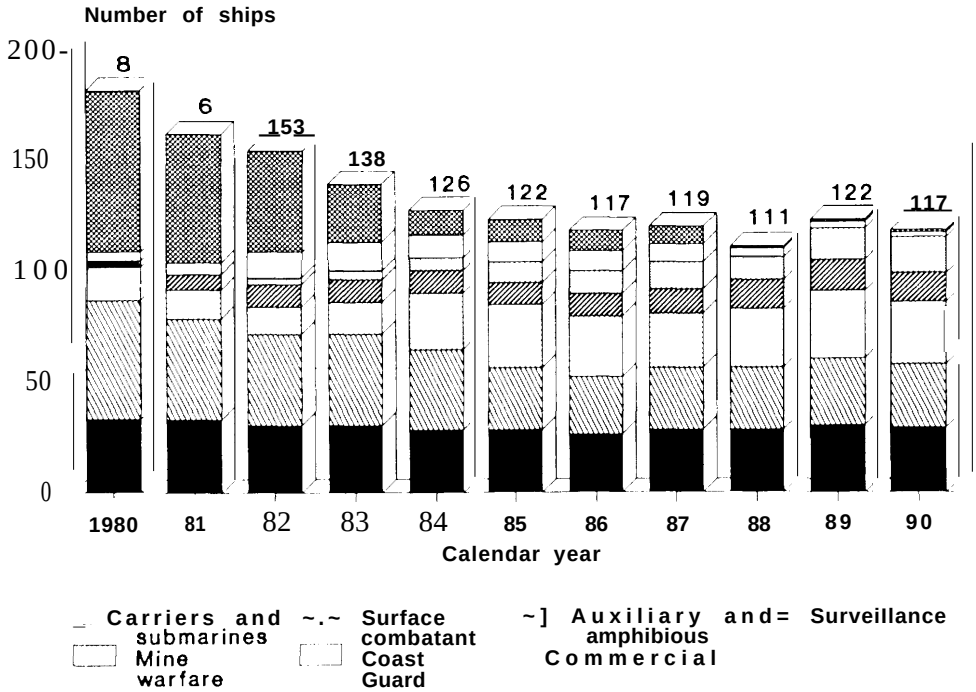
In shipbuilding, as in many other areas of defense contracting, there are significant differences in the structure and focus of an organization responding to the defense market as opposed to the commercial marketplace. Not only are the 'e obvious differences in naval and commercial hips related to the installation of complex modern weapons, but the hull structure and machinery of warships are built to much more demanding specifications to provide resilience against blast damage, flooding, fire, and other hazards of combat. These differences demand a larger and more technologically advanced workforce at yards doing naval work.

16 For example, the aluminum roadwheels on the Abrams tanks are finished by Urdan Industries in Israel.

17 The President is authorized by P.L. 85-804 to grant extraordinary contractual relief to failing firms judged 'essential to the national defense.' This law was recently applied in the case of the Action Manufacturing Co. The slowing defense economy of the late 1980s and increased competition due to new laws requiring increased competition (CICA, to be discussed below) eventually forced this company to cease operations in 1989. This loss to the production base threatened to shut down or interrupt manufacturing at five Army ammunition plants and arsenals, and two contractors. Action was awarded relief on the grounds that the company was essential to the national defense because of its impact on mobilization other producers, and readiness. (U.S. Congress, General Accounting Office, ''Army Contract Adjustment Board: Decision to Grant Contract Relief to Action Manufacturing Company,' GAO/NSIAD-91-230, July 1991, pp. 1-2 and 8-11.)

18 U.S. Navy, Naval Sea Systems Command, Corporate Operations Directorate, "U.S. Shipbuilding Industrial Base, 1980-1990,'' briefing book, July 1990.

Figure 4-4-Navy and Commercial Ships Under Construction, 1980-90



SOURCE: Naval Sea Systems Command, July 1990

Table 4-2—Endangered Navy Shipbuilding Support Industries

	Domestic manufacturers			
Products	1980	1985	1990	2000
Boilers	3	3	2	1
Air circuit breakers	1	1	1	1
Condensers	8	8	6	4
Large diesel engines	3	2	1	0
Periscopes	2	2	2	2
Propellers	9	9	7	5
Reduction gears	9	9	9	2
Large shafting	6	5	4	3
Steam turbines	3	3	3	2
Power distribution switchboards	11	10	9	6

SOURCE: Naval Sea Systems Command, July 1990.

Shipyard **subcontractors** and suppliers, which can number in the thousands for a complex naval vessel, also face a difficult future. The number of primary subcontractors is expected to fall by the year 2000 to less than 75 percent of 1990 levels.[19] Moreover, many critical subtier vendors are dependent on a single class of vessel for their continued existence. Table 4-2 lists some of the more threatened capabilities, most of which are older technologies. Analysts are also concerned about the future of companies involved in nuclear ship propulsion. The Bush Administration's revised 5-year shipbuilding plan for fiscal years 1993 to 1997 includes only one nuclear-powered ship, an aircraft carrier, and no nuclear-powered submarines. The supporting nuclear propulsion companies have no civilian market to fall back on in a period of decreased shipbuilding. Nuclear-qualified shipyards may find some work in overhauls and decommissioning nuclear-powered vessels being taken out of the active fleet.

19 Ibid

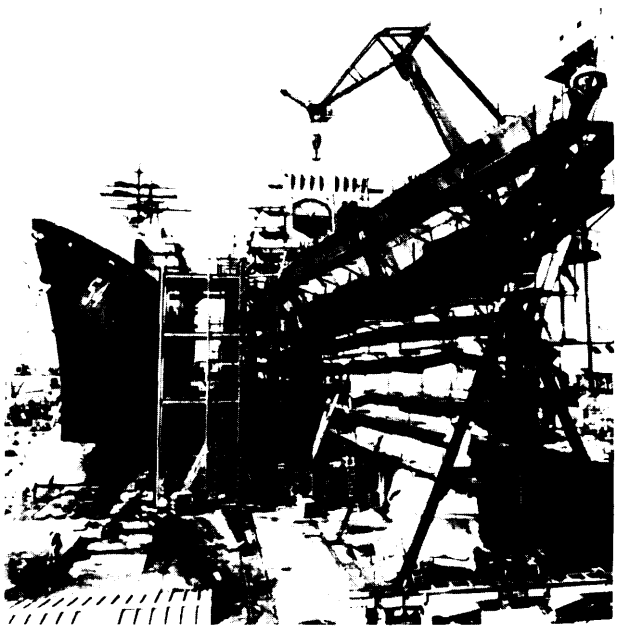


Photo credit: The DoD

The Aegis guided-missile cruiser *Antietam* (left) prepares to be launched from the Ingalls shipyard, while work continues on the *Leyte Gulf* (right).

As with the other sectors discussed, the government can adopt measures to maintain domestic capabilities or, in some cases, fill gaps in production through foreign sourcing. For example, the U.S. Navy already depends on foreign purchases of large diesel power plants, periscope lens glass, and large seamless pipe.[20] Subcontractors and suppliers in advanced technology will, however, have substantial markets abroad.

Some analysts project a resurgence of the international shipbuilding market in the second half of the 1990s because of the growing obsolescence of the world merchant fleet. For the United States to take advantage of this trend, commercial yards will have to survive until the upturn begins and then build ships that are cost-competitive both in unit price and financing arrangements. Competition will be tough, particularly in the construction of technologically unsophisticated ships (e.g., single-hull tankers). U.S. shipbuilders might be advised to concentrate on those ship types that require more expertise (e.g., double-hull tankers, refrigerator ships, liquid-chemical container ships, and self-unloaders). They could also profit from increased foreign sales or subcontract work on naval wessels. If any of this is to occur, however, industry armlysts argue that some governmental action will be required to break down foreign shipbuilding subside!:, primarily in Western Europe, and to promote foreign military sales.[21]

Conventional Munitions

The conventiontil munitions sector differs from the other industrial sectors cited above in that it produces in large quantities, often in the millions per year. In 1985 the U.S. ammunition budget was about $5 billion; in 1991 it had fallen to $2.3 billion with further reduction expected.[22] As in other sectors, there is considerable overcapacity in munitions production, including some mothballed plants. The military requirement for munitions is the sum of peacetime replacement needs (from training and testing) and war reserve requirements. This requirement has generally not been fully funded in the past and, with ever tighter procurement budgets, is unlikely to be fully funded in the future.[23] Moreover, surge efforts in preparation for the Persian Gulf War filled inventories with ammunition that went largely unused. Angelo Catani, President of Olin Ordnance, described this situation as ‘‘ac{;eleratirtg our way out of the business. ”[24] The Persian Gulf War also validated ‘‘smart munitions’ at the expense of traditional “dumb munitions. ‘ These smart munitions are produced in smaller quantities and have higher unit costs, with most of the cost going for guidance systems and not explosives.

Olin Ordnance, as one of the three domestic manufacturers of medium- and large-caliber ammunition, plans to survive the changes in defense production by restructuring and downsizing, and exploring new markets, such as ordnance disposal and environmental cleanup.[25] However, the oppor-

m Ibid.

21 Shipbuilders Council of America, ‘‘Update on World Shipbuilding Subsidies,’ special report, March 1991.

22 ‘‘From the Boardroom: Angelo A. Catani, President, Olin Ordnance, ’ *Armed Forces Journal International,* October 1991, p. 73.

23 Kenneth Girardini, “The Army’s Conventional Munitions Acquisition Process,” Rand Note N-2864-P&L, The Rand Corp., July 1989, p. v.

24 “One on One, ” an interview of Angelo Catani, *Defense News,* July 1, 1991, p. 23.

25 “From@ the Boardroom,’’ op. cit., footnote 22, p. 74. As this report went to publication, Alliant Techsystems, another domestic ammunition producer, had tentatively agreed to purchase the defense operations of Olin Corp.

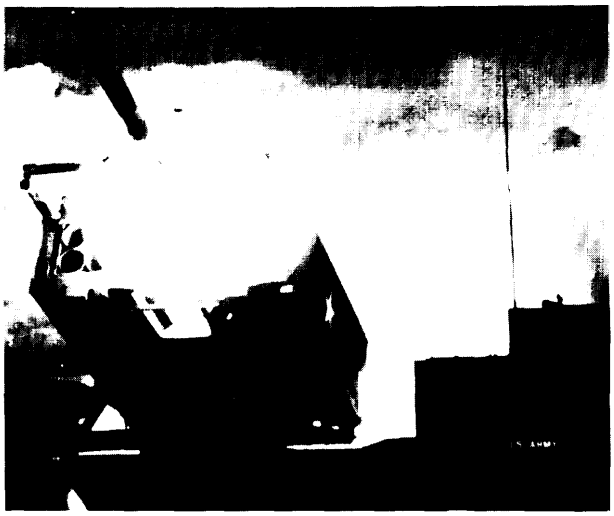


Photo credit: DoD

The three man crew of the Multiple Launch Rocket System can fire 12 rockets over 30 km. in less than a minute.

tunities for saving the production facilities themselves are severely limited by the specialized nature of the manufacturing equipment and the lack of commercial markets for large ammunition.

When Preserving the Current Base Is Not Critical

Maintaining all parts of the current production base **for a given weapon system might not always be necessary, particularly if the Administration and Congress adopt a long-term, mission-oriented approach to defense procurement.** In many areas, reduced U.S. forces can be equipped from the current stockpile of weaponry for years. The technological edge of these systems could be assured through periodic upgrades, as described in chapters 3 and 5.

Meanwhile, design, development, manufacturing, and maintenance engineers could build and test experimental weapon prototypes that emphasize affordability, producibility, usability, and maintainability, in addition to performance (see ch. 3 for a discussion of prototyping). These prototypes maybe direct descendants of current systems (e.g., a prototype follow-on to the Abrams tank) or they may achieve the mission of the current system in a new way (e.g., the Multiple Launch Rocket System v. traditional artillery).

Photo credit: TRH, London

The soldier of the future will live in an world vastly different from our own.

When a prototype has been sufficiently tested and a requirement appears, the new weapon system could enter production and replace aging equipment. **Since the new system could be truly revolutionary in design, its production base might be substantially different from the current base.**[26] **(For example, the ability to cast large steel turret rings would not be needed to manufacture a ceramic, turretless tank.) New systems could be designed with common components, thereby simplifying and concentrating the production base and making lower production rates economical. Many firms working on current systems will recognize these shifts in**

26 In the past, few new weapon systems have been so revolutionary that the old production base was bypassed entirely. Products have tended to be more evolutionary as producers of old components have moved on to new components. This will probably be true in the future as well, although a series of prototypes may advance to the point where their basic hardware differs from the last produced model. Moreover, the new system may have little in common physically with systems preceding it (e.g., atomic weapons and guided missiles),

Box 4-A Competing Goals of Defense Production

Efficiency is not the only grounds on which to judge the defense production base. Other public interest goals have been important factors in the structure of the current production base. These goals include:

. Maintaining employment levels and geographic distribution.
. Providing workers with education and skills.
. Fiscal accountability and safeguarding the taxpayers' money.
• Supporting small and disadvantaged businesses.
. Stimulating the national economy.
. Competition to ensure fairness and access.
. Buying American products to protect American jobs.

In a period of much reduced defense spending, policymakers might choose to adopt efficiency as the prime goal for the future defense production base to ensure that limited defense funding provides the maximum defense capability. Political realities, however, make it unlikely that the influence of public interest goals on defense procurement will disappear completely. As defense resources become increasingly stretched, policymakers may choose to elevate the relative importance of efficiency in restructuring the base. At a minimum, it might be necessary to make efficiency paramount in critical sectors where the future production base is especially threatenexi. Congress might review DoD efforts to identify vulnerable portions of the base where alternative sources are not readily available or are politically unacceptable (e.g., sole foreign suppliers) and request further studies if these efforts are found deficient. Then, Congress might exempt critical firms or the defense industry as a whole from public interest laws and regulations.

This report leaves the judgment of the appropriateness of various public interest goals to policymakers and focuses solely on options for producing "the most bang for the buck. "

SOURCE: Office of Technology Assessment, 1992.

production opportunities and redirect themselves of their own accord.

EFFICIENT PRODUCTION

An efficient peacetime production base is defined as one that manufactures materiel that is affordable, manufacturable, usable, maintainable, and of good quality. (Two other desirable characteristics of the future production base——responsiveness and mobilizability in crisis or war-are addressed in subsequent sections). Congress, the Administration, and private industry can adopt several measures—separately or in combination-to create an efficient production base for the 21st century. The measures include: streamlining production and consolidating industries; operating at lower production rates; shifting away from the manufacture of end items toward prototypes, upgrades, spare parts, and maintenance; reducing barriers to civil-military integration; cooperating with allies; stimulating innovation; and increasing procurement and equipment commonality. The goal of efficient production is sometimes in conflict with other interests that have shaped the production base in important ways in the past. This conflict is discussed in box 4-A.

Streamline and Consolidate Industry

Streamlining g and consolidating the current base are essential for efficient production. Defense manufacturers across the board are streamlining their operations. They are trying to sell off excess facilities, laying off or retiring workers, and diversifying into other businesses. Some companies have abandoned defense work; resulting in a consolidation of their industrial sector.[27]

Attrition will eventually reduce the size of the production base to a level (consistent with decreased defense spending, but a lack of long-term planning will leave the base weaker and potentially crippled in key sectors f important manufacturers fail. The DoD did not regard this as a major concern until recently. In a report to Congress last November, the DoD wrote: "In a broad context,

27 The Industry, Technology, and Employment Program at OTA is engaged in a companion study on how to smooth the transition of businesses and personnel into the private sector. Their first report is 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).

28 "Report to Congress on the Defense Industrial Base, ' op. cit., footnote 15, p. ES-7.

free market forces will guide the industrial base of tomorrow. '[28] The DoD argued that active government intervention in the defense market would only be required in areas where technological or manufacturing capabilities critical for national security were threatened. The guiding principle at the DoD had been that the government is not ''wise enough' to pick winners and losers and that, for the most part, market forces should make these determinations.[29] In recent months, however, DoD officials have begun to discuss more active options for preserving portions of the DTIB, including a prototyping strategy of sorts.[30] However, outside analysts rogue that the coming budget reductions will be larger than the Bush administration is planning for and that unless decisive action is taken to protect the future base, it will be severely undermined.

Internal Streamlining

The government can influence the internal streamlining of individual firms in several ways. It can stabilize the business environment by making more reliable force projections and by predictable multiyear program funding. It can reduce administrative barriers that block the integration of commercial and military production. And it can support the transfer of relevant manufacturing technology. (Each of these actions is discussed below.) Most internal streamlining, however, must be company-initiated to enable firms to compete for fewer and smaller defense contracts.

Consolidation of Industrial Sectors

The government can have a more direct impact on the degree of consolidation of defense industrial sectors. In industries where future procurement will be much smaller than present production levels, the government might decide to pursue policies that ensure only that the best manufacturers survive, even if this means that others do not. For example, the fighter aircraft industry now consists of seven prime contractors.[31] Reductions in the number of U.S. Air Force and Navy fighter wings in the future will probably force one or more of these companies to leave this business.

Defense firms are unlikely to leave the defense business readily (as box 4-B suggests). Government action might either prop up these companies (e.g., by distributing contracts to maintain their survival or by waiving competition requirements)-perhaps weakening all of them-or help encourage consolidation among the firms to a number more commensurate with demand.[32] Facilitating mergers among sector participants would foster consolidation and avoid the loss of unique capabilities and talents.[33]

Changing Competition Rules

Government rules and regulations could also be changed to emphasize maintaining the health of innovative manufacturers in critical sectors.[34] (Less critical sectors might also benefit from these changes, but the need for them might be outweighed by social considerations, as was discussed in box 4-A). *Redesigning Defense* reported that industrialists pointed to the Competition in Contracting Act (CICA) of 1984 (Public Law 98-369) as a major source of problems in the DTIB.[35] In their view, the focus of CICA on full and open competition based on low-price bidding instead of quality or past performance has allowed some unqualfiled and inexperienced companies to get into the defense business at the expense of established and reputable producers. Without the discipline of past performance evaluation, new competitors may submit bids

29 ''Atwood: Purely 'Industrial Base' Contracts on the Horizon,'' *Aerospace Daily*, June 3, 1991, p. 370.

30 ' 'Statement of the Secretary of Defense Dick Cheney, ' op. cit., footnote 13.

31 Boeing, General Dynamics, Grumman, Lockheed, McDonnell Douglas, Northrop, and Rockwell.

32 The Army Munitions and Chemical Command is using existing regulations and statutes, including the 1861 Arsenal Act, to consolidate its ammunition mobilization base.

33 The geographical distribution of the remaining manufacturers is an important factor in consolidation planning. Concentrating them in one area allows workers to flow from one company to another according to production schedules,

34 A DOD Advisory Panel on Streamlining and Codifying Acquisition Laws, composed of senior government and industry representatives, has been established by Congress to review all acquisition laws and offer recommendations for change where appropriate. This panel is subdivided into 6 working groups covering socioeconomic, contract formation, contract administration intellectual property, standards of conduct, and other acquisition statutes. Final recommendations are expected in January 1993. (56 *Federal Register 215*, pp. 56635 -56637.) This panel will not address how the DoD implements legislation. For example, single-source contracts are legal under specified conditions, however, procurement officers avoid such exemptions from usual practice because they raise the possibility of legal challenges by other producers.

35 For a more detailed discussion of CICA see ''Box 4-B—Problems with the Competition in Contracting Act,'' *Redesigning Defense*, op. cit., footnote 1, p. 70.

Box 4-B—Teaming Arrangements

A few of the larger defense prime contractors have sought to avoid betting their future on all-or-nothing contracts by joining forces in teaming arrangements where several companies share the risk and rewards of competing for large contracts. A prominent example of industrial teaming occurred in the Advanced Tactical Fighter (ATF) competition, where virtually the entire fighter aircraft industry signed up to support one or the other (or both) ATF prototypes. The two teams together are estimated to have invested between $1.2 and $2 billion in the competition, with the winning team getting the chance to build perhaps the only new fighter this century. In late 1991, the Navy ran a similar competition for the AX attack plane and awarded concept exploration and definition contracts to the following teams of prime contractors (shaded) and major subcontractors:

Major partners of AX Team Proposals

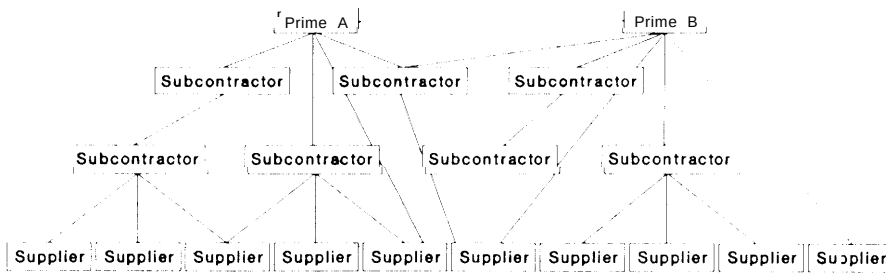
Team A	' Grumman	Boeing] [Lockheed		
Team B		Boeing I Lockheed	General Dynamics	
Team C			General Dynamics] McDonneii Douglas	Northr;p]
Team D				D @ ' : [L + v = " 1
Team E		Lockheed		Rock wel l ~

• As t his re por t went to p reas, the ownership of LT V C or p o rat 10 n's Aerospace Div IS io n waa being deter mined by bankruptcy proceed ings.

SOURCE: *Washington Post,* 1991; *Defense News,* 1992; U.S. Navy, 1992.

Teaming arrangements can be good for industry and the DoD if companies with complimentary skills work together to produce a system that no single company could build alone. Indeed, almost all major weapons are built by teams. In the AX competition, for example, Grumman, McDonnell Douglas, and LTV have past experience with the special demands of naval aviation; Lockheed and LTV have expertise in stealth technology; and Boeing is strong in avionics.[1] But teams may also be founded less on unique qualifications than on a desire to carve out a piece of a diminishing market and to share financial risks.[2] In such a case, the combined resources of the partners are less of an advantage and more of a burden: the extended collection of prime and subcontractors seines as a source of increased bureaucratic overhead, conflict between corporate cultures, and miscommunication (see figure below). This is particularly true in competitions like the AX where a single firm may compete on more than one team, requiring internal barriers to the transfer of information. Moreover, there is a possibility that partners competitive in other programs may withhold their best ideas and personnel from the team. In the end, however, no amount of tearning to win a piece of what will be a smaller contract pie will support the current-sized base. Government policymakers, understanding this, should be wary of awarding contracts to teams that do not have complementary technological strengths.

Interlining Teams



SOURCE: Office of Technology Assessment, 1992.

1 Steven Pearlstein, "Strange Bedfellows Emerge to Chase A-X Bid," *The Washington Post,* July 21, 1991, p.H1 and H12; and Anthony L. Velocci Jr., "AX Competition Critical to Many Team Members," *Aviation Week and Space Technology,* July 22, 1991, pp. 18-19.

2 In the ATF competition, each major player had a 50-50 chance of winning a share of the contract, instead of a 1-in-7 *chance if the* aircraft primes had gone it alone.

SOURCE: Office of Technology Assessment 1992.

that they cannot fulfill without more funds later or transferring the contract to another manufacturer-all at added cost to the DoD.

Low-price bidding often favors companies that "build-to-print' (i.e., they produce off someone else's drawings), because these companies do not carry the high overhead cost of maintaining an R&D capability.[36] Build-to_print companies are an important segment of the current defense production base, often producing products of highest quality. However, as industrial sectors consolidate, policy makers will need **to decide whether it is better to support firms that** develop new systems rather than build-to-print companies.

One option for placing defense bidding on firmer ground lies in further efforts to change the criterion for contract award from lowest bid to ''best value, based on the past record of a company in meeting price, schedule, and quality goals, the capability to do the job, and, in a few sectors, the importance of an individual company to the maintenance of the base.[37] New competitors could still be invited to submit bids, but they would need to be particularly innovative to overcome the handicap of no past performance record. Another option is the preelection of qualified bidders. The U.S. Navy applies a combination of best value and preelection in certain procurements. Rather than bidding for each contract as it comes due, firms are interviewed once and put on a list in order of their assessed ability to complete a job successfully. If the first company on the list refuses the contract, the next company is called in for negotiations. The list is then reused for similar procurements.

The U.S. Army is currently experimenting with alternative approaches to contract awards. One initiative has separated the risky development phase of procurement from the more predictable production phase. The uncertainties of development, combined with the pressure to submit the lowest bids, led to repeated cost overruns in the development phase in all Services during the 1980s. Cost overruns often hurt both the Services and the contractors, especially if the latter were working under a fixed-price arrangement with cost overruns charged against firms. The Army covered all development costs on its new light helicopter, the RAH-66 Comanche, and then looked for production bids that were realistic and demonstrated an understanding of the program. According to the Army, fully funding development reduces the likelihood of costly surprises and delays in production.[38] Although a team comprised of Boeing and Sikorsky was awarded the contract, recent budget cutbacks have left the future of the Comanche in doubt.

Public and Private Arsenals

In some cases, procurement might be so low that, even after extensive restructuring, there is only enough work for one manufacturer. The result would be what is known as a "natural monopoly. '[39] For easily produced items, a natural monopoly would still allow competition, since other companies could bid to take over the contract when it expired. But for items requiring special machinery and skills, competition would have to be induced artifcially and the government would have to absorb the costs of helping a new contractor develop the capability to produce these items whenever the contract changed hands. Moreover, the changeover might leave gaps in production capability. As the dominant buyer of defense equipment, the government would retain significant leverage for modifying the behavior and prices of a monopolist vendor.

In *Redesigning Defense,* OTA suggested that private or public arsenals might be established in **sectors where natural monopolies exist.** Private arsenals could be either GOCOs or companies that receive noncompeted contracts. Examples of important defense industrial sectors that might be forced into arsenal production are armored vehicles and

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36 If the policymakers took a radical approach to restructuring the DTIB and located all development responsibilities in R&D centers, then the distinction between build-to-print houses and other manufacturers would disappear (see ch. 3). Quality of production, however, would remain as a legitimate standard for consolidating the production base.

37 The commercial strength of a company might also be an advantage in a best value Competition. A diversified company might be better able to weather lulls in defense production than a less diversified company and maintain its defense capabilities without DoD support. In any case, best value criteria would need to be made explicit to limit subjectivity and deter legal challenges.

38 Caleb Baker, ''Army Calls for Changes in Contract Process,'' *Defense News,* vol. 6, No, 11, Mar. 18, 1991, pp. 4,44.

39 A natural monopoly ''is a monopoly that occurs because it is economically impractical to have competition, as when the position of consumers would not be improved by having 30 water companies offering their services to every household in a certain city. The extra cost of installing 30 sets of pipe would more than offset any possible price reduction brought about by competition, so in the U.S. most natural monopolies are *regulated* monopolies. " In Donald W. Moffat, *Economics Dictionary (New* York, NY: American Elsevier Publishing Co., 1976), p. 198.

ships. Designating one source for armored vehicles (e.g., tanks, personnel carriers, and self-propelled artillery) and funding it specifically to maintain its capabilities might be necessary to preserve manufacturing skills and guarantee a mobilization capability. In shipbuilding, rather than let the shipyards go out of business one by one, it might be in the national interest to select the most modern and efficient yards, or those with unique capabilities, as shipbuilding arsenals. These arsenals would likely be privately operated, possibly GOCOs.[Q] The Navy is reportedly planning to streamline shipyards on both coasts and create administrative hubs that will reduce overhead at individual shipyards.

Closing or Mothballing Facilities

In instances where the current supply of a weapon system is sufficient for the foreseeable future, the government might shut down all current production facilities—perhaps mothballing them—and accept the substantial costs and delays of reestablishing production if the need ever arose [41] **The** existence of an experienced workforce to revive a facility would depend on related work being conducted elsewhere.

Second-Source Contracts

The past emphasis on second-source contracts must also be reextied in light of a perceived need to strengthen quality manufacturers. Second sourcing was intended to protect the military from the unanticipated loss of a manufacturing capability and to reduce unit costs by injecting competition into the procurement process. But unless carefully handled, second sourcing may be unfair to the original producer, may lower incentives for firms to invest in R&D, and may not result in lower real costs.[42]

The original developer of an item carries overhead costs (e.g., R&D and design teams) that a second-source producer, particularly a build-to-print firm, may not have. Moreover, just when the original producer is lowering its cost through greater manufacturing experience and higher volurnes,[43] the second source must build or maintain facilities, train personnel, and often repeat the mistakes already made by the primary source, perhaps resulting initially in lower quality. If the policy makers) goal **is to forge a stronger future production base, the government could support fully those companies that develop new systems, rather than weaken them by giving second-source work to inexperienced firms or those without R&D capability** on **the grounds of furthering competition. If** second sourcing is still deemed important, then the second-source field could be limited to those producers that have a development capability. Another option for the DoD is to fully fund development, making it profitable in its own right, or to separate production from R&D through the establishment of independent design houses. (See ch. 3.)

Technical Data Rights

DoD procurement officers often demand all technical data as part of a production contract in order to establish second sources. (See ch. 2.) Companies report they have to release technical data rights to win a contract even when providing it is not legally required. Prime contractors are largely unaffected by the technica1 data rights issue, since their major task is systems integration, **which is a difficult capability to transfer. In contrast, subcontractors see their proprietary information in products and processes, many of which have commercial applications, as the primary feature that distinguishes them from their competition.** Build-to-print defense firms can use this data to undercut R&D-intensive companies in defense contract competitions based strictly on

40 Although the U.S. Navy in the past constructed its own ships in naval shipyards, it has not done so since the 1960s. Currently, the naval shipyards specialize in overhaul and repair, while all new construction is done in private yards. Because it would be difficult and expensive for the naval shipyards to relearn how to build ships, any shipyard arsenals would most likely be established at private shipyards currently engaged in shipbuilding.

41 For example, General Dynamics estimates that if its tank facilities were completely shut down, it would take a minimum of 4 1/4 years after a reopening decision to produce the first tank and 5 years to achieve a rate of 60 tanks/month. The components that determine this delay, however, could be identified (i.e., gas turbine engines and depleted uranium armor) and stockpiled to cut down the time to first-unit production.

42 The extent of direct cost savings gained through second sourcing is very difficult to measure. A Rand Corp. study of second sourcing noted, "in some cases (especially in the procurement of major systems) it may be actually less costly for the government to forgo competition and rely on a single supplier." This is primarily due to the need to facilitize the second source and transfer manufacturing procedures. In order to achieve true cost savings, the planned production quantity must be sufficient to allow both firms to achieve maximat productivity and offset the additional costs of the second source. (See J.L. Birkler, E. Dews, and J.P. Large, "Issues Associated With Second-Source procurement Decisions," R-3996-RC, The Rand Corp., December 1990, pp. v, ix, and 26.)

43 The cost of production for most items decreases over time as experience is acquired and past mistakes are avoided. These savings are found in shorter production cycle times, fewer manufacturing defects and design changes, and less waste. This decrease in cost can occur regardless of second sourcing.

lowest price and to gain advantages in commercial markets.

In the future, innovative firms will have a greater stake in holding on to technical data rights to help their commercial work. They may therefore refuse to bid for defense work if the DoD enforces technical data rights rules as it does today. Useful alternatives would be for the DoD to:

1. put the burden of proof on the government to demonstrate an explicit need for access to proprietary data;
2. limit the requirement for proprietary data to certain vital components;
3. keep collected data confidential until needed, perhaps in escrow, with government access contingent on specific conditions;
4. let businesses withhold this information for a period of time (similar to a patent) that will allow them to develop more advanced capabilities (a relatively short period in the electronics field)[44] or
5. compensate firms financially or with advantages in procurement for the full value of their proprietary data,

Strategic Partnerships

In the future, fostering a quality, integrated subcontractor and supplier base will be at least as important as supporting the best prime contractors. Yet consolidation among subtier firms is inhibited by many constraints. Although the primes are not always legally bound to compete their subcontracts, many do compete subcontractor awards in the belief that otherwise they will lose the contract. The primes argue that competing subcontracts is often expensive and sometimes results in poor quality work by the low bidders, causing the primes to be blamed for schedule delays and cost overruns.

Spokesman for the primes argue that the subcontractor and supplier tiers should be rationalized through strategic partnerships. This is currently occurring in the civil sector, where commercial enterprises are shedding their past practice of competing for lowest-priced components in favor of long-term relationships with subcontractors and suppliers of proven quality and dependability. Spokesmen for commercial industry argue that these partnerships result in lowest real cost (e.g., they avoid costly mistakes, redesigns, and the cost of reworking defective incoming parts). The Federal Government could ensure fair pricing through competitive bidding at the prime level and periodic audits .45

Reduce Production Rates

Policy makers should plan for future defense production that will be much lower than present levels. Funding cuts and equipment surpluses generated by force reductions will continue to lower production. This is not to suggest that all production will cease. Even with the largest **cuts now forecast,** the military will continue to purchase tens of billions of dollars worth of equipment annually. Future forces will still need to be outfitted; aging stocks will need to be replaced periodically.

One way of maintaining manufacturing capability in the future DTIB would be to set low production rates in lieu of traditional rapid rates.[46] The decline of a major Soviet-size conventional threat has made it less important to produce systems rapidly .47 Low-rate production would allow the DoD, with a lower procurement budget, to maintain core manufacturing personnel, equipment, and facilities. These would serve as the base for fulfilling surge, mobilization, or increased peacetime requirements. (See box 4-C.)

Whether or not low-rate production increases unit costs depends to some degree on when and how the production decision is made. If a decision is made during the design phase of a product, then the design can be optimized for existing low-rate manufacturing equipment and processes. Manufacturing facili-

44 In fact, businesses often delay *handing* over technical data until they have developed a more advanced capability.

45 Commercial businesses that are now organized in strategic partnerships feel they can avoid price gouging **by their** restricted subcontractor and supplier base without the extensive oversight common in defense procurement by negotiating a long-term relationship in exchange for a reasonable price.

46 Low-rate Production in this report differs from the concept of ''low.mte initial production' ' (LRIP). LRIP is often intended as a trial period during which the manufacturing processes and equipment are validated and final design changes are made before shifting to a higher rate. In this report, low-rate production remains constant and does not assume higher future rates, Thus, the best manufacturing processes, facilities, and equipment for LRIP may differ significantly from what is needed for low- rate production, See *Defense Manufacturing Management,* op. cit., footnote **4,** ch. 11, pp. 12-13.

47 In the commercial sector, the speed with which new products can be brought to market is becoming increasingly important. Low-rate production, designed to maintain a critical production capability over an extended period of time, necessarily contradicts this trend. Joseph T. Vesey, ' 'Speed-tmMarket Distinguishes the New Competitors, ' *Reseurch-Technology Management, vol. 34, No. 6,* November- December 1991,

Box 4-C—Low-Rate Production is Not Always the Best Option

During the transition to a smaller, more efficient future production base, not all manufacturing skills, equipment, and facilities will need to be actively protected by the DoD. Many capabilities may t e relatively common in the defense or broader commercial base. As long as workers and equipment can be assemble din a timely manner when production is needed, the DoD need not take extraordinary action to preserve a continuous capability in the defense production base. (Policies addressed in this chapter for fostering efficiency and preserving capabilities, however, may still be beneficial in these noncritical areas as a means of lowering procurement costs and raising quality.)

Stretching out production is particularly problematic for the wide variety of defense items that are procured in small quantities of less than 100 (e.g., special aircraft, ships, and satellites). In such caseS, the indiscriminate adoption of low-rate production could result in unrealistic work schedules and therefore needlessly expensive costs. Instead, these products should be procured in economic batches as long as their associated manufacturing capabilities can survive between orders through related work or because the manufacturing processes involved are relatively simple. The use of economic production rates applies to subtier firms as well as to prime contractors. For example, even if it was decided to manufacture attack helicopters at a slow, steady rate to maintain worker familiarity with the process, many basic subcomponents and hardware could be procured up front to lower costs. (Of course, savings for bulk purchases would have to be balanced against storage costs and the requirement for earlier spending.)

SOURCE: Office of Technology Assessment, 1992.

ties and staffs can be sized appropriately, thus minimizing unit costs.[48] But transformin g an active high-rate production facility to a lower rate will in general be difficult, less efficient, and expensive, and will require an arduous transition period when excess capacity and workers are reduced.

Predictable funding through multiyear procurements would enhance low-rate production, Such funding would facilitate long-range planning and lessen firms' fears of failure; thus it would permit more aggressive restructuring. This should in turn result in lower unit costs than would occur otherwise.[49] The disadvantage of multiyear procurement is that it reduces government budget flexibility, front-loads costs, carries significant penalties to the government for contract cancellation, and may make it more difficult to institute late design changes.[50] Adoption of multiyear procurement would require a consistency of defense planning and funding that is not evident today.

The key to the success of low-rate production is to establish an acceptable minimum production rate. This rate will allow the prime contractor to remain profitable and obtain all necessary subcomponents and supplies. The rate will depend on the size of operations, the flexibility of the factory, and the nature of other products produced. Rates will also be affected by the adoption of measures discussed later in this chapter.

Detailed information will not only be needed about the lowest sustainable production rate of the prime, but that of suppliers and subcontractors as well. In some cases, the lowest rate may be determined by the need to keep production lines open for a critical subassembly. Alternatively, rather than produce more of the final integrated system, the government might find it cheaper to subsidize the manufacturer of this subassembly, find another company willing to produce it or a redesigned replacement at lower rates, move production into a

48 The capital investment in facilities and equipment for a new product can be a substantial proportion of the total program cost. A company that agreed to low-rate production for a new product might limit itself to one production line, because that is all it needs to manufac ure the item. Moreover, the company might choose to rely on flexible and existing equipment, rather than investing in specialized equipment, to lower costs and leave open opportunities for altering production processes over the duration of the extended production run. Under traditional procureme nt, the same company would more likely run several production lines using specialized equipment in order to receive the quickest return on its investme it. Cutbacks in procurement to this company after it had made this investment would result in higher unit costs,

49 Conversely, unpredictable funding and production rates will raise unit costs, because Of an inefficient uSe Of manuf acturing resources.

50 Karen W. Tyson et al., ' 'Acquiring Major Systems: Costs and Schedule Trends and Acquisition Initiative Effective ness, ' IDA Paper P- 2201, Institute for Defense Analyses, March *1989,* ch. *6,* pp. 1-11.

Table 4-3 Impact of Low-Rate Production on t he Abrams Tank's Subcontractor Base

Component subcontractor	Number of tanks produced per month	
	10	30
Electronics/Optics		
Sterling Heights, GDLS	Some problems	Acceptable risk
Cadillac Gage, MI	Some problems	Acceptable risk
Cadillac Gage, OH	Significant risk	Some problems
Texas Instruments	Some problems	Acceptable risk
Smith Industries	Some problems	Acceptable risk
Kollmorgan	Some problems	Acceptable risk
Precision Sensors	Some problems	Acceptable risk
GE	NA	NA
J-Tech Associates	Some problems	Acceptable risk
Hughes Aircraft	Some problems	Acceptable risk
Computing Devices	NA	NA
Kearrfott	NA	NA
Complex machining		
Scranton, PA, GDLS	Significant risk	Some problems
Detroit, MI, GDLS	a	a
Lima, OH, GDLS	Some problems	Some problems
Basic ***materials***		
Atchison Casting	Some problems	Some problems
Lukens Steel	Some problems	Some problems
Idaho, U.S. DOE	b	b
Weapons		
RIA	Some problems	Acceptable risk
Watervliet Arsenal	Some problems	Acceptable risk
Propulsion		
Textron Lycoming	Some problems	Some problems
Allison	Some problems	Some problems
Stanley	NA	NA
Urdan	NA	NA
FMC	NA	NA

KEY: Companies that are least affected by lower production rates are listed as having "some problems." Companies listed as being at "significant risk" will be most negatively affected, with a potential for facilit y shutdown. NA means not available.
a M1 assembly line closed in 1991.
b Scheduled to begin closing in December 1992.

SOURCE: General Dynamics Land Systems (GDLS) Division, 1991.

government-owned arsenal, or stockpile all that will ever be needed in a one-time ''life-of-type' buy.

A company might implement its low-rate **production in different ways: spread even] y throughout the year, in odd-sized batches as orders come in, or all at once in a short period to allow a shift to other products for the remainder of the year. The sole mandatory requirement would be that critical capabilities and skills are maintained from** *one* **year to** the next. OTA asked General Dynamics Land Systems to estimate the impact of low-rate production on the Abrams tank contractor base. The results are shown in table 4-3.

Firms that emphasize flexibility in manufacturing organization, processes, and equipment will be well positioned for a transition to low-rate production, as well as to the production of new products. (See box 4-D.) **Flexible manufacturing systems enable businesses to build several different products simultaneously on the same line (or at the same stall) and to shift from one project to another with a minimum of expense and effort.** In the extreme, each item on a flexible line might be unique. While flexible manufacturing can be capital intensive, requiring new flexible machines, this is not true for all products. For example, the most flexible and cost-effective manufacturing method for one-of-a-kind satellites might be to build them by hand.[51]

51 Sandwich shops are often used as an example of a completely flexible assembly line with no automation at all—customers have a wide variety of sandwiches and ingredients to choose from.

Box 4-D—Restructuring for the Future: BMY-Combat Systems

One company that has already successfully navigated the transition to low-rate production is BMY-Combat Systems. In an interview in *Armed Forces Journal International,* the president of BMY revealed that the company reduced the production rate of the M-88 tank recovery vehicle from 20 per month to 3 to 4 per month and remained profitable. This rate reduction was one aspect of a company-wide strategic restructuring.[1] The success of this effort depended on a total restructuring of the production process so that six fairly similar products that use many common parts and processes could be produced on the same line. It also required the infusion of $80 million for plant modernization from BMY's parent corporation, Harsco; the replacement of most government tooling with the company's own, more flexible tooling;[2] a consolidation and rationalization of facilities; a 50 percent reduction in workforce; and a relative increase in foreign sales of its products from about 40 percent in 1986 to about 65 percent in 1991. The company can take small orders (5 to 6 vehicles) and integrate them with orders for other vehicles to maintain the production line. With the restructuring almost complete and a couple of years' orders on its books, BMY-Combat Systems' employment is now rising again. The firm's main concern about future production is how to ensure continued supply of key parts from subcontractors and suppliers. Commonality of products has allowed BMY to award multiyear contracts to its subtiervendors, but some of them are on the verge of going out of business.

1 John G. Roos, "From the Boardroom: Barret W. Taussig, President BMY-Combat systems," *Armed Forces Jo urnal International,* May 1991, p. 27; and an OTA interview with BMY-Combat Systems officials on Nov. 14, 1991.

2 Tooling that is purchased as part of a government contract remains government property and car not be used for other work—governmental or commercial—without compensation. Companies will often purchase their own tooling and forgo government equipment to avoid the inflexibility of having tools that can only be used for one purpose without more paperwork and negotiations, This tooling is added to overhead charges

SOURCE: Office of Technology Assessment, 1992.

Shift Business Focus

A company can lower its minimum viable production rate **for a specific product by expanding its range of activity to include prototyping, upgrades, spare parts, and maintenance, and by manufacturing multiple products.** Chapter 3 discussed the implementation of a prototyping-plus strategy that would provide certain manufacturers with the opportunity to build technology demonstrators or even an entire operational unit of prototypes prior to force modernization as a means of both fostering innovation and supplementing or temporarily replacing limited production.

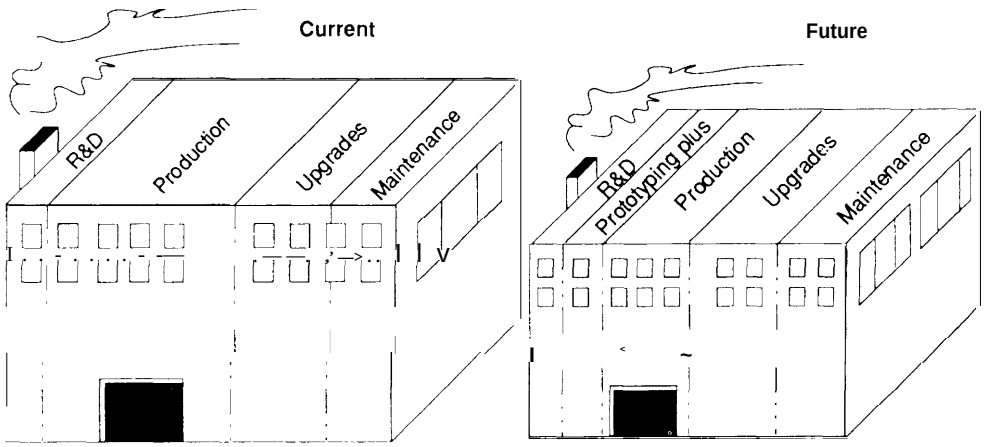
In addition, a reexamination is in order of the DoD's practice of awarding spare-part production contracts to firms other than the original manufacturer. Although intended to increase the number of sources of supply and lower costs, this practice also has the effect of supporting build-to-print shops with little or no design capabilities, at the expense of the original manufacturer. In the commercial world, spare-part sales are often an important source of income to the original producer. Similarly, upgrade contracts that would have been competed in the past might be directed to a particular manufacturer, or competition might be limited to quality producers to help alleviate losses in production. Spare parts and **upgrades can be a significant fraction of** an **industry's** business. For example, the commercial market for spare parts for large aircraft engines is about half as large as the market for engines.[52]

Another important shift in business focus is for the DoD to transfer some depot-level maintenance work from the public sector to the private, as discussed in chapter 5. One reason to do this is to augment the dwindling world bad of the original equipment manufacturer. As systems become more sophisticated, and perhaps modular, they could be returned to their originating factory for maintenance rather than duplicating this capability at government depots and shipyards.

Companies might also adtapt to procurement shortfalls by diversifying their product lines. In some industrial sectors, market attrition or government policy might result in a consolidation of manufacturers such that products previously spread

52 Pratt & Whitney predicts that the relative size of this market will grow well into the 21st century. projections of the military market for large engine spare parts are clouded by procurement decisions, but they range from about 35-100 percent of the military engine market "or the same period. Pratt & Whitney briefing, West Palm Beach, FL, Sept. 10, 1991.

Figure 4-5--Hypothetical Shift in a Defense Manufacturer's Activities



NOTE: Proportion of activities varies by individual sector and individual firm.
SOURCE: Office of Technology Assessment, 1992.

over several companies (e. g., ships and ammunition) become the domain of a few companies. A company might also seek to expand into other government or commercial activities (described below). Companies that are flexible in their manufacturing processes and that utilize similar equipment and skills will avoid many of the costs associated with starting new production.

Figure 4-5 depicts how a company might shift its business focus. Caution must be used, however, in any attempt to substitute other activities for production. For some industrial sectors (e.g., defense electronics) and types of companies (e. g., subcontractors) such activities are reported to be a viable way to survive lulls in production. Yet, for companies that produce complex integrated systems or products that require little maintenance, this option may not be a feasible way of preserving their full range of critical manufacturing skills (see box 4-E), facilities, and equipment. Companies whose manufacturing capabilities are critical to the base must be examined on a case-by-case basis to determine the viability of this strategy.

Reduce Barriers to Civil-Military Integration

The efficiency of the future defense production base may also be enhanced by changes in the relationship between industry and government. Re-*designing Defense* reported a broad consensus that government/industry relations **have become increasingly adversarial.**[53] This stems from laws and regulations adopted in response to public fears of waste, fraud, and abuse. legislation, regulations, and the resulting procurement culture have 1ed to Voluminous contracts, layers of restrictive product specifications and auditing procedures, and barriers to communication among industrialists and with government program officers, and it has impeded off-the-shelf purchasing .54

Companies expend enormous energy and time on the paperwork associated with DoD contract bidding and auditing. These costs are included in overhead and ultimately added to the price of procured items. While large firms can ''afford" specialized staffs to cope with this paperwork, smaller firms face a disproportionate burden. Paperwork requirements

53 The Persian Gulf war eased relations temporarily. Procurements that usually take months or years were sped through in weeks. Spare parts and upgrades were rushed to the front in record time. Food, fuel, water, and other commodities were bought in local markets in Saudi Arabia and the United States until logistics officers could catch up with the rapid buildup. And commercial items were used to bridge gaps in Service procurement. For example, the Navy's Safety and Survivability Non-Development Item Office bought a number of products commercially, such as fire-fighting and detection equipment, air hammers, and body armor, and delivered them to the fleet within 45 days. (U.S. Department of Defense, ***Conduct** of the Persian Gulf Conflict: An Interim Report to Congress,* July 1991, ch.8, pp. 1-4.)

54 These issues will be discussed in more detail in ch. 6, but are presented here as they relate to production specifically.

Box 4-E—Worker Skills in the Defense Production Base

The streamlining of the defense production base has forced many companies to focus on short-term survival over long-term health. In addition to eliminating excess capital equipment and facilities, these companies feel compelled to reduce personnel costs. Reductions have focused largely on the early retirement of older, more experienced workers and layoffs of young new talent. There has also been a retrenchment in spending on worker training programs and apprenticeships. Many who have benefited from these services in the past are now moving into the commercial sector. Moreover, nondefense workers and students, seeing the downward slide of defense procurement, are looking for careers elsewhere.

In the short term, this situation is tolerable to the DoD, if difficult for some of the workers Involved. The future production base will not need the number of people currently engaged in defense manufacturing. However, employee reductions that do not take into account future needs may undermine the long-term health of the base. Manufacturers need to retain their most qualified personnel, while production base planners need to ensure a continued supply of manufacturing talent. If the base becomes more commercialized, free mark:et competition may be sufficient to generate the necessary talent. Government support may be needed to preserve select critical skills-from shop floor machinists to naval architects. This help could take the form of scholarships or trade school subsidies to employees or grants or tax breaks to businesses having trouble finding workers trained in needed skills. Alternatively, textual, audiovisual, and computer methods for storing manufacturing experience could be funded. Colleges and universities could strengthen the Nation's future production base by emphasizing manufacturing in engineering and business school curricula. A better educated workforce will make the future base more flexible.

SOURCE: Office of Technology **Assessment,** 1992.

have also deterred some commercial companies from bidding on defense contracts.[55]

Further inefficiencies result from the DoD's requirement that manufacturers produce items according to military specifications that dictate every facet of a product, including acceptable manufacturing processes. Many studies argue that these specifi--cations are out-dated and overly rigid.

Many companies have segregated their defense and commercial work because of DoD requirements for specialized military manufacturing processes and the need to avoid burdening their commercial work with military accounting requirements. This segregation might entail separate production lines on the same shop floor, separate production facilities, or even totally distinct operating divisions within a company. Segregation can **create redundancies in equipment, personnel, facilities, and management, and create barriers** to communication between military and civilian operations. In the extreme, manufacturers in a defense division may have no direct contact with their counterparts in a commercial division. Such segregation raises costs and hinders the transfer of technology between the commercial and defense sectors.

Policy makers **need to reasess the tradeoff** between the costs of fraud and abuse and the cost **of oversight to prevent them. While preventing abuse is an important task of government, the cost of current efforts to do both, both direct and indirect, are large and may outweigh the monetary and moral gains of catching the abusers. Program** officers, auditors, and inspectors engaged in often uncoordinated and overlapping jobs pervade the defense industry. Congress might commission an in-depth study of the diret and indirect costs and benefits of military contract oversight. Accountability must be maintained, but policy might be redirected towards punishing transgressors more severely and rewarding responsible businesses, perhaps by making past behavior an important factor in awarding best-value contracts.

Government action to facilitate a more efficient integration of civil and defense industry can range from mild corrective measures to a radical restructuring of defense production. some sectors of the defense production base are more amenable to integration than others (e.g., defense electronics v. shipbuilding), making sweeping decisions more difficult.

55 For example, Lotus Corporation spent over $2 million trying to comply with DoD **accounting system** standards before giving up. Hewlett Packard only deals with the DoD on a commercial basis. See Jacques S, Gansler, ''Restructuring the Defense Industrial Base,' Issues *in Science and Technology,* Spring 1992, p. 51.

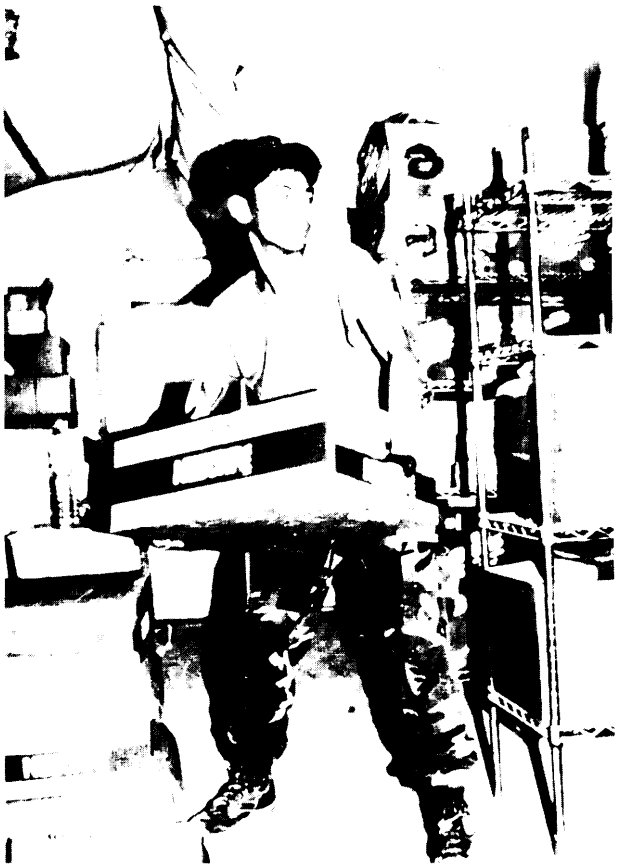


Photo credit: *The DoD*

Soldier stacks provisions in a food tent in Saudi Arabia.

The DoD has not ignored the complaints of industry and has made repeated efforts to smooth relations. In recent years, it has adopted a few programs designed to lessen the intrusiveness of government oversight. The Qualified Manufacturing Line program for the semiconductor industry, which began in 1987, is one example. Under this program, a company can demonstrate that its production lines meet military standards and thus avoid having to test each chip, as has been traditional. The electronics industry has created the National Electronic Component Quality Assurance System as a self-policing measure. Among other activities, this system conducts an audit of the supplier base that used to be done by each company individually .56 Neither of these programs is widespread at this time.

Industry has also joined with the defense acquisition, inspectorate, and auditing communities in the voluntary Contractor Risk Assessment Guide (CRAG) program to reduce oversight burdens on businesses. The CRAG outlines five critical auditing areas: indirect cost submissions, labor charging, material management accounting systems, estimating systems, and purchasing.[57] If a company demonstrates effective internal accounting controls in one or more areas, the Defense Contract Audit Agency (DCAA) reduces its oversight of that area. While the CRAG program has been implemented successfully in a few tens of companies, the incentives for businesses to participate are mixed. On the positive side, the CRAG program potentially reduces the DCAA presence at a company; on the negative side, companies may find themselves paying for internal auditing services that the DCAA would otherwise do for free, while the presence of oversight officials from other government agencies is not reduced.

The defense production base could also take greater advantage of products already on the commercial market. Efforts to increase the percentage of DoD products bought from the private sector have been under way for almost 20 years.[58] DoD Directive 5000.1 requires that the "maximum practicable use shall be made of commercial and other nondevelopmental items. ' For example, the Navy is installing commercial computer systems on combat ships for many functions that were formally performed by unique, Navy-designed computers.[59] Off-the-shelf procurements can be facilitated in a number of ways, including: 1) elimination of unreasonable specifications that block commercial purchases (e.g., requiring nuclear effects hardening on

56 See Debra Polsky, ' 'DoD Chip Oversight Plan Gains Favor, ' *Defense News,* July 1, 1991, p. 9.

57 Defense Contract Audit Agency, ''A Report on Activities, '' DCAAP 7641.81, March 1990, p. 3, and Department of Defense, ''The Contractor Risk Assessment Guide, " October 1988.

58 U.S. Congress, U.S. General Accounting Office, ''Defense Acquisition Reform: Implementing Defense Management Review Initiatives, ' GAO/NSIAD-91-269 (Gaithersburg, MD: U.S. General Accounting Office, August 1991), p. 11.

59 Neil Munro, "Navy Wants More Commercial Computers Aboard Ships, " *Defense News,* Jan. 27, 1992, p. 30.

products that are a part of an unhardened system),[a] and 2) redesign of systems to use off-the-shelf components (e.g., instead of making a monitor rugged, enclose a commercial TV in a shock-resistant shell). Buying many copies of a commercial product instead of one militarily unique product might save money and provide sufficient redundancy to overcome a lack of ruggedness or capability.[61] Of Course many items will still have to be procured according to military specifications to ensure that they will perform reliably under demanding field conditions.

The efficiency of the peacetime defense production base may **be** greater if the relationship between government and defense manufacturers moves to a more commercial basis. Manufacturers would be evaluated on their ability to produce items on time, at an agreed price, and of agreed quality. Military specifications would focus more on the essential characteristics of form, fit, and function, and less on laying out explicit manufacturing procedures. For many products, commercial seals of approval or certification might be sufficient (e.g., Underwriters Laboratory or the International Organization for Standardarization). It might be important for the DoD to continue outlining some critical procedures (e.g., specialized welding), but these specifications could be arrived at through negotiations with the manufacturer, who might know of superior processes. Military specifications should only be passed on from one project to another if they are demonstrably relevant.[62]

Several studies argue that increased reliance on commercial business practices will give industry more flexibility in carrying out contractual obligations, will allow integration of commercial and defense facilities, equipment, and supplies (now largely segregated), and will reduce overhead spent on paperwork. These practices will lower unit prices and decrease the competitive penalties associated with working for the DoD. The adoption of commercial practices could open competition to a wider circle of companies, because nondefense firms that presently avoid defense work would take advantage of the new environment.

For defense companies with little or no experience with commercial operations, lowering the barriers to civil-military integration will create unique challenges. In the defense market, the government defines the product, determines appropriate pricing and profit margins, and specifies manufacturing procedures. The challenge to the company is to convince the government that it can develop the product more efficiently than its rivals. In the commercial market, on the other hand, a producer must rely on its own resources and insight to define products and must carry the fill cost of developing them until they can be sold. Moreover, it must convince customers to purchase the new product and possibly provide warranties and product support as a consumer relations strategy more than a contractual obligation.[63]

At the extreme, policy makers could undertake a radical restructuring of the DTIB based on the wholesale elimination of administrative and legal barriers to civil integration, combined with the redesigning of military systems and the acceptance of form, fit, and function specifications. **These policies would effectively merge the DTIB into the national industrial** base. **Many defense items could be close variants If commercial products (e.g., the KC-10 tanker is based on the** DC-lO).[64] Products that are truly militarily unique would still be built, but could take advantage of

60 Some commercial products, notably in the aerospace Sector, are manufactured at or above military specification standards. The DoD might be able to safely buy these items off-the-shelf at a lower cost. Periodic testing or performance reviews would ensure quality control. In other areas, a lowering of military requirements might make the product sufficiently inexpensive to procure enough copies of an item to compensate for the lowered specifications. Representatives of the shipbuilding industry have suggested that specifications on sealift vessels be lowered n this way so that more such vessels can be procured. These vessels would be protected by combatant ships built to military specifications.

61 During the Persian Gulf War, the DoD bought 10,000 commercial light-weight, global positioning system receivers to help troops, particularly in helicopters and tanks, locate themselves in the featureless open desert. See Conduct *of the Persian Gulf Conflict,* op. cit. footnote 53, ch. 8, p. 3.

62 One proposal being discussed *in the* Pentagon calls for a ''ZCXO basing' of military specification.s. This proposat would reverse the incentive structure of the current acquisition system by forcing program officers to defend the application of any military specification to a product. See Lucy Reilly, ''Milspecs Go Under the Gun: Pentagon Considers 'Zero-Basing' Approach," *Washington Technology,* vol. 7, No. 2, Apr. 23, 1992, pp. 1, 13.

63 Defense manufacturers are increasingly being asked to provide warranties for their products. If these warranties are paid fOr in a production contract, they may be one way to shift maintenance work back to the original manufacturer.

64 McDonnell Douglas *is* developing a new helicopter, the MD-900 Explorer (formerly the MDX), justi.tied on commercial grounds alone, but said to be sturdy enough for utility, armed scout, medical evacuation, and other military missions. See Frank Colucci, ''hmx in Uniform,'' *Defence Helicopter,* vol. 11, No, 1, March-April 1992, pp. 24-27.

Photo credit: U.S. Air Force

McDonnell Douglas KC-10 Extender refuels F-15A Eagle fighter.

many of the same production facilities, equipment, and workers as commercial products. 65 Unique military specifications on products or processes would be an exception. Any activities that require secrecy could still be segregated, but only when absolutely necessary. Future flexible factories and other innovations described below would increase the likelihood that this radical strategy would succeed.

Cooperate With Foreign Nations

The U.S. defense production base can be bolstered through making greater use of the international base. First, sales of military equipment to foreign countries can be used to keep production lines open that might close otherwise.[fi] Second, U.S. fms might increase cooperative activities with foreign countries, perhaps establishing joint ventures. Third, the DoD might purchase items overseas that either are not produced domestically or are cheaper abroad. Fourth, foreign business might purchase U.S. defense enterprises that are failing and make them productive again. All of these activities are currently under way and raise opportunities and concerns. Policy makers will need to evaluate how changes in these activities might affect the production base and what their foreign policy and national security implications might be.

As domestic procurement declines, foreign sales may be one way to keep production lines running. A few defense firms already produce a majority of their equipment for export. As one industry trade group official stated, ''Exports are no longer just the icing on the cake. They are the cake. ' '[67] For many companies, exports have become relatively more important as domestic sales have declined. For example, General Dynamics projects overseas sales to increase from 17 percent in the mid-1980s to about 50 percent in the mid- 1990s, while Martin Marietta plans to move from 8 percent in foreign sales in 1991 to about 20 percent in 1994.[68] Firms were particularly optimistic about future sales after the success of U.S. armaments in the Persian Gulf War. Arms sales to foreign nations may also provide the United States some political leverage over recipients through the sale of upgrades and spare parts.

There are, however, two major problems with an expansion of foreign sales. First, as a result of the end of the cold war, many countries, particularly NATO and former Warsaw Pact nations, have less need for weapons.[69] The shrinking world market for weapons is increasing global competition. Second, the spread of advanced weapons technology around the globe has raised concerns over weapon proliferation and the threat modern U.S. weapons may pose to U.S. forces engaged in future conflicts .70 Without the global Soviet threat, calls for regional bans on

65 I, the few instances where a commercial remedy could not be found, the government might establish a public or private arsenal (e.g., nuclear submarines).

66 For example, Air Force Secretary Rice testified before a Senate Appropriations subcommittee that the General Dynamics F- 16 fighter production facility in Fort Worth, TX will stay warm based solely on foreign sales and aircraft upgrades when the Air Force cancels F-16 orders after next year. The Air Force may need the plant again for a new F-16 variant sometime in the future. A General Dynamics official and some members of Congress were skeptical of this approach. See Ron Hutcheson, "Plan Threatens GD Plant, Official Says," *Fort Worth Star-Telegram, Mar. 18, 1992,* p. 1.

67 Joel L. Johnson, international vice president of the Aerospace Industries Association, cited in Steven Pearlstein, ''Stmggling to Keep Weapons Programs Alive," *The Washington Post,* Mar. 9, 1991, p. C2.

68 Ibid.

69 *Developing* countries, *Which* have been less affected by the political changes in Europe, accounted for over 75 percent of arms import sales in 1988. U.S. Bureau of the Census, *Statistical Abstract of the United States: 1991,* 11 1th ed. (Washington, DC: U.S. Government Printing Office, 1991), p. 339.

70 For more information on the negative aspects of arms transfers, see US. Congress, Office of *Technology* Assessment, *Global Arms* Trade, OTA-ISC-460 (Washington, DC: U.S. Government Printing Office, June 1991).

weapon sales may inhibit the traditional desire to fortify friendly nations against their adversaries and block sales to regions that still demand new weapons.[71] Congress will have to weigh the importance of controls on international weapon exports against the risk that such controls will be circumvented and the need of the defense production base and U.S. allies for arms sales.

Moreover, the decline of the world arms market is consolidating defense industries on a global scale. In Europe, defense companies are increasingly engaging in translational mergers and joint ventures.[72] Collaborative weapon development or production with foreign companies can spread development costs and risks, while pooling technical knowledge among allies. Collaboration with foreign firms has the drawback of transferring American defense technology to companies overseas and reducing opportunities for domestic production. The benefits and costs of cooperative efforts will need to be weighed in terms of their long-term effect on the production base and the national economy.

When systems either are not available or are more expensive on the domestic market, the United States can also place greater reliance on foreign sources of military supplies and components. This choice between materiel autonomy and increased interdependence raises many questions. In the extreme, the DoD could compete procurement contracts worldwide and take the best bid whatever its origin. Currently, foreign sourcing is restricted primarily to the lower tiers of the production base, although important subcomponents (e.g., flat-panel displays) and systems (e.g., the AV-8A Harrier jump jet, the Ml 19 105mm howitzer, and the Berretta 9mm sidearm) have been purchased or produced under license. The full extent of foreign content is not well understood by the DoD because of the difficulty of tracking all the parts in a system.[73] Moreover, many large corporations generally ragarded as American (e.g., IBM) are in fact international in scope and perspective.

The risks of foreign sourcing will have to be weighed against the cost of sourcing components and systems domestically .[74] the risk is a political cutoff of items that affect U.S. capabilities in a crisis or war[75] Cutoffs could also result from a milit~ blockade.[7b] Stockpiling items that will not quickly become obsolete and multiple sourcing of foreign components can decrease vulnerability to a cutoff. Another risk is the potential for U.S. technological dependence on other countries. This dependence would not only affect current systems, but the capability to produce future systems as well. Creating protected industries to preserve an uneconomical capability against a product cutoff will cost the government more, reduce incentives to innovate, and constrain access to foreign technological advances. Since purchases overseas will deprive the U.S. industrial base of the dollars transferred abroad, Congress might consider loosely tying foreign military purchases to foreign military or commercial sales.[77]

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71 Unless bans are universally enforced, they will not prevent countries from obtaining weapons and may serve primarily to cut signatory nations out of the export sales market. If all the industrialized democracies participate in a ban, however, the level of weapon sophi: tication sold into unfriendly hands may decline.

72 One journalist reported a trend in Europe towards a protected defense market. Trade barriers, offset agreements, and tariffs have been combined to create a Buy European atmosphere. Great Britain and the Netherlands are attempting to deregulate a community that in much of Europe is government-controlled or-owned. (Patrick Oster, ' 'Europeans Shelving Rivalries Over Big Weapons Contracts: Possible Trend Concerns U.S. Defense Firms, " *The Washington Post,* Sept. 11, 1991, pp. Cl and C3.)

73 U.S. Congress, General Accounting Office, ''Industrial Base: Adequacy of Information on the U.S. Defense Industrial Base, ' GAO/NSIAD-90-48 (Gaithersburg, MD: U.S. General Accounting Office, November 1989).

74 Testifying before the House Armed Services Committee's Panel on the Structure of U.S. Defense Industrial Base, Nov. 1, 1991, E. Gene Keiffer proposed that instead of investing money to reproduce domestically what can be bought more inexpensively abroad, it would be wiser to invest in leapfrogging the foreign competition and produce a next generation of the item.

75 For example, normal sandbags intended for use in the Persian Gulf War were too porous for the fiie sands Of the Saudi desert, allowing their contents to filter out overnight. The only bags on the international market made for this type sand were being distributed by a Dutch firm whose main supplier was Iraq. The General Services Administration instead turned to U.S. manufacturers, which in the end produced 71 minim bags. (''The Finer Points of Sandbagging, " *Parade Magazine,* Jan. 12, 1992, p. 14.)

76 Purely domestic sources are not immune to production cutoff. A variety of factors (e.g., accidents, severe weather, strikes, or moral outrage) @@t result in a shutdown in production. One example is the loss of tritium production as a result of environmental and safety concerns. For a discussion of the risks of both domestic and international dependencies, see "An 'Adequate Insurance' Approach to Critical Dependencies of the Department of Defense, ' op. cit., footnote 8.

77 At present, the United States sells far more military equipment overseas than it buys.

Global interdependence may also result in an increasing number of foreign acquisitions of U.S. defense companies. This situation may not be critical if the acquired companies continue to work for the DoD and obey export laws. During the Persian Gulf War, for example, Conventional Munition Systems of Tampa, a wholly owned subsidiary of the German firm Messerschmitt-Bolkow-Blohm, rushed U.S. Army orders for Patriot missile warheads and parts, in addition to manufacturing Maverick missile warheads.[78] If a foreign-owned firm opted not to assist the DoD in a crisis, it could be compelled legally to live up to existing contracts, or, in extreme cases, be nationalized. Moreover, such firms workforces and infrastructures remain resident in the United States, although patents might be held abroad. If such a company decided to leave the defense business, it would be no different than any number of American-owned firms now doing so. The Committee on Foreign Investment in the United States reviews foreign acquisitions and warns the President of potential threats to national security,[79] The DoD can also restrict foreign investment in firms that do classified defense work.

Promote Manufacturing Innovation

The introduction of manufacturing innovations is another method to stretch limited defense procurement dollars. Capital investment, design, and production can be altered to reduce the life-cycle costs of a product.

If procurement funding were to be made more predictable in the future (e.g., through multiyear allocations), contractors' capital investments could be optimized for long-term production efficiency, particularly when initial production has not yet begun. Facilities, personnel, and manufacturing equipment could be sized appropriately for the job without the higher costs associated with overcapacity or the delays caused by undercapacity. And organizational structures could be adapted to fit new production realities. Many ideas have been proposed to modernize American manufacturing-largely as a response to foreign competition—that have relevance for defense manufacturers. These range from well-understood techniques and technologies that can be implemented immediately to futuristic visions that give manufacturers a sense of direction, but cannot soon be irnplemented.[80]

In the near term, manufacturers can increase their current reliance on computer technologies to manage resource allocations more efficiently (e.g., just-in-time supply or staffing) and communications with suppliers and customers (e.g., computer-aided acquisition and logistics) .81 Computer-controlled machine tools that can flexibly switch from manufacturing one item to another with a change of programing are already a common component in many factories and may become more prevalent as defense procurement moves away from high-rate production toward low-rate production .82 Typically, these machines are limited to a few related tasks and do not manufacture a complete system. Organizational innovations, such as quality programs (e.g., Total Quality Management or Zero Defects Management) and working in group cells, can also be adopted.

Martin Marietta has adopted several of these innovative technologies and techniques in its Orlando, Florida, LANTIRN navigation pod production facility, where it has established what it terms a ''paperless factory.' The factory uses a centralized computer system to keep track of all elements of the production process from inventories to product testing. The computer system even displays step-by-step manufacturing process information through

78 **Stuart** Auerbach, "U.S. Firms Angered by Kuwaiti Contract Award, " *The Washington Post*, Oct. *29, 1991,* p. D1. This article focuses on a controversy over awarding CMS a contract set aside for American businesses to carry out demolition work in Kuwait.

79 *Report to* Congress *on the Defense Industrial Base,* op. *cit.,* footnote 15, ch. 4, p. 5.

80 The Iacocca Institute at Lehigh University is championing one such vision, which it calls ''Agile Manufacturing. ' This manufacturing strategy for the next century, sponsored in part by the DoD Manufacturing Technologies (MANTECH) program, describes a wholesale renovation of traditional American manufacturing that emphasizes brainpower and flexibility. The goal is the creation of a world-class business organization and infrastructure that can rapidly design and produce small lots of high-quality and long-lasting custom products more economically than mass produced goods. See Roger N. Nagel and Rick Dove, *21st Century Manufacturing Enterprise Strategy*, vols. 1 and 2 (Bethlehem, PA: Iacocca Institute, Lehigh University, 1991).

81 According to DOD documents, cost **savings** of **up** to *20* percent of a program's budget are possible through Computer-tided Acquisition and Logistics Support (CALS) systems alone. (Neil Munro, ''Pentagon Urges Industry to Streamline With CALS,' *Defense News,* vol. 6, No. 36, Sept. 9, 1991, p. 39.)

82 In 1988 the U.S. Bureau of the Census reported that numerically controlled machines were used in 32-56 percent of the heavy industry businesses sampled. Elaborate information systems, such as CALS, were employed in significantly fewer companies. See *Statistical Abstract of the United States: 1991,* op. cit., footnote 69, p. 760.

video and animation at each employee workstation. Construction, however, remains primarily a hands-on process, with little reliance on robotics. According to Martin Marietta, the $40 million dollar investment reaped $100 million in cost savings in the first 4 years.[83]

Further in the future, already extant computer-aided design (CAD) capabilities will become increasingly integrated with computer-tided manufacturing (CAM). At first, this will mean making data packages from CAD systems readily convertible to CAM systems;[w] eventually, this process will be automated and directly linked. Then engineers will be able to draft their designs on the same computer system that will later direct man and machine through the manufacturing process. Late design changes and error corrections made by engineers will be transferred immediately throughout the factory, ensuring configuration and inventory control.

Initially, CAD/CAM systems will be used to make discrete components of a system, but not the system itself. A plant of the future, where artificially intelligent computers create the actual design of a product (as opposed to simply graphically representing a human design) and then task robots to manufacture it with limited human intervention, is well beyond current capabilities in most industrial sectors, but it is the target many innovators are working toward.[85]

Another means of improving defense production efficiency is *concurrent engineering.*[86] *In* concurrent engineering, the traditional sequential process of design, development, production, and maintenance is abandoned in favor of a more unified approach. Experts in manufacturing and maintenance are brought early into the design process to lend their expertise. This multidisciplinary team eases the normally rough transition from development prototype to production by emphasizing producibility at every step. (See figure 4-6.)

Figure 4-7 compares program spending over time for procurement contracts based on concurrent and traditional engineering. The curve corresponding to concurrent engineering rises earlier, reflecting the cost of including manufacturing engineers and maintenance personnel in the design process. In order for this "front-loaded" curve to pay off, the total cost of the program spread over the full production run (and over the entire product life cycle) must be less for concurrent engineering than would be paid traditionally. This reduction in overall cost comes from a smooth transition from development to production, which wolds many of the mistakes, waste, and delays common in traditional production runs, making manufacturing and maintenance easier. Development time can also be shortened through concurrent engineering, although in an era of tight budgets and reduced threats short cycle time may not be a high priority. Special attention needs to be applied to how concurrent engineering will fit into an acquisition strategy that emphasizes prototyping over production. (See ch. 3.)

Companies with a large proportion of commercial work are more likely to innovate in the manner described above. Defense contractors now dependent on the DoD, however, may need special incentives to innovate their manufacturing.

In all cases, the benefits of reproved manufacturing technologies and ~ recesses must be **weighed against the costs of continuing defense production in the current fashion.** For many industries, particularly those that produce specialized products in small lots, automation may not be

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83 OTA site visit on Sept. 11, 1991; and Steven Pearlstein, "Contractors' New Watchword: Efficiency, ' *The Washington Post,* Dec. 11, 1991, p. Al and A18.

84 A 1985 DOD report stated that "a common database between design and manufacturing functions has inherent technica problems but has the highest potential payoff in product quality and productivity. ' Department of Defense, Assistant Secretary of Defense for Acquisit on and Logistics, *Transition from Development to Production, Solving the Risk Equation,* DoD 4245.7-M (Washington, DC: Department of Defens e, September 1985), ch. 5, p. 24.

85 U.S. Congress, Office of Technology Assessment *Computerized Manufacturing Automation: Employment, Edu cation, and the Workplace,* OTA-CIT-235 (Washington, DC: U.S. Government Printing Office, April 1984), p. 6.

86 In a study of concurrent engineering for the Office of the Assistant Secretary of Defense for Production and Logistic s, analysts at the Institute for Defense Analyses came up with this definition of the term:

> **Concurrent engineering is a systematic approach to the integrated, concurrent &sign of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements.**

Se-e Robert I. Winner et al., "The Role of Concurrent Engineering in Weapons System Acquisition, ' IDA Report R-388 (Alexandria, VA: Institute for Defense Analyses, December 1988), p. 2.

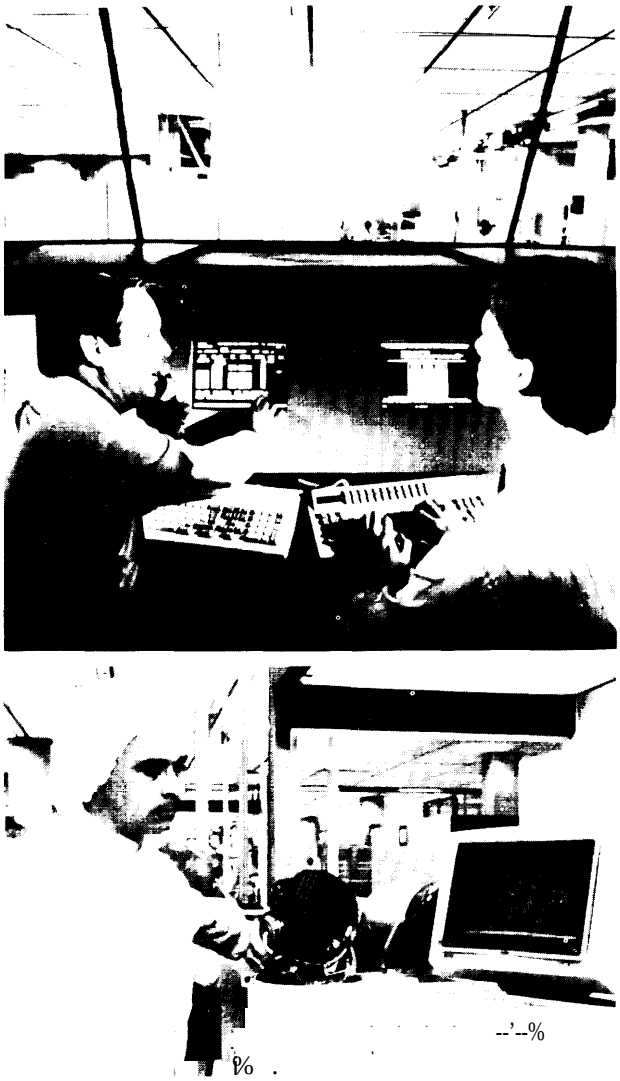


Photo credit: *Martin Marietta*

(Above) Engineers in a centralized control room oversee production in Martin Marietta's "paperless factory." (Below) A technician checks his work against a diagram on his computer terminal.

a cost-effective alternative to hand crafting and assembly, Moreover, it makes little sense to spend resources reducing direct labor in the construction of an item where labor costs are negligible compared to component costs (e. g., satellite assembly) or where industry is currently overcapitalized, unless such investment produces other gains (e.g., increased reliability).

Currently, defense firms are constrained in the adoption of manufacturing innovations by many factors, including the disincentive of annual contract renegotiations that eliminate profits achieved through increases in productivity. Until now, almost all the manufacturing innovation that has occurred has been evolutionary, stemming largely from contractor initiative, contract requirements (e.g., new composite material fabrication techniques on the B-2), independent research and development (lR&D), and through manufacturing technology programs sponsored by the DoD, such as the Manufacturing Technology Program (MANTECH) and the Industrial Modernization Incentives Program (IMIP). MANTECH programs fund manufacturing process, material, and equipment R&D. IMIP progams incorporate incentive clauses into contracts to motivate contractors to adopt proven manufacturing innovations that the contractors would not be able or willing to sponsor themselves. increases in productivity, quality, and reliability are designed to benefit both the company and the government. MANTECH and IMIP funds have largely gone to prime contractors and not to subcontractors and suppliers.[87]

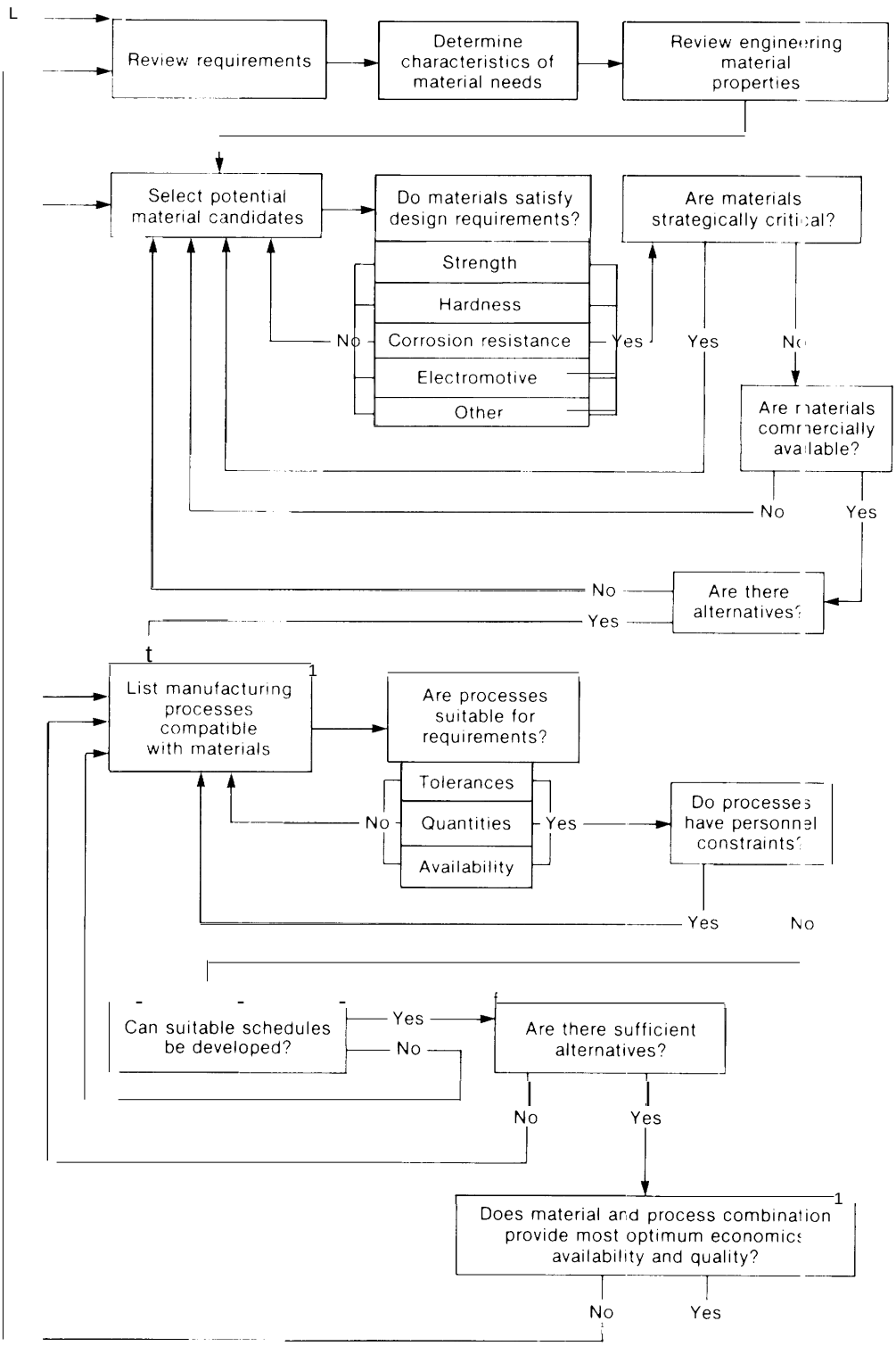
As the United States moves into an era of reduced defense procurement, many of the traditional sources of funding for manufacturing innovations are beginning to dry up. Many surviving defense firms will not be compelled by commercial market pressures to innovate and will have fewer procurement dollars to invest than -in the past. Natural monopolies will have less incentive to update their manufacturing technology than companies forced to stay competitive. In these circumstances, Congress could fund MANTECH and IMIP programs as one approach to bringing innovation to these segments of the future base.[88]

Although manufacturing technology programs have been in existence since the 1950s, they have become much more prominent in recent years,

87 John A, Alic et al., *Beyond Spinoff: Military and Commercial Technologies in a Changing World* (Boston, MA: Harvard Business School Press, 1992), p. **344.**

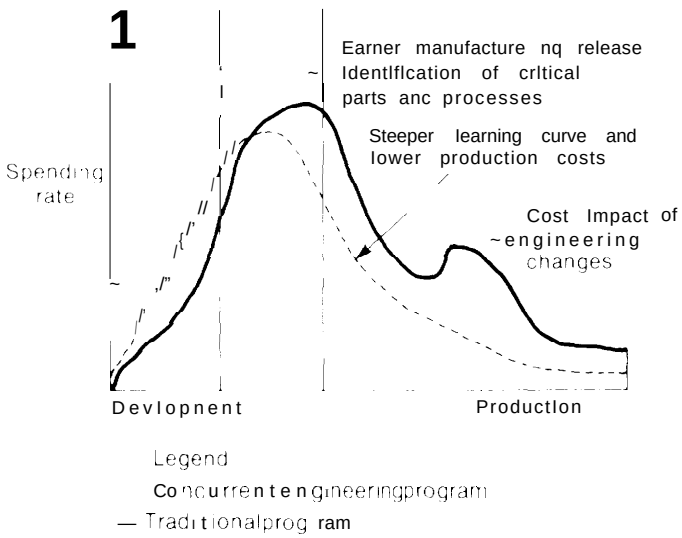
88 U.S. Department of Defense, Defense Systems Management College, *Defense Manufacturing Management Guide for program Managers*, 3d ed. (Washington, DC: U.S. Government Printing Office, April 1989), ch. 4, p. 5 and ch. 8, p. 5.

Figure 4-6-Decisions Concerning Producibility



SOURCE: Defense Systems Management College, 1989,

Figure 4-7—Theoretical Comparison of Concurrent v. Traditional Development and Production Programs



SOURCE: Office of Technology Assessment, 1992.

largely through congressional intervention.[89] Each of the Services runs a separate MANTECH program, in addition to a program run by the Defense Logistics Agency. These programs, while focusing on different segments of industry, strive to bring government, industry, and academia together (often in regional technology centers) to produce generic manufacturing technology innovations that can be transferred to the defense production base. MANTECH ventures have been successful in processing gallium-arsenide wafers for advanced microelectronics, in nondestructive imaging of products, and in robotic ship welding.[90] In addition, since 1985, the Navy's Best Manufacturing Practices program has sent survey teams to manufacturers to discover what they are doing right and transfer this knowledge to the rest of the Navy's production base.[91] The DoD has also used the Asset Capitalization Program, authorized by Congress in fiscal year 1983, to fund the modernization and acquisition of equipment for such operations as depots and shipyards. (See ch. 5.)[92]

A final method for increasing production base efficiency through manufacturing innovation would be to construct systems to incorporate modular subsystems so that when a subsystem is broken or needs to be upgraded, it can be readily replaced with a new, self-contained unit. The removed unit would then either be sent back to a depot or to the original equipment manufacturer (OEM) as part of a strategy to maintain the manufacturing capability of the OEM. Modular subsystems could be made common across several platforms (e.g., a plane, helicopter, and tank could all use the same radio) to generate economies of scale in production, and they would allow generic weapon platforms to be specially outfitted for different missions.

The primary drawback of switching to modular systems is that they may require built-in slots or boxes to hold them that would increase the overall cost and weight of the system, resulting perhaps in lower performance. For example, it has been suggested that many naval ships could be built according to one basic hull design that would accept a variety of weapon and equipment modules according to its mission (e. g., antisubmarine warfare, air defense, cargo, or amphibious assault) .93 While containers for these modules might add as much as 5 percent to the cost of a single ship, the economies of producing identical ship hulls might result in lower total cost.[94] Other modular systems might include the next-generation tank or multirole fighter. The potential added cost and reduced optimization of modular systems will have to be weighed against

89 Congress has repeatedly authorized more funds for MANTECH than the DoD has requested. This is duc in part to a difference in perspective. The DoD, along with the Services, sees MANTECH as a tool for increasing productivity for specific weapon systems. Congress, on the other hand, sees MANTECH as a stimulus to the production base as a whole, including the nondefense community.

90 Torelli et al testimony before the U.S. Congress, House Armed Services Panel on Future Uses of Manufacturing and Technology Resources, Oct. 24, 1991; **and** *Computerized Manufacturing Automation,* op. cit., footnote 85, pp. 314-316,

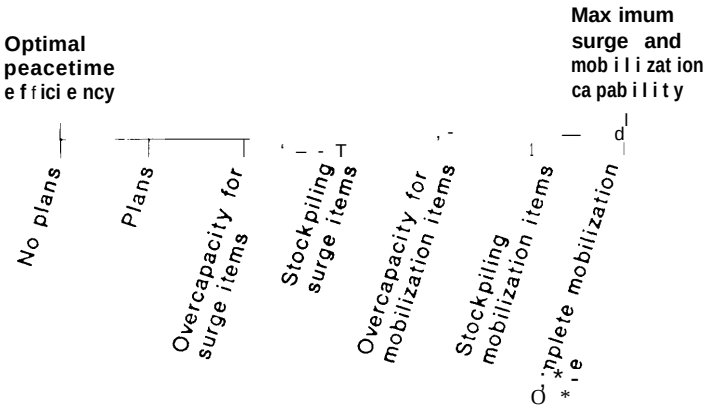
91 Torelli, ibid; and Department of the Navy, *Best Practices: How to Avoid Surprises in the World's Most Complicated Technical Process, The Transition from Development to Production,* NAVSO P-6071 (Washington, DC: U.S. Government Printing Office, March 1986)

92 U.S. Congress, General Accounting Office, "Industrial Funds: The Department of Defense's Management of ACP Funds, GAO/NSIAD-90-202FS (Gaithersburg, MD: U.S. General Accounting Office, June 1990); and U.S. Congress, General Accounting Office, " 'Plant Modernization: DoD's Management of the Asset Capitalization Program Needs Improvement, ' GAO/NSIAD-89- 147 (Gaithersburg, MD: U.S. General Accounting Office, August 1989).

93 The German shipbuilder Blohm and Voss constructs two classes of modular ships: the Meko and the Deutschland (Type 123) frigates,

94 About 70 percent of the cost of a modern warship is for systems, such as weapons and electronics, other than the hull, See Gary Hart and William S. Lind, *America Can Win. The Case for Military Reform* (Bethesda, MD: Adler and Adler, 1986), pp. 98-107,

Figure 4-8—Tradeoffs Between Production Efficiency and Surge and Mobilization Preparation



SOURCE: Office of Technology Assessment, 1992.

lower production and maintenance costs and higher operational readiness. (Ch. 5 discusses maintenance issues in greater detail.)

Increase Commonality

Increased commonality in Service procurement and among defense products could make the base more efficient. One notion is the creation of a more common procurement process among the armed services. The aim would be to reduce redundant procurement programs and to make larger purchases to achieve economies of scale. (Ch. 6 discusses options for rationalizing the procurement structure in more detail.)

The Services could also try harder than they currently do to build new systems with a greater emphasis on common components and standardized parts. The Army is attempting greater standardization of parts and systems through such programs as the Armored Systems Modernization program which is designing the next generation of armored vehicles.[95] This program is being redefined, stretched out, and scaled down in the face of budget reductions. Current plans call for the development and production of the Advanced Field Artilery System and the Future Armored Resupply Vehicle-Ammunition on a heavy-level protection chassis and the Line-of-Sight Antitank system on a medium-level protection chassis. Three other vehicles intended for the heavy-level protection chassis have been deferred indefinitely: the Block III tank, the Combat Mobility Vehicle, and the Future Infantry Fighting Vehicle. In addition to the common chassis, these armored vehicles will have significant commonality in components, including armor, engines, tracks and suspension, electronics, instruments, hardware, and software. Although the parts for the vehicles will not be completely interchangeable,[96] they will be as compatible as their differing missions will allow.[97] More universal parts would help those subcontractors that might go out of business if them product supported only one weapon system.

In addition to the above steps, the DoD should examine how much standardization of parts, munitions, and systems there should be internationally, especially with our NATO allies One of the DoD's

95 A General Motors Corp. study of an earlier armored vehicle modernization plan developed several manufacturing] options that emphasized commonality in construction, vendors, and parts. See General Motors Corp., Military Vehicle Operations, "Manufacturing Plan Appendix," *Armored Family of Vehicles (AFV) Phase I Study*, 1986.

96 John G. Roos "5). -Billion Armor Mod Plan Has Only One Tread on the Ground, ' *Armed Forces Journal International*, October 1991, p, 60.

97 An example of the increased efficiencies of commonality is found in the Mazda Miata. This petite and sassy sports car -- the automotive sensation of 1989 — appeared completely different from other Mazdas, but was built with 80 percent standard parts. This strategy allc wed Mazda to bring a new product to market quickly and make a profit despite low volume sates. (Peter F. Drucker, "The Big Three Miss Japan's Crucial Lesson," *The Wall Street Journal*, June 18, 1991, p. A18.)

long-standing objectives has been to promote the adoption of standardized or interoperable equipment among allies and friendly nations. This issue should be examined from the perspective of cost savings, base support, foreign dependence, and the changed international environment.

RESPONSIVE PRODUCTION

A future crisis might require the production base to react through either a responsive surge of the defense base or a longer term mobilization of the broader national industrial base.[98] The next two sections discuss the balance between peacetime production efficiency and crisis requirements. Figure 4-8 illustrates some tradeoffs between efficient peacetime production and surge and mobilization preparations.

Policy makers can make the future base responsive to crises short of a national emergency in three ways: by surging production as required by commanders, by stockpiling products in advante, or by relying on allies. Each of these options has advantages and disadvantages.

If production is sufficiently responsive, then the government does not need to pay for surge items unless there is a crisis, nor does it have to pay for storage. Relying on surge carries the risk that items cannot be produced quickly enough to meet the field commanders needs. Moreover, surge facilities may entail higher overhead costs by maintaining more production capacity than is needed for peacetime requirements .99

If items are stockpiled, they are available on demand if ever needed, but at a high up-front cost, and they may not be replaceable if production facilities close and requirements surpass stocks. Some items, like electronic components, become obsolete so quickly they are not conducive to long-term storage.[100] A rolling production inventory-an early buy of components to be used in final production items—might reduce some of these costs,

Table 4-4-Examples of Surge and Mobilization Items

Surge items	Mobilization items
Ammunition	Surge items (from list at left)
Food	New weapon systems
Fuel	Mothballed weapons
Uniforms	Commercial transport
Spare parts	Commercial engineering vehicles
Medical supplies	National Defense Stockpile materials
Merchant marine	
Prepositioned equipment	

SOURCE: Office of Technology Assessment, 1992.

Foreign acquisitions have the possible advantage of lower cost, but run the risk of political cutoff and are less likely to be able to meet the quantity requirements of the U.S. military. Foreign items may also suffer from excessive transportation lag times.

Planners should use contingency plans for future crises to designate which items should be procured in advance, which should be surged, and which should be obtained from allies. The resulting system will need to be properly funded and exercised periodically to ensure it will work when needed.

It is unlikely that production of major weapon systems will have to be surged for a conflict that falls short of a national emergency. Moreover, if the United States pursues low-rate production, the surge of such systems will be virtually impossible. It is more likely that field commanders will need increased production of consumable or personal items, such as munitions, spare parts, fuel, food, and clothing. (See table 4-4.)

The DoD interim report to Congress on the conduct of the Persian Gulf War provides some

98 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), p. 4. This report maintains the definition used in *Adjusting to a New Security Environment. Surge* is the term used within the DOD to refer to the expansion of military production in peacetime without the declaration of a national emergency. *Mobilization* refers to the rapid expansion of military production to meet material needs in a war and involves the declaration of a national emergency. Several types of mobilization are considered. *Full mobilization* refers to mobilization to fill the existing or ''program force' structure. *Total mobilization* describes a mobilization effort that expands beyond the existing force structure. Mobilization is often referred to as ' 'reconstitution' by the current Administration.

99 Plants designed for efficient peacetime production can expand their work hours, at least temporarily, if they are not already operating at maximum capacity. Longer term reliance on extended or additional work shifts will require the hiring of skilled or trainable personnel,

100 The market lifespan of an electronic component has decreased from 10-12 years to 4-5 years, while weapon system longevity is 20 years or more. U.S. Congress, General Accounting Office, ''Defense Inventory: DoD Could Better Manage Parts with Limited Manufacturing Sources," GAO/NSIAD-90-126 (Washington, DC: U.S. Government Printing Office, August 1990), p. 8.

useful examples.[101] Generally, the Services had the major equipment and supplies they needed before the crisis, but shortages of some items soon emerged. T-rations, designed to feed 8-10 people, had not been included in the war reserves and, for a time, industry could not meet the increased demand. Troops were temporarily forced to eat the less palatable Meals, Ready-to-Eat (MREs), which had been stockpiled. Many troops also were initially stationed in Saudi Arabia dressed in uniforms camouflaged for European woodlands, while the clothing industry manufactured clothing and boots patterned for the Kuwaiti desert. While both of these shortfalls caused problems, they did not significantly impede operational preparations. Shortages in the U.S. inventory of heavy equipment transporters and offroad vehicles were compensated for by leasing, buying, or requesting donation of trucks from U.S. trucking companies, and from Saudi Arabia, Germany, Egypt, Italy, and Czechoslovakia.

According to the report:

> Literally thousands of items were accelerated to meet the increased requirements of U.S. Central Command (CENTCOM). From weapons systems to individual items of supply, a tremendous demand was placed on the nation's industrial base. Items such as chemical protective clothing were surged from 33,000 per month to 70,000 per month, desert combat boots went from zero to 124,000 per month, and desert camouflage uniforms went from zero to 376,000 per month over a six month period. In some cases, the increase in the production rate was the direct result of an individual contractor's performance, in other cases, additional contracts were required. Preliminary investigation indicates that despite some shortcomings, the industrial base was reasonably responsive to the needs of the force, These and similar instances reinforce the continuing requirement to balance our war reserve programs and depot production capabilities with a realistic assessment of industrial base capability. [102]

Extensive preparation time, control over the timing of operations, a short war, relatively light combat damage, support from Saudi Arabia and the other coalition partners, and a lack of a major threat elsewhere made the Persian Gulf surge effort easier than it might have been otherwise.

Photo credit, The DoD

Meals, Ready-to-Eat (MREs) are nutritious and energetic foods packaged to survive the rigors of a combat environment.

Flexible manufacturing systems, besides being useful for an efficient peacetime base, can affect future responsiveness. On the positive side, they will make it easier for companies engaged in peacetime defense work to shift from a lower to a higher priority product mix (e.g., from dress to camouflage uniforms) to meet specific surge demands.1°3 **Com**panies that produce both commercial and defense products would be able to temporarily halt commercial work and expand defense production. However, a production line set up for flexible manufacturing—where excess capacity has been cut to the bone—may make any expansion of production more difficult if the majority of a company's products are required for surge.

PREPARATION FOR MOBILIZATION

If a future crisis is severe enough to warrant a declaration of a national emergency, the surge capability described above may not be adequate to meet the challenge. Full or total mobilization (currently dubbed "reconstitute on") of the broader national industrial base, in addition to the defense production base, may be necessary. With the disappearance of the Warsaw Pact threat to NATO in Europe, a war on this scale seems unlikely for the

101 *Conduct of the Persian Gulf Conflict*, op. cit., footnote 53, ch. 7, pp. 1-7. This report carries the caveat that its information is preliminary and subject to change.

102 Ibid., ch. 7, p. 2.

103 The time it takes to shift from one product to another will depend on the degree of tool flexibility and product similarity.

foreseeable future, so it appears prudent to give more priority to peacetime and surge planning. Nevertheless, **realistic planning for mobilization against a major threat remains essential to the security of the Nation and its allies, especially considering the long lead times involved.**

The most critical factor in mobilization plaming is the amount of warning time the industrial base will have. This warning time depends on the speed of an adversary's mobilization, the timeliness and reliability of intelligence, the length of time ready forces can hold their own before being reinforced with mobilized reserves and supplies, and the time required for a political decision to mobilize. The national industrial base would have about 2 years warning of a major war in Europe, according to current projections.[104]

Overestimating warning time in the planning phase can lead to serious shortages in the early stages of a war. Underestimating warning time can lead to an overinvestment in stockpiled supplies and too little investment in manufacturing resources, leading to a full inventory at the beginning of the conflict, but a declining capability as it proceeds. Improved planning tools based on detailed production data and models can help prepare for large-scale mobilization, but only if the subjective inputs of crisis scenarios are accurate. '[05]

Once planners have made their best estimate of mobilization warning times, they can decide the best way to meet mobilization requirements. Equipment that cannot be produced within the warning time must be stockpiled in the national War Reserve or obtained from U.S. allies. Other items might also be stockpiled, but as mentioned above, stockpiling involves a large up-front investment in equipment and supplies that may never be used. Moreover, the military may have difficulty replacing stocks if demand has been underestimated or after the crisis is over, Products that can be manufactured within the warning period but exceed the surge capacity of the defense production base will need to be procured through an expansion of the defense sector or from the commercial sector.

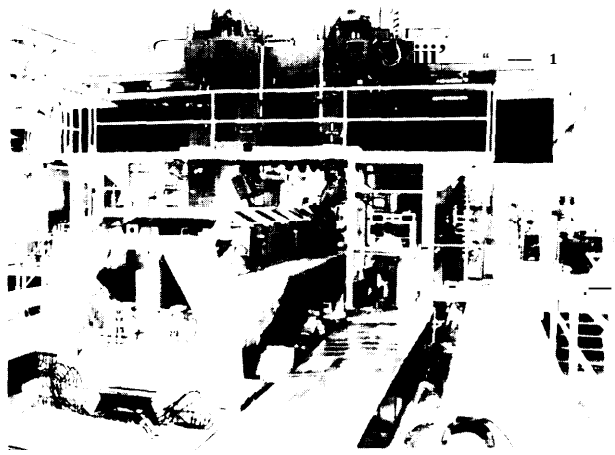


Photo credit: BMY-Combat Systems

The flexibility of a computer-controlled machining center permits BMY to move in minutes from working on aluminum armored vehicle hulls to steel hulls, such as the M88 Medium Recovery Vehicle pictured here.

The dedicated defense production base provides a core around which the civilian base can be mobilized. The existence of a solid core of personnel, equipment, and facilities will depend on what measures policy makers take now during peacetime procurement cutbacks (e.g., none, creation of an arsenal, low-rate production, or civil-military integration). The implementation of rapid acquisition rules and simplified procurement procedures after the declaration of a national emergency will allow existing facilities to be expanded and new ones to be built. Facilities that would require long lead-times to build and outfit may have to be mothballed in peacetime (e.g., shipyards).[106] Companies that have been participants in mobilization planning and those

104 *Redesigning Defense*, op. Cit., footnote [1], p. 24.

105 For example, the Army is funding a prototype Production Expansion/Acceleration Capability Enhancement (PEACE) computer model developed by Salvador Culosi at the Logistics Management Institute, which optimizes funding for a particular product and its subcomponents to meet peacetime and mobilization requirements based on such **inputs** as likely crisis scenarios, plant capacity, industrial planning measures, process flow times, and product and critical subcomponent lead times,

106 Mothballing facilities may not be a good Option for maintaining a Production capability if similar work is not being performed elsewhere. For example, a company that currently produces ammunition or armored vehicles might be able, with significant difficulty, to bring on-line another mothballed munitions plant or tank facility, but it would face greater, if not insurmountable (in the time provided), difficulties in restarting production if it had not manufactured the product for several years. The Canadian Navy recently encountered this dilemma when they tried to construct a frigate without having built one in a decade. The result was a substantial expansion of costs and schedule and the need to rely heavily on foreign expertise. If it is necessary to mothball an entire capability for financial reasons, then every effort should be made to document production procedures and worker experience {perhaps by creating computer expert systems) before they are lost.

Table 4-5—Comparison of Production Issues

Desirable characteristics of the future production base	Policy options				
	Streamline and consolidate	Enhance government and industry cooperation	Foreign moderation	Reduce productim rates	Promote innovation
Etflcient	Reduces overcapadt y, preserves vital production capabilities	Lowers product cost, allows defense base to draw on national base, makes defense work more appealing, but risks abuse	Expands sates market, source of technology and mmponents, but undermines domestic base	Short-term effici(mcy loss, but maintains production capabilities efficiently after streamlinirqj	Raises efficiency, but may demand capital investment
Responsive	Maintains production capabilities, but decreases capacity	Cooperative atmosphere eases planning for future	Expands domestic base, but risks cutoff	Maintains production capabilities, but reduces capacity	Flexibility aliowssurge of select items, may reduce capacity
Mobilizable	Maintains production capabilities, but decreases capacity	Cooperative atmosphere eases planning for future	Essential for large-Scale conflict but risks cutoff	Maintains production capabilities, but reduces capacity	Future flexibility may ailow easier transfer of production to nationai base

SOURCE: Office of Technology Assessment, 1992.

that are flexibly organized (e.g., with working group cells) will be better prepared to make the transition to mobilization.

The health of the national economy is vital to a successful mobilization. In a national emergency, the DTIB will need to draw extensively on the skills, facilities, and management of nondefense manufacturers. The commercial sector can be relied on for a large number of off-the-shelf items or items that are easy to adapt to military standards. This will be particularly true if steps are taken now to integrate the DTIB with the broader civil production base. Mobilization of militarily unique systems, such as armored vehicles and airplanes, will require preplanning by mobilization planners with the cooperation of defense manufacturers and the retention of critical manufacturing skills and equipment.

In the future, the spread and standardization of flexible computerized manufacturing tools throughout industry might make it easier to switch in a national emergency from commercial to defense production.[107] This might be especially t.rile in factories that produce both military and civilian items on the same equipment. During mobilization, designated companies wou1d cease commercial production and use that freed capacity to manufacture military items. The DoD can foster such a future by lowering the barriers to civil-rnilitary integration (as described earlier) and though manufacturing technology programs that emphasize equipment and data-format standardization. For example, a government-funded model factory or laboratory might be established to design machine-tool data packages and software for manufacturing, weapon components that could be transferred easily to flexible comrnercia1 plants in the event of a mobilization. Currently, manufacturers in both the commercial and defense industries lack this degree of flexibility, but the necessary technologies are emerging and might be fostered with the right incentives.

The industrial bases of U.S. allies will also be an integral part of any future mobilization effort. The magnitude of such a crisis would demand some division of labor among allies, regardless of the risk of material cutoff. Promoting mutual defense cooperation with allies and friendly nations, protecting

107 Flexible manufacturing will also make it easier for pure defense producers to switch from lower to higher priority end items. For e-pie, the Armored Systems Modernization program mentioned earlier, which planned six armored vehicles based on two common chassis, is being designed for more flexible manufacturing. The two chassis wilt be manufactured on the same assembly line using numerically contrc lled machine tools. Mission packages in more or less modular form will permit relatively rapid shifts from producing one type of vehicle to some o'her vehicle that is in higher demand. Unlike a shift from commercial to defense production however, flexibility in strictly defense firms alone will not expand their total military output, only priority items (e.g., a tank rather than an artillery vehicle). See Roos, op. cit., footnote 96, p. 60.

Table 4-5--Comparison of Production Issues (continued)

Policy options (continued)					
Support manufacturing skills	Increase common system procurement	Increase component commonality y	Maintain surge capability	Stockpile	Lay-away facilities
Fills critical gaps	Reduces product life-cycle rests, but products are less mission oriented	Lowers costs and concentrates manufacturing	Raises overhead rests	Allows short-term production, but product may never be needed	cost without product
Provides labor pool for base expansion	Eases logistics	Eases logistics	Allows increased production on short warning	Products avalabie when needed, reduces foreign dependency, may be irreplacable once used	Eases expansion of production, particularly for facilities that are difficult to rebuild
Provides labor pool for base expansion	Eases logistics	Eases logistics	Allows expanded defense base production while national base gears up	Products available when needed, reduces foreign dependency, may be irrepkmableonceused	Eases expansion of production, particularly for facilities that are difficult to rebuild

global sea lines of communication, and, perhaps, maintaining a forward presence, would help ensure the viability of such overseas collaboration.

CONGRESS AND THE PRODUCTION BASE

Deciding on the necessary steps to restructure the defense production base will challenge many past notions about how the base ought to be run. Congress, in cooperation with the Executive Branch, will need to reevaluate many controversial issues, such as the relative importance of competitive procurement, contractor accountability, and buying American. Efficient peacetime production will have to be balanced against potential surge and mobilization requirements.

The measures Congress adopts during the transition to the future production base will depend on how damaging it believes procurement reductions of 50 percent or more will be to the Nation's defense industry. If Congress believes that production base problems will be limited to select industries with the rest able to adapt successfully to the new environment, it will opt for small adjustments to existing laws and practices. If it views the problem as more severe and fundamental, it may opt for a general restructuring of the production base and defense procurement. In either case, policies will need to be sensitive to the complexities of the base, particularly the different industrial sectors and tiers. Table 4-5 summarizes the measures discussed in this chapter, Below, these measures are discussed in groupings of particular interest to Congress.

Funding Decisions

Congressional control over DoD procurement funds and the rate at which these funds are reduced will have the most direct impact on the production base. Thoughtful reductions can ensure that future military requirements will be met. Greater consistency in procurement projections, perhaps with multiyear contracts, will allow the production base to reorganize more efficiently and manufacture defense equipment effectively at lower rates. Congress might further the efficiency of the future base by providing additional funds for the study of the base (e.g., composition and effect of laws and regulations), the adoption of manufacturing innovations, and the maintenance of critical manufacturing skills. Funding will be necessary for long-range planning, stockpiling, and the maintenance of excess peacetime production capacity in select areas to meet potential surge and mobilization requirements.

Base Structure

Congress has a range of options for restructuring the future production base. At a minimum, Congress should insist that the DoD identify critical producers at the supplier, subcontractor, and prime contractor levels that are at risk due to procurement reductions, and use existing laws and regulation to save their core capabilities, Public or private arsenals could be established for those industrial sectors that can no longer maintain themselves through DoD contracts.

Next, Congress could support government intervention in the market, if necessary, to save and strengthen critical producers through a combination of sole-source production, prototyping, upgrade, spare part, and maintenance contracts. For the good of the production base, the government might pick ''winners and losers' or substitute ''best value' for the lowest bid as the basis for awarding contracts. Congress could act to lower legal and regulatory barriers to mergers, strategic partnerships, and the creation of monopolies (e.g., antitrust laws and CICA) that undermine the consolidation of the base around select quality producers.

At the extreme, Congress might remove the legislative barriers to a fill integration of the civil and military production bases, thus drawing on the size, efficiency, and innovation of the larger national base. After a time, only the most unique military items would remain in a separate DTIB, perhaps in arsenals (e.g., nuclear submarines).

Business Environment

Short of complete integration, Congress can act to relieve industry of many stifling characteristics of current defense work. These characteristics include costly paperwork requirements from bidding to final accounting, pervasive government oversight, outdated and obsolete specifications on many aspects of production, and a potential loss of a fro's competitive edge through the transfer of proprietary data rights to the government. The present business environment makes the production base inefficient and uninviting to innovative companies interested in doing defense work. Next January, a congressionally mandated DoD advisory panel will present its findings on how to streamline current acquisition laws.[108] Congress can act on the findings of this panel and of this report to foster a less adversarial relationship with industry. It can also encourage ongoing DoD efforts to procure more commercial products.

Acquisition Strategy

Congress could also promote the simplification and consolidation of the prodtuction base by supporting the consolidation of acquisition programs and organizations. It might also support commonality and modularity in weapon systems and subsystems and the use of multi-Service procurement to provide a more economic workload for a smaller number of core manufacturers. The government might also consolidate procurement efforts.

International (Change

Finally, Congress needs to consider the role that the international defense production community will play in the future domestic base. The internationalization of the domestic base is already a reality, particularly at the lower tiers Congress can act to increase this interaction by promoting military sales, purchases, and cooperative ventures; or it can opt to sever some or all of these ties, relying more on American industry.

SUMMARY

This chapter has discussed alternative policies to ease the transition to a future production base that has the desirable characteristics of efficiency, responsiveness, and the ability to mobilize. A thoughtful, orderly restructuring of the defense production base, in the face of a reduced international threat and pressing domestic financial concerns, is one of the biggest challenges facing defense policymakers. If the Administration and Congress do not take measures in the next few years, market forces combined with reduced defense spending will perform this restructuring haphazardly, resulting in a smaller, weakend, and potentially crippled DTIB. Some firms would weather these changes and continue to manufacture defense products. Others would be forced into other business areas or close. More than likely, should the need ever arise to surge capacity or mobilize, the United States would find itself lacking in critical capabilities.

[108] See footnote 34.