Chapter 4

Trends and Problems in the Base

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INTRODUCTION

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

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

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

GENERAL TRENDS

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

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

Table 4-I—Trends in the Current Base

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

SOURCE: Office of Technology Assessment, 1991.

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

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

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

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

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

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

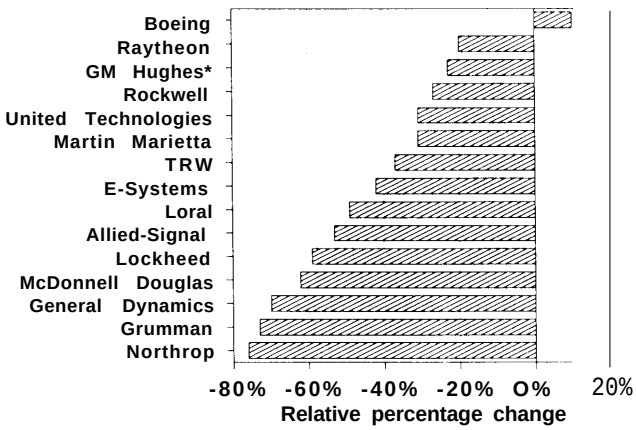
Court decisions have established the government's right to examine company accounting records covered by these regulations for the sole purpose of collecting information, even if the aim is not cost verification.[2] If a company thoroughly integrated its civil and military production, then virtually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

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

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

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

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



*4- year performance

SOURCE: Paine Webber Inc.

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

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

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

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

SPECIFIC ISSUES

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

Disincentives for Manufacturing Investment

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

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

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

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

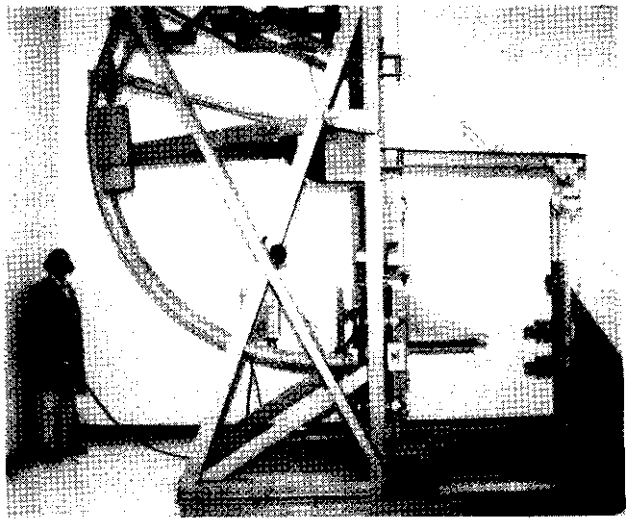


Photo credit: General Dynamics

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

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

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

Inappropriate Competition

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

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

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

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

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

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

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

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

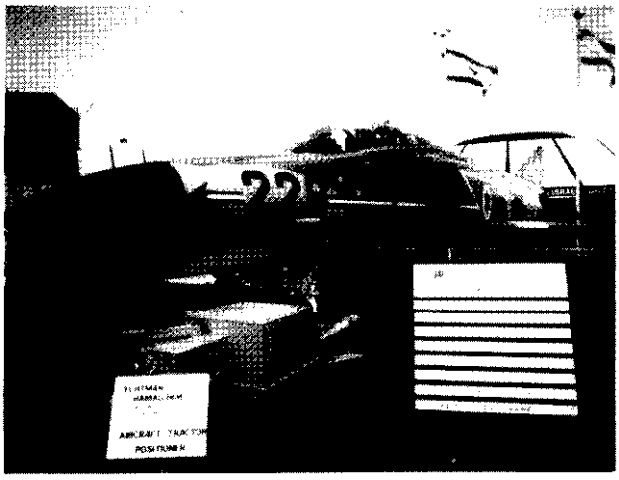


Photo credit: U.S. Department of Defense

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

Increasing Globalization of the Defense Base

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

Changing R&D Priorities

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

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

OTA DEFENSE INDUSTRY SURVEY

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

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

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

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

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

OTA DEFENSE INDUSTRY SURVEY

Box 4-C—Industry Views on Research and Development

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

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

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

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

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

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

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

Photo credit: Litton Industries, Ingalls Shipbuilding Division

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

Diminishing Industrial Capabilities

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

Management Inertia

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

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

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

CURRENT GOVERNMENT AND INDUSTRY STRATEGIES

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

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

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

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

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

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

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

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

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

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

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

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

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

Consolidation

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

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

Concentration on Defense Work

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

Diversification

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

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

Arms Exports

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

Box 4-D—Export Control Laws

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

Defense Exports

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

Continued on next page

Box 4-D—Export Control Laws-Continued

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

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

Role of the Congress

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

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

Exports of Dual-Use Technologies

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

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

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

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

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

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

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

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

SUMMARY

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

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

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

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

[11] Michael T. Klare, "Growing Firepower in the Third World," *Bulletin of the Atomic Scientists*, vol. 46, No. 4, May 1990, pp. 9-13.