Integrating Processes for Goods and Services 5

Chapter 4 examined opportunities for increased use of commercial goods and services to meet defense needs. Some defense requirements, however, are so highly specialized that they cannot be met by the commercial marketplace. It may nevertheless be possible for the Department of Defense (DOD) to obtain many benefits of the commercial market through a procurement environment that encourages integration of commercial and defense R&D, manufacturing, and maintenance at all levels: industrial sector, firm, and facility.

An **integrated process** is one in which common assets—technology, people, facilities, and administrative organization—are used to produce both defense and commercial goods and services. At the industrial sector level, examples of integrated processes might include joint industrial and government standards bodies, shared national test facilities, and the use of common technologies. At the firm level, integrated processes might include common corporate functions (e.g., planning, personnel, training, and possibly R&D) but separate defense production facilities. At the facility level, integrated processes might entail commercial and defense products being developed, manufactured, or maintained side-by-side by the same personnel.

Many of the processes used to design, develop, produce, and maintain military and commercial equipment are technically identical or very similar. But current acquisition policy often makes military processes substantially more costly and time consuming. Eliminating process integration barriers might lower acquisition and life-cycle costs, provide both sectors with greater access to innovative technologies, reduce acquisition time, expand the potential defense technology and industrial base (DTIB), and even enhance U.S. commercial competitiveness.[1]

This chapter opens with a survey of the current level of process integration and estimates of the potential for further growth. The chapter then builds on the analyses in chapters 3 and 4 in assessing the barriers to process integration. It concludes with a discussion of policy options for increasing integration across all levels and analyzes potential implications of such policies.

THE CURRENT AND POTENTIAL USE OF INTEGRATED PROCESSES

Estimates of the current and potential use of integrated processes are even harder to obtain than estimates of commercial purchases. In large part, this is because DOD has not collected relevant data.

The lack of estimates is also due to the inherent ambiguities in defining process integration. These ambiguities stem from the wide variety of processes that may or may not be integrated. At the facility level, a manufacturing plant may include a number of general processes (e.g., receiving, stocking, internal transport, manufacturing, packaging, shipping, cost accounting, maintenance, and R&D) and specific processes (e.g., use of a particular stamping press, touch labor by a particular employee, and quality inspection), any of which may be divided along commercial and defense lines.

Commercial businesses with no connections to DOD do not, in fact, necessarily integrate all similar processes. While they commonly separate many of their processes along product lines, businesses base their decisions to integrate on a variety of factors (e.g., proximity to sources of supply or transportation nodes, differing equipment requirements, differing production volumes, and special labor skills). (See box 5-1.)

Determining which processes have been segregated for economic reasons, as opposed to those segregated primarily because of the DOD procurement environment, is extremely difficult, and often the results are subjective.

While data on integration are scarce, a 1992 Center for Strategic and International Studies (CSIS) survey of 206 government prime contractors asked specifically about current levels of integration.[2] The survey found that 15 percent of those surveyed did no commercial business, while 13 percent sold only off-the-shelf commercial items to the government. Thirty-nine percent of the respondents segregated their commercial and federal business operations. Twenty-one percent set up unified management systems within a single operation to comply with government requirements. Only 12 percent conducted both government and commercial business in the same

[1] Certainly, many of the technologies and industrial sectors of interest to DOD-including aircraft, aircraft engines, electronics, communications, and avionics—have significant commercial, as well as defense, value. U.S. aerospace firms, for example, exported over $43 billion worth of aerospace products in 1991, over 80 percent of which was civil aerospace products. Firms have long argued that better integration of their R&D, manufacturing, and maintenance processes not only could lower the cost of aerospace goods purchased and maintained by the U.S. military but also would help make U.S. producers even more competitive abroad. U.S. Department of Commerce, "Aerospace," *U.S. Industrial Outlook 1993* (Washington, DC: U.S. Government Printing Office, January 1993), pp. 20-25. In that same year, the aerospace industry accounted for more than *25* percent of the Nation's R&D expenditures, while DOD ordered $22.7 billion in aircraft engines and parts, and funded more than $6 billion in aeronautics R&D. This market has declined, with 1993 exports of $39.6 billion, and 1994 exports estimated at less than $34 billion.

[2] Debra van Opstal, *Integrating Civilian and Military Technologies: An Industry Survey* (Washington, DC: The Center for Strategic and International Studies, April 1993), p. 5.

BOX 5-1: The AMRAAM, Part II: Integrated Processes

At the systems-integration level of production, the Advanced Medium-Range Air-to-Air Missile (AMRAAM) is a militarily unique item. The missile is built by Integrated firms (Raytheon and Hughes), but prospects that the missile could be assembled on an Integrated production line in an Integrated facility alongside commercial items appear practically nil. At the subcomponent level, in the lower production tiers, some manufacturing processes are Integrated. There appears to be room for further Integration in the future For example, a current ARPA-funded project involving Hughes and a smaller firm seeks to use commercial gyros in the AMRAAM. Research is ongoing to upgrade the AMRAAM's computers, computer software, sensors microelectronics circuits, and advanced composite materials These technologies overlap the defense and nondefense sectors Therefore, R&D might be accomplished by Integrated firms, possibly in Integrated facilities, and the resulting products might be dual-use

Estimates on the amount of Integration possible for R&D, manufacturing and maintenance, or from system Integrator to the lowest hers, are difficult to make Industry representatives interviewed for this report were optimistic that much more Integration could occur, but they noted that Incentives for Integration were lacking.

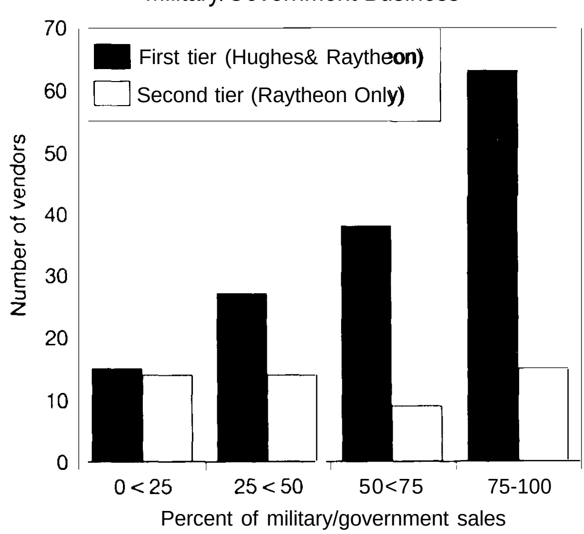
One way to judge Integration potential is to compare the technologies embedded in the missile with the technologies in commercial products. The AMRAAM and other guided missiles draw from a number of advanced technologies, including

microelectronic circuits	fiber optics	sensors and components	radar
photonics	explosives	advanced composites	
computers	software	rocket motors and propulsion	

Of the 10, only two (rocket motors and propulsion, and explosives) primarily serve defense The remaining technologies have significant commercial applications

The figure shows that while the first tier of suppliers to the two AMRAAM prime contractors depends heavily on military and government business, vendors in the next tier are far less dependent on government sales About 44 percent of the vendors in the first tier depend on the military/government for more than 75 percent of their business volume, and 45 of the 135 first-tier vendors produce more than 90 percent of their output for defense. Second-her vendors have a much more commercial orientation.[1] It is not difficult to understand why software, optical sensors, and microelectronics are among the driving forces of modern electronic products for industry, business and the home

Concentration of AMRAAM Vendors in Military/Government Business

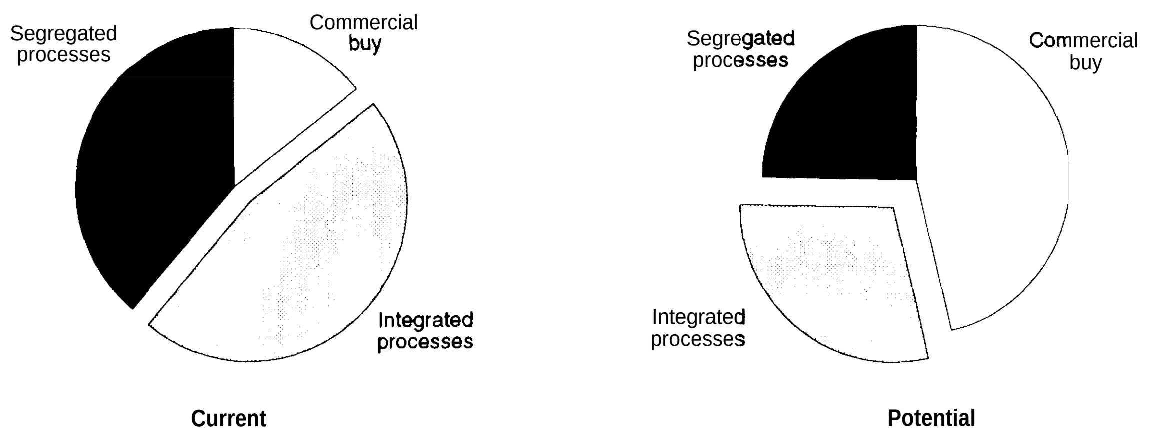


SOURCE Ivars Gutmanis Analysis of the Civil-Military Integration Feasibility for Selected U S Industry Sectors Washington, DC

[1]It is important t. remember however, that while a firm may perform both commercial and defense work the work they do for each is not necessarily related

SOURCE Ivars Gutmanis "Analysis of the Civil-Military Integration Feasibility for Selected U S Industry Sectors Report for the OTA Assessment on Civil-Military Integration Washington DC, 1993

FIGURE 5-1: OTA Estimates of Current and Potential National Defense Spending on Goods and Services Produced: A Focus on Integrated Processes



SOURCE Industrial survey conducted by the Off Ice of Technology Assessment, 1994

facilities. The amount of segregation observed in the CSIS sample is noteworthy because the firms surveyed were concentrated in three industrial sectors that appear to be amenable to integration of processes:[3] aircraft, aircraft and missile engines, and radio and TV communications equipment.

OTA Estimates

The responses to OTA's industrial survey (outlined in chapter 4, box 4-2) suggested that approximately 46 percent of the value added to goods and services in the private DTIB is from integrated processes. (See figure 5-1.) These estimates include both direct and indirect purchases.[4]

While the pie charts depicting current and potential degrees of integrated processes seem to suggest a reduction in the "integrated processes" wedge, this change reflects what actually are major shifts from "integrated processes" to "commercial buy" (discussed in the previous chapter) and from "segregated processes" to "integrated processes."

Previous studies and OTA's own analysis of additional selected industrial sectors[5] indicate that lower tiers of industry are more integrated

3 The OTA definition of integration is more expansive than that used by the CSIS study team. As noted in chapter 3, OTA considers integration at various levels from sector, to firm, to facility and workbench or assembly line. OTA was given access to the CSIS data and could therefore apply its definition to CSIS data. OTA's assessment of the CSIS data would show a somewhat higher level of overall integration than would the CSIS's interpretation of the same data, but still shows considerable segregation.

4 The expansive OTA definition of integration attempts to identify and estimate integration at discrete points in the development, production, and maintenance process, and OTA's estimates of current integration therefore may be higher than other estimates.

5 In addition to the OTA survey of randomly selected sectors and its case studies, OTA earlier examined 11 industrial sectors and conducted extensive interviews with personnel in firms that produced products ranging from large weapons systems to basic raw materials. The sectors were: shipbuilding, aircraft, communications equipment, portable laptop computers, flat-panel display technologies, apparel industry, munitions, circuit breakers, fluid power products, gear manufacturing sector, and composite materials. Also see Office of the Under Secretary of Defense for Acquisition, Defense Science Board Task Force Report, *Engineering in the Manufacturing Process,* Aug. 21, 1992.

than are the prime-contractor system integrators. Opportunities for increasing integrated manufacturing are greater at the lower industrial tiers, but the lowest tiers are already extensively integrated.

The policy options considered in this chapter are designed to foster the shift from segregated processes to integrated processes. The OTA industrial sector survey estimated that this shift will affect about 15 percent of private DTIB value added. After accounting for those goods and services estimated to shift to the commercial category, the OTA industrial survey produced an estimate that about 30 percent of the future value added will come from integrated processes. The policies principally affect the 15 percent of goods and services moving from the segregated base, but may also produce savings and enhance technology transfer even in those operations that do not shift categories.

Many DOD efforts to increase the use of integrated processes have occurred at the industrial sector and facility level. The policy options discussion later in this chapter considers measures of effectiveness of current DOD programs.

BARRIERS TO INTEGRATING PROCESSES

There are many well-documented barriers to process integration. Some are inherent in the technology—a technology may have no immediate commercial value. Technology barriers limit the amount of process integration that can take place, how rapidly such integration can occur, and, ultimately, the amount of money that might be saved. Other barriers, such as unique acquisition policies, are imposed by DOD and could be quickly lowered to promote DTIB process integration with the commercial technology and industrial base (CTIB).

■ Inherent Barriers

Many defense technologies are not amenable to process integration for a number of reasons, including the absence of a commercial market, uneconomic production rates, or classification.

Weapons and other military systems meant to perform and support combat missions, for example, are often complex and expensive, incorporating unique technologies with few, if any, commercial counterparts. The electronics for fighter aircraft and precision-guided munitions often require greater miniaturization and the ability to withstand more extreme stresses than the electronics aboard commercial aircraft. And although the polymer composite material in stealth aircraft may be the same basic material used in a commercial airliner. the precision construction of a radar-evading aircraft is far more demanding than is the construction of a commercial aircraft.

Such differences extend to manufacturing itself. Many of the skills and technologies involved in the construction of a nuclear submarine, for example, are unique to the military. Similarly, the ammunition sector is estimated to be more than 90-percent segregated. Much of this separation is likely to continue in the future. Unique product requirements, coupled with the absence of a commercial counterpart, make it difficult to envision profitable civilian and defense R&D or manufacturing of ammunition.

These inherent barriers are exacerbated by the low rates of production characteristic of military items. Over the past decade, for example, modern fighter aircraft have been produced at a rate of about two to five per month. Aircraft carriers are produced at the rate of about one every five years. Attack submarines have been produced at the rate of three per year. Other products, such as small-arms ammunition, clothing, and rations, may involve highly varied production rates that change with little notice. Such fluctuation in production. combined with the military character of the products, promotes the growth of specialization in which contractors are dependent on defense business.

Finally, some technologies are deliberately kept off the commercial market. The nuclear weapons industry is a case in point. Much of the industry involved in the fabrication of weapons and in the processing and reprocessing of nuclear materials remains highly restricted.

Imposed Barriers

There are, however, many defense goods and services that might be appropriate for commercial processes, even if the final product is not itself commercially viable. Further, some rapidly evolving commercial technologies may offer DOD more advanced capabilities than are available from purely defense sponsored R&D efforts. Computers, for example, share much of their hardware and production techniques with their commercial counterparts. Commercial computers may not need to be as rugged as military ones, but some civilian uses are nearly as demanding, such as oil exploration and field research of various sorts. Many of these computers could be developed in a common R&D program, produced on a single line, and maintained by a common labor force using common procedures.

But just as many goods and services that might be purchased commercially currently are not, many of the goods and services that are amenable to integration continue to be produced in segregated facilities or production lines. While the total amount that is needlessly segregated due to laws, regulations, and current procurement culture is unclear, OTA's survey estimated that at least an additional 15 percent of goods and services might be moved from the segregated into the integrated process category.

Most of the barriers to the use of commercial products discussed in chapter 4 also impede process integration, albeit within a different context.

The primary barriers are:

- government cost-accounting requirements;
- procurement process, culture, and skills;
- military specifications and standards;
- rights in technical data; and
- unique contract requirements.

These barriers are listed roughly in the order of their overall effect as reported in the CSIS industry survey and in OTA's interviews.[6]

Government Cost Accounting Requirements

Special cost accounting and oversight requirements may be an even greater barrier to integrating processes than they are to purchasing commercial items. Indeed, the Defense Science Board Task Force on Defense Acquisition Reform called the current cost-based contracting system, with its unique cost accounting, "the most important single intrusive element of the current process."[7]

A principal part of the problem, as noted in chapter 4, is that government accounting standards do not conform to modem commercial accounting practices. Government contracts require far more detail in allocating costs than do commercial management information systems. Firms doing defense work must carefully track all hardware and components, not only to ensure the reliability of the parts but also to verify their cost. They must also track personnel billing against specific contracts and monitor the use of government furnished equipment. In addition, prime contractors are required to collect cost and pricing data from suppliers, although the suppliers are not required by law to supply such data to the prime contractors.

The risk of criminal penalties for errors compounds the burden, discouraging some business executives from seeking defense work. Industry representatives report that government accounting requirements increase the amount of oversight, which, in turn, raises the cost of the goods and services supplied to the government.

Industry observers think that the Federal Acquisition Streamlining Act (FASA) of 1994 may

6 As noted elsewhere, ranking either [he most important barrier, or the most important response is difficult. There are differences among industrial sectors and among tiers. Lower tier firms, for example, are often more concerned about rights in technical data than are weapon systems assemblers. Firms responding to the CSIS industry survey placed provision of cost and pricing data and accounting requirements as number one, followed by unique government contract requirements, protection of proprietary data, penalties for certification errors, and technical requirements and quality control standards (military specifications and standards).

7 Office of the Under Secretary of Defense for Acquisition, *Report of the Defense Science Board Tusk Force on Defense Acquisition Reform*, July 1993, p. 6.

have little effect on these issues for firms making militarily unique items.

The problems imposed by government cost accounting extend to R&D as well as manufacturing. The 1993 CSIS industry survey, for example, reported that firms ranked cost and pricing data requirements as a primary reason for segregating their R&D activities. An earlier CSIS CMI study reported that some firms' reluctance to engage in defense R&D could be traced to past experience with government cost-accounting rules.[8]

The precise costs associated with the government cost-accounting system are difficult to measure and may differ across industrial sectors. Both General Electric and Pratt & Whitney, the two principal U.S. producers of jet aircraft engines, have reported several million dollars a year in additional costs associated with meeting defense orders. Much of this is attributed to cost accounting requirements. Intel Corp. reportedly spent $2 million in a failed attempt to put an acceptable government cost accounting system in place.[9]

Government cost accounting was introduced to maintain oversight on tax dollars. Supporters of these procedures argue that they remain necessary to control waste, fraud, and abuse. As proof, they cite continuing reports of inappropriate charges by defense contractors.[10]

A lack of data on the relative costs and benefits of the current government oversight regime forestalls analysis of the utility of government cost accounting. Reports by the Defense Contracts Audit Agency (DCAA) and the General Accounting Office stress the problems found and largely ignore the costs of oversight itself.

Some studies suggest, however, that the present system for preventing waste, fraud, and abuse is ineffective at holding down government costs. A recent study by the Defense Science Board Task Force on Defense Acquisition Reform, for example, argued that "the public protection offered by the current system is not a very high standard.'" It characterized the current system as one that "encourages increases in the price of goods and services, discourages investments in efficient production, and creates a regime of contention between the government and its suppliers."][2]

Procurement Process, Culture, and Skills

The acquisition workforce poses somewhat different challenges for process integration than for commercial purchases. Commercial purchases raised questions about: the workforce's knowledge of available goods and services, the definition of what constitutes a commercial product, and requirements for cost and pricing data on commercial goods and services. While process integration also raises some of these issues, they must now be considered within the context of program management, plant oversight, and quality control. What is at issue here is the ability of the acquisition workforce to adopt commercial manufacturing standards and quality controls in place of existing defense operating methods.

The estimated acquisition workforce, as defined by the Packard Commission and according to dataasofDecember31, 1993, is approximately 178,000, 94 percent of whom are civilians. This includes 23,000 contracting personnel and 4,500 contract auditors in DCAA. (See table 5-1.) Many observers argue that the 23,000 contracting personnel are hard-pressed to keep up with current contracting requirements and that this situation will continue even with legislative changes.

[x] Jeff Bingaman et al., *Integrating Commercial and Military Technologies for National Security: An Agenda for Change* (Washington, DC: The Center for Strategic and International Studies, 1991), p. 18.

[9] Defense Science Board Task Force on *Defense Acquisition Reform,* op. cit., footnote 7.

[10] See for example, *Inside the pentagon.* "Defense Contractors Still Abusing Overhead Cost Guidelines," Oct. 12,1993.

[11] Defense Science Board Task Force on *Defense* Acquisition *Reform,* op. cit., footnote 7, p. 13.

[12] Ibid.

[redacted]

	Army	Navy	Air Force	DLA	DOD totals
Civilian	40,479	73,610	30,638	22,366	167,093
Military	1,356	2,836	7,012	—	11,204
Total	41,835	76,446	37,650	22,366	178,297

SOURCE Defense Manpower Data Center, 1993

Changes might include far less onsite government presence and fewer industry reports. The government workforce could adopt techniques such as statistical process control. They might, for example, conduct periodic inspections rather than be onsite. Some changes are already occurring. The government is examining and accepting new process control techniques—including accepting the use of commercial manufacturing standards in place of military standards.

The Army has also instituted a program to eliminate many program management tools that had been designed, in turn, to prevent a repeat of earlier acquisition failures and are frequently included as contract deliverables. These include: development of integrated logistics plans; risk management plans; and the numerous meetings between government and contractor personnel to discuss these plans.

Such costly government requirements have not been a focus of private sector concern, since contractors were paid for them. In some cases they have added millions of dollars to a contract. The Army has concluded that since these activities are inherent in good program management the Army does not need to check the plan-just the results.

Differences in the manufacturing standards adopted by each Service have led firms to make similar items for different Services in separate facilities. Integrated firms producing militarily unique and commercial items still face several different government oversight requirements. Developing a common DOD standard would improve prospects for integration with commercial operations too.

Facility exemptions have also been advanced for streamlining direct government oversight. Past efforts have included: the Exemplary Facility Program; the Army's Continuous Process Improvement Program; and the Defense Contracts Auditing Agency's Corporate Risk Assessment Guide (CRAG). These have often been viewed as unsuccessful by industry. They involve upfront costs paid by participating firms, with few guarantees of recouping those costs. The Office of the Secretary of Defense (OSD) discontinued the Exemplary Facility Program, for example, after little discussion with the companies involved. Firms also argue that relief from oversight in one area merely invites oversight in another area.

Overall savings from changes in the culture and skills of the acquisition workforce maybe partially quantified by considering the potential reductions in oversight workforce. The Defense Science Board Task Force on Defense Acquisition Reform estimated that a 30-percent reduction in the acquisition workforce might be possible, which could translate into a $4 billion annual saving. OTA's own estimate of potential savings is about $2.1 billion. This estimate is based on a 178,000 person acquisition workforce earning an average of $40,000 per person.[13]

13 Average provided by the office of the DOD Comptroller.

BOX 5-2: Reliability of Electronic Equipment

The complexity and difficulty of changing and applying specifications and standards are evident in the argument over alternates for predicting reliability in electronic equipment, MIL-HDBK-217, the "Reliability Prediction of Electronic Equipment Handbook" currently used to estimate the reliability of military electronics, has been criticized as being out-of-date and inaccurate, Critics argue that it does not reflect emerging technologies, leads to costly overdesign, and prevents higher reliability from being achieved. For example, they point out that the Handbook has a

> bias toward MIL-SPEC screened ceramic parts that essentially precludes consideration of modern plastic-encapsulated parts that can be more reliable than more costly ceramic-packaged chips in many military and aerospace applications.[1]

Supporters of the Handbook counter that it provides "a necessary standardized medium for assessing reliability and comparing designs, " based on careful analysis. They maintain that any problems result from misuse or misinterpretation of the Handbook. Moreover, they argue that the Handbook is a flexible analytic tool, designed to provide a database for comparing design options, Identifying over-stressed parts, and providing input for analysis. They further hold that very little money is spent to keep the Handbook current

In June 1992, the Army authorized $1 million to pursue an initiative aimed at providing alternatives to the Handbook The Air Force and Navy are both reportedly Interested in the Army project.

[1] George Watson "MIL Reliability A New Approach, " *IEEE Spectrum* August 1992, pp 46-49

Military Specifications and Standards

As discussed in chapter 4, military specifications and standards have been used to define not only the physical characteristics and expected performance of the product, but also-most importantly from the perspective of issues addressed in this chapter—many of the manufacturing processes to be followed. Standards that describe, among other things, how the system is to be built and tested and how the work is to be managed are cited as major cost drivers and impediments to process integration. The Defense Science Board Task Force on Defense Acquisition Reform, for example, estimated a "20 percent to more than 50 percent" additional cost to a product when compared with best commercial practices.[14]

According to the Advisory Panel on Acquisit ion Law Reform, military standards often require commercial companies to depart not only from commercial practices but also from a company's individual processes that often lie behind the firm's commercial success.[15]

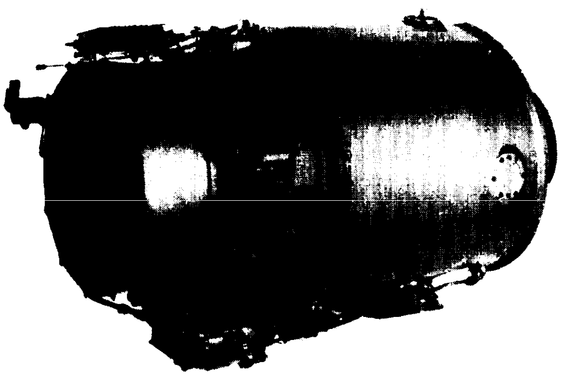
Debates over the appropriateness of particular military specifications and standards can be contentious. Box 5-2 looks at one example from electronics. Critics argue that this is an area in which acceptance of commercial standards and integration of processes might be particular y appropriate for DOD.

The flowdown of specifications and standards to lower tier contractors makes it more difficult to acquire dual-use materials, components, and subsystems for major systems. There have been few incentives for prime contractors or suppliers to seek alternatives to militarily specified components, or to propose changes in process standards

[14] Defense Science Board Task Force on *Defense Acquisition Reform,* op. cit., footnote 7, p. 6.

[15] The Defense Systems Management College, "Streamlining Defense Acquisition Law, " *Executive Summary: Report of the Acquisition Law Advisory Panel to the United States Congress, 1993,* p. 14.

UNITED TECHNOLOGIES/PRATT & WHITNEY



The Pratt & Whitney Canada JT15D *turbofan engine is designed for small executive, commuter and military training jets.*

used. That situation is changing with Secretary of Defense William J. Perry's June Memorandum on Military Specifications and Standards, which endorsed the recommendations of DOD's Process Action Team for Specifications and Standards and directed the Service Secretaries and other Service personnel to implement changes. [16] The Team recommended that:

- Manufacturing and management standards be canceled or converted to performance or non-government standards.
- Future contracts provide incentives to contractors to propose alternative solutions to military specifications and standards.
- The use of military specifications and standards be prohibited except where required for truly militarily unique needs.
- Process control of nongovernment standards be used in place of quality control testing and inspection, and militarily unique quality assurance systems. [17]

DOD had already begun to act on some of the recommendations even before Secretary Perry's memorandum. For example, in February 1994, Under Secretary of Defense John M. Deutch authorized program offices to use ANSI/ASQC Q90 and the ISO 9000 service standards in contracts for new programs. The offices could also use these standards for follow-on efforts to existing programs instead of MIL-Q-9858A (Quality Program Requirements) and MIL-I-45208A (Inspection System Requirements). Under Secretary of Defense Deutch stated that the purpose was to improve process capability, control, and quality "by endorsing a single quality system in any contractor facility." [18]

Case studies have attempted to document the costs associated with the inappropriate use of' military specification and standards when commercial standards would do, but the cases available, while providing insights on the costs, do not provide a basis for generalization. The Defense Science Board Task Force on Acquisition Reform estimated savings from 10 to 25 percent or more from integrating the production of transport aircraft, jet engines, electronics and software, and similar items. [19] Such savings are difficult to document across the budget. But in individual cases it is clear that adoption of commercial standards sometimes offers dramatic savings. DOD can make many, if not all, of these necessary changes under its current authority.

Rights In Technical Data

Almost half of the respondents to the CSIS Industry Survey listed protection of proprietary data as a reason for segregating operations. While there is

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16 Secretary of Defense William J. Perry, *Memorandum for the Secretaries of the Military Departments, Subject: Specifications and Standards—A New Way of Doing Business,* June 29, 1994.

17 Briefing: *Process Action Team for Specifications and Standards Final Report, Nov.* 19, 1993.

18 Under Secretary of Defense, John M. Deutch, *Memorandum for Secretaries of the Military Departments, Subject: Use of Commercial Quality System Standards in the Department of Defense (DOD),* Feb. 14, 1994.

19 Defense Science Board Task Force on *Defense Acquisition Reform,* op. cit., footnote 7, p. 8. Estimates of savings on some individual items were far greater-examples of gloves and radar provided an estimated 60-percent savings and some communications equipment was estimated to cost only one-tenth that of similar militarily specified items.

general agreement between government and industry that the government should have access to the data it needs to install, operate, and maintain its systems, tension arises concerning other uses of data that could compromise commercial proprietary information.

Chapter 4 noted that the government's ability to distribute a contractor's technical data can have the advantage of creating new producers in the supplier base (theoretically driving down costs) and/or ensuring continued capability. Since the government maintains many of its systems in service for decades, the cost and risk of dependence on a single supplier can be significant. From the contractor's viewpoint, however, this approach can put at risk the very technologies and processes that convey competitive advantage in the commercial marketplace.

There are three categories of rights the government can acquire:

- *limited* rights—which allow the government to use all delivered data for government purposes:
- *government purpose license rights—which* allow the government to distribute the data to others under a limited use restriction (e.g., the third party promises not to use the knowledge acquired in other activities); and
- *unlimited rights-which* grant the government the right to distribute the data without restriction.

Under any of these arrangements the government may receive and use internally any data delivered under the contract. But there is disagreement over the government's requirements for unlimited rights to the manufacturing and process data needed to reproduce an item (e.g., to distribute the technical package to other contractors; to order, redesign, or manufacture an identical product or system).

Under current regulations, the government may require unlimited rights in data when the technology was specified by, developed during, or required for the performance of a government contract or subcontract. This gives the government wide latitude to demand unlimited rights in data or software for products or technologies used in or modified for DOD systems and presents problems for a competitive firm.

An example illustrates the problem: The government fully funds the development of a part or system and the item is then built in a privately financed manufacturing facility. The government clearly has a right to data pertaining to the operation, installation, maintenance, and repair of that part or system, but in requiring the data that would permit it to second source the item, the government also obtains de facto rights to the privately funded process technology. Industry argues that the government merely exercises the contractor's manufacturing capability and expertise; it does not own the process, only the product to which that process was applied.

While the provision in FASA that provides the presumption that technical data under contracts for commercial items are developed exclusively at private expense may have a positive effect on commercial purchases, it does not appear to address many of the problems facing those attempting to integrate processes (e.g., potential requests for a commercially developed manufacturing process used to make a militarily unique item).

These technical data rights rules are grave disincentives for commercial firms to employ state-of-the-art products or processes in DOD systems. Under the current system, any producer willing to integrate facilities risks compromise of proprietary process information. The Defense Science Board noted: "the unique DOD demand for data rights beyond normal commercial practice . . . results in separate processes being developed for DOD and commercial work."[20] During interviews, the OTA assessment team found a number of cases that supported this conclusion. Disputes over rights to data are likely to escalate with any increase in the use of commercial products and increased integration of processes.

20 Defense Science Board Task Force on *Defense Acquisition Reform*, *Op. Cit.*, footnote 7. p. 5.

Whatever the costs of duplicating production facilities, the real cost of this barrier is probably its negative impact on DOD's ability to access cutting-edge process technology.

Unique Contract Requirements

A host of unique requirements appear in government contracts. Five categories are said to create serious barriers: affirmative action laws, procurement integrity statutes, small business subcontracting plans, domestic sourcing requirements, and contractor responsibility laws. All are intended to achieve important national goals beyond government procurement.[21] Some specific examples were outlined and discussed in more detail in chapter 4.

The effect of these unique contract requirements on processes is to disrupt long-term supplier relationships by requiring alternative suppliers; and disrupt normal business processes by requiring tracking and reporting of compliance. Critics argue that attachment of these conditions as specific contractual obligations adds incremental cost to the procurement process for possibly small social benefit (in the case of the existence of other relevant law).

The negative effects of these contract requirements on integration of processes are concentrated at the firm and facility level. Tracking and reporting on compliance adds to the operating costs. Full compliance may undermine the development of long-term business relationships with suppliers. This may be a particular problem as the base is down-sized. FASA is viewed as providing no relief in this area for the bulk of DOD funds (e.g., in the case of contract actions greater than $100,000 for militarily unique items).

POLICIES FOR INCREASED PROCESS INTEGRATION

A number of approaches to reducing or eliminating the imposed barriers that impede process integration have been suggested. To succeed, they must be tailored to the three broad activities (R&D, manufacturing, and maintenance) that govern the life-cycle of military goods and services. Furthermore, although integration is usually discussed with regard to the facility level (manufacturing line or R&D lab bench), it might also occur at the industrial sector and firm levels. To be effective, policies must be tailored for the level or levels at which they might have positive effects. Table 5-2 provides some examples.

A truly integrated approach would address all commercial and defense technology and industrial processes from R&D, to manufacturing and services, to maintenance.

The Impact of Technology

Modem technology may be facilitating a shift toward integrated processes. (See box 5-3.) A recent example of process integration from the outset is a new modular avionics radar designed by Westinghouse to detect wind shear. The basic designs of both the defense and commercial versions share many common characteristics and can be modified to fit on a variety of aircraft.[22] An often cited example of earlier integration is the Air Force's KC-135 tanker and the commercial Boeing 707. Both aircraft were spawned from a common jet transport prototype developed by Boeing.[23]

In the past, integration has often involved "spin-off," i.e., the transfer of technology from the military to the commercial sector. Radar, computers,

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21 Debra van Opstal, "White Paper on Barriers to Commercial-Military Manufacturing Process Integration" (Washington, DC: Center for Strategic and International Studies, Dec. 10, 1992).

22 James J. Hughes, *Making Dual-Use Technologies Work* (Baltimore, MD: Westinghouse Electronic Systems), 1993.

23 John A. Alic et al., *Beyond Spinoff: Military and Commercial Technologies in a Changing World* (Boston, MA: Harvard Business School Press, 1992), p. 69.

TABLE 5-2: Process Integration at Three Levels

Level of integration	M/hat might be integrated	Examples of integration at this level	Examples of barriers to further process integration	Rationale for benefits of further process integration	Policies for increasing process integration
Industrial sector	All activities in a particular 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 in-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 DOD; classification of technologies, absence of measure of long-term effectiveness, opposition by Services and parts of the government.	Increase process technology transfer; reduce costs by avoiding duplication, increase international competitiveness; leverage limited R&D funds.	Foster DOD participation in commercial consortia and standards-setting bodies, open unique government facilities to commercial use; rationalize the DTIB and increase reliance on the commercial sector; promote joint development of manufacturing technologies, accept common technologies.
Firm	Senior 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; maintenance of capabilities in commercial or defense downturns; economies of scale; in-increased long-term stability due to diversification, capital availability	Change requirements for rights in technical data, modify the use of military specifications and standards; design for dual-use, create more predictability in defense budgets through multi-year contracts.
Facility	R&D, production, maintenance, and/or administrative processes within a single facility,	Sharing of personnel, equipment, stocks, and administrative processes 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/supply systems, military uniqueness; use of military specifications and standards; limits on uses of government equipment, classification.	Cost savings; economies of scale, reduction of redundancies, reduction in capital investments; less worker retraining; lower overhead costs, direct process technology transfer; job retention,	Streamline acquisition rules and reduce direct oversight; promote commercial standards; develop function-based standard data packages, design for dual-use; fund technology areas rather than individual technologies.

SOURCE Office of Technology Assessment, 1994

BOX 5-3: Technology Trends Facilitating Process Integration

The Defense Science Board and others have noted that many important technologies are converging in products with both military and civilian applications.[1] These developments may enhance the ability to integrate CTIB and DTIB processes, Convergence is especially prevalent in the electronic industrial sectors, where commercial technologies often lead their defense counterparts and where commercial firms emphasize consistent quality and durability.

In addition, advances in computers, manufacturing, and communications technology hold the promise of more flexible or agile manufacturing. Many believe these advances will cause a fundamental change in mass production to "mass customization. " Several benefits could follow from this shift:[2]

- the flexibility to produce at low rates, with cost and quality similar to that in high-volume production,
- the capability to mix production—converting rapidly from one product to another with minimal retooling costs or delays—in cases where products are procured in small quantities; and
- the ability to adapt and rapidly Incorporate new product and manufacturing technologies in existing or new products,

Simulation and modeling techniques are increasingly useful in testing designs. Reportedly, "the adoption of rapid prototyping technologies has reduced by 50 to 80 percent the time Involved in getting prototype parts."[3] These techniques can help validate manufacturing, maintenance, and management processes, While some of these tools are becoming available even at the smallest firms, the more complex tools still require expensive computing equipment. Firms or facilities might benefit from the capacity to easily share the costs of such equipment across defense and commercial product lines. DOD would benefit from this cost sharing, as well as from the direct benefits of modeling, such as rapid prototyping.

Meanwhile, various testing and quality control methods or philosophies, such as statistical process control or '(zero defects, " have improved the reliability of commercial products, often to the point that they are more reliable than defense items produced on assembly lines run according to military standards. Studies have argued that many of the military manufacturing standards developed in the past may be both unnecessary and detrimental to production (e. g., visual testing of electronic parts).

These developments may provide new opportunities to manufacture specialized military products on the same assembly line as similar, or related, commercial products, employing the same tools, stocks, and labor, Even if process Integration is more applicable in components and subcomponents than in final assembly, it could still have a major impact on overall weapon systems costs and the size of the potential base. DOD might especially benefit from manufacturing flexibility, since peacetime production rates are often relatively low—essentially batch production—while wartime production rates might be much higher.[4] The Defense Logistics Agency (DLA) has been experimenting with harnessing technical developments to hedge against wartime needs using contractual agreements that take advantage of such flexibility. The DLA, for example, has negotiated and exercised standby agreements with commercial firms and supported the Introduction of new technology to ramp up production of military clothing in the event of a national crisis

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1 Defense Science Board 1986 and 1989 Studies on *The* Use *of Commercial Components in Military Equipment* Also see John A Alic et al *Beyond Spinoff Military and Commercial Technologies in a Changing World* (Boston, MA Harvard Business School Press 1992), p 47

2 Manufacturing Systems Committee, DOD MANTECH Advisory Committee, *Manufacturing Systems Strategic Plan*, March 1993 p 59

3 Office of the Under Secretary of Defense for Acquisition, Defense Science Board Task Force Report, *Engineering in the Manufacturing Process,* Aug 21 1992, p F9

4 Analysts note, however, that the total capacity of a flexible line might be relatively inflexible, because such a line would be planned for use at near full capacity during peacetime The ability to Increase defense products, therefore, will depend on displacing nondefense products on demand

and composites are examples of spin-off technologies. But technological changes and the shrinking defense base suggest that in the future there may be more "spin-on" of commercial product and process technologies. applied to defense needs. Raytheon's MILVAX computers, manufactured under license by the Digital Equipment Corp., are military versions of Digital VAX computers and can use commercial software .24

Some technology, however, will undoubtedly still be transferred from the military to the commercial sector. A recent example involves Raytheon Corp. 's design of its first gallium arsenide monolithic microwave integrated circuit (MMIC) chip for commercial use. The commercial chip was produced in the same facility that produces chips for Raytheon's Missile Systems Division. Raytheon reports that the chip is of high quality and meets the commercial market demand for high-performance devices, without the use of DOD testing and documentation.[25]

Policy changes should seek to take advantage of technology trends, to facilitate technology transfer both into and out of the DTIB, and to reduce duplication of effort.

Process Integration at the Industrial Sector Level

Government policies affecting process integration may be easiest to institute and least controversial at the industrial sector level. Recent broad policy initiatives, such as the Technology Reinvestment Project (TRP), will affect integration at all three levels, but the important technology development effort will have immediate, and possibly greatest, effect at the industrial sector level.

As noted in table 5-2, at the industrial sector level, process integration may involve cooperation in the development and distribution of process and product technology. It may also involve rationalization of specialized technical or industrial assets to meet defense and nondefense needs. Sector-level integration allows the DTIB and CTIB to work from the same base of knowledge and make better use of resources. While all technologies in a sector might not be relevant to both defense and commerce, many technologies might be---especially if efforts are made to exploit dual-use opportunities.[26]

Commercial participants in the integration of a particular industrial sector might include business, labor, professional organizations, and standards and testing bodies. Defense participants might include defense firms and representatives from the public sector (DOE and DOD laboratories, depots and other maintenance facilities, manufacturing arsenals, and test centers). The degree of overlap in private sector representatives from the DTIB and CTIB might provide an indication of current integration.

Industrial sector integration might involve developing common manufacturing or maintenance techniques; participating in standards and testing bodies; establishing joint centers for R&D; conducting common trade conferences and exhibitions; and sharing assets, such as wind tunnels, launch pads, and test stands. Sharing resources can help ensure that an industry is not permanently divided into a DTIB and a CTIB. The aircraft engine industry, for one, has had a long-term, Air Force-sponsored engine development program in which the results are shared by military and commercial participants.

DOD and DTIB involvement may influence decisions (e.g., on research emphasis, test protocols, and maintenance techniques) in directions that benefit DOD needs, but decisions also must be commercially sound. For this reason, propo-

[24] Ibid., p. 73. Chapter 4 discusses the option of buying many commercial items directly. thus taking full advantage of the commercial R&D embedded in those items.

[25] "Raytheon Designs MMIC Chip for Commercial Use," *Aviation Week and Space Technology*, July 20, 1992, p. 50.

[26] Such integration does not imply centralized industrial planning, but rather a concerted effort to take advantage of available resources and developments.

nents of integration argue that a fundamental principle for successful integration is the design of defense equipment to make optimum use of dual-use items.

The SEMATECH consortium, for example, uses government funding to develop manufacturing technology for future generations of microchips—a development that may be more critical to international industrial competitiveness than to defense. The recent DOD initiative on flat-panel displays is designed to support the development of a commercial industry that might also meet the needs of a more limited defense market. Underlying assumptions in both efforts include that civilian developments in these fast-moving sectors drive technology and that future defense needs can be ensured at lower cost through a strong commercial industry.

But critics of such efforts argue that government initiatives are unlikely to be as efficient as the market in supplying defense needs. Such efforts, they allege, will "waste money, fall prey to political pressure and distort competition."[27] Still, most critics do not deny that there is a role for government in technologies of importance to defense—what they question is the size and character of that role. (See box 5-4, pp. 119-120.)

Three key objectives of a industrial sector-level process integration effort are: 1) leveraging funds, 2) increasing the level of knowledge in the sector, and 3) diffusing new technology.

Leveraging funds is especially important given the downward trend in defense spending. Increasing industrial sector-level process integration might allow DOD to eliminate redundancies that exist between the public and private sectors of the base and focus future DOD efforts on militarily unique technologies that have no commercial market, rather than duplicating commercial efforts.

Limited government funds might be directed at these militarily unique areas, with some continued spending in commercial sectors such as microelectronics, where government seed money may be important.

The ability to leverage funds depends on DOD's readiness to exploit technologies with both defense and commercial application. This is not always possible, since the military may have specific performance requirements (stealth aircraft) that do not exist in the commercial sector.

But even where differences in the final application exist, it may be possible to identify processes applicable to both defense and commercial products. Software and design technologies, for example, are important to both the commercial and defense composites industry. Both markets are demanding increasingly sophisticated product designs. An Army Research Office effort to develop design software that will reduce the time from product concept to delivery has both defense and private-sector applications.[28]

Rationalization of public and private R&D, production, and maintenance activities will also leverage funds. One of the principal R&D integration challenges, for example, is to identify proper public and private roles and to effectively rationalize the activities. In the past, 30 to 40 percent of defense R&D was conducted in military service laboratories or in Department of Energy (DOE) weapons laboratories. These public-sector facilities generally focus on technologies with high military potential, and pursue research with a potential for long-term payoff. Future research will have to take maximum advantage of commercial developments, while maintaining some militarily unique research.

Cooperative Research and Development Agreements (CRADAs) can also help leverage funds by transferring technology from federal lab-

27 Robert J. Samuelson, "Flat Screens and Subsidies," *The Washington Post*, May 19, 1994, p. A23.

28 OTA Composite Materials Case Study, forthcoming background paper supporting this assessment.

TABLE 5-3: Funding for Defense Related Economic Adjustment (dollars in millions)

	FY 1993 Awards	FY 1994 Appropriations	FY 1995 Authorization conference bill
Technology reinvestment project			
ARPA Dual-Use Partnerships	82	150	245
Commercial-Military Integration Partnerships	42	100	96
Advanced Manufacturing Technology	23	30	30
Regional Technology Alliances	91	100	80
Manufacturing Engineering Education Program	28	24	24
Manufacturing Extension Program	87	0	25
Dual-Use Technology Assistance Extension	91	0	0
TRP-related Small Business Innovative Research	7	NA	NA
Subtotal	451	404	500
Reprogrammed funding	—	120	
MARITECH	—	30	50
Other dual-use technology programs			
Agile Manufacturing and Enterprise Integration	29	35	35
Advanced Materials Synthesis and Processing	29	30	30
U S -Japan Management Training	9	5	10
Subtotal	**67**	70	75
Small Business Innovative Research (SBIR)	85[a]	145[a]	161[a]
Nonpartnership dual-use technology programs			
High Definition Systems	92	85	68
Optoelectronics	23	32	26
Multi Chip Modules	22	29	25
Advanced Lithography	71	58	60
Advanced Simulation	—	59	21
Other Materials and Electronics Programs	32	64	32
New Navy Initiative	—	—	50
Subtotal	240	327	282
Grand total	758+85	951 +145	907+161

[a]SBIR funding is an estimate no specific amount mandated by law

SOURCE Off Ice of Technology Assessment, using Defense Budget Project, CBO, and DOD data, 1994

oratories to the private sector. The use of CRADAs has expanded as a result of changes in the law. There also appears to be more real interest at government laboratories in the face of budget cuts and mission changes, and greater interest by business.

The Technology Reinvestment Project (TRP) can also leverage government and private-sector funding. (See table 5-3.) The TRP is divided into several broad areas: Technology Deployment, Technology Development, and Manufacturing Education and Training. Its goals include diversification from defense to commercial products, integration of defense and commercial production facilities, deployment of technology to and from commercial industries, and development of dual-

OAK RIDGE CENTERS FOR MANUFACTURING TECHNOLOGIES

The Oak Ridge Manufacturing, Prototyping, and Demonstrations Center offers commercial companies expertise and demonstration equipment m a variety of manufacturing technologies, including multiaxis and nontraditional machining.

use technologies.[29] It can potentially leverage investment through the commercial-military technology partnerships, defense dual-use control technology partnerships, and defense advanced manufacturing partnerships.

TRP received $404 million in fiscal year 1994, of a total of about $1.7 billion for defense conversion and dual-use technology programs government-wide. This effort centered more on technology development and less on deployment, with priority given to developing dual-market items for the defense and commercial markets.[30]

The project may have its most immediate impact at the sector level. In the long run, however, it can affect integration at the firm and facility levels too, by creating dual-use technologies.

Although TRP has received significant support from Congress, the program has raised concerns about how technical research areas are selected, whether DOD and ARPA should be managing the project, and how the success of the project is ultimately to be determined.

Finally, the government is attempting to leverage past investments by making available the unique capabilities of government R&D facilities. The naval ship design facility at the David Taylor Model Basin has been touted for new commercial ship designs. Other facilities under discussion include the Arnold Engineering Center aerospace test facilities and supercomputer facilities at Los Alamos and Lawrence Livermore. The Oak Ridge Y-12 Production Facility has organized 15 Centers for Manufacturing Technology and is applying expertise developed during the Cold War to commercial manufacturing problems.

Increasing the level of knowledge in an industrial sector is a second key industrial sector-level goal. Achieving this goal will require an understanding of defense and civilian technology needs.

While the military Services have long had science and technology plans aimed at pursuing useful technologies, a comprehensive DOD-wide plan has only recently begun to emerge. In response to congressional requests to develop a process for evaluating the allocation of resources in the late 1980s, DOD developed a "critical technology plan."[31] The yearly submissions of this plan, however, were criticized as being a listing of interesting technologies rather than a guide to resource allocation. The *DOD Key Technologies Plan,* released in July 1992 and tied to the Department Science and Technology Strategy, was thought by some to be nearer the mark.[32] The S&T strategy contained seven research thrusts directed at military forces and operational requirements.

29 Advanced Research Project Agency Briefing, Apr. 6, 1993.

30 Ibid.

31 P.L. 101-189, 103 Stat. 1512 Paragraph 2508(a) directed the Secretary of Defense, working with the Secretary of Energy, to submit annually to the Armed Services Committees of the House and Senate a plan for developing the technologies considered most critical to ensuring the long-term qualitative superiority of U.S. weapons systems.

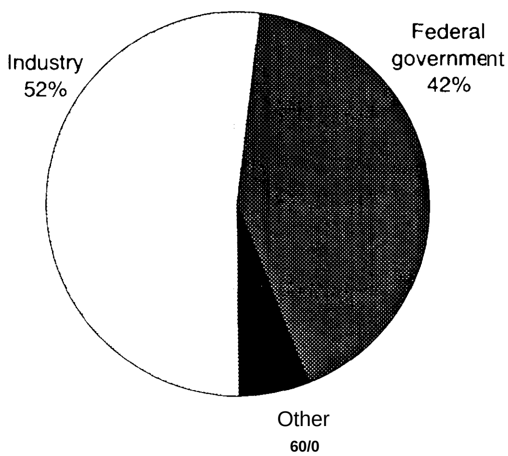
32 U.S. Department of Defense, Director of Defense Research and Engineering, DOD Key *Technologies Plan,* July 1992.

BOX 5-4: The Role for the Government in Integrated R&D

The government will undoubtedly continue to play an Important role in both commercial and defense R&D. The figure below-left shows total estimated R&D spending by source for 1993 The federal government provided $69.7 billion, about 42 percent of the total, Twenty-five federal agencies were engaged in funding R&D But 93 percent of the funding comes from the six shown in the figure below-right DODs share has dropped from a peak of 64 percent in 1986, to an estimated 52 percent in 1993, This is expected to drop to about 51 percent in 1994.[1] Increased Integration of commercial and defense efforts might streamline the national R&D effort by eliminating personnel and avoiding unnecessary duplication

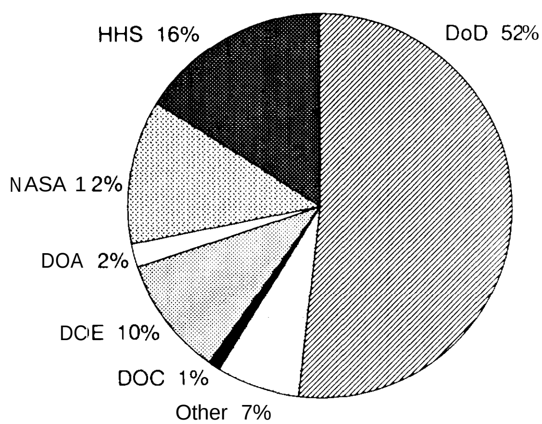
There are a number of initiatives, aimed at better coordination of the government R&D effort, that can potentially have a positive effect on the Integrated base. The development of a National Science and Technology Council (NSTC) raises coordination of government science and technology to a Cabinet-level group with the authority to establish budgets and resolve conflicts.[2]

R&D Funding by Source, 1993



Total $160.7 billion

Estimated Federal Obligation, 1993



Total $69.7 billion

SOURCE National Science Board, *Science and Engineering Indicators*, National Science Foundation (Washington DC U S Government Printing Off Ice 1993) (NSB93-1) pp 92 and 111

[1]National Science Board *Science and Engineering Indicators*, National Science Foundation (Washington, DC U S Government Printing Off Ice 1993) pp 104-111

[2]"Where N. Policy Has Gone Before , " *Washington Technology,* Mar 10, 1994

(continued)

BOX 5-4 continued: The Role for the Government in Integrated R&D

DOD initiatives to promote R&D integration include Project Reliance, a program designed to streamline Service activities, improve coordination, and avoid unnecessary duplication. Reliance could result in substantial savings. Second, the Off Ice of the Secretary of Defense and the Services are all examining opportunities for using civilian R&D in place of DOD-funded efforts. But efforts to identify specific civilian scientific activities of interest to defense are only just beginning. Third, the Services plan to direct more research effort to projects with potential commercial application. The Air Force, for example, plans to spend from 10 to 20 percent of its research funds on such projects. Both the Navy and Army plan to improve coordination of research involving Service laboratories, industry, and universities in order to leverage their limited research funds. Fourth, all the defense laboratories have increased their participation in technology transfer, The National Science Foundation notes that technology transfer activities can run the "gamut from the informal exchange of ideas between visiting researchers to contractually structured research collaborations involving the joint use of facilities and equipment."[3] They include Cooperative R&D Agreements (CRADAs), Patent License Agreements (PLAs), and technical outreach programs. The government, for example, expects to have more than 3,200 CRADAs in effect in 1995, many with defense-oriented laboratories—especially the DOE weapons Iaboratories, CRADAs are designed to allow transfer of technology to the private sector. Under these agreements, federal laboratories and the private-sector collaborators share resources in collaborative R&D. The laboratories also assist industry, both on a reimbursable basis and in an informal manner by responding to requests for information Oak Ridge National Laboratory, for example, provides support on technology development in materials forming and processing, and researchers at Los Alamos National Laboratory provide technical advice to small business, The government can thus assist industry Informally, provide more formal consulting help on a reimbursable basis, and grant licenses of technology developed within the government,

Government organizations also support and participate in a number of R&D consortia with defense and commercial applications, including the Great Lakes Composites Consortium, SEMATECH, and the Advanced Battery Consortium. DOD also provides support for activities led by other government agencies, such as the Automated Manufacturing Research Facility at the National Institute of Standards and Technology

The Advanced Research Project Agency is supporting several integration activities under its Technology Reinvestment Project (TRP). TRP is a mix of eight individual programs whose goal is to bolster the economic competitiveness of defense-dependent resources and increase the availability of dual-use technologies for national security purposes, TRP involves competitive awards, participation of a wide range of Industry, universities, nonprofit organizations, and state and local governments; and cost-sharing,

But government Involvement in many of these activities is not universally supported. While many in business welcome government activities, others in the business and academic communities complain that federal laboratories are competing directly with the private sector—and doing so unfairly because of U.S. government backing, These concerns have resulted in moves in Congress to bar federal laboratories from conducting research and services that "conflict with existing capabilities in the private sector."[4] The dividing line between government activities viewed as helpful and those viewed as threatening differs by firm, Drawing that Iine will be difficult.

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[3] 1 bid p 119

[4] "Competition from Department of Energy Laboratories Gets Capitol Hill Attention,"' Technology *Transfer News*, p 8

One—Technology for Affordability—was specifically intended to promote technologies that would result in more affordable defense systems .33

But DOD has never made a strong link with commercially relevant technologies. A 1991 report by the National Critical Technologies Panel compared DOD critical technologies, the Department of Commerce "'Emerging Technologies," and the Panel's "National Critical Technologies." There were to be sure many areas of overlap, but little evidence that DOD has sought to systematically exploit civilian technology investments. This may be changing. The Director of Defense Research and Engineering (DDR&E) is reportedly reviewing Department R&D efforts to identify research needs and determine those that can be met in the civil sector.

DOD and defense industry involvement in standards-making bodies can supply insight into developments of interest in the commercial sector. But a conscientious effort to incorporate commercial technology into defense systems is ultimately the most important step for the Department. Such a commitment, if enforced, will force military equipment designers and the Services to maintain an up-to-date understanding of commercial developments in their sectors.

Diffusing new technology is the third key aspect of integration at the industrial sector level. Many observers argue that the U.S. government can play a major role in diffusing technology. They argue that America's international economic competitors owe part of their success to a government role in developing critical manufacturing technology and in diffusing that technology throughout industry.

According to a 1988 Defense Science Board report, for example, the Japanese Ministry of Industrial Trade and Industry (MITI) "engages in effective, long-range planning for development of both the defense and civil sectors. This broad industrial planning effectively transfers technologies and products originally developed for civilian goods to the defense sector and vice versa."[34] Although there is a growing recognition that MITI has been neither all-powerful nor infallible in selecting and supporting technology, it has facilitated the development of government-commercial partnerships and has championed the growth of key industries.

CRADAs are one means of diffusing technology. DOD has developed a number of other mechanisms to help diffuse technologies. One involves government-commercial consortia to perform research in areas of mutual interest such as the Great Lakes Composites Consortium and the Great Lakes Industrial Technology Center, both of which conduct research on matters of interest to DOD and act as conduits for technology between the defense and commercial sectors.

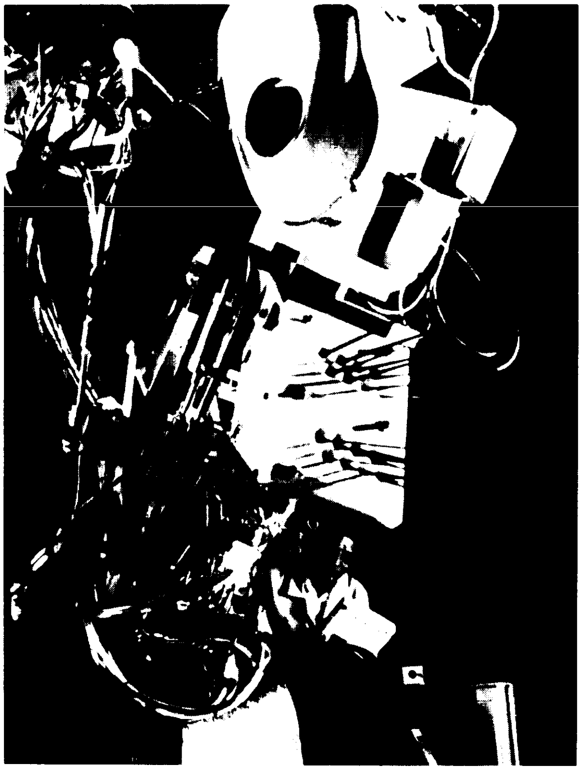
The Army's National Automotive Center (NAC) at the Army's Tank-Automotive Command also appears to address sector-level capabilities. NAC promotes collaborative R&D in dual-use technology in the automotive sector. It has CRADAs with Chrysler, Ford, and General Motors. NAC is also working with the Advanced Research Projects Agency, DOE, and the U.S. Council for Automotive Research on the clean car initiative that seeks to produce high-performance, fuel-efficient vehicles. The Army hopes to save millions in development costs through such cooperation and believes that the research has commercial benefits.[35]

Program-specific actions can help diffuse technology at the sector-level, but less wide] y than

[33] The thrusts were Global Surveillance and communications, Precision Strike, Air Superiority and Defense, Sea Control and Undersea Superiority, Advanced land Combat, Synthetic Environments, and Technology for Affordability.

[34] Office of the Under Secretary of Defense for Acquisition, *Final Report of the Defense Science Board 1988 Summer Study on the Defense Industrial and Technology>' Base*, October 1988, p. 18.

[35] Stacey Ever\, "Lockheed Charts Course Through Defense Cuts," *Aviation Week & Space Technology}*, Jan. 3, 1994, p. 60.



GREAT LAKES COMPOSITES CONSORTIUM

The government and industry are forming consortia to develop new dual-use technologies. Here, the Great Lakes Composites Consortium applies advanced robotics to composite fiber placement.

broader efforts. The DOD Manufacturing Technology program (MANTECH) often funded manufacturing technology efforts directed at a specific program problem and made solutions available to industry. Another interesting example is the Manufacturing Operations Development and Integration Laboratories (MODILs) Program developed by the Strategic Defense Initiative Office (SDIO). The program promoted process integration at the industrial sector level, as well as at the firm and facility levels. (See box 5-5.)

Developments in integrating manufacturing technology can potentially benefit both the defense and commercial sector. The DOD Manufacturing Technology Advisory Group on Materials Processing, for example, argued that:

> The most immediate and obvious spin-off benefit of [its processing and fabrication] plan will go to the U.S. commercial aircraft industry. These same manufacturing technologies developed for military systems are directly scaleable and transferable to commercial airplane systems.[36]

A DOD advisory group on manufacturing strategy argued that:

> The most important government roles in advancing the technologies of manufacturing systems are to provide seed money for promising technical opportunities that would not otherwise be pursued and to bring individual companies together for mutual leveraging in areas of common need.[37]

The group concluded that a broad-based strategy—rather than programs aimed at a particular weapon system or company—was essential. The payback period on technology is far too long, the risks are too high, and the development costs are too great for individual companies or even entire industrial sectors to handle alone. Rather, the group argued, DOD and its contractors must join with the commercial sector in stimulating the development of manufacturing systems technologies and commercial products based on those technologies in advancing appropriate standards, and in sharing implementation experiences.[38]

The NIST manufacturing extension centers, partially funded through TRP, provide help to smaller manufacturers in adopting new manufacturing technology. There are other avenues, though, that DOD might explore in diffusing knowledge across sectors, including supporting standards-setting bodies. With reductions in military standards and specifications, and greater reliance on commercial specifications and stan-

[36] DOD Manufacturing Technology Advisory Group, Materials processing & Fabrication Committee, *Materials Processing & Fabrication Technical Committee Strategic Plan,* Apr. 21.1993, p. 11.

[37] Manufacturing Systems Committee, DOD MANTECH Advisory Committee, *Manufacturing Systems Strategic Plan,* March 1993, p. 3.

[38] Ibid.

BOX 5-5: MODILs

Manufacturing Operations Development and Integration Laboratories (MODILs) were designed by the Strategic Defense Initiative Off Ice (SDIO) to bring unique government capabilities together with industry and university participants to develop and demonstrate new production and automation processes for specific technologies SDIO's objective was to ensure that an industry would exist to produce items that might be developed through its R&D program. With a relatively small budget of $5 million to $7 million per year, SDIO used a combination of focused workshops, joint projects, and equipment testing in its MODILs.

The Optics MODIL at Oak Ridge National Laboratory, for example, uses state-of-the-art precision-machining equipment to support collaborate experiments, Other MODILs Included the Advanced Infrared Sensors MODIL and the Signal Processing MODIL, both at Sandia National Laboratories, the Software MODIL at the National Institute for Standards and Technology; and the Space Fabrication and Test MODIL at Lawrence Livermore Laboratory Cuts in funding for strategic defense resulted in a loss of funding for the MODILs Only the Optics MODIL at the Oak Ridge Center for Manufacturing Technology will continue The other MODILs are being terminated.

Although the original purpose of the MODILs was to ensure that a future capability would be available to support weapons production, and not dual-use technology per se, the efforts developed technology in precision finishing and coatings and diffused that technology to firms for both defense and commercial applications.

dards, DOD might reasonably contribute to setting standards in sectors that serve both commercial and defense needs.

A recent example is a report by the Air Force Commercial Acquisition Streamlining Team urging electronic firms to adopt certain military specifications and standards as commercial specifications and standards. The report also urged DOD to use Qualified Manufacturing Lists to allow increased integration.[39]

The Maintenance Base

At the industrial-sector level the maintenance base will benefit from acceptance of common defense and commercial technologies. But the most important civil-military integration maintenance policy issue is rationalizing the public and private bases and eliminating redundancies. If defense and commercial activities use common technologies and equipment, then the preservation of a unique government maintenance base may no longer be necessary, and in an era of much reduced spending, it is surely less affordable.

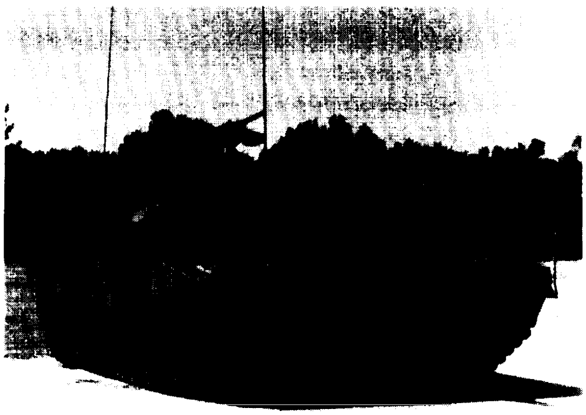
The Benefits anti Costs of Sector-Level Process Integration Policies

The potential benefits of industrial sector-level integration, outlined earlier, include: 1) leveraging limited R&D investment funds, thus lowering costs to both defense and commerce; 2) increasing the potential defense suppliers by diffusing technology; and 3) providing access to new technology through increased involvement in consortium.

The potential savings in the rationalization of the public and private maintenance and overhaul base are substantial. But getting savings from rationalizing this portion of the base will require closing facilities and elimination of many government jobs. Current legislation strictly limiting the amount of maintenance that can be performed by the commercial sector would have to be revised or

[39] Pat Cooper, "DOD Study Touts Military Standards for Microelectronics," *Defense News*, June 6, 1994.

US ARMY



Many armored vehicles, originally manufactured by private companies, are maintained and upgraded at army depots

repealed. There is also resistance to closing government R&D facilities.

Deciding how much time, money, and energy to invest in policies aimed at sector-level integration is a challenge. Past studies have illustrated the difficulty of linking specific research funding with ultimate results.[40] Current initiatives may be even more difficult to evaluate. But, both TRP and CRADA raise questions on how to evaluate program effectiveness. If such activities are not to be viewed simply as jobs programs, then some metrics will need to be developed to judge their success.

A number of possible benefits in addition to new technology developments have been suggested for TRP. Deputy Secretary of Defense John Deutch has argued that the teaming of defense and nondefense firms is itself a measure of success. So too, he said, is the increased cooperation within the government. He has advised waiting until 1996 before making a broad judgment on the success of the project.[41]

But any benefits have to be weighed against the fact that TRP costs the U.S. government several hundred million dollars per year in direct funding and some tens of millions more in reimbursable independent research and development (IR&D) funds for proposal writing. Additional sums, perhaps tens of millions in nonreimbursable R&D funds, are spent by business on associated research and matching funds.

CRADAs can also transfer technology from laboratories to business, and introduce technology to the laboratories. But again, long-term program effects may be difficult to measure. Supporters envision the results of billions of dollars in federal research being transferred to U.S. business to promote international competitiveness and solve other nondefense problems. But skeptics argue that much past research has had little commercial potential. Further, some argue that CRADAs constitute a "mining of U.S. R&D investment." Without continued long-term investment in fundamental research, there will be eventually little new knowledge to transfer.

The most commonly suggested metrics for measuring TRP, CRADA, and other industrial sector-level activities, unfortunately, are all short-term, input metrics: dollars spent, TRP projects proposed, number of CRADAs, consortium established, and other input-oriented activities. While such measures may be of some initial use, they are insufficient in the longer term.

An effort to measure both short-term effects and long-term economic benefits of projects has been undertaken as part of the Advanced Technology Program at NIST. (See box 5-6.)

Several metrics that focus on measuring long-term effects of the TRP and other DOD programs have been suggested. These include: the number of patents granted or products developed over a given period of time; the amount of technology transferred from the public sector to the commercial and vice versa; and the relative success of industry in comparison with America's international competitors. (See box 5-7.)

40 In the 1960s and 1970s, two studies, Operation Hindsight and Project Traces, attempted to link DOD research investment to product development. Neither was very successful in doing so.

41 "Deutch: TRP Unites Industry Bases," *Defense* Conversion, May 23, 1994.

BOX 5-6: Evaluating NIST's Advanced Technology Program (ATP) Projects

The ATP, begun in 1990, invests in projects that support technologies with strong potential for economic benefit The ATP evaluation plan stresses measurable goals whenever possible.1 The program has tracked and reported input data on nearly 1,000 applications and awards to nearly 90 projects, The ATP also sponsors third-party studies to track project results.

Tracking the short-term *and intermediate project results* provides an indication of ATP's Immediate effect on participating companies. ATP tracks how well businesses follow through on the business and commercialization strategies outlined in their ATP proposals Project managers collect the information during quarterly. year-end, and end-of-project reviews ATP is field testing a new, customizable questionnaire designed to gather more detailed data than are now available A key goal is to gather data in a form that allows for easy updating and minimizes the reporting burden Several measurable short-term effects are thought to also provide Indicators of long-term economic success So, in addition to straightforward tracking of technical milestones, other Indicators are examined, including:

- Increased R&D Investment and R&D in new areas leveraged by ATP funds,
- increased Industrial collaborations and strategic alliances,
- strengthened technological Infrastructure,
- shortened R&D cycles,
- Investment in production capacity, and
- productivity Improvements.

Long-term economic impact is the bottom line for ATP. Program goals include Increased U S economic growth, Increased Industrial competitiveness, and creation of high-value jobs, Measures of the long-run success of ATP include:

- creation of new industries or industrial capabilities,
- Improvements in manufacturing costs, product quality, and time-to-market;
- increased worldwide market share;
- job creation, and
- private and social rates of return on investment.

At present, NIST says it is too early to measure long-term effects. Several products Incorporating the results of ATP-supported research have been Introduced or are near commercialization In addition, one company has Introduced ATP technology into a manufacturing process on a pilot scale, In general, however, almost all ATP projects are still in R&D. In most cases, it will take several years before a long-term effects study can be undertaken.

The planned approach to these long-term studies is to use macroeconomics case studies to estimate specific benefits and costs of new technologies developed under ATP. Statistical sampling techniques will be used in selecting specific projects and programs for detailed study.

NIST reports that the measurement of long-term economic impacts of ATP requires three major efforts

- development of quantitative measures of the influence or effect that ATP has on the introduction and diffusion of each new technology it supports,
- development of quantitative and qualitative measures of the Influence or effect of each ATP-funded technology on the economy, and
- estimates of private and social aggregate economic benefits and costs from each new technology developed under ATP funds.

[1] NIST u s Department of Commerce *Setting Priorities and Measuring Results at the National Institute of Standards and Technology* U S Department of Commerce, Jan 31, 1994, p 13

BOX 5-7: Evaluating the Technology Reinvestment Project

Any evaluation of TRP would be more extensive and difficult than that of ATP, since its eight programs Involve several different goals education and training, technology development, and technology deployment

Possible measures for manufacturing education and training include:

- Number of students trained and placed per year.
- Client satisfaction with trained personnel.

The outcomes of technology development and deployment activities are more directly traceable to the mission of TRP. Several measures might be employed to evaluate technology development activities:

- Number of technical successes.
- Number of technologies adopted by military programs,
- Number of patents and citation of patents.[1]
- Number of organizations that form joint research ventures as a result of their experience in TRP.[2]
- Number of reapplications to the TRP.[3]

To some extent, these same metrics may also apply to TRP's technology deployment activities. Since the deployment activities include both the creation of technologies and the provision of extension services, the following supplementary metrics might be considered

- Changes in defense dependence-defense sales/total sales—attributable to deployment services or technologies.
- Increases in produchvity—increase in output per worker attributable to deployment services or technologies.
- Increases in market share attributable to deployment services or technologies,
- Customer satisfaction.

Assessing synergies across program activities would be a valuable way of measuring TRP's overall impact This will take time.

[1] Numerous studies have shown that citation-weighted patents are highly correlated with other measures of technological ancl economic Importance See, for example, F Narin et al , "Patents As Indicators of Corporate Technological Strength, "*Research Policy (16) 1987,* pp 143-155, M Albert et al , "Direct Validation of Citation Counts as Indicators of Industrially Important Patents, *Research Policy* (20) 1991, pp 251-259, A FJ Van Raan (ed), *Handbook of Quantitative Studies o/Science and Technology,* (North-Holland 1988), M Trajtenberg, "A Penney for Your Quotes, " *Rand Journal of Economics, No* 1, 1990, pp 172-187

[2] A Link and L Bauer, *Cooperative Research in* U S. *Manufacturing* (Boston, MA D C Heath, 1989), suggests that firms cooperatively engaged in research not only revest more in R&D than they would have done in the absence of the relationship, but also that their other R&D is more productive owing to the transferability of basic technical knowledge and related research skills

[3] Firms applying to the Baldridge Award process report that they learn something useful about their Organization every time they apply In fact, many companies go through the process several times without any hopes of winning The same phenomenon might apply to TRP Also, if the activities undertaken by awardees would not have been undertaken in the absence of TRP money and if awardees reapply, this may indicate that know-how markets are being created by the award process

Technology development efforts are by nature risky. The industry sector-level efforts are relatively long-term. Some will succeed and some will inevitably fail. Their primary impacts are intended to come to fruition at some time in the future. For these reasons, any evaluation process should be ongoing and designed to assess the progress of each major effort rather than a few high-profile projects.

Costs and Risks

The policies directed at integrating processes at the sector level have a number of potential costs and risks. CRADAs, for example. have been criticized as potentially detrimental to the laboratories' defense mission, diverting critical personnel to short-term problem-solving rather than longer term scientific discovery. If the government has only limited R&D dollars, some argue that they should go exclusively toward technologies that the commercial sector cannot provide.

Some of the government personnel interviewed for this assessment expressed the concern that if process integration is too extensive, the government may lose all of its inhouse capabilities. It might lack sufficient technical expertise to be either a "smart buyer" or an "intelligent manager" of the technology it needs to support the nation's security.

Such concerns may be overdrawn. Other countries (e.g., Japan) do not have comparable public sector defense capabilities.[42] Still it would appear prudent to ensure that sufficient inhouse defense capability continues to exist to buy and maintain new technologies.

A concern raised in Congress, DOD, and industry is the amount of money earmarked by Congress for integration. Representative George Brown has noted that $103.8 million of the $474 million appropriated for dual-use technology for fiscal year 1994 (22 percent) was earmarked.[43] Representative Brown stated that $145.6 million of the $377-million conversion fund appropriated in the Operations and Maintenance accounts was earmarked as well. Those concerned about earmarking claim that the loss of financial flexibility will make development of a coherent integration program much more difficult, Certainly, such mandates have sometimes limited DOD flexibility to make economically sound choices. Representative Brown pointed out that earmarks make it difficult to follow the law mandating competition in spending of government funds for TRP.

Final] y, the government does not al ways appear to be of one mind about various measures aimed at increasing industrial sector-level process integration. Rationalization and consolidation between the private and public elements of DTIB are important. Yet the Services disagree about the extent to which commercial firms can meet maintenance needs. While the Navy is reportedly willing to make maximum use of industry's production capabilities and capacity for aviation depot-level maintenance, the Air Force has been far less enthusiastic about reducing the size of its depot system.

Given the large numbers of high-paying jobs at government facilities, Congress has been reluctant to rationalize R&D and maintenance bases, Retaining some inhouse capability is extremely important to guide technology developments in ways that are most helpful to operational commanders. These issues are discussed in more detail in chapter 6.

■ Process Integration at the Firm Level

Firm-level integration—the sharing of corporate resources (management, finances, possibly R&D) across divisional lines—is primarily a private-sector issue. There are public-sector organizations that engage in both defense and commercial activities (e.g., the DOE weapons laboratories): these were discussed under industrial sector-level integration. In the context of this discussion, an integrated firm is one that continues to do both defense unique and commercial business—but chooses to use separate divisions and facilities.

It maybe to the government interest for firms to integrate internally (e.g., go to facility-level integration). in order to reap the maximum benefit from shared resources. But the government cannot mandate such integration, nor. except in crisis and

[42] Supporter\ of inhouse capabilities note, however, that the Japanese have not yet had to battle test their equipment.

[43] "Pet Projects Endure at Defense Despite Opposition by Brown," *Federal Technology Repot-t,* Nov. 25.1993, TRP supporters have argued that despite attempted earmarking, competition has governed project selection.

war, can it compel the use of private capabilities to perform defense work. It can, however, influence integration by removing some of the acquisition barriers outlined in this chapter. Still, as long as businesses fear that their commercial activities may be forced to carry burdens from defense work, they will choose to separate their activities. Retention of special government cost accounting, for example, even with the elimination of the use of many military specifications and standards and the elimination of rights in technical data requirements, is likely to result in retention of separated facilities.

Integration at the firm level, however, offers benefits to the government. Most importantly, it may allow the government to retain world class commercial firms in defense business--even if these firms separate those defense divisions from their commercial operations. Firms doing both defense and commercial business have access to, and might continue to develop, dual-use technology. The past view that integration at the firm level is a problem, and unacceptable, appears less valid now than during the Cold War. In the future, it will be a challenge to keep internationally competitive commercial firms involved in defense work. Certainly, the trends are toward consolidation and specialization—potentially increasing technological and industrial segregation just when access to commercial technology is most critical.

An integrated firm has advantages over a segregated defense producer. A recent study on dual-use technology indicated that firms doing both defense and commercial work may facilitate technology transfer through a policy of transferring personnel between their defense and nondefense operations, or at least not prohibiting such movement. The study found indications that between 1982 and 1986, about 24 percent of the scientists and engineers working on defense moved from defense to nondefense work, and about 27 percent moved in the opposite direction.[44] Personnel movement can increase the flow of information and technology, even if facilities themselves are segregated.

The main benefits of process integration at the firm level are: 1) preservation of a viable base, 2) stronger and more competitive firms involved in defense work, and 3) greater technology transfer—both spin-off and spin-on.

The elimination or reduction of current procurement barriers might persuade firms to adopt, or continue to pursue, a firm-level integrated strategy. Changing the rules on rights in technical data would eliminate the disincentives to incorporate commercial, company-developed technology (product or process) into defense products. Eliminating the use of many military specification and standards will move more components into the commercial category. Dropping the requirement for costs and pricing information on commercial products will promote the use of components from a firm's commercial division.

While firm-level integration may produce fewer directly measurable benefits than might facility-level integration (e.g., savings on individual products), it appears preferable to relying on totally segregated firms to conduct defense manufacturing, since the latter may have less access to commercial technology. Profitability and access to technology are incentives for integration. Government policies to promote firm-level integration will have to address these incentives. Even in the absence of radical acquisition reform that would promote facility-level integration, firms might still undertake defense work if such work allows them to leverage their technology, personnel, and assets; acquire new technology; and diversify into other areas.

Defense work will have to be profitable, or, if access to novel technology is available, at least not lose money. A strong advanced technology development program may entice some firms, particularly in sectors amenable to integration, such as

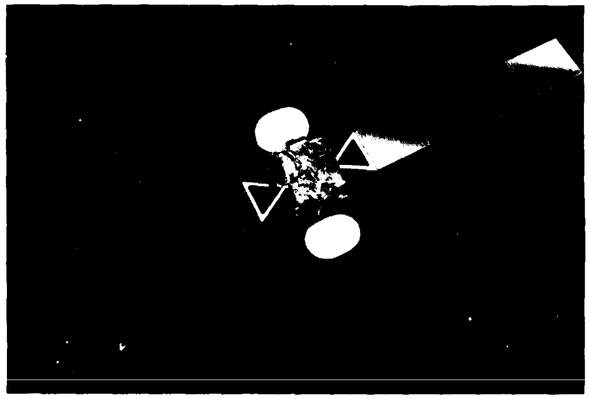
[44] Alic et al., *Beyond Spinoff*, op. cit., footnote 23, pp. 112-113. According to the report, indirect evidence indicated that most of this movement occurred within firms with both defense and nondefense divisions.

aviation and electronics. In more mundane production sectors, contracts will have to be of sufficient size to attract the interest of a firm that also engages in commercial operations. Multiyear contracting and government use of more commercial buying practices may also provide incentives for engaging in defense activity at the firm level. DOD use of commercial specifications and standards, or military performance specifications, may provide some incentives to pursue defense work even if acquisition rules continue to result in segregated activities.

Leveraging technology is especially attractive to firms in technologically intensive industrial sectors. Indeed, a Harvard study indicated that some firms have actively sought both defense and commercial business in order to fully exploit their competitive advantages. Thus, in the aerospace industry, many firms "(notably Boeing in aircraft, GE and Pratt & Whitney in engines, Hughes in satellites) have been able to specialize their design, marketing, and management for each market [commercial and defense] while leveraging a substantially common technology base."[45]

Similarly, communications satellite producers have leveraged technology. Westinghouse Corp. has reported leveraging the technology and expertise gained from decades of defense work to develop products such as a Modular Avionics Radar (MODAR), a dual-use product designed for look-ahead detection and avoidance of wind shear.[46]

Studies indicate that the incentives for sharing technology, labor, and equipment within a firm vary. Firms with large commercial sales relative to their defense sales may have little interest in increasing defense sales, especially if defense sales volume is uncertain, profit is low, and there are few if any potential technology benefits. In the absence of changes in the government's approach to rights in technical data, integrated firms will be cautious about sharing technologies between divisions. The OTA assessment team found a number



HUGHES SPACE AND COMMUNICATIONS COMPANY

Firm-level integration allows *Hughes to leverage corporate resources, benefiting both its defense* and commercial *satellites.*

of instances in which a firm's commercial division refused to supply technology to its defense division because of government demands for rights in technical data and for cost and pricing data.

One firm, for example, reported a case in which its corporate parent decided it could not risk disclosing the results of millions of dollars of commercial, company-financed research for a relatively small government development contract whose terms included a demand for the technology used in the item. Therefore, instead of using the advanced technology available in the parent corporation, the division searched out a small firm with similar, but less advanced, technology to support its research effort. The corporate parent of that defense division is now considering getting out of defense work altogether.

Acquiring new technologies and processes to allow a firm to better meet current or future needs has been another reason for corporations to integrate. The General Motors Corp. 's purchase of Hughes Aerospace might fall under this category. Firms might still stay in defense work if they deem the work to have sufficient overlap with other corporate objectives. A strong DOD research emphasis on dual-use products might attract such firms.

[45] Alic et al., *Beyond Spinoff*, op. cit., footnote 23, p.188.

[46] Hughes, op. cit., *Making Dual-Use Technologies Work*, footnote 22

Finally, firms may integrate to **diversify the portfolio of their capabilities and subsidiaries.** Corporate diversification was a major business strategy during the sixties, seventies, and early eighties, but was called into question during the mid- to late- 1980s as U.S. firms lost global market share-partly because of loss of quality in many firms' critical core areas. Studies indicate that successful corporate diversification involves an effort to retain and use a common core of interests and capabilities rather than develop entirely new ones.[47] If DOD is going to retain high-quality firms as defense suppliers, it will need to seek synergistic ways to exploit and enhance the core capabilities of these firms.

The Benefits and Costs of Firm-Level Process Integration Policies

As discussed earlier, during the Cold War when U.S. defense budgets were high, concern over civil-military integration largely focused on integrating facilities. Integrated firms-those with both civilian and defense divisions—were common. Proponents of integration sought to reduce the acquisition barriers that they identified as contributing to segregation within a firm and subsequent increased costs resulting from redundancies in facilities, workforce, etc. Yet there were benefits derived from integration at the firm level, internal transfer of technology probably being one of the most important.

The future defense situation is likely to be even more fiscally challenging than CMI proponents have previously anticipated. Under these circumstances, the government may well lose the services of many firms. The principal benefit to be derived from retaining integrated firms (e.g., retaining as much of the segregated portion of the future DTIB as possible within commercial firms) may not be cost savings, but the potential for shared technology between divisions within firms. Firms may transfer personnel (or allow the transfer of personnel) between defense and nondefense work and thus promote both spin-on and spin-off technology transfer. This is critical if DOD is to rely more on commercial technology in the future. Such firms may also integrate some critical activities—possibly having a combined R&D facility—while separating the remainder.

While the chief benefit is the potential retention of quality firms doing defense business, there are also risks. One risk is that specialized defense capabilities might atrophy if too much emphasis is placed on shared (i.e., commercial) technologies. Electronic warfare systems, for example, may use many technologies similar to other commercial electronic systems, but still require a set of specialized skills (an up-to-date understanding of the electronic threat) that demands full-time attention and does not overlap with the commercial base.

An integrated firm also faces risks to critical commercially developed technology if reforms dealing with rights in technical data have not been achieved. Indeed, retention of any acquisition rules that make the defense divisions of firms operate differently than the commercial division is likely to increase costs and reduce the benefits of firm-level integration.

■ Process Integration at the Facility Level

Almost all previous studies on CMI have focused on integration at the facility level.[48] Facility-level process integration is a special case of firm-level integration, in which the integration occurs within a single facility (e.g., on the same factory floor, on a single assembly line). Such integration involves the sharing of personnel, equipment, facilities, and material to research, design, produce, and maintain defense and commercial goods, or to provide defense and commercial services. While

[47] David Leech *Patterns of Diversification: An Annex to the Report of the Defense Conversion Commission*, February 1993. See also Alic et al., *Beyond Spinoff*, op. cit., footnote 23, pp. 174-186.

[48] The Report of the DSB Task Force on *Acquisition Reform* is an exception in including the potential impact of rationalization of the private and public sectors.

the greatest benefits of process integration, in terms of savings and potential for technology transfer, may be found at the facility level, the acquisition changes required to achieve such integration may be among the most difficult to achieve. There are technical barriers to facility level integration (unique products and processes, classified technologies), but the principal barriers appear to be the acquisition laws and regulations that have been constructed to protect public funds. It is at the facility level that military operations and standards, government cost-accounting rules, rights in technical data, and other roles have had their full effect.[49]

Process integration at the facility level is expected to eliminate redundancies in equipment and personnel. Machinery, tools, personnel, management resources, buildings, etc., can all be used more efficiently if they can be employed for both commercial and defense ends.

The fungibility of a firm's assets and the similarity of its defense and commercial products and/or services affect the company ability to conduct defense and commercial work side-by-side. The case studies examined for this assessment, as well as OTA's industry interviews, confirm that the flexibility to work in both the commercial and the defense sectors is currently more prevalent among firms at lower tiers, among firms producing components and materials, and where the process and product technologies are largely common and government regulations are often felt only indirectly.[50]

OTA found that many facilities manufacturing military parts, subcomponents, and materials, for example, operate within more or less integrated manufacturing facilities. Such facilities include those that supply metal sealing material, silicone, dopants and wiring for defense electronics, glass for optical systems, chemicals for explosives, and certain resins for plastics.

ATLAS HEADWARE/DLA

Atlas Headware has completely *integrated its production of military and commercial caps*

"Higher order" defense-related components and systems, such as hydraulic systems, various valve assemblies, hoist systems, certain aircraft engines, computers, fiber optics components, and gyros and other navigation devices, may be manufactured in integrated facilities. That they are not, however, appears to be due at least in part to the imposition of the special accounting requirements, unique contract requirements, demands for technical data rights, etc., that have been so often identified as barriers to integration. As a result, the firms interviewed reported that there are often substantial inefficiencies. due to the need to maintain additional workers and resources in order to comply with these requirements.

■ Current Facility-Level Integration Efforts

Many of the ongoing efforts to increase facility-level process integration have been discussed ear-

49 The conclusion that acquisition barriers rather than technical barriers are the problem has been a consistent conclusion of studies such as the 1991 CSIS Study on Civil-Military Integration, the subsequent CSIS survey of 206 firms, and a study by the Electronic Industries Association, "Dual-Use in Government Electronics: Outlook for Commercial/Military Integration," which surveyed 33 firms in 1993.

50 The data base for this conclusion includes the assessment case studies, interviews with firms in 10 different industrial sectors, discussions at the manufacturing workshop, and analysis of the findings of previous CMI studies.

lier in this chapter. Changes in the law that allow companies to use IR&D funds to conduct R&D with commercial (as well as defense) potential, for example, have enhanced the ability of defense firms to perform dual-use R&D. Several of the firms visited by OTA were actively pursuing commercial possibilities using technologies originally developed for military application. Some of the firms visited by OTA combined their R&D operations, even though they maintained separate manufacturing processes. The Honeywell Corp., for example, maintains an integrated R&D Center of Excellence for its avionics work, but separates the defense and commercial manufacturing activities of these items. The changes in the use of military specifications and standards announced by Secretary of Defense Perry will surely affect facility-level process integration as well as increase the purchase of commercial items.[51]

Several firms interviewed were also involved in TRP projects. Some of the work is being done in integrated facilities, but in some cases the firms were planning to separate future commercial and defense operations.

Despite the changes being implemented, concerns over government oversight, the possible loss of proprietary data, and cost-accounting requirements continue to pose real barriers to integrating defense and commercial activities in a single facility. According to industry, the most important changes are eliminating the unique government cost-accounting requirements that result in separate cost accounting systems and layers of oversight, and the supporting certification process.

Concern over the rights in technical data remains very important not only in R&D but in manufacturing, where there is particular concern about the potential for loss of process technology should the government ask for that technology.

The changes in military specifications and standards recently proposed by DOD are critical, because they will promote the ability to design for dual use. It has repeatedly been argued that taking better advantage of commercial specifications and standards could save money and result in better products. The 60 percent savings that Westinghouse Corp. reported for its dual-use Modular Avionics Radar, compared to the militarily unique version is said to have come partly from waivers on military specifications and partly from initially designing for dual-use.

Future Efforts

Acquisition reform that addresses government accounting rules for integrated facilities may be difficult to implement. Executives attending the OTA manufacturing workshop stated that accounting procedures explain 90 percent of the reason for separation within their firms. The respondents to the CSIS industry survey also placed government cost accounting high on the list of reasons for segregating their defense operations. Many firms in the CSIS survey, principally aerospace and electronics manufacturing firms, had integrated portions of their operations but maintained two administrative systems for accounting purposes. The costs of such partial integration cannot be inconsequential.

One possible alternative would be facility exemptions from special government cost accounting requirements. Otherwise, firms producing both militarily unique and commercial products will have to retain an accounting system for its militarily unique items and spread the cost of that system over its commercial products, and thus become noncompetitive. Some firms believe that activity-based accounting holds the promise of providing a solution to this seeming impasse.

Secretary of Defense Perry has begun the changes on military specifications and standards, but these changes must be implemented by a sometimes reluctant acquisition workforce. To

[51] Secretary of Defense William Perry, *Memorandum for the Secretaries of the Military Departments, op. cit.,* footnote 16.

promote integrated facilities, DOD must ensure that the three Services reconcile their own individual standards so that industry does not continue to be faced with special, and often conflicting, Service requirements for similar items.

Revision of the acquisition laws and regulations is necessary but insufficient to implementing acquisition reform that will allow integrated facilities. There must also be changes in the procurement culture—for example, eliminating outmoded government quality control procedures in favor of those used in the commercial world; eliminating the adversarial relationship that has characterized some contract and plant oversight; and retraining the government workforce so that they are able to effectively operate in this new environment. Integrated circuits or advanced materials, for example, may be differentiated by additional quality control checks, rather than different materials. The Hughes satellite system, with its modular design, embodies another possible approach to the problem, allowing different satellites, with different capabilities, to be built on a single "chassis." (See box **5-8.)**

The requirement that a facility be able to produce at a specified surge and mobilization level, combined with the extreme variation of defense contracts, has resulted in an overcapacity maintained by firms. This added overhead inhibits facility integration. Companies making private investments in commercial facilities that have payback periods of several years are unlikely to put defense and commercial work in the same facility and risk transferring underfunded government overhead costs to commercial production.

Multiyear defense contracting can help reduce the uncertainty of government funding, but the greatest potential benefits might come from a recognition on the part of government that DOD must pay to maintain surge capability for defense manufacturing. This now occurs with government-owned and contractor-operated (GOCO) ammunition facilities and is more of a problem at the prime contract level than at the lower tiers.

Some small firms trying to integrate commercial and defense work have raised the issue of insufficient financial support for commercial work. Many firms traditionally dependent on defense progress payments have not developed sufficient commercial lines-of-credit to finance investment in commercial programs. Banks are reluctant to loan money to small defense firms. One suggestion is that government funds be made available in the form of loan guarantees to support the commercial operations of small firms. However, while there is evidence that lack of funds is a problem with some firms and possibly some locations (e.g., Long Island, southern California), a recent survey by the Logistics Management Institute found that lack of capital is not a universal problem.[52] More data need to be collected to inform policy development here.

The opportunities for process integration in the **maintenance** base parallel those found in manufacturing, since items built on the same line should lend themselves to common maintenance procedures. But government procurement rules—especially cost accounting requirements—are a critical barrier. Facility exemptions would be helpful. But even more important might be the rationalization of the public and private maintenance bases. This is discussed in chapter 6.

Finally, **services** other than R&D (e.g., engineering, telecommunications, construction, and private security) may be the easiest segment to integrate if the defense and commercial work are related sufficiently and the problems of dealing with DOD regulations (including security) do not prevent the workforce from working on both defense and commercial projects. But chapter 4 noted that services appear relatively easy to commercialize,

[52] The LMI survey went to 1,217 randomly selected small contractors (chosen from among businesses having a prime DOD contract between fiscal years 1980 and 1992). LMI qualifies their results by noting that the total number of firms doing only subcontracting could be large compared to those with a prime contract. Still, 72 percent reported that lack of capital had not hindered conversion.

BOX 5-8: Designing for Dual-Use

Advocates of greater CMI argue that the real "key to commercial-military integration is designing for dual-use."[1] Weapons and other DOD equipment would be designed from the outset to incorporate commercial rather than militarily unique technologies.[2] Cost and manufacturability would be included in the design process as critical considerations. Advocates have argued that a dual-use strategy would require that "the DOD product will fit the parameters established by the supplier for flexible manufacturing, The products must have similar processes, use standard parts, employ identical Information systems, and require consistent manufacturing administrative practices."[3] Thus, the concept of designing for process integration from the start is essential.

When establishing requirements, DOD should take into account commercial developments in the relevant technological sectors. This would exploit not only the latest technologies, but also technologies that appear to be in the mainstream--rather than developing entirely new technologies.

Implementing such a strategy will require that DOD have trained personnel who keep abreast of technological developments, Moreover, DOD will need to consider the manufacturability of components in the process of setting requirements. It will also require more dialogue with industry in developing industry specifications and standards, as well as its own performance specifications.

Designing for dual-use may ease the integration of maintenance facilities significantly, since they will essentially be supporting the same goods.

Hughes Aircraft has reportedly followed a successful dual-use, or multi-use, design strategy in its satellite communications business using many common components on both its defense and commercial satellites.[4] The Hughes strategy was facilitated by the fact that defense and commercial communications satellites have many similar requirements. A critical aspect to the success of Hughes' communications satellites revolved not only the ability to design for dual use, but the ability to develop a "product line" of satellites that can accommodate several needs with minor modifications, rather than to focus on an individual program for each satellite, as has characterized much of past DOD acquisition strategy.[5] Advocates of a dual-use strategy argue that a "product line" approach is mandatory. But pursuing this type of strategy will require changes in the program specific way in which DOD organizes its funding and Congress oversees it.

1 Richard Engwall, briefing on Designing for Dual-Use Electronics, Westinghouse Electric Corp

2 Ibid The Electronics industries Association dual-use technology study estimates that "85 PerCent of product life cycle cost is 'locked in in the original systems engineering design approach "

3 Office of the Under Secretary of Defense for Acquisition, Defense Science Board Task Force Report, *Engineering in (he Manufacturing Process,* Aug 21, 1992, ch 3, p 7

4 John A Alic et al , Beyond *Spinoff Military and Commercial Technologies in a Changing World* (Boston, MA Harvard Business School Press, 1992), pp 179-180

5 Engwall, Op cit , footnote 1

perhaps leading to a situation where services are bought from either commercial or segregated entities, but not those in between.

Benefits and Costs of Facility-Level Process Integration Policies

There have been numerous attempts to quantify the potential benefits of facility-level integration. There is considerable evidence that there are cost savings to be derived from facility-level integration and that such integration will probably enhance technology transfer. But estimates of the amount of potential savings are largely based on extrapolation from findings of individual case studies.

Previous case studies reviewed for this assessment, for example, provided estimates of savings on individual items of equipment resulting from integrating R&D and manufacturing processes ranging from 20 percent to as high as 60 percent .[53] Case studies reported in the 1991 CSIS study on CMI provided estimates of about 25 percent savings from integration of the production process. The Process Action Team on Military Specifications and Standards estimated that some $550 million might be saved over a period of two years if many of the military specifications and standards were eliminated.

Most previous estimates are made on the basis of examination of portions of the DTIB. The 1994 DSB Task Force on *Defense Acquisition Reform* looked at the entire base and estimated that in general, savings from integrating the production processes of defense systems might range from 10 to 25 percent. Further, the Task Force attempted to estimate the amount of savings that would occur after a five-year implementation period.[54]

Table 5-4 illustrates a range of potential cost savings in the private portion of the DTIB derived from implementing the process integration policy options discussed in this chapter. These estimates are based on data from OTA's industry survey, and include only facility-level integration, excluding any savings from sector- or firm-level integration.

Because the policy options for increasing process integration affect a relatively small portion of national defense spending—a 15-percent increase estimated in our survey-the net savings from process integration will be relatively small. Cost savings derived from potential savings of O to 30 percent might range from O to 5 percent of total national defense spending in the private sector. Although smaller than sometimes considered. these savings are still significant.

Additional savings might, of course, accrue from industrial sector-level integration that involved reduction of any duplication between the private and public sectors, and closing redundant facilities. These savings have been estimated to be several bill ion per year, depending on the amount of estimated reduction.

TABLE 5-4: Budgetary Impact of Increased Facility-Level Process Integration[a]

Estimated average savings	Impact on total private DTIB budget
0%	0%
5 %	1 %
10%	2%
15%	2 %
20%	3 %
25 %	4 %
30 %	5 %

[a]Based on OTA's industrial sector survey and a shift of 15 percent from segregated to Integrated for a total of about 30 percent in the integrated category

While savings are important, in the longer term, increased technology transfer between the defense and commercial bases may be the greatest benefit derived from integration of processes. The increase in technology transfer may occur within a single facility—but it will also come from the activities, such as consortium and TRP research activities, at the sector and firm level described in this chapter. Developing a method to track projects and their results is an important step necessary to support government initiatives at these levels. The metrics outlined in this chapter might be considered.

The benefits of these policy changes will not be immediate. Actual savings from changes in military specifications and standards depend not on changing the rules but on making new purchases of commodities, components, or new systems. Savings from changes in cost accounting requirements will come from oversight jobs eliminated.

53 The Modular Avionics Radar developed by Westinghouse uses all commercial parts but was built in facilities primarily used to support DOD. The radar costs 60 percent less than a comparable defense radar. and was developed in 50 percent of the time.

54 Defense Science Board Task Force, *Defense Acquisition Reform*, Op. cit.. footnote 7, p. C-8.

facilities consolidated, etc. Significant savings might begin appearing in three to five years. Access to new technology is unlikely to be any quicker. The possible time phasing of benefits is considered in the discussion of alternative integration strategies in chapter 2.

Costs of increasing process integration include: training of government and private sector personnel to operate in a new quality environment, training in examining alternative technologies, and costs of implementing different cost accounting procedures. There would also be expenses associated with closing any government facilities and eliminating jobs.

There are also risks involved in implementing policies that enhance facility-level integration. One of the most often mentioned is concern over the possibility of increased waste, fraud, and abuse, as a result of any change in cost accounting requirements at a facility.[55]

Concerns include the possibility of unfair allocation of costs towards the government. The R&D necessary for a dual-use product, for example, could be charged against the government's accounts, rather than against a corporation's commercial activities (although fixed-price R&D contracts may well resolve that issue). Similarly, costs associated with the construction of production facilities, tooling, etc. might also be allocated against DOD, rather than against the commercial consumers. In particular, in the absence of current, relatively strict accounting requirements, and without a commercial market for the militarily unique products produced in a facility, there are questions raised about how actual costs would be determined.

Government agencies report the overall amount of questionable contractor billing, but the OTA assessment team could find no good studies on the costs of the current regulatory system, nor comparative studies of alternative oversight structures. It has been suggested that the amounts saved by the current U.S. system may well be less than the costs generated in the system as a result of actions to prevent and prosecute identified abuses. Critics do not advocate overlooking abuses, but rather argue that most of these abuses can be identified in other, less intrusive ways.

Quality control is another concern. Critics note that as a result of the elimination of military specifications and standards, knowingly or unknowingly, substandard parts and components may be used, possibly due to lower quality control standards imposed by the commercial sector. There have been several reports in recent years, for example, of the proliferation of counterfeit, substandard fasteners in various commercial processes, including those within the aircraft industry. Process integration and the use of commercial items might make DOD more susceptible to these problems.

There is also the possibility of proliferation of advanced weapons technologies to other nations. To the extent that integration and commercialization are successful, American exports of manufacturing processes and technologies common to both commercial and military products may spread military technologies to other parties.

SUMMARY

There is potential for increased process integration with potential cost savings and increased technology transfer. Savings resulting from integration in the private sector ranging from 1 to 5 percent of future DTIB spending do not appear unreasonable. The full impact of these savings will not be realized for several years.

The greatest potential benefit of increased process integration may not be cost savings, however, but rather the potential for technology transfer. Future defense design and engineering teams will be more dependent on developments in fast moving commercial sectors, such as software and electronics. Integration at all three levels might enhance defense access to technology,

55 For example, "Congress To Consider Acquisition Pilot Efforts Next Month," *Defense Daily*, Dec. 9, 1993, p. 353.

Congress has played a critical role in developing the current process integration policies aimed at technology development and diffusion. These policies may be extremely important in the long term, but Congress may want to consider the development of measures to evaluate and compare the returns on investments for efforts such as the TRP, CRADAs, and other activities. Future metrics need to be output-oriented, rather than measuring input activities, as is often done today.

At the industrial sector level, process integration also requires rationalization of public and private capabilities, and increased defense access to commercial technology. Rationalization of the public and private R&D and maintenance facilities, discussed in more detail in chapter 6, might provide the most significant near-term returns, but is also likely to face the greatest opposition. Congress will need to consider the rationalization of the DTIB and the closing of facilities, if significant savings are to be achieved.

Process integration at the firm-level is designed to retain world class product development and manufacturing firms in defense work. This is important, even if the defense operations in those firms remain separated. Defense work will have to be made sufficiently attractive, either by profitability or by research, development, and testing in new technologies and ideas. Advanced Technology Demonstrators may provide a means to keep firms technologically engaged. Congress will need to be supportive of long-term technology programs that may produce few immediate results.

Process integration at the facility level depends not only on actions directed at the sector and firm that produce common technologies, but also on substantial acquisition reform. Only by altering the current government cost accounting requirements, modifying demands for rights in technical data, and minimizing the use of military specifications and unique contracting requirements will the full benefits of designing for dual-use be likely to accrue.