Overview

In response to the changing global military situation, Congress requested the Office of Technology Assessment (OTA) to conduct a number of assessments examining the health and viability of the technology and industrial capabilities that provide the United States with the goods and services necessary to meet its national security needs. OTA was asked to assess trends in the technology and industrial base, future technology and industrial base needs, and options for preserving a viable defense technology and industrial base (DTIB). OTA has produced a series of reports on these issues.[1] The latest report, *Assessing the Potential for Civil-Military Integration*, examined the potential for making greater use of commercial goods and services to meet defense needs.

BACKGROUND

Assessing the Potential for Civil-Military Integration found that a strategy aimed at making greater use of the commercial technology and industrial base to help meet national security needs—often termed civil-military integration (CMI is defined in some detail in box 1.)—had the potential to produce substantial future government savings and provide access to critical technology. OTA's analysis, however, indicated that savings may be lower and take longer to be achieved than some advocates have

[1] U.S. Congress, Office of Technology Assessment, *Adjusting to a New Security Environment: The Defense Technology and Industrial Base Challenge*, OTA-BP-ISC-79 (Washington, DC: U.S. Government Printing Office, February 1991); *Redesigning Defense: Planning the Transition to the Future U.S. Defense Industrial Base*, OTA-ISC-500 (Washington, DC: U.S. Government Printing Office, July 1991); *American Military Power: Future Needs, Future Choices*, OTA-BP-ISC-80 (Washington, DC: U.S. Government Printing Office, October 1991); *Lessons in Restructuring Defense Industry: The French Experience*, OTA-BP-ISC-96 (Washington, DC: U.S. Government Printing Office, June 1992); *Building Future Security: Strategies for Restructuring the Defense Technology and Industrial Base*, OTA-ISC-530 (Washington, DC: U.S. Government Printing Office, June 1992); *Assessing the Potential for Civil-Military Integration: Technologies, Processes, and Practices*, OTA-ISS-611 (Washington, DC: U.S. Government Printing Office, September 1994); and *Other Approaches to Civil-Military Integration: The Chinese and Japanese Arms Industries*, BP-ISS-143 (Washington, DC: U.S. Government Printing Office, March 1995).

BOX 1: Definition of Civil-Military Integration

OTA found no single definition of CMI. The term encompasses a number of different activities, each of which is viewed as an element of integration. For example, those advocating the increased use of nondevelopmental items, including commercial off-the-shelf items, consider such use to be CMI. Analysts recommending changes in government acquisition laws to promote combined R&D, or production of civilian and defense products on a single assembly line, consider such changes to be CMI. Others maintain that CMI involves increased cooperation between government research facilities and the private sector in both R&D and manufacturing technologies. Still others claim that the rationalization of private and public depot-level maintenance facilities (e. g., transferring jet aircraft engine maintenance and overhaul from military facilities to existing private sector facilities) is a component of CMI.

These definitions are not mutually exclusive. Accordingly, OTA has incorporated all these elements in its definition of CMI as:

> The process of merging the Defense Technology and Industrial Base (DTIB) and the larger Commercial Technology and Industrial Base (CTIB) into a unified National Technology and Industrial Base (NTIB)[1].

More specifically, in an integrated base, common technologies, processes, labor, equipment, material, and/or facilities would be used to meet both defense and commercial needs. Decisions on how to use Integrated resources would be based on the same technical, legal, and economic reasoning that commercial firms use when servicing global markets.

[1] The NTIB includes other noncommercial elements, such as public utilities and other non-DOD government procurements The national base is also embedded in the larger Global Technology and Industrial Base

SOURCE Off Ice of Technology Assessment, 1995.

claimed. The findings of OTA's CMI assessment are summarized in box 2.

Integration is usually discussed as a function of activities occurring at a firm or a specific facility. However, OTA's assessment revealed that integration actually occurs at various levels within the base and should be analyzed at three separate levels—the technology or industrial sector level, the firm level, and the facility level. Each level presents its own unique set of policy challenges.

Integration at the technology or industrial sector level is characterized by the DTIB and the Commercial Technology and Industrial Base (CTIB) sharing common technologies, processes, and specialized assets (e.g., unique test stands, wind tunnels, and industrial research centers). An industrial sector can be said to be integrated if its defense goods or services are drawn from the same pool of technologies, specialized assets, and processes (and, by extension, standards) as are commercial goods or services. However, while integration at the sector level aids the development of common products, it does not assure that defense and commercial products will be the same, that they will be produced in the same facilities, or that they will be less expensive than if they were produced without such integration.

Integration at the firm level is characterized by the sharing of corporate resources to meet both defense and commercial needs. These resources include management, workers, research centers, equipment, stocks, and common facilities. A corporation that readily moves staff between defense and commercial work and transfers manufacturing and product technologies back and forth can be considered integrated at the firm level, even though it may separate its operating divisions along commercial and defense lines.

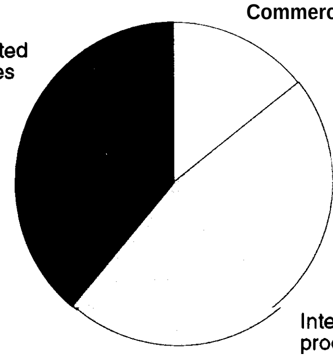
The third and deepest level of integration is at *the facility level.* Integration at this level is characterized by the sharing of personnel, equipment, and stocks within a single facility. In an integrated facility, defense and commercial goods would be manufactured side by side, with any differences in

BOX 2: Assessment Findings

Despite several previous initiatives to promote integration, much of the DTIB remains isolated. Still, significant CMI currently exists. OTA's estimate of current integration is shown in figure 1.[1] Increased CMI is possible, but requires changes in government acquisition policy, taking advantage of technological developments, adapting technologies for both defense and commercial use, and restructuring the DTIB. The growth of CMI depends on the extent of policy change. OTA's estimates of the potential for increased CMI, based on significant acquisition reform and restructuring, are shown in figure 2.

Some technologies, industrial sectors, and product tiers are **more amenable to integration** than others. Prime contractors performing systems integration on complex defense systems may have a limited ability to integrate production. Lower tier tier activities, such as production of components and subcomponents, appear far more amenable to integration. Services appear particularly amenable to commercial purchases

FIGURE 1: Current Facility-Level CMI Division of the Private DTIB at All Tiers

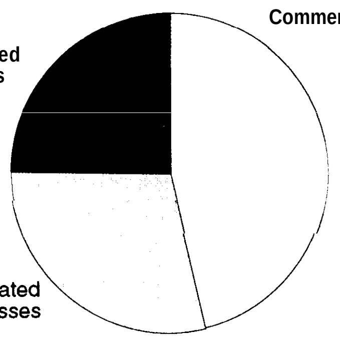


SOURCE: Industrial survey conducted by Office of Technology Assessment, 1994.

Cost savings and increased technology transfer are difficult to quantify. OTA's analysis, however, indicates that savings may be lower than some advocates have claimed. Implementation may be more difficult, and take longer to achieve, than many anticipate because: 1) integration is already occurring in many of the tiers and technologies most amenable to CMI, 2) change is more difficult to implement than many have anticipated, and 3) important portions of the base may not be amenable to integration.

Still, after several years overall savings could amount to several billion dollars per year. Possibly more important than direct savings, however, is that increased CMI can provide access to those rapidly developing commercial technologies in critical areas (e.g., electronics) that will be essential to defense in a more fiscally constrained environment.

FIGURE 2: Potential Facility-Level CMI Division of the Private DTIB at All Tiers



SOURCE: Industrial survey conducted by Office of Technology Assessment, 1994.

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[1] Estimates for figures 1 and 2 are for the private sector DTIB only. They are based on a macroeconomic examination of the DTIB and an industry survey of 16 randomly selected industrial sectors providing goods and services to national defense. Since the estimates are based on a limited industrial sector survey, they should be considered suggestive rather than definitive. OTA also used interviews, case studies, and analyses of selected industrial sectors to validate its estimates

(continued)

BOX 2: C

The assessment identified no "silver bullet" policies that might easily achieve CMI goals. The complexity of the DTIB demands a diverse set of CMI policies. Some policies can have broad effects, but in most instances the barriers to CM I are sufficiently intertwined to demand a comprehensive (and complex) set of policies if projected benefits are to be achieved. Operations and Maintenance spending, for example, may be influenced by policies directed at increased use of commercial items and greater use of commercial practices. R&D, on the other hand, would be influenced by research goals that encompass both civilian and defense uses, and by modifying government requirements for rights in technical data.

The assessment outlined three strategies for consideration: Readjustment, Reform, and Restructuring. Together they form a phased implementation of CMI. A Readjustment Strategy modestly increases CMI, but retains many of the current procedures for oversight of defense expenditures; thus both the risks and the benefits are likely to be relatively small. A Reform Strategy builds on the foundation of a Readjustment Strategy and takes a more expansive approach to fostering CMI. It promises more benefits, but with a corresponding increase in potential risks. Finally, a Restructuring Strategy might gain the maximum potential CM I benefits, but would demand major changes in future military acquisition policy, system design, and force structure, and could present greater risks.

SOURCE. Office of Technology Assessment, 1995

production processes and parts dictated solely by product function. Table 1 illustrates some of the activities that comprise integration at the various levels, the barriers to such integration, and the rationale for increased integration.

Early in the assessment, OTA found that almost all of the previous studies of civil-military integration were based on case studies of specific products or firms.[2] Although many of these studies produced useful findings, there were concerns about the ability to generalize the findings of individual case studies.

The previous case studies were, for example, largely concentrated in areas of electronics and aviation. While these are important defense sectors, OTA estimated that they account for less than 30 percent of the value added to total defense goods and services purchased from the private sector.[3] Further, these particular sectors appeared to be somewhat more amenable to commercial use than many other industrial sectors. The cases selected also largely excluded many other important defense product sectors (e.g., conventional ammunition, ground vehicles, and shipbuilding). Finally, the previous case studies largely ignored services—a category that accounts for roughly 20 percent of the spending for direct final purchases, and about 40 percent of the spending for indirect and lower tier defense purchases.[4]

[2] A listing of many of these case studies is found in ibid., *Assessing the Potential for Civil-Military Integration,* Table 3-5, Selected Previous Civil-Military Case Studies, pp. 53-54. An exception to the concentration on the case-study approach was one study then ongoing by The Analytic Sciences Corp. (TASC), *The DoD Regulatory Cost Premium: A Quantitative Assessment, The* Analytic Sciences Corp., Arlington, VA, December 1994. This study considered macro level data collected from the Census Bureau in an attempt to validate the findings of earlier case studies.

[3] Electronics and aviation may represent a greater percentage of direct sales, but OTA's estimates were directed at value-added by particular sectors---and thus attempted to disaggregate such things as distribution, transportation, and other embedded activities from the sales figures for major categories of equipment.

[4] Department of Defense, *Projected Defense Purchases Detailed by Industry and State: Calendar years 1991-1997,* p. 4.

TABLE 1: CMI at Three Levels

Level of integration	What might be integrated	Examples of integration at this level	Examples of barriers to further CMI	Rationale for further CMI
Industrial sector	All activities in an industrial sector, including companies, industry groups, standards bodies, government labs, defense acquisition officials, and academia.	Use of common technologies, processes, and specialized assets (e.g., unique test stands, wind tunnels, and industrial research centers) within an industrial sector,	Differing commercial and military product and process requirements; separate specification and standard systems; go-it-alone attitude in businesses or the DOD; classification.	Product and process technology transfer; reduced costs by avoiding duplication; increased competitiveness; leverage limited R&D funds
Firm	Corporate management, divisions, branches, and assets of an individual company or corporation,	Sharing of corporate vision and resources, including management, workers, research centers, accounting and data systems, equipment, stocks, and facilities,	Need to shield commercial work from DOD oversight and added overhead costs; different accounting/data systems; different management and marketing environments; classification.	Internal technology transfer; preservation of capabilities in commercial or defense downturns; economies of scale, Increased long-term stability due to diversification; capital availability
Facility	R&D, production, maintenance and/or administrative processes within a single facility.	Sharing of personnel, equipment, material, and administration within a single facility; joint defense and commercial activity on a production line, in a work group cell, or at an R&D lab bench,	Need to shield commercial work from DOD oversight and added overhead costs; different accounting, data and supply systems; military uniqueness; use of military specifications and standards; limits on uses of government equipment; classification.	Source of cost savings; economies of scale, reduction of redundancies; lower capital investments and over-head costs; less worker retraining, direct process technology transfer; job retention

SOURCE: Office of Technology Assessment, 1995.

As a result of these early findings, OTA decided to base its assessment on a combined analysis of macro level industrial base data with examinations of the findings of previous case studies and some additional case studies undertaken specifically for the assessment. It was thought that the combination of macro level data and individual cases would provide better insights into trends in the base and the implications of change than would either case studies alone or simply examining macro level data.

Indeed, despite their short-comings, case studies have been, and continue to be, essential to the study of CMI. Case studies can serve one or more of three purposes:

1. cases are useful as anecdotes, to illustrate degrees of varieties of CMI or barriers to CMI,
2. cases can provide essential information and insights on critical firms or sectors, and
3. randomly selected cases---combined with proper statistical considerations--can be used to represent the larger population of companies, contracts, or programs from which they were drawn.

Previous case studies on CMI have served the first two purposes noted above. Case studies, however, are very time consuming, and many must be done to provide good insight.

Examination of available macroeconomic data or larger surveys, on the other hand, can provide additional useful CMI information. Such surveys could address the critical barriers to integration and assess why some commercial businesses avoid defense work. While surveys have the benefit of reaching an under-studied population, they: 1) demand extensive private sector time, 2) provide far less detailed information than that obtained from case studies, and 3) are expensive to conduct.

This background paper reports on three of the case studies that were conducted during the assessment: flat panel displays (FPD), polymeric composite materials, and shipbuilding. They illustrate varieties of CMI, barriers to CMI, and provide insights useful for developing CMI policy. Some of the general observations are briefly outlined below.

OBSERVATIONS

Many of the CMI issues discussed in *Assessing the Potential for Civil-Military Integration* are illustrated in these three cases. These cases represent important industries and technologies with both commercial and national security application. FPDs, for example, are being increasingly used in a wide variety of commercial products. Their size, weight, and ability to convey data make them useful in many military applications. But the future commercial market is expected to far exceed the defense market. Integration in the FPD sector is seen as a means to provide the DOD with access to rapid technological developments and lower DOD costs in meeting its needs.

The polymeric composites industry also provides important national security capabilities. Like the FPD industry, these capabilities generally involve critical performance-enhancing components of military systems rather than end products. There are important commercial as well as defense uses for these materials. Aerospace applications are of particular interest. Like FPD, integration is seen as important for both providing access to new technological developments, and for lowering DOD's product costs.

The shipbuilding industry differs from the other two industries in that the industry provides critical end products (aircraft carriers, submarines, and frigates to name a few) directly to the military, as well as providing components and subcomponents for these systems. Further, in contrast to the other two cases, shipbuilding is a relatively mature industry with an extensive history in the United States. But the commercial shipbuilding business has been in long-term decline; during much of the 1980s, few (in some years, zero) large commercial ships were built in U.S. shipyards and the industry became highly dependent on U.S. Navy work for survival. Thus, the greatest challenge for creating the integrated shipbuilding base, viewed as essential to preserve the nation's ability to provide affordable naval craft for national defense needs, is creating a viable, domestic large-ship commercial shipbuilding base.

Current Level of Civil-Military Integration

As with the base as a whole, all three of these sectors already have some degree of integration. As noted above, there is currently little integration at U.S. shipyards, but some CMI exists in the development and production of components.

Polymeric composites have considerable integration at lower tiers and face their greatest CMI challenge at the first tier where the specific military application (e.g., surface manufacturing to obtain stealth characteristics) may have little or no commercial counterpart.

A good deal of integration exists at the sector level in the FPD industry, for example, where many common technologies are pursued for both commercial and defense application. At the firm and facility levels, however, there is relatively little integration in the United States, where only a small domestic industry currently exists. If successful, the National Flat Panel Display Initiative, combined with recent DOD changes in the use of military specifications and standards, and continued acquisition reform, may increase both firm- and facility-level integration in the United States.

Potential for Civil-Military Integration

OTA's assessment of CMI indicated that integration is more likely at the lower industrial tiers than at the level of the prime assembler where many components are combined to fashion unique military products.[5] These cases generally support those findings. Both FPD and polymeric composites appear to be more amenable to integration than does shipbuilding; however, component producers in the shipbuilding sector report an ability to integrate, and where a commercial market exists, they are already producing in integrated facilities. The shipyards and design firms also report that much greater integration is possible.

The polymeric composites industry reports the potential for greater integration. Government procurement practices were identified during interviews for this assessment as a major inhibitor. Composites firms were reportedly hopeful that government changes in these practices would improve prospects for integration.

The potential for integration could probably be enhanced in all three industries by concerted efforts during the design phase of military equipment to make greater use of commercially available (or useful) technologies, and by making greater use of common process technologies (design and manufacturing). In the past, however, the introduction of more efficient commercial manufacturing technologies into defense application has been inhibited by the inability to adequately recoup investment costs. This problem must be addressed if greater use of common process technology is to become acceptable to industry.

Factors that Inhibit CMI

The case studies revealed a number of factors that inhibit CMI. There are sometimes technological inhibitors to CMI. For example, the relatively greater use of complex electronics and the need for integrated weapons systems on warships make it more difficult to use a common workforce to perform many production functions in shipyards building or service both civilian and military ships. Similarly, the need for great precision in the fabrication of the surface shape of composites used on stealthy aircraft does not exist in commercial aircraft and thus calls for different skills. This increases the difficulty of integration. The need for good, all-aspect viewing of cockpit displays in bright sunlight places somewhat different technical demands on those displays used in defense from those used in the commercial sector. Yet none of these examples make increased integration impossible; rather, they challenge those who wish to exploit the synergies of CMI to greater thought in designing both the process and product technologies involved.

Despite the recent changes in acquisition laws, new implementing regulations, and the changes in the use of military specifications and standards, integration continues to be inhibited in the three industries by current acquisition procedures. In part, this is a function of the inherent time lag between change at the top of a large organization and change at the bottom. *Assessing the Potential for Civil-Military Integration* outlines some of the reasons for this lag.[6] But, recent DOD and congressional actions making changes in the use of military specifications and standards and in acquisition reform (e.g., the Federal Acquisition Reform Act of 1994—FASA) appear likely to positively affect the potential for successful CMI. Still, further acquisition changes are essential if firms that produce both militarily unique items as well as commercial items are going to effectively integrate at the facility level.

Finally, some market factors inhibit integration. For example, the high cost of some FPDs needed for fighter aircraft cockpit applications limit their use in commercial aircraft. Similar limitations exist in the application of composites.

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[5] OTA, *Assessing the Potential for Civil-Military Integration*, op. cit., footnote 1, pp. 9-10.

[6] Ibid., pp. 29-42.

Yet even where market factors inhibit some integration, there is potential for greater integration in the design and production processes of many of these products.

Factors that Favor CMI

A number of factors, if exploited, appear to favor increased CMI in these three cases. There are, for example, clear indications in these three cases that trends in technologies are blurring the differences between commercial and defense technology. One good example is that process technologies are converging to make it easier to design and build defense and commercial products in a more integrated fashion. Many design software packages are applicable to both needs.

Product technologies—particularly at the lower tiers—also often overlap. The same composite materials may be used in both commercial and defense aerospace products. Common components can be used for many defense and commercial display applications. Commercial aerospace needs in displays and materials often overlap with all but the most demanding defense needs. Some pumps and valves can be used on both commercial and military ships.

The fact that many technologies are converging is also having an impact on markets, where the commercial markets are demanding products that are lightweight, rugged, and reliable—attributes long prized in the defense sector.

An even more important market factor clearly evident in all three cases is the growing gap between worldwide levels of spending for commercial and defense purposes in industries such as FPD. This trend makes it more difficult for defense to influence more than small portions of the industries, and increases the importance of integration if DOD is going to have access to essential technology.

Finally, recent government policy initiatives already mentioned (e.g., changes in the use of military specifications and standards, changes in acquisition practices, and initiatives aimed at exploiting commercially available technologies) all favor increased CMI.

Implications of Increased CMI

Interviews and workshops resulted in an overall consensus that both increased access and reduced costs are likely—if greater CMI is achieved in these three industries. Yet it is difficult to quantify either the amount of DOD's increased access to newly developed commercial technology, or the potential savings from increased integration.[7] *Assessing the Potential for Civil-Military Integration* estimated some of the potential savings based on survey interviews and estimates of the potential for increased integration in 16 randomly selected sectors supplying goods and services to national defense.

Estimates of overall possible savings ranged from a few percentage points off expected baseline expenditures to a high of 15 to 20 percent of expected baseline expenditures. Analysis indicated that a range of 5 to 10 percent savings off expected baseline expenditures appeared most probable. Interviews supported the conclusion that many rapidly evolving technologies might not be available to the defense effort in a timely fashion without increased CMI. Considering the relatively low risks and costs of pursuing a CMI policy that were identified in *Assessing the Potential for Civil-Military Integration*, these potential returns appear to favor pursuing policies that will enhance CMI.[8]

[7] Ibid., pp. 23-42. *Assessing the Potential for Civil-Military Integration* does make some estimates based on surveys and estimates on the speed of likely introduction of CMI policies.

[8] Ibid., p. 17.