Chapter 7

Defense Companies

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INTRODUCTION

Since 1986, U.S. defense companies have faced a Shrinking market. But it took the collapse of the Soviet Union and the definitive end of the Cold War to bring home the fact that the days of defense spending at near-wartime levels were gone, and that companies *were in* for serious long-term adjustments.

In the buildup of the 1980s, defense spending as a percent of gross national product (GNP) never reached the heights of either the Korean or Vietnam Wars. However, in constant dollars, outlays during the 1980s buildup were greater than in the peak years of the Vietnam War, and total defense spending in 1986-89 was at least as high as in any 4-year period during the Korean and Vietnam Wars (figure 7-1).[1] Thus, defense dollars were fully as significant to the *companies* doing military business in the 1980s as in wartime years after World War 11.[2]

Appropriations for defense started going down (in real terms) in 1986, dropping 13 percent in the 5 years 1985-90. Awards of new prime contracts also began to decline (even in current, nondeflated dollars) in 1986, with most of the drop coming in the sectors that had grown fastest during the buildup: aircraft and electronics and communication equipment (figure 7-2). Some declines in the defense budget had already begun as the military expansion collided with attempts to control the mounting Federal budget deficits. But with the end of communism in the Soviet Union and cessation of the Cold War, the prospect is for long-term cuts in defense spending that were hardly conceivable 2 or 3 years ago, and a new, far leaner environment for defense companies.

The 1991 defense budget, down over 10 percent in real terms from the year before, has already cut deeply. To stay within this budget, major programs that several defense companies expected to sustain them through the 1990s must come to an early end. A minor portion of the cuts might be accommodated by companies' streamlining their operations (e.g., centralizing maintenance and computer operations or reducing spare parts inventories). A substantial portion will come from military personnel reductions and base closings. But big bites will certainly come from DoD contract awards for production of items such as aircraft, missiles and space systems, ships, tanks, guns, and ammunition. Prime contract awards amounted to about $145 billion in fiscal year 1990, of which $124 billion went to private businesses (the rest went to educational and other nonprofit institutions).

Sharp cuts in these awards could threaten the stability, perhaps the existence, of some defense contractors. This raises concerns that a shrunken defense industrial base may not be able to meet national security needs in an uncertain new world of regional conflicts, smoldering national antagonisms, and a possible reappearance of large-scale conflict. OTA is addressing the national security concerns related to weakening or disappearance of defense companies in a companion assessment to this one.[3] This report considers issues relating to defense companies from the standpoint of the civilian side of the economy.

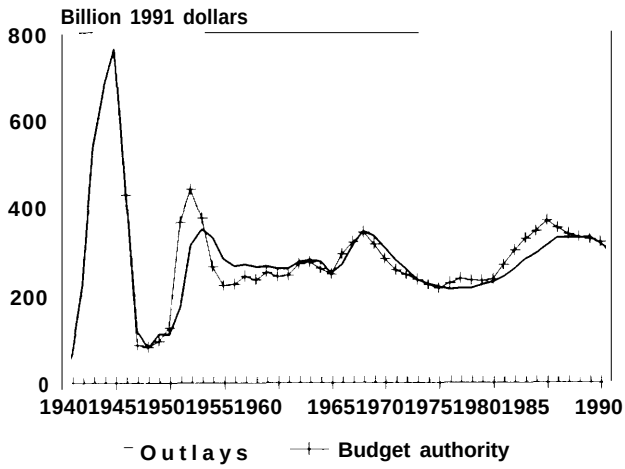
On the civilian side, worries about the survival of defense companies mostly come down to effects on jobs, communities, and technologies that could boost commercial competitiveness. Most immediate is the threat to jobs. The coincidence in 1990-91 of a recession and tens of thousands of layoffs from major defense companies made that threat real. A longer term worry is what may happen to defense-dependent communities that are deprived of their main livelihood. As of late 1991, none had yet become a ghost town, but a few were looking at a

[1]Defense budget authority reached its peak of the decade in *1985.* Outlays-actual spending under several years' budget authority—peaked in 1989.

[2]Defense outlays for 1990 and 1991 exclude Desert Shield and Desert Storm. If the estimated costs of Desert Storm ($61 billion) were included, spending in 1991 might appear higher than at any time since 1946. However, much of the war's cost was defrayed by contributions from other nations. In addition, a portion of the ''cost" was drawdowns from the huge Cold War inventories. Although a few items went into high gear production (Patriot and Tomahawk missiles), most were not replaced, so the effects on defense companies were less than it might appear.

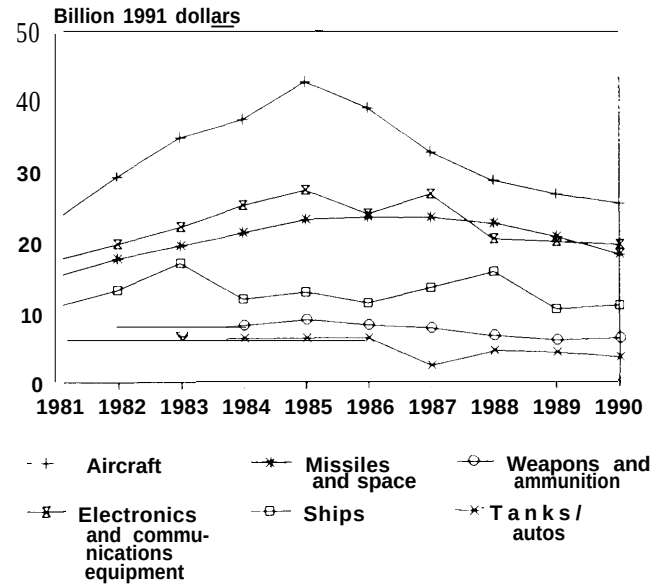
[3]An interim report of the companion assessment, U.S. Congress, Office of Technology Assessment, *Redesigning Defense:* Planning *the Transition to the Future U.S. Defense Industrial Base,* OTA-ISC-500 *(Washington* DC: U.S. Government Printing Office, July 1991); the final report of this assessment *Managing the Nation's Defense Industrial Strength in a Changing Security Environment, is* forthcoming.

Figure 7-1—National Defense Spending, 1940-1991



SOURCE: Department of Defense, Office of Comptroller, *National Defense Budget* Estimate (Washington, DC: 1980 and 1991); and President's Council of Economic Advisers, *Economic Report of the President* (Washington, DC: 1991).

Figure 7-2—Prime Contracts for Hard Goods



SOURCE: Department of Defense, Washington Headquarters Services, *Prime Contracts Awards, Fiscal Year 1990* (Washington, DC: 1991).

fairly bleak future, especially if further contract cancellations, big layoffs, or plant closings are added to those already occurring (ch. 6).

The other major worry about defense companies is that if they closeup shop, valuable experience and technologies will go with them. Throughout four decades of Cold War, the Department of Defense (DoD) has been a huge source of funds for pushing advances in technologies. DoD spending is not an efficient or reliable instigator of technologies with commercial applications, but through sheer size it has been a very important one.[4] Defense companies accomplished much of the DoD-funded technology advance over the decades, often in research and development (R&D) projects but also in actual manufacture of leading edge, high technology products.[5] Some of the knowledge thus created can be transferred out of the companies involved (e.g., through publications, through licensing of patented processes or products, or perhaps through people leaving the company and enriching other companies or institutions with their technical knowledge). But some tacit knowledge that resides in the people who have developed the technologies does not travel so easily. It can dissipate when teams of people break up, labs close down, and divisions or whole companies disappear. This doesn't apply just to lab researchers or design engineers, but also to production engineers, foremen, and workers on the shop floor.

Thus the strategies that companies adopt in the face of declining defense spending matter not only to their own employees and shareholders, but also to their communities and to the Nation's reservoir of technology. This chapter opens a discussion but does not fully examine the wider effects of defense companies' adjustment strategies. The potential for redirecting technological resources-including those of defense companies-from military purposes to dual use or strategic commercial applications will be the subject of a second and final report in OTA's assessment of Technology and Economic Conversion. This chapter concentrates mostly on issues of jobs and community effects. A major question it raises is whether there are possibilities now, under present conditions, for companies to replace lost defense business with commercial business and in that way continue to provide jobs for workers and an economic base for communities. Previous chapters have discussed programs to help workers recover from loss of defense jobs and communities from loss

[4] A second and final report of this assessment will examine issues of dual use (military and commercial) technologies and industries. Past OTA assessments have also dealt with the dual use issue; see ***Holding the Edge: Maintaining the Defense Technology Base, OTA-ISC-420*** (Washington, DC: U.S. Government Printing Office, April 1989).

[5] Universities and government-owned laboratories also conducted much of the DoD-funded R&D.

of defense business, but recovery from loss is inevitably harder than avoiding the loss-assuming that is possible.

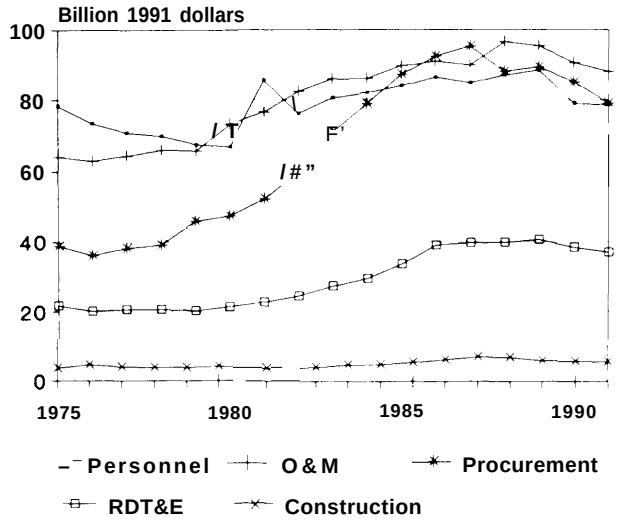
Many large companies in the defense business can expect to survive cutbacks, though perhaps at the cost of brutal downsizing. Many smaller companies face just two choices: get more commercial business or go under.[6] Not only the motivation but also the opportunities for switching over may be greater for small fins, which typically make parts and components, than for large prime contractors whose business is assembling big ticket items like tanks or missiles. Machine shops, for example, can often use the same tools and processes to make metal parts for trucks as for tanks. Small firms handle a significant share of DoD purchases of goods and services—probably about one-third of the total bought from private businesses over the last decade, Still, the two-thirds handled by large companies has the major impact on jobs and communities. The final report of this assessment will delve into the prospects for dual use production by the whole range of companies, large and small, and the potential contribution of dual use technologies and industries to the Nation's commercial competitiveness.

THE OUTLOOK FOR MAJOR DEFENSE COMPANIES

Defense contractors provide everything from food and clothing for military personnel to major hardware systems such as aircraft and submarines, construction of military facilities, and basic research on advanced concepts that may have future military value (e. g., materials science). Figure 7-3 shows defense outlays by major function. The only one in which defense contractors have no part is pay for military and civilian DoD personnel.

As noted, the weapons system experiencing the steepest drop in prime contract awards since 1985 has been aircraft. Consider the escalating blows to aircraft companies. When the Navy's T-46 trainer was canceled in 1987, 3,000 people lost their jobs and the manufacturer, Fairchild-Republic, was driven out of the business of making airplanes. That event foreshadowed the broader, deeper cuts of the early 1990s. For example:

Figure 7-3-Outlays for National Defense Functions, 1975-1991



NOTE: RDT&E refers to research, development, test and evaluation; O&M refers to operations and maintenance.

SOURCE: Office of Management and Budget, *Budget of the United States, Fiscal Year 1992* (Washington, DC: 1991).

- Secretary of Defense Cheney canceled the Navy's A-12 attack airplane in January 1991 because of delays and cost overruns, and although continuing research on an alternative was promised, 5,000 people at McDonnell Douglas and 2,000 at General Dynamics were immediately out of work, and actual production of a substitute receded uncertainly into the future.
- General Dynamics, having lost the A-12, was also slated to have DoD purchases of its Air Force F-16 Falcon fighter cut from 150 to 48, with the last buy in 1993. General Dynamics was, however, on the winning team (with Lockheed and Boeing) for the Advanced Tactical Fighter (ATF), a program projected to cost as much as $65 billion over 10 to 15 years.
- McDonnell Douglas, the other big loser in the A-12 decision, also lost out for the ATF and had no prospects for an Air Force fighter to replace its F-15 Eagle, for which DoD purchases were slated to end in 1991. It was left only with planned continuing buys of the Navy F/A-18 Hornet and the new Air Force C-17 cargo plane.

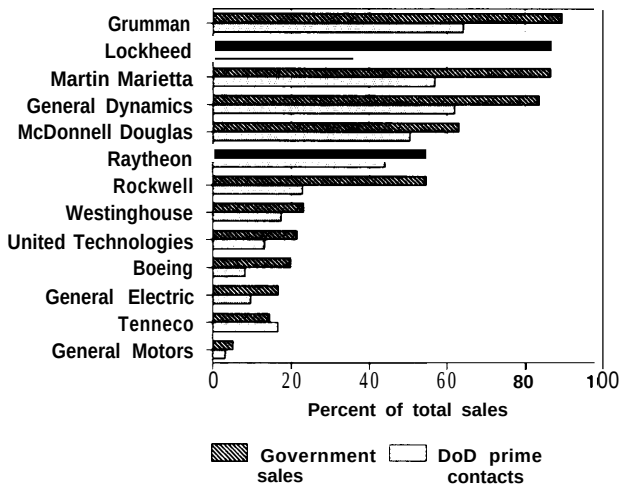
[6] The Small Business Administration defines a small business as one that is not dominant in its field of operations and with its affiliates does not have more than a specified number of employees (usually 500 to 1,000 in manufacturing, depending on the kind of product) or, for construction and service firms, a certain amount of annual sales.

. Northrop, another loser in the ATF competition, had nearly $5 billion penciled in for B-2 Stealth bombers in the administration's 1992 budget, but this proposal failed to survive passage through Congress, which voted in November 1991 to suspend B-2 purchases at the 15 already in various stages of production. This could be the death knell of the B-2, since further purchases depend on test results and approval by both the Senate and the House; the House has previously voted twice to end the B-2 program.

Since aircraft takes the biggest portion of DoD funding both for R&D and for procurement, the aircraft industry is taking the biggest dollar losses. But companies in other sectors will be hit just as hard-maybe harder. For some aircraft companies, there is at least some refuge in the commercial business, whereas the civilian markets for missiles, ships, and tanks are small to nonexistent (though foreign military sales for some of these items are large and growing). These stories are representative:

- In military land vehicles, DoD made its last buys of M-1 tanks and Bradley M-2 fighting vehicles in 1991, with production to end in 1993, Although research and development of advanced armored vehicles will continue, procurements are not expected to resume until late in the decade.
- As for ships, the last Trident missile-launching submarine will be funded in 1991; those planned for 1992 and 1993 are canceled, which means a loss in prospective procurements of $1.3 billion for the builder, General Dynamics' Electric Boat company of Groton, CT. And procurement of the SSN Seawolf attack submarine is slated to be cut from three a year to one a year. Electric Boat and Tenneco's Newport News Shipbuilding and Dry Dock Co. of Newport News, VA, had expected to share production of the Seawolf. They are tussling over which will get the remaining one per year, with General Dynamics threatening to close the Electric Boat submarine yard if it does not get all the Seawolf contracts and Tenneco vowing to cut its work force by half and get out of the submarine business if it does not get half the contracts.[7]

Figure 7-4-Percent Government Sales of Major Defense Contractors, 1990



SOURCE: Department of Defense, Washington Headquarters Services, *100 Companies Receiving the Largest Della; Volumes of Prime Contract Awards, Fiscal Year 1990* (Washington, DC: 1991); and company annual financial reports.

Until defense appropriation bills pass the Congress and are signed by the President, it is impossible to know exactly what programs will be cut by how much, and just what kind of hit each company will take. What is certain is that cuts are deep, imminent, and real.

For some companies-those most dependent on defense sales-the prospect is more threatening than for others. Figure 7-4 shows government sales as a percent of total sales for a dozen of the top defense companies (ranked by dollar value of prime contract awards). Note that this is government sales, not DoD sales; data for the latter are unavailable for several companies. For some companies, nearly all government sales are to DoD, but others sell sizable amounts to other U.S. Government agencies (primarily the National Aeronautics and Space Administration (NASA), the Federal Aviation Administration, and the Department of Energy). Box 7-A, which describes the military products of the top 13 companies, identifies some of the companies that make large sales to government agencies other than DoD. Note also that DoD prime contract awards as a percent of a company's sales in a given year can be misleading because sales to DoD in any year include sales under contracts dating from earlier years. However, the figure on prime contract awards does

[7]Robert Holzer, "Navy's Seawolf Sub Award Threatens Future of Losing Shipyard," *Defense News*, Mar. 25, 1991.

Box 7-A—Top Defense Firms

***McDonnell Douglas: Military aircraft (over** 36* percent **of 1990 sales) are the F/A-18 Hornet,** F-15 Eagle, AV-8B Harrier, C-17 transport, T-45 Goshawk trainer, and AH-64 Apache helicopter. Missiles, space, and electronics (20 percent) include the Harpoon, SLAM, and Tomahawk missiles; Delta II rocket, and vision and C^3I (Command, control, communication, intelligence) systems. Net sales in 1990 were $16.2 billion; DoD contract awards were $8.2 billion.

Gerwral Dynamics: GD's military aircraft division (36 percent of 1989 sales) produces the F-16 Falcon and is on the winning Advanced Tactical Fighter (ATF or F-22) team. The Electric Boat Division (17 percent of 1990 revenues) builds the Ohio Class SSN Trident submarine and has the first SSN-21 Seawolf class nuclear attack submarine contract. Land Systems (10 percent of 1990 revenues) makes the Ml Abrams tank Missiles, space and electronics **produce Tomahawk Standard, Sparrow, and Stinger missiles; Atlas and MLV II launch vehicles, plus Centaur upperstages for Titan IV boosters; and a variety of electronic communications and test equipment. Net sales for 1990 were $10.2 billion; DoD contract awards were $6.3 billion.**

General Electric: **GE makes military fighter, bomber, and tanker aircraft engines. Aircraft engine division revenues were 13 percent of 1990 revenues, more than half of which is for commercial engines. GE Aerospace (10 percent of 1990 sales) produces the Aegis fleet air defense system; a variety of radar, guidance, flight control, and visual simulation systems; and communications satellites, GE Aeropsace is also flight control subcontractor to McDonnell Douglas on the C-17. Consolidated 1990 corporate revenues (including GE Financial Services) were $58.4 billion; DoD contract awards were $5.6 billion.**

General Motors: The **Hughes aircraft division is a supplier of Maverick AMRAAM, and Phoenix missiles. It also produces targeting systems for the AV-8B Harrier attack jet and the** TOW 2 missile, and has contracts for **Army and Navy software systems for personnel and supplies. Revenues in 1990 were $103.3 billion; DoD contract awards were $4.1 billion.**

Raytheon: Raytheon's Electronics **Division (59 percent of 1990 revenues) has prime contracts for the Patriot, AEGIS, Hawk and Sparrow missile systems. It is the second source after Hughes for the AMRAAM, Maverick, and Phoenix** systems, and after General Dynamics for the Sea Sparrow, Standard 2, and Stinger missiles. The division also produces Aegis radar and fire control systems, and other radar, communications, computer, anti-submarine warfare (ASW), and electronic countermeasure systems. Its Beech Aircraft subsidiary will **produce the Air Force's T-1A Jayhawk tanker/transport trainer aircraft. Revenues in 1990 were $9.3 billion; DoD contract awards were $4.1 billion.**

Lockheed: In **aeronautics (23 percent of 1990 sales), Lockheed heads the winning F-22 Advanced Tactical Fighter team, makes the F-1 17A Stealth fighter, C-130 Hercules, the P-3 Orion, and avionics systems. Lockheed also has a strong missile and space systems program (51 percent), producing spacecraft, satellites, and ballistic missiles. It is the largest Strategic Defense Initiative (SDI.) contractor. Sales in 1990 were $9.9 billion; DoD contract awards were $3.6 billion.**

(continued on next page)

provide some indication of what companies can expect in the future.

As figure *7-4* shows, some top defense companies count on government sales for more than half of their income; these include General Dynamics, Grumman, and McDonnell Douglas. Another group of large contractors, including Martin Marietta, Lockheed, Raytheon, and Rockwell International, also depend on the U.S. Government for more than half of their sales, but their customers include other agencies besides DoD. Still other large prime contractors are diversified commercially, relying on defense for less than one-third of their business; in this group are United Technologies (parent of the aircraft engine company Pratt and Whitney) and Boeing. One other group of large defense companies including General Electric, Westinghouse, General Motors, IBM, GTE, and ITT which are fundamentally commercial firms that maintain defense divisions.

Although defense dependence at the corporate level gives a good idea of the vulnerability of the company as an institution, it does not accurately portray the likely impacts from a company's loss of defense business on particular communities, or on workers in particular divisions or plants. Take

Box 7-A—Top Defense Firm--Continued

Martin Marietta: Martin Marietta is highly diversified within **defense. The Electronics, Information and Missiles** Group **(42 percent of 1990 revenues) has contracts for some aspects of the Patriot, Hellfire, ADATS, Small ICBM, Minuteman, Pershing, and Peacekeeper missiles systems; navigation, target acquisition, and night vision systems; and ASW and radar systems. The Information Systems Group also has significant DoD contracts. Astronautics (53 percent) makes Titan IV rockets and NASA systems. Net sales for 1990 were $6.1 billion; DoD contract awards were $3.5 billion.**

United Technologies: **Flight Systems (including subsidiaries Sikorsky and Norden; 18.5 percent of 1990 revenues) leads the Army's winning light** helicopter team, and produces UH-60A Black Hawk, Seahawk, Super Stallion, and Sea Dragon helicopters, plus radars, avionics, and environmental controls. The Pratt&Whitney Power Group (33.5 percent) produces aircraft engines, including engines for the F-22 Advanced Tactical Fighter. Sales for 1990 were $21.8 billion DoD contract awards were $2.9 billion.

Grumman: Grumman Aerospace (72 percent of 1990 revenues) makes F-14 Tomcats, EA-6B Prowlers, E-2C Hawkeyes, and A-6 Intruders. Electronics (12.5 percent) is the lead contractor in the E-8 Joint STARS airborne surveillance and target acquisition system and produces other aircraft electronics, computerized test equipment, and trainers. Revenues for 1990 were $4 billion; DoD contract awards were $2.7 billion.

Tenneco: **Tenneco's Newport News Ship and Drydock Co. subsidiary (14.5 percent of total 1990 revenues) builds submarines and overhauls aircraft carriers for the Navy. While nearly all the business of the Newport News Division is in defense, Tenneco's other divisions are focused on commercial markets. Corporate revenues in 1990 were $14.5 billion; DoD contract awards were $2.4 billion.**

Boeing: **Boeing's military aircraft division (14.9 percent of 1990 sales) makes the Air Warning and Control System (AWACS) and E-6 submarine communications aircraft, B-2 structural components, and had contracts to update CH-47 Chinook helicopters, A-6s, F-4Es, and the P-3 Orion. It is teamed with Lockheed and General Dynamics on the F-22 Advanced Tactical Fighter, and with United Technologies on the light helicopter. It also makes avionics, electronic warfare support measures, C^3I systems, and missiles, and is developing the V-22 Osprey. Revenues in 1990 were $27.6 billion; DoD contract awards were $2.3 billion.**

Westinghouse: Westinghouse's electronic systems division (24.7 percent of 1990 sales) does about 75 percent of Westinghouse's defense work. The division builds radar and electronic countermeasures devices for systems including the F-16 fighter and AWACS. The division has been expanding its nondefense markets with products such as mail-processing equipment and commercial airport radar systems. Corporate sales in 1990 were $12.9 billion; DoD contracts awards were $2.2 billion.

Rockwel ***International: Electronics (40*** percent of 1990 revenues) makes avionics, aircraft communications, guidance and control, and CI systems. Aerospace (30.5 percent) was the B-lB lead contractor, does aircraft modification, and makes rocket engines. Rockwell also is NASA's largest contractor. Revenues in 1990 were $12.4 billion; **1990 DoD contract awards were $2.2 billion.**

General Electric as an example. Even though GE is a huge defense contractor in dollar amounts~ranking third in value of prime contracts ($5.8 billion) in 1989, it ranked much lower in defense dependence, relying on government sales for only about one-sixth of its total corporate revenues in 1990. However, GE Aerospace is essentially a defense company. At the beginning of 1989, GE Aerospace had 46,000 employees; by April 1, 1991, employment was down to 38,000 and the company planned to eliminate another 2,000 positions by the end of 1992.[8] The diversification of the GE corporation as a whole does not provide much help to the local economy when the GE Aerospace plant in a small town like Pittsfield, MA closes-down. In 1986, 7,800 of the Pittsfield area's 41,000 workers worked for GE Aerospace. By 1991, GE Aerospace employment was down to less than 3,000, with a loss of 3,000 jobs in just 1 year, 1990 to 1991.

MAJOR COMPANY ADJUSTMENT PLANS

Most large defense companies now realize that there will not be a new round of defense procurements on the lavish scale of the 1980s. While some

[8]Data provided by GE Aerospace division.

still expect that their special abilities will win them an outsize share of dwindling defense contracts, many are having to face the fact that their own piece of the pie will diminish at least in proportion to the smaller size of the whole pie, if not more. The big companies see their options along two principal lines, one which continues to concentrate on the defense business and the other broadening out more into the civilian economy.[9] In the first category, one option is simply to shrink in size: close plants, lay off workers, cut suppliers loose, and get down to a smaller core defense business. Another is to try to sell more to foreign military purchasers.

In the category of greater activity in the civilian economy, one alternative is to diversify at the corporate level through purchase of going concerns that already sell commercial products. Another option, in parts of the aircraft business and perhaps a few others where military and commercial end products have much in common, is to switch resources into making the commercial product. The potential for this kind of switch is probably greater with subsystems and components than with end products, though much depends on the companies' marketing abilities. Some companies, figuring they know how to deal with the government, are pursuing nondefense government agencies as customers for systems and technologies originally developed for the military. Not part of company plans, but an interesting possibility from the standpoint of technology transfer, is the startup company formed by a few entrepreneurs peeling off from large defense fins, to exploit technologies of military origin for commercial markets, The option that comes dead last, in the estimation of most large defense companies, is what is often termed conversion: that is, the company itself develops a new commercial product line that makes use of plant, equipment, work force, and technological know-how formerly devoted to military products, and lines up the financing and marketing needed to make large-scale production viable.

Shrinking in Size

Most companies are following more than one of the options outlined above, although they may single out one as their main strategy. General Dynamics Corp. (GD), second in DoD prime contract awards in 1990, perhaps best exemplifies the strategy of preserving core abilities in defense while shrinking radically in size. The company defines itself as a "pure-play" defense firm whose primary business is making major hardware systems-aircraft, missiles, submarines, and tanks. Since late 1989, when signs of a steep defense build-down became unmistakable, top officers of General Dynamics have made it clear that their principal strategy is to get smaller.

GD corporate employment peaked at 105,400 in 1987. It was down to 85,000 by fall 1991, and the company planned to shrink to 63,000 jobs by the end of 1994, even with some new defense contracts in hand. For example, the ATF award might keep employment at the company's Fort Worth plant above 10,000, but that would still be less than half the 22,000 employed there in 1990. Some entire plants will be closed, others drastically downsized. As noted, GD intends to shut down its big Electric Boat submarine yard in Groton, CT, if it does not win all the future Navy contracts for the new Seawolf attack submarine. Production of Ml tanks at GD's Detroit plant was scheduled to end in 1991, with nothing left behind but machining of some parts for the Lima, OH facility. At the same time GD employment is shrinking, so are investments. In 1990, GD's planned capital expenditures for 1990-93 were cut by $1 billion to $575 million, and planned R&D spending for 1990-93 was reduced by $380 million to half the level of the previous 4 years.

While getting smaller, GD also planned to increase dividends to shareholders and compensation to managers. The company increased profitability standards for new contracts, and adopted a plan to link executive bonuses to financial performance, The plan based bonuses for Chief Executive Officer William Anders and about 25 other top GD executives on the price of GD stock. Bonuses totaling approximately three times the officers' annual base

[9]Material in this section is drawn from annual reports of 10 leading defense companies, from interviews with company officials, and from articles in general and trade press.

pay were awarded in May and October 1991.[10] However, in November 1991 GD's board of directors voted to drop the plan and substitute a more traditional stock option incentive program.[11]

While shrinking is the major GD strategy, a minor theme is to look for modest increases in commercial business. The company expects its commercial missile launch service business to grow; orders for five new launches of communications satellites were taken in 1990. Also, GD is a subcontractor to McDonnell Douglas, making fuselages for that company's big new commercial jet transport MD-11. However, the company underscored its commitment to its core defense business when it announced plans in 1991 to sell its Cessna subsidiary. GD had bought Cessna, a maker of small aircraft for both commercial and military buyers, only 5 years earlier.

Finally, like a number of other big defense companies, GD is seeking opportunities to transfer military technology to nondefense government projects. Its first such venture was in magnets for the Superconducting Super Collider. Based on its expertise in cryogenic fluid-handling technologies, largely gained in the Atlas launch vehicle, GD was selected as the leader for the design and prototype test of preproduction magnets for this multibillion-dollar government project.

Exporting Arms and Military Technology

Virtually every big defense company wants to increase its military sales to foreign buyers. When asked for suggestions about government policy to ease the impact of the defense build-down, most company officials put relaxation of U.S. export controls on military items at the top of the list. Moreover, reliance on exports to bolster the U.S. defense industry has some support from the Bush administration.[12] Although this strategy holds little promise for strengthening commercial competitiveness or creating dual use abilities in U.S. industry, it has a strong appeal from the companies' point of view. There are two serious problems, however. First, the end of the Cold War has sent world defense purchases into steep decline, while overcapacity of production exists in many countries; military sales are a buyers' market. Second, the international arms business is "building up a dangerously armed world' in which potentially renegade or terrorist nations can use military equipment or technologies imported from the advanced industrial states to threaten or invade weaker neighbors.[13]

Most arms-producing nations collaborate with other nations in developing advanced weapons systems in order to reduce costs, and they also use exports of their latest equipment to reach economies of scale in production. In fact, some European arms producers, with the support of their governments, export half or more of their military output. In contrast, U.S. policy has long been to control military exports quite strictly, and to use them mostly to strengthen allies and oppose expansionary communism; the United States exports only about 10 percent of its military production. However, U.S. arms production is so huge that on a dollar basis American military exports in recent years were greater than those of all the other Western powers combined (nearly $12 billion a year on average from 1982 to 1986) and were second only to those of the Soviet Union. (Japan prohibits military exports altogether).

The situation in the United States is changing. In the last couple of years, direct commercial sales of military equipment to foreign buyers (which require

[10]Robert J. McCartney, "Defe~ Firm's Executives Reap Bonus Bonanza," *The Washington Post*, Oct. 9, 1991, p. F1. An executive did not receive the bonus immediately; instead half was set aside until the executive's 65th birthday and the other half until the expiration of the plan in 1994. Meanwhile, the executives were paid interest at above market rates on the deferred payment (13.9 percent in October 1991, compared to typical current rates of 7 percent on certificates of deposit), so long as the stock price stayed above the level that triggered the bonuses.

[11]Anthony L. Velocci, Jr., "GeneralDynamics to Roll Back Controversial Compensation Plan," *Aviation Week and Space Technology*, Nov. 18,1991, pp. 68-69.

[12]" . . . The long-term survival of a number of important domestic arms programs are tied to foreign sales,' according to U.S. Department of State and Defense Security Assistance Agency, *Congressional Presentation for Security Assistance Programs, fiscal year* 1992, p. 6, cited in U.S. Congress, Office of Technology Assessment, *GlobalArms Trade: Commerce in Advanced Military Technology and Weapons*, OTA-ISC-460 (Washington DC: U.S. Government Printing Office, June 1991), p. 3. Moreover, some high-ranking U.S. military officers have departed from tradition to advocate foreign sales of U.S. military equipment-including Ml tanks and F- 16 fighter aircraft-in order to support the U.S. defense industrial base and keep production lines open. Ibid., p. 13. Much of the material in this section is drawn from this OTA report.

[13]Ibid., pp. 16,17. An example of foreign military sales that were used for purposes far from those intended by U.S. policymakers is found in Iran. The United States sold about $11 billion of military hardware to Iran from 1969 to 1979 and trained 11,000 military officers. These weapons and trained officers failed to save the Shah's regime, and were later used in the war against Iraq. The Soviet Union, France, and several developing countries were major suppliers of weapons to Iraq before the invasion of Kuwait.

approval but no participation by the U.S. Government) have greatly increased. In many of these deals, the sale of a tank or fighter aircraft, for example, is combined with sufficient transfer of the underlying technologies for indigenous production, under license, by the buyer nation. These were the terms of a proposed sale by McDonnell Douglas of its F/A-l 8 aircraft to Korea; that sale fell through when General Dynamics offered a lower price and more technology transfer for its F-16 fighter, but the GD sale is expected to include similar terms. U.S. firms making these sales argue that the most advanced technology is not transferred. ''We don't sell the crown jewels, " they say, arguing that yesterday's technology has a limited shelf life and marginal relative warfighting capacity. However, with the present sharp cutbacks in military procurement and development of many new weapons systems delayed for years, much of the equipment used by the U.S. armed forces until well into the next century could be based on yesterday's technology. Some of the most successful weapons demonstrated in the Persian Gulf War were designed in the 1970s or even earlier.

Despite a trend toward relaxation of controls on U.S. military exports, there are cross currents. It has been sobering to realize that Western allies of the United States furnished a large share of the Iraqi military machine-including its most advanced aircraft and missiles and components for missile guidance systems, nuclear weapons, and chemical weapons. Not only the large-scale export of weapons but also the worldwide proliferation of technologies and industries for building modern weapons are sources of increasing concern. U.S. policy is unclear. On the one hand, the Bush administration proposed in 1990 a sale of over $26 billion in U.S. weapons to various Middle Eastern countries (Congress has already permitted approximately $10 billion of that proposed sale[14]), the State Department has instructed U.S. embassies to help U.S. defense exporters, and the administration has proposed up to $1 billion in loan guarantees by the Export-Import Bank for purchase of U.S. defense equipment by NATO members, Australia, Japan, and Israel.[15] On the other hand, President George Bush proposed in May 1991 that major supplier nations exercise ''collective self-restraint' in arms sales to the Middle East.[16] In Congress, there is a substantial interest in seizing the moment to create a system of multilateral controls over the global arms trade.[17]

Whatever the outcome of the policy debate, the prospects for greatly increased exports by the entire U.S. defense industry are dim. Foreign buyers may be lining up for certain American-made weapons systems that scored brilliant successes in the Persian Gulf War, and this could give a boost to some companies. But overall world spending for defense has plummeted, and the competition from other countries is stiff. Like DoD contracts within the United States, there is not enough export business to go around. It is not just a zero-sum game, it is negative sum.

Shifting to a Similar Commercial Product

The similarities between some military and commercial products are great enough that it should be possible to shift people, R&D resources, and even some production equipment from one to the other with relative ease. Aircraft is the prime example. Both of the U.S. producers of large commercial airplanes-Boeing and McDonnell Douglas—produce military aircraft as well, though the military side of the business is far more important to McDonnell Douglas than to Boeing (figure 7-4). Because of the lucky coincidence of a strong commercial market in the late 1980s and early 1990s, both companies have big backlogs and are shifting to a greater proportion of commercial work.

In the same way, the two U.S. manufacturers of large jet engines, GE Aircraft Engines and Pratt and Whitney, have tilted toward more commercial production. Not only that, all of the U.S. airframers that specialize in military aircraft are either already doing subcontract assembly work for Boeing's and McDonnell Douglas's commercial jets (e.g., fuselages, tail sections) or are planning to do so. At least one military airframer, Lockheed, has offered every commercial manufacturer in the United States and Europe anything from small parts to final assembly,

[14]Sen. John McCain ''Arms Sales to the Middle East Since the Gulf War. " *Congressional Record, Senate, Nov.* 19, 1991, *p.* S16981.

[15]U.S. Congress, office of Technology Assessment, *Global Arms Trade,* op. cit., p. 21.

[16]*The* Washington *Post,* May 30, 1991, p. A1.

[17]For example, in June 1991 the Senate Committee on Foreign Relations approved foreign aid and State Department authorization bills that would direct the President to convene the major weapons supplier nations to establish a ''cartel" to ban the sale of chemical nuclear, and biological weapons and ballistic missile delivery systems to the Middle East, and to curtail sales of advanced conventional arms.

but a possible deal with Airbus Industrie fell through because of the European member companies' desire to keep as much work as possible in Europe. Lockheed has, however, succeeded in expanding its division that does maintenance and rework of aging aircraft, including big commercial jets. It doubled its corporate capacity for overhaul and structural rework with a facility in Tucson that opened in 1989. And it has agreed to refurbish Japan Air Lines' 747 fleet in hangars at California's Norton Air Force Base, which was on DoD's 1988 base closing list and will soon be vacated by the Air Force. Moreover, Lockheed has a relatively small but thriving commercial business selling a civilian version of its C-130 Hercules military cargo plane; among its customers are oil companies drilling on Alaska's North Slope.

The shift from military to commercial production in aircraft is not without difficulties. The biggest impediments lie less in technology than in business practice. True, military aircraft are designed with different goals than commercial planes; in some military planes (especially fighters) the highest value is put on performance pushed to the limit, with cost secondary, while in commercial airplanes the top goals are safety and cost control, with performance important but a step behind. More significant than these differences, however, is the fact that defense contractors have one customer to deal with--DoD--and that customer imposes by law and regulation accounting and audit practices that are costly, cumbersome, and unknown to the commercial world. [18] Successful defense contractors are adept at working with these requirements, but that set of skills gives them no advantage whatever in the commercial side of the business, rather the opposite. More will be said on this subject later. For now, suffice it to say that some military airframes find that the cost structure in their military business makes it very hard to do large-scale commercial subcontracting.

Some companies do manage to work both sides of the street quite effectively. GE Aircraft Engines is the leading example; this GE division combines all aspects of its military and commercial business except for marketing, while still complying with DoD requirements. Boeing (airframes) and Pratt and Whitney (large jet engines) both keep military and commercial production much more separate. McDonnell Douglas is in something of a middle position, with most of its military and commercial production physically separated but with some interchange of managers and engineers. And despite the separate structure at Boeing, there is at least some opportunity to move people from the military to the commercial side (see ch. 4, box 4-C, which describes Boeing's retraining program in Wichita, KS for 176 military aircraft engineers) .19

At the level of subsystems and components, integration of military and commercial production is often greater, and so is the opportunity to shift rather easily into more commercial work. For example, the aerospace division of Allied Signal Corp. makes a whole range of items for aircraft, including auxiliary power units and environmental control systems for large transports, engines for smaller aircraft, actuators, engine controls, flight control systems, wheels and brakes, avionics and cockpit displays. About half the company's business is military, and according to company officials it is not too difficult to shift to commercial work; people, accounting systems, facilities, and technologies are shared. Production is shared when possible, as when there are common parts (e.g., in heat exchangers, actuators, valves).

Even at the subsystem level, exchanges between the military and commercial sides of the business are not always trouble-free. For example, Rockwell Collins, a world leader in both military and commercial avionics, segregates the two sides of the business except for R&D---even though avionics is the one part of the aircraft sector in which technology flows most freely between military and commercial projects .20 The reason is simply that military specifications (which often cover manufacturing processes as well as the product itself) and accounting requirements put too much of a cost burden on the commercial side. Despite the problems, Collins does assign engineers from its military side to

18 For a discussion of DOD contracting requirements, the costs they impose, and the reasons (hey were adopted, see OTA, *Holding the Edge*, op. cit.

19 Boeing's first major reduction of defense. related jobs in (& current defense build-down was announced in October 1991; 2,500 jobs are to be eliminated in the MX missile and the Short-Range Attack Missile II programs, which will be ended following President Bush's decision to abolish several nuclear weapons programs.

20 As leading examples of the technology flow, Collins officials cited ring-laser gyros (initially developed by the Navy), which accurately measure an aircraft's attitude, and the global positioning system (GPS) for satellite navigation.

commercial projects when they are needed, although some retraining for attentiveness to costs may be in order.

Altogether, despite the difficulties, the commercial aircraft business proved useful in tempering job loss and community disruption from the very sharp cutbacks in military aircraft procurement in the early 1990s. As a haven for some of the engineers, computer programmers, and technicians displaced from the defense sector, it helped to staunch dissipation of the technology embedded in people's minds. It should be noted, however, that these positive effects were fortuitous. It was good luck that the end of the Cold War coincided with an upswing in the cyclical commercial aircraft industry-strong enough, it seems, to have escaped any immediate dampening from either the Gulf War or the 1990-91 recession. Also, even a commercial industry with tens of billions of dollars in backlogs was by no means enough to avert serious displacement in some aircraft-dependent communities, i.e., Fort Worth, St. Louis, Long Island, and Los Angeles.

While the aircraft industry provides the most opportunities for direct transition from a military to a commercial product, there may be some smaller openings elsewhere. For example, AM General (a division of LTV Missiles and Electronics Group) announced plans in June 1991 to sell commercially its Persian Gulf War star vehicle, the Humvee (or Hummer, more formally the High-Mobility Multipurpose Wheeled Vehicle) .21 To be offered in three versions, priced from $40,500 to $44,000, the civilian Hummer got off to a well-publicized start with a $60,000-plus custom order from Arnold Schwarzenegger. [22]

Sales to Civilian Government Agencies

A first line of retreat for many companies losing military contracts is to go for more business with NASA. All of the leading defense contractors are involved in space technology, making missiles, launch vehicles, satellites, electronic control systems, or all of the above, and most have some NASA as well as DoD contracts in space applications. NASA's $14.3-billion appropriation for fiscal year 1992 was only a modest 2.5-percent increase over the 1991 level, but it included a 19-percent hike for the new space station *Freedom*, up to $2.03 billion. President Ronald Reagan had proposed building a new space station, to be launched by the end of the century, in 1984; from 1985 to 1991 Congress appropriated a total of $5.7 billion for the project. However, in recent years, estimates of the space station's cost skyrocketed, NASA scaled it down,[23] and scientists questioned its value. In fact, several scientific associations have opposed any further finding for the project. The generous FY92 funding for the project does offer opportunities for increased sales by some defense companies, though whether the project will eventually be fully funded is still not certain.

Several large defense companies are aggressively following a strategy of packaging their technologies in a form suitable for civilian government agencies, including several others besides NASA. Although there may be differences between DoD and civilian agencies, government sales are still a world apart from commercial marketing, and are what defense companies understand. Martin Marietta is a leading example of the strategy. Building on its defense work in C^3I (command, control, communication, intelligence), the company's Information Systems Group has set its sights on 15-percent growth annually from sales of information and data processing systems to civilian agencies. Already, Martin Marietta is the overall systems engineer and integrator for the Federal Aviation Administration's (FAA) $16-billion upgrade of weather and air traffic systems at U.S. airports, an effort involving several other defense contractors, including TRW and Norden Systems (a subsidiary of United Technologies). Martin Marietta has sold similar services in Canada, France, and Australia. The company is also supplying software for data processing to the Social Security Administration, data processing facilities to the Department of Energy's (DOE) Western Area Power Administration, remote data networking and processing services to the Agriculture Department's

[21] Jack Keebler, "$40,000-plus Hummer Goes Public," *Automotive News*, June 24, 1991, p. 4.

[22] The price to DoD for the Hummer is $26,000. Ibid.

[23] The cost of building space station *Freedom* was originally estimated at $8 billion; a 1990 estimate was nearly $39 billion. A scaled down and stretched out project would cost $30 billion by 1999, according to NASA, but the work on the station would not be complete—it could later be enlarged and enhanced. The U.S. General Accounting Office estimated the overall cost of building, launching, and maintaining the station in space for 30 years, through 2027, at$118 billion; a more recent estimate is $180 billion.

National Agricultural Statistic Service, and automated mail-sorting machines to the Postal Service.

This strategy is a fruitful one for technology transfer from military to civilian activities. It also holds promise for easing the transition for workers and communities, avoiding dislocation and disruption by continuing the same kind of activities in the same places with many of the same people.

Spinoff Companies

Sometimes, enterprising employees of large companies decide to form their own companies to exploit for commercial uses military technologies that the large company has developed but does not wish to bring to market. The value of this approach is in technology transfer. It usually does not save existing jobs or use existing plant and equipment, but if it succeeds it may create new jobs, energize local communities, and contribute to the Nation's industrial competitiveness.

Little has come to light about entrepreneurial spinoffs in the current defense build-down, and it may be too soon to judge the success of such efforts. However, examples from earlier periods of defense cutbacks illustrate how they can work. One such is the Schenectady, NY company Environment One, founded in 1969 by six engineers who left GE's General Engineering Lab to commercialize a technology that originated in an antisubmarine device. Box 7-B tells the story.

Assuming that there are enterprising people who want to start up a company based on military technology, such as the founders of Environment One, often the main impediment is getting enough financial backing. Obtaining necessary intellectual property rights could also be a problem in some cases. The large companies that were the seedbed of the technologies sometimes help startup companies get past these obstacles. For Environment One, GE was helpful in licensing its technology on affordable terms. A few years later, in the 1970s, GE tested the idea of a Ventures Group in which it supported small spinoff companies trying to commercialize technologies developed in GE's basic science Research Lab. (Not all the technologies were military in origin, but about 60 percent of the lab's funding at that time came from DoD). For the 5 years the program lasted, GE fostered the startup of eight companies, putting up enough funds to hold a 45-percent interest in each.

Eventually GE abandoned the program, but it did chalk up some successes. For example, Intermagnetics General was founded in 1971 as part of the Ventures Group by Carl Rosner, who had been head of GE's superconductivity research program. At that time, GE itself was unwilling to bet on the commercial potential of the technology, but supported Rosner's startup with 45-percent GE financing. Before long, Intermagnetics General bought out GE's share and afterwards grew from an initial investment of $7 million to a company of 450 people with annual sales of $50 to $60 million. Its main products are materials and magnets for the medical diagnostics industry.

Corporate Diversification

A defense company that faces big losses in military contracts can try to protect its corporate fortunes by buying firms that are already successful in making and selling commercial products. Thus the defense company does not have to learn unfamiliar management and marketing skills, but can rely on its new subsidiaries to keep on doing what they know how to do. There is a danger in this strategy. In the conglomerate vogue of the 1960s, many corporations (including but not limited to defense companies) acquired diverse strings of companies on the theory that if one line of business declined another would prosper and keep corporate profits on an even keel. The trouble with some of these conglomerates was that corporate managers got into businesses they did not understand and turned successful firms into failures or, more often, found that the subsidiaries fell below the profitability standards of the parent corporation.

In some cases, however, diversification has worked very well. An example is the Raytheon Co. based in Lexington, MA.[24] Raytheon is a top defense company, fifth in prime DoD contract awards in 1990, and the maker of the acclaimed Patriot missile as well as several other missile systems and components, radar systems, and electronic and communications equipment. Raytheon is also a major nondefense company; nearly half its sales are nonmilitary.

[24] Much of the material on Raytheon's diversification experience is drawn from Robert W. DeGrasse, Jr., "Corporate Diversification and Conversion Experience," in John E. Lynch (cd.), *Economic Adjustment and Conversion of Defense Industries* (Boulder, CO: WestView Press, Inc., 1987).

Box 7-B—Environment One: From Detecting Submarines to Monitoring Air Pollution

Environment One of **Schenectady, NY, is an example of a successful spinoff** from **a major corporation, using technology originally developed for the military to produce commercial items.[1] In the mid-1950s the General Engineering Lab at GE (the advanced engineering lab, at that time separate from the pure science Research Lab) developed a submarine detection system for the Department of Defense using condensation nucleide monitoring to detect submicron particles. The principle is that of the** Wilson cloud chamber, in which the presence of particles too small to detect optically is inferred by observing the beads of condensation they trigger in a small chamber of cold, low-pressure vapor.

GE's research engineers developed a device with a very small (2 inch by 5/8 inch diameter) chamber that could take afresh sample of air every second and expand it rapidly to supercool it, and represent condensation by an analog voltage. This resulted in the ASR-3 antisubmarinee device, capable of detecting the trail of diesel smoke particles left by a snorkeling submarine as far as 100 miles away. NATO used the device for submarine detection through the early 1960s. The same technology was applied during the Vietnam War for a "people sniffer" that could detect people hiding in foliage.

The group working on the technology in the General Engineering Lab realized that it could also be applied to monitoring air pollution, detecting smoke, and finding faults in polymers, which emit minute particles prior to failure. In view of the growing concern about pollution at the time, the engineers proposed that GE develop this aspect of the technology. **GE chose** not to, and in 1%9 a team of six engineers, including Frank Van Luik the present chief executive officer (CEO), left the lab to found Environment One, taking with them 20 lab workers. In an amicable arrangement with GE, the six entrepreneurs bought the patent for the particle detector and also the patent for an innovative grinder pump for home sewage treatment, which some of the six had developed. The price was $20,000 plus a royalty of 4.5 percent. GE was offered the chance to retain a 51-percent share in the company with the option of buying the rest back if successful, but declined out of wariness of potential antitrust violations.

The company began with a good technology base, but slender financing and no name recognition. Learning how to market its products was the biggest challenge, made more difficult by the disappointment of not having the GE label to instill customer confidence. With no financial backing from GE, the fledgling company had to rely on the founders' savings and startup money from a small private investor group that knew of the founders' work at GE, to take the company through the process of licensing the novel grinder pump and generally becoming known.

The company had sales of $12 million per year in the early 1990s. Its business remained largely in the manufacture of the two original product lines, with a small fraction (about 10 percent) in a measurement service. CEO Frank Van Luik attributes Environment One's survival to its concentrating on a few specialized products in which it excells technically.

[1]Information on the company, its products, and the technologies they are based on was provided to OTA by company officials, including CEO Frank Van Luik and George Skala, Senior Engineer, Incipient Fire Detectors and Generator Condition Monitors.

Raytheon's experience as a defense contractor goes back to World War II when it was a leading manufacturer of radar equipment. As early as 1946, when DoD canceled hundreds of millions in contracts with the company, Raytheon managers decided to diversify. Most of the early attempts (into television and germanium semiconductor production) failed to pay off, but by the mid- 1960s a new CEO, Thomas Phillips, was ready to try again. By the late 1950s Raytheon had developed a commercial microwave oven, originated by a Raytheon engineer right after the war and based on military radar. But the expensive Radarange was sold mostly to institutions such as hospitals and restaurants. Not until 1965, after Raytheon bought the consumer-oriented Amana Refrigeration, Inc., did the company make a vigorous effort to bring the price down to a level households could afford. Amana was given the job of producing and selling microwaves to consumers.

Raytheon later bought two other major appliance subsidiaries, Caloric and Speed Queen and, mostly through acquisition, has entered such diverse fields as small aircraft (Raytheon owns Beech Aircraft), energy services, heavy construction equipment, and textbook publication. A few more of these ventures, besides the microwave oven, were based on genuine transfer of the parent firm's defense technology. For example, the sound-emitting device used by Raytheon's oil exploration firm, Seismograph Service Corp., sprang from the company's military work on

sonar. Beech Aircraft offers examples of technology transfer both ways: the Air Force made a big buy of Beech business jets for trainers; and the newest, still experimental, Beech executive jet is the Starship, made of advanced composite materials first used in military aircraft.

For the most part, however, Raytheon got into its commercial ventures through purchase, not internal development. Where there was internal commercial development of a military technology, the process was complex, both from the engineering and the management standpoints. Raytheon executives stress that although the company is about half defense and half nondefense, the two halves are separate. Explaining the reason for commercial acquisitions, a company executive said: "We knew almost nothing about commercial marketing."[25] The separation means that crossover of employees from the defense to the commercial business has been limited. In fact, when the Vietnam War was winding down in the late 1960s, Raytheon terminated 8,000 employees, or 15 percent of its work force-mostly in defense plants in the Boston area.[26] This suggests that while diversification can be a valuable strategy for the firm and its shareholders, it may not offer much to communities and workers affected by the defense build-down.

Conversion

Conversion, defined as redirecting an existing work force, some technologies, and possibly some equipment from military into commercial production, has taken place in the past with widely varying results. Conversion after World War II was massive, fast, and successful. But conditions then were very different from those of the 1990s. For one thing, in those pre-Cold War days military production was universally seen as a temporary diversion from normal business. In the auto industry, for example, tooling and machinery for making cars were put in storage after Pearl Harbor, but within weeks after war's end they were back in service and producing 1942 models. Conditions after the Vietnam War were more like those of 1990-91-a substantial reduction in defense spending combined with detente and a U.S. economy in recession.[27] Following Vietnam, several large firms tried conversion with results that are remembered in corporate history as unmitigated fiascoes that should never be repeated.

As the discussion and examples below indicate, there is a good deal of justice in that evaluation, but it does not tell the whole story. There were some modest successes, especially in technological innovations. There were also some large technological failures, as aircraft companies ventured into the unfamiliar but seemingly simpler businesses of making light rail cars and buses; it proved to be harder than it looked. While the companies' difficulties were compounded by shifting government policy, another very important factor was the different demands on managers in a commercial versus a defense business-especially control of costs, attention to product reliability, and marketing know-how.

Aerospace to Mass Transit

The best-known attempts at conversion in the 1970s (see box 7-C for details) were those of Boeing Vertol, Boeing's helicopter division, and Rohr Industries, a long-time manufacturer of nacelles (housings for aircraft engines). Both companies ventured into making light rail cars for trolley, elevated, and subway systems and both left the business after some costly losses. Grumman's ill-starred attempt to manufacture buses is an example of diversification rather than conversion, since it came about through purchase of a going concern, the Flxible Co., from Rohr. However, like the Boeing and Rohr stories, it illustrates the perils of taking on a complex new product without sufficient understanding of cost and reliability problems and without allowing time to test the new product in operation.

It is interesting to note that while neither Grumman nor Rohr solved the technological difficulties plaguing their mass transit vehicles before getting out of the business, Boeing did. The light rail cars that Boeing hastily put into service in Boston to comply with its contract-the cars that were such a notorious failure-were later improved and given lengthy tests under actual operating conditions in other cities. These improved cars performed suc-

[25]David Gumpert, "Raytheon Prospers Despite Big Slow Down in the Defense Industry," *The Wall Street Journal*, Mar. 5, 1971.

[26]DeGrasse, op. cit., p. 108.

[27]There are significant differences as well. Defense spending was a larger share of GNP in the @Vietnam War years (9.2 percent in 1968 v. 6.5 percent in 1986). On the other hand, defense outlays in constant dollars were larger in the Reagan buildup, and the Nixon-Kissinger detente of the early to mid-1970s was fragile compared to the definitive end of the Cold War in the early 1990s. See ch. 1 for further discussion.

Box 7-C—Aircraft Companies as Makers of Mass Transit Vehicles

Boeing Vertol—A decline in military orders for the Chinook CH-47 helicopter in the late 1960s and early 1970s led Boeing's Vertol division (located in Delaware County, PA) to start work on light rail vehicles.[1] Boeing managers hoped to capitalize on the company's experience in systems integration, on company technologies they saw as superior to those of competitors in the light rail car industry, and on national demand projections for roughly 2,000 cars during the 1970s, Further, the facility Boeing Vertol planned to use, formerly owned by Baldwin Locomotive, was well suited to testing and shipping rail vehicles. Finally, Boeing thought it likely the Federal Government would offer subsidies for mass transit and, at least as important, would develop national standards for transit cars. Indeed, before getting into production, Boeing won contracts with the Department of Transportation's (DOT) Urban **Mass Transit Administration (UMTA) to** develop transit car specifications and standards.

In 1973, Boeing Vertol won its first production contract-an order to produce 150 cars for Boston and 80 for San Francisco of what was optimistically called the U.S. Standard Light Rail Vehicle (SLRV). UMTA had developed the SLRV specifications in the hope they would encourage economical mass production of transit vehicle-and UMTA had the means to urge cities to buy into the standards, since at that time it provided 80 percent of capital funds to local transit authorities. The two cities did specify some differences in requirements on the first order, but these were no more than variations on the same basic design. Boeing Vertol hoped other cities would order the standard vehicle and select options to tailor it to local needs.

The SLRV was in fact anew-generation trolley car, designed to be safer and more comfortable than cars then being made in the United States and Europe. But Boeing agreed to a compressed schedule for the Boston order, without building in time for thorough operational testing of the new design. In the rush to meet the schedule and avoid penalties, Boeing tore out unsatisfactory components and modified the cars on the production line. The first of the new vehicles began service in Boston in January 1977 and within weeks developed problems with brakes and other major components. In response, Boeing made over 65 design modifications in the first year of operation, but in the end had to settle without delivering the last 40 of the 175 cars originally ordered, and with losses of tens of millions of dollars on the contract.

Learning from the Boston experience, Boeing modified the trolley cars subsequently delivered to San Francisco, and they proved reliable. A 1974 contract with Chicago for 200 cars for its elevated system included a substantial testing period, and these cars too have performed well over the years. Nonetheless, Boeing decided to leave the transit market at the end of the 1970s. First, the transit market turned out to be more sluggish than had been projected. But also, by the mid- 1970s UMT.A was backing off from national transit car standards, leaving local transit authorities free to demand their own designs. The differences in each order increased costs. Perhaps most important, the upturn in defense spending in the last years of the Carter administration and the enormous increases in the Reagan years promised much bigger defense business (and probably many fewer headaches) than anything the transit business had to offer.

Even at its height, the transit car operation did not reemploy a large proportion of Boeing's idle defense workers or resources, although most of those used (75 to 85 percent of the engineers and 95 to 100 percent of the production workers) had previously been involved in the helicopter operation. Transit production never involved more than 550 people, compared with 4,300 still employed at the Chinook plant in the mid-1970s, and a high during the Vietnam War of 13,000. However, some of the production techniques and tools employed on the trolley line were borrowed from aerospace production.

Rohr Industries--Rohr's venture into mass transit was more ambitious and ultimately less successful than Boeing's.[2] It began in the middle 1960s, not in response to a defense build-down but as an outgrowth of a new company president's wish to ''fill valid, rational human needs. ''[3] Rohr made a bid to San Francisco's Bay Area Rapid Transit system (BART) that was below expected expenses, in the hope of establishing a strong position in the market. The company believed it could apply its aerospace skills to advance the state of the art in mass transit,

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[1]Much of the Boeing-Vertol story is drawn from Robert W. DeGrasse, Jr., "Corporate Diversification and Conversion Experience" in John E. Lynch (cd.), *Economic Adjustment and Conversion of Defense Industries* (Boulder, CO: WestView Press, 1987); and Linda Kravitz, "The Wages of Peace, ' contract report prepared for the Office of Technology Assessment August 1990. Information about the SLRV was amplified by telephone interviews with Earl Weinstein of Allied Signal Aerospace.

[2]The principal source for this section is DeGrasse, ibid.

[3]Ibid., citing Roy J. Harris, "Shattered Dreams: Rohr Industries Grew Fast and Currently It's Shrinking Fast Too," *Wall Street Journal*, Nov. 5, 1976.

(continued on next page)

Box 7-C-Aircraft Companies as Makers of Mass Transit Vehicles--Continued

It undertook to develop a transit vehicle that was a "quantum jump" in sophistication and reliability. In 1%9, Rohr won a contract to supply 450 rail cars to BART, and 3 years later contracted with the new Washington, DC subway system for another 300 ears.

Rohr found the task far harder than expected. Cars were delivered late both to San Francisco and to Washington, and once delivered the cars developed problems with brakes, doors, and car seals that persisted even after extensive modifications. Continuing financial losses and a change in Rohr's management prompted withdrawal from the rail car business in 1976.

Like Boeing, Rohr had tried to produce a new generation of rail cars without allowing enough time first for development and then for debugging. Again, like Boeing in Boston, Rohr had to modify cars that were already in service--an expensive proposition. Unlike Boeing, Rohr did not stay in the business long enough to iron out the technical problems but opted to cut its losses--especially since UMTA's failure to establish national standards for transit cars made forecasting the market very chancy.

Grumman--Grumman's excursion into mass transit was in buses, through purchase of the Flxible Co. of Loudonville, OH from Rohr.[4] Grumman did not attempt to use its own technology, equipment, or work force in the venture; the bus it launched was a Rohr design, representing another of that company's attempts to advance mass transit technology. Rohr had bought Flxible in 1970 as part of its diversification into transit. It sold the company to Grumman in 1978 when, shaken by losses in its rail transit business and having changed management, it abandoned the transit market On Grumman's side, the purchase was a hedge against diminished expectations of Navy orders for its F-14 fighter (the Tomcat, which as it turned out had many lives, undergoing repeated modifications and lasting through 1991).

The new Flxible—Rohr—Grumman bus, dubbed the 870, ran into trouble almost as soon as it went into service. One of the New York buses collapsed when the A-frame supporting the body over the rear axle snapped. In quick succession, all the transit systems using 870s took the buses off the streets for inspection and repair. Checks revealed that four major components in the bus's chassis were likely to crack and give way altogether. In the end, Grumman agreed to retrofit all of some 2,900 buses it had built and to extend the warranty. In 1983, Grumman sold its bus company to the General Automotive Corp., and by 1988 had settled lawsuits with Chicago and New York transit authorities.

Grumman claimed that the 870 was the most thoroughly tested bus that Flxible had overproduced. But the 870, like the BART and Washington subway cars, was a new design. And the approach to testing was that of the aerospace industry, with a computer analysis followed by a test to destruction under extreme conditions, and then a drive testona''torture track. What it did not have was a lengthy test on real city streets, complete with potholes; the only actual driving on city streets as part of the test was of a bus specially fitted with advanced measuring instruments operated by an engineer.

As noted, Grumman's bus enterprise was diversification through purchase, not conversion of its own resources to nondefense production. But three decades earlier, right after World War II, Grumman did undertake a conversion that succeeded, and became two subsidiaries of the company that are still thriving todays The company found itself with excess aluminum manufacturing capacity after the war and looked for new uses for it, other than military airplanes. One was canoes; another was the bodies of large high-sided commercial trucks. The subsidiary making both products became Grumman Olson, which is still the largest producer of walk-in truck bodies, sharing the market with Union City Body Co., a GM subsidiary.

Another offshoot of Grumman's World War II aluminum production is Grumman's Long Life Vehicle (LLV) subsidiary, which makes Postal Service vehicles. Grumman won out against three other companies in a competition to make mail delivery vehicles that would stand up much longer than the previous steel-bodied jeeps. Grumman's aluminum vehicle, designed to last 24 years, won the Postal Service contract in 1986. The company will make 99,150 vehicles under the contract, and is now producing nearly 20,000a year (using a GM chassis), with sales in 1990 of $391 million.

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[4]Much of the Grumman story is drawn from David Young, "Putting the 870 Back Together," *Mass Transit, May 1981.*

[5]Material on Grumman Olson and Grumman LLV is drawn from the company's annual reports and from telephone interviews with Steve O'Brien, Director of Business operations, Grumman LLV and J. Edward Waesche, Director of Operatons Analysis, Grumman Corporation Bethpage, NY.

There is very little connection today between Grumman LLV and the Grumman aerospace company. The kinds of aluminum used in trucks and aircraft have diverged so greatly that the companies do no joint purchasing, and LLV is now big enough to stand on its own. On rare occasions, LLV **might use an engineer from the parent company to solve a special problem in working with aluminum. But for the most part, the connection is only corporate.**

Allied Signal Aerospace--This company is a maker of a wide range of equipment for both military and commercial aircraft. "If it flies in the Western world and doesn't have a beak, it has something on it from Allied Signal,' company officials says The things the company makes include power units for large commercial jet transports, engines for smaller planes, actuators, wheels and brakes, flight control systems, avionics, and cockpit displays.

Like Rohr, Allied Signal foresaw an expansion of the demand for public transport and in the mid-1960s decided it could apply some of its experience in aerospace control technology to transit systems. Its strength lay in its electronic "chopper" switches, which were superior to the mechanical switches in use at the time for controlling transit cars. Allied Signal had developed several advanced control systems by the end of the 1960s and tried them out on the BART test track. On the basis of these tests, BART specified chopper controls in its Request for Proposals for design of the system.

Although Allied Signal failed to win the initial BART contract (Westinghouse got it), the company became the leading contractor for several experimental prototype rail vehicles for DOT'S Office of High Speed Ground Transportation. And by 1973, it joined Boeing Vertol in production for the Boston/San Francisco order for Standard Light Rail Vehicles. The company's reputation grew, and at one point in the 1970s it was the supplier for every U.S. and Canadian light rail program requiring electronic controls.

Despite Allied Signal's technological success and its domination of the market for transit control systems over much of a 15-year period, the venture was barely self-sustaining financially. In 1988, Allied Signal sold its transit control business to the Swedish-Swiss firm Asea Brown Boveri. The lackluster financial performance was partly due to the fluctuating fortunes of mass transit in the United States. Not only did UNTA back off from developing a standard rail car, but Federal Government financial support for mass transit was cutback deeply during the Reagan years while defense spending skyrocketed. It was not just defense-based neophytes that left the business but also such well-established pillars of the American industry as Pullman, Budd, and GM. More and more of the business moved abroad, especially to Canada and Italy where governments do offer some support to mass transit and the industry that makes the vehicles.

Allied Signal officials offer another reason for the transit venture's lack of financial success. The ups and downs of the transit business meant that there were never enough orders to justify setting up a separate division, so the transit venture was conducted together with the company's aerospace business. The tendency in defense aerospace to elevate performance over cost control "infected" the transit business. Costs were geared to meeting the exacting demands of the military. But to win orders, the transit business had to lower the price to a point where it was hard to make a profit.

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[6]Material for this section is drawn from OTA interviews with Allied-Signal Aerospace officials in Torrance, CA in April 1990 and telephone interviews in Oetober-November 1990.

cessfully in Chicago and San Francisco, giving years of reliable service. They did not prove enough of a moneymaker to persuade Boeing to remain in the business, especially since Boeing's expectation of a national standard for light rail cars (which would have helped producers achieve economies of scale) came to nothing. Moreover, the defense buildup of the early 1980s offered plenty of profitable business to occupy the company's plant, equipment, and work force. At the same time that government spending for defense soared to wartime levels, Federal subsidies for mass transit systems shrank from a peak of $5.6 billion in 1981 (1991 dollars) to $2.9 billion by 1988.

A company that scored a clear technological success in a mass transit venture was Allied Signal. That did not, however, translate into financial success. As described in box 7-C, Allied Signal was the dominant North American producer of electronic controls for transit systems over a 15-year period in the 1970s and 1980s. Yet the venture did little better than break even, and was sold to a European firm in 1988. Part of the reason for the failure to make money was the instability of government support for

mass transit but another part, according to company officials, was the burden of producing in a defense business environment that paid too little attention to control of costs.

Shipbuilding to Multiple Options

Ingalls Shipbuilding of Pascagoula, MS, a division of Litton Industries, Inc., was able to put together several military and commercial alternatives when two major Navy contracts were winding down in the late 1970s, and there was little hope for new jobs because of the Carter administration policy to reduce Navy shipbuilding.[28] Company managers saw no single option that would produce enough business in the short term to keep the shipyard going and maintain its skilled work force, and in the long term enable the company to bid on future high technology Navy contracts. Ingalls first made itself into an overhaul and repair facility for Navy ships, which kept its outfitters busy. Then it went after commercial business with the offshore drilling industry, starting with overhaul and repair of drilling rigs and proceeding to license the design for a unique kind of deep water jack-up rig. The rig business employed Ingalls steel workers and succeeded well enough to capture 10 percent of the market from 1979 to 1982, keeping several thousand people employed. A venture into rail car assembly was less successful, not because of technical or marketing failure, but because demand for rail cars for grain exports fell far short of expectations in the early 1980s. Ingalls also pursued miscellaneous construction projects, such as making steel decks for bridges.

With all these various and modestly successful attempts at conversion, Ingalls employment was still cut in half (from 25,000 to 12,000) with the retrenchment in Navy ship construction. The Reagan administration's program for a 600-ship Navy put IngalIs back mainly in the defense business, with some increase in employment in the mid and late 1980s. In the 1990s, the company may well face the necessity for a more permanent transition to a mixed defense and commercial business.

GE Aerospace Conversion in the 1970s

In the early 1990s, the defense-oriented GE Aerospace group was committed to a strategy of focusing on military business and shrinking in size if necessary; employment dwindled from 46,000 in 1989 to 38,000 in 1991, and was expected to go lower. A quarter of a century earlier the Re-Entry Division of GE Aerospace tried a different strategy, embarking on a series of projects that sought to transfer technology, people, and products from military work into new nondefense business.[29] From 1967 to 1980, the share of DoD work in the division fell from 100 to 50 percent.

One motive for the strategy was to redirect GE's innovative technologies into important new areas as the Vietnam War wound down. Another motive, at least as compelling to the Re-Entry Division, was to win out (or at least survive) in the internal competition among GE divisions. In the 1960s, the Re-Entry Division, which had developed the heat shielding for intercontinental ballistic missiles in the 1950s, found itself competing for space and defense business with a new Satellite Division. Re-entry problems, fairly well solved, were now taking aback seat to the weaponry component in ICBMs and to rocket research generally. The Re-Entry Division was losing work but it still needed to meet the corporate revenue requirements for every GE division, and its director wanted to keep his talented team of engineers together.

The division, expanding into new fields that managers saw as socially useful and technically challenging, was renamed the Re-Entry and Environmental Systems Division. Ground rules for new projects in the division were that they should: 1) have government assistance, to reduce GE's costs and provide insulation from market uncertainties; 2) take full advantage of GE's Corporate Research Center and transfer as much technology as possible; and 3) concentrate on areas where GE had a significant technical advantage.

As described in box 7-D, at least one of the projects, manufactured housing, had a fair degree of success despite a turnabout in government policy that withdrew the assistance GE had counted on. Others were promising but were sold off at an early stage, or failed to meet GE's financial requirements but were taken up profitably by other companies. At

[28] The Ingalls story is based mostly on DeGrasse, Op. cit.

[29] Information on GE Aerospace's conversion projects in the 1970s is drawn from OTA interviews and telephone interviews in October-December 1990 with GE officials, including Otto Klima, who was manager of the GE Aerospace Re-Entry Division during the years when the projects took place.

Box 7-D--GE Aerospace Conversion in the 1970s[1]

Manufactured Housing: A Modest Success

GE Aerospace chose low-cost manufactured housing as a promising project for conversion from military to nondefense business in part because the venture had some government support. From about 1968, a U.S. Government market existed-housing at Air Force bases. More government support was added the next year when George Romney, then Secretary of Housing and Urban Development, introduced Operation Breakthrough, a scheme to advance low-cost housing technology. As a former President of American Motors Corp., Romney believed that the mass production techniques of autos could be applied to housing. GE Aerospace was among 22 successful bidders (selected from 530 proposals) for awards of $300,000 to $500,000 to design and build housing modules.

GE Aerospace went so far as to produce a number of manufactured houses in west coast facilities. But its domestic modular production halted in January 1973 with the repeal of Operation Breakthough's subsidies for low-cost housing using new technology (the repeal was one of a range of Federal cost-cutting measures). Without the subsidies, it was no longer feasible to transport bulky house modules as far as 1,000 miles from where they were made.

The collapse of the domestic market was not the end of manufacturing housing for GE Aerospace, however. It was operated successfully in Iran and Japan for several years, providing some payoff on GE's investment. In Iran, GE served as the government's engineering consultant in building anew town to support a copper mining project. The houses were built onsite using GE expertise to construct steel frames that supported traditional local materials, such as adobe. A fortuitous benefit of having designed housing modules suitable for U.S. rail transport was that the frames could stand up to Iranian earthquakes.

The Iranian venture was only marginally profitable. A joint venture with a Japanese partner proved more lucrative. The partner duplicated GE's factory in Japan, and GE made $6 million on the sale of 450 houses to Saudi Arabia. The modules were shipped in flotillas of ocean-going barges that could be cut loose when storms threatened and rounded up afterwards. With an assured market, production became so efficient that the houses were delivered 3 months early, netting an extra bonus for the partnership. Plans to sell the houses in Japan never materialized, however, because the Japanese housing market suffered heavily in the 1974 oil crisis. The operation came to an end in 1976.

Along-term benefit for GE turned out to be the international experience gained from working in Iran and Japan. Some people involved in the housing ventures put their experience to work in the Aircraft Engine Division (which is strong in international sales), and the chief engineer from Iran went into product support for commercial aircraft.

[1]Information for this box was provided by former and present officials Of GE Aerospace.

(continued on next page)

least one, hydroponic farming, never got off the ground.

In 1981, with the Reagan administration defense buildup and many new opportunities for military contracts in GE Aerospace, enthusiasm for the conversion projects waned. At the same time, Jack Welch became GE chairman, and his credo is that if GE is not number one or number two in a business, then GE should not be in it. Also, GE's hurdle rate—i.e., the required rate of return on a new investment-is reputed to be the highest of any major U.S. corporation.

All of this has added up to a decision by GE Aerospace to undertake no more conversion attempts. Even those present and former GE officials who point to successful aspects of the 1970s program tend to believe that defense companies are ill-suited to meet the marketing and cost demands of the commercial sector. Another possible way of converting military technology to commercial products is outside the defense firm, perhaps with some form of government assistance to encourage the flow of technology into the startup companies.

Community-Based Conversion Efforts

In some cases of threatened closure of major defense facilities, community activists have tried to avoid the closure by proposing---a demanding—that the company undertake conversion through joint community-labor-management efforts. The reasoning is that because of the community stake in economic stability and the workers' stake in jobs, they as well as company managers should be

Box 7-D-Aerospace Conversion in the 1970s-Continued

In the **United States, there may be some mom general long-term benefits to the public from Operation Breakthrough.[2] Although the goal of building** whole houses like cars was never fully achieve& there were fruitful aspects to the program--in particular, cooperation with States to develop building codes appropriate for industrial housing, with the Interstate Commerce Commission to set reasonable transport rates, and with building trades unions to agree to manufactured housing. Moreover, some of the elements pioneered by GE in its modular manufacturing housing are reappearing m current energy-saving technologies for dwellings.

Spinoffs

Several of the conversion projects GE Aerospace undertook in the 1970s never came to fruition for GE itself, but were taken up successfully by smaller, flexible companies with lower overhead and lesser requirements for payback on investment One example was an oil and water separator that involved no moving parts but was simply a series of carefully designed baffles that drew on GE's skill in fluid flow modeling. The product was just beginning to make money, although not much by GE standards, when it was sol&

Another example involves a more complex technology-too complex in fact for commercial success, in the form developed by GE. Bearing the intriguing name of cybernetic anthropomorphic manipulator (CAM), the device was a remote manipulator GE developed for the Navy, based on earlier GE work for the Army. The CAM allowed an operator to perform delicate tasks in a hostile environment not only working with distant objects but also feeling and responding to their resistance to motion through a force feedback control mechanism. GE saw commercial possibilities for the device in undersea work for the oil industry, in a joint venture with Exxon; in handling 500-pound blocks of hot titanium in TRW's Cleveland foundry; and m building Wankel engines on an automated assembly line.

The project met various setbacks. Neither the TRW foundry nor the Wankel engine program survived the 1974-75 recession. Exxon found that the CAM's five degrees of freedom and force feedback mechanism were more sophisticated than needed for its undersea maintenance work, and GE soon sold the technology to a minisub company, which successfully developed a simpler and cheaper version. However, GE's version of the CAM did eventually, in a roundabout way, find application in the space shuttle. GE Aerospace provided it as a prototype to help NASA develop bid specifications for the space shuttle manipulator arm, but GE Aerospace did not win the production contract SPAR of Canada with the backing of its government for development costs, submitted the low bid, after which it subcontracted to GE Canada. All GE research and expertise on the CAM technology was transferred to GE Canada.

Still another technology that failed as a GE project but ultimately helped many small startup firms in the biotechnology field was nutrient reclamation. GE Corporate Research Laboratory engineers developed a genetically altered microbe that could recycle cattle manure into protein for animal feed When moved from lab to ranch, the project failed because Contaminants, including heavy metals, blown in from the desert made the process unworkable. Although GE had by this time abandoned the venture, it did win a patent for the microbe in a landmark Supreme Court decision in 1978. This provided a timely stimulus to several small firms that started up in the aftermath of the GE experiment. Only a large corporation like GE, with a powerful legal and patent staff, could have pursued such a case, and in this way it was responsible for entrepreneurial activity by others.

[2]Information on public benefits from Operation Breakthrough was provided by Henry Kelly, U.S. Department of Energy; David Moore, U.S. Department of Housing and Urban Development; and Professor Charlie Brown, University of Oregon.

involved in exploring alternative uses of a plant that is no longer in defense production.[30] The same reasoning has been applied to closures of major nondefense plants that are the source of a community's livelihood. In some of these cases, early warning that a firm planned to close, combined with assistance from government agencies and communities, have helped to change a company's decision to close a plant; in a few others, employees have bought out the company.[31] In many cases, however, the

[30]For an exposition of this view, see Ann Markusen and Joel Yudken, *Dismantling the Cold War (New* York, *NY:* Basic Books, forthcoming); Seymour Melman, *The Demilitarized Society: Disarmament and Conversion* (Montreal: Harvest House, 1988).

[31]For a brief discussion of conditions in which government assistance or community efforts may help to save a troubled plant, see U.S. Congress, Office of Technology Assessment, ***Technology and Structural Unemployment: Reemploying Displaced Adults,*** OTA-ITE-250 (Springfield, VA: National Technical Information Service, 1986), pp. 209-213.

changes needed for plant survival are so great that closing down is the only reasonable option. Moreover, when a large U.S. company decides to close one of its plants for strategic reasons, that decision is usually not open to change. In the United States, there are neither the laws nor customs that exist in Europe and Japan impelling large companies to look for solutions other than worker layoffs to changing market conditions or company strategy.

If it is difficult for community efforts to keep a nondefense plant that is slated for closing in business (often without even a change in product line), the difficulties multiply with defense plants. Managing defense production is a world apart from managing commercial production (see the discussion below). Conversion of a defense facility means undertaking the design, production, and marketing of quite different products—a challenging feat even for managers with commercial experience. Even in Germany, which does have laws, institutions, and customs that encourage alternatives to layoffs in industries undergoing structural change, community planners are finding that it is difficult to convert defense companies or divisions directly into commercial production and sales. They are looking instead at alternatives where the government is the customer, for example, in environmental cleanup programs.

In the United States, there have been several energetic attempts by community activists, joined in some cases by labor unions, to encourage defense plants threatened with closure to convert to commercial production, but none so far has succeeded.[32] A bill in the 102d Congress that would require defense companies to establish alternative use committees to plan for economic conversion in case of closure of reduction was referred to several House committees; at this writing no action had been taken on the bill.[33]

BARRIERS TO CONVERSION

The Defense Company Culture

The main reason defense companies give for reluctance to venture into commercial production is the great differences in company practice and culture between defense and commercial business. Many studies and reports have called attention to the differences that make it difficult to combine defense and commercial business.[34] Defense companies have evolved over 40 years of Cold War into separate organisms. Most large defense contractors that assemble complex weapons systems or make major subsystems are geared to low-volume production of highly specialized, expensive equipment. In designing the equipment, the main emphasis is on technical performance and meeting DoD requirements. In contrast, many commercial products have to combine reliability and affordable cost with high-volume manufacture. Even in the aircraft industry-where the defense and commercial products have a good deal in common, many manufacturing processes are similar, and final assembly of both is a painstaking labor-intensive job-the differences are striking. In 1990, while Boeing was turning out about 12 per month of its all-time best-selling commercial jetliner, the 737, it was planning to complete work on just one B-2 bomber per month (the production cycle for a much reduced order of B-2s will be still longer).

It is possible to exaggerate the differences in design requirements and manufacturing processes between defense and commercial production. Some military items (e.g., small arms and ammunition) and many intermediate goods destined for military items (e.g., some kinds of semiconductors) are mass produced in much the same way as-sometimes together with-their commercial counterparts. In fact, the famous American system of manufacture, involving interchangeable parts made on machine tools, was invented in the 19th century partly in U.S. armories for the manufacture of guns. Nevertheless, there are enough differences in design goals and manufacturing practices to add up to some wide divergences between defense and commercial companies. The DoD practice of imposing rigid, detailed specifications and standards throughout procurement further exaggerates the differences, and has blocked technological progress for defense applications in fast-moving fields such as fiber optics and optoelectronics. Defense contracts may lock in technologies and applications that no one producing commercially is willing to build at reasonable cost.

Still more pervasive are different management practices. In large part, these are a response to

[32] Markusen and Yudken, op. cit.

[33] H.R. 441.

[34] See, for example, U.S. Congress, Office of Technology Assessment, *Holding the Edge*, op. cit.

detailed government supervision. Defense contracting is probably the most heavily regulated business in the United States. In addition to the usual environmental, health and safety, and fair labor regulations that apply to all firms, defense companies must comply with DoD reporting requirements and undergo extensive reviews and audits. Some firms refuse to do defense work because they find that putting up with the audits is more trouble than it is worth. The reason for such detailed oversight was the government's concern that taxpayers' dollars not be wasted and that defense contracting not be prey to favoritism or fraud. But the supervisory system developed under Federal law and DoD regulation is extremely costly, both to the government and to companies. It demands extra people and time on both sides; the Pentagon has over 25,000 auditors, investigators, and inspectors, and the companies must employ tens of thousands of their own auditors to respond to DoD's demands for information. All this generates large overhead costs, which are then passed along in higher prices to the government. Probably a leading reason why most companies doing both defense and commercial work keep the two sides separate is so as not to burden the commercial business with the overhead from the defense side. Many companies, or divisions of companies, that learn to work with DoD's demands for high technical performance, to meet confining and sometimes outmoded military specifications, and to live with detailed supervision, simply restrict most of their business to defense.

Finally, commercial marketing and distribution are alien to defense companies. DoD prime contractors have a very few buyers to deal with and no need for a distribution network. It was marketing and distribution capacity, at least as much as experience in cost-conscious, high-volume manufacturing, that made Amana indispensable to Raytheon when the company went into the business of making microwave ovens for households.

DoD Practices on Development Costs and Data Rights

If a defense company does see commercial promise in military technologies it has developed, certain DoD practices related to government-funded R&D could be a real hindrance to commercial development either by the company itself or by a startup company licensing the technology. At present, DoD regulations require that companies selling products based on technologies developed at the department's expense to non-U.S. Government customers must pay DoD back for a pro rata share of its development costs.[35] The law does not explicitly require this recoupment of development costs, except in the narrow situation of sales of major military systems to foreign governments[36] (the idea is that the foreign governments should not get a free ride at the expense of American taxpayers). And the recoupment requirement is contrary to the spirit of several other laws and an Executive Order that encourage granting companies intellectual property rights to technologies developed with Federal funds, as an incentive to commercialization.[37]

The Administration recently proposed new regulations that would limit this cost recovery somewhat.[38] DoD would not demand recovery of R&D costs from subsequent commercial sales in some cases of minor military procurements (roughly, those that cost DoD under $50 million in development cost and result in less than $200 million in total sales to DoD and other parties). Also cost recovery would be restricted to sales of products using at least 50 percent of the original military system; the threshold now in force is 10 percent. Many in industry consider the proposals an improvement, but still question the need for any recoupment beyond what the statute requires.

Another impediment to the commercialization of military technologies lies in the treatment of data that firms develop or use for contracts with DoD. The issue is the extent to which DoD can acquire, use, and pass on such data. DoD often needs the data

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35 48 C.F.R., Part 271.

36 Arms Export Control Act of 1968, Public Law 90-629, as amended, see. 21, codified at 22 U.S.C. 2761(e).

37 These laws include the Stevenson-Wydler Technology Innovation Act of 1980, the Patent and Trademark Amendments Act of 1980, the Bayh-Dole Patent Amendments of 1984, the Federal Technology Transfer Act of 1986, the Omnibus Trade and Competitiveness Act of 1988, and the National Competitiveness Technology Transfer Act of 1989. The Executive Order is No. 12591 (Apr. 10, 1987). See the discussion in U.S. Congress, Office of Technology Assessment, *Making Things Better: Competing in Manufacturing*, OTA-ITE-443 (Washington DC: U.S. Government Printing Office, 1990), pp. 184-194.

38 56 Federal *Register 55250, 55264* (Oct. 25, 1991).

for various purposes. At the most basic level, it needs enough data to perform in-house training, operation, and maintenance. In some cases, DoD might want to hire third parties to perform some of these functions, and would need to pass on some data for the purpose. To allow competitive follow-on procurements of additional units and/or spare parts, DoD needs to provide data to prospective bidders. However, a problem for commercialization arises here. DoD's sharing of data rights with third parties could stop a company from developing commercial applications of a military technology, since if the data are available to others, the value to the company of the commercial product is likely to be lessened or lost. In fact, some company officials have told OTA that the prospect of DoD sharing their technical data with other firms is one reason for separating the commercial and defense sides of their business; they do not want to endanger the confidentiality of technology they have developed for commercial products by using the data in military projects.

DoD has considerable discretion in negotiating rights in technical data, within a broad statutory framework.[39] DoD always takes at least ''limited rights," for in-house use of the data for operation, maintenance, and so on, and on the whole industry does not complain about this. Companies do often complain when DoD seeks rights to use all the data for "government purposes. " This includes sharing the data with other firms for competitive follow-on procurements as well as for outside maintenance contracts. In principle, DoD can demand that other firms keep the information secret and use it only for the procurement at hand. However, it is hard to ensure that competitors will restrict their use of key information. Finally, DoD sometimes demands 'unlimited rights," which means that DoD can use or pass on the data for any purpose.

The technical data rights issue has been troublesome for decades. The pendulum has swung back and forth toward more or less rights for the government, and the law has grown quite complex, but so far there is no satisfactory solution that meets both the need for efficient procurement and the need to promote commercialization of government technology. Industry officials have asked to sit down with the government representatives to negotiate and draft regulations cooperatively, but the government has so far not seen fit to do this. In October 1990, the Administration proposed new regulations on technical data rights,[40] but these met with sharp criticism from industry and were withdrawn. The Defense authorization act, passed in November 1991, requires the establishment of an advisory committee with representatives from industry, government, and academia to draft revised regulations by June 1992.[41] Given the complexity of the issues, a cooperative effort may be the only way to get the problem solved.

MAJOR COMPANIES: PROSPECTS FOR CONVERSION IN THE 1990s

The obstacles to large-scale ventures by major defense contractors into commercial production are serious. Nevertheless, several companies had taken at least initial steps in that direction in the early 1990s, often beginning with sales to civilian government agencies.[42]

On the negative side, the differences between civilian and defense business are a daunting impediment to conversion. The record of defense companies that tried to make the transition in the 1970s—mediocre at best, technically embarrassing and financially draining at worst—is no inducement.

Prospects for conversion are still dimmer for a number of defense companies because they are carrying a high burden of debt. One reason is that many companies used debt to finance big expan-

39The governing statute is found at 10 U. C. 232o. DoD's governing regulations are found at 48 C.F.R. 227.4. The controversy is perhaps the greatest for data developed jointly at government and industry expense, for which the statute gives the least guidance.

@55 Federal *Register* 41788 (Oct. 15, 1990). The regulations would have applied to all Federal agencies.

41National Defense Authorization Act for Fiscal Years 1992 and 1993, Public Law 102-190, sec. 807. The act further provides that the Secretary Of Defense must issue revised regulations by September 15, 1992, and that for every regulation recommended by the advisory committee that he does not adopt he must report his reasons to Congress.

42A 1991 survey of executives at 125 defense companies found that most were planning to at least study commercial markets, that one-half had tried a commercial venture in the past 5 years, and that of those, one-half reported a success. However, these commercial ventures apparently included acquisition of existing commercial enterprises as well as conversion (as defiied here). David Hughes, ''Sumey on Defense Firm Commercial Efforts Shows Surprising Rate, Activity. " *Aviation Week & Space Technology,* Dec. 9, 1991, reporting on a survey by the Fraser Group and DRI/McGraw-Hill of Lexington, MA and the Winbridge Group, Inc. of Cambridge, MA.

sions in the Reagan buildup and now don't have the defense business needed to amortize those investments. According to one estimate, total debt as a percentage of capitalization in the defense aerospace industry rose from 28 percent in 1981 to 34 percent in 1989, and several big companies are considerably worse off than the average. For example, both Grumman and Lockheed have debt-to-equity ratios of more than 50 percent.[43] Moreover, some companies have taken enormous losses on freed price development contracts, in which they gambled hundreds of millions of their own money hoping to make it up by winning the production award. The losing team for the Advanced Tactical Fighter, Northrop and McDonnell Douglas, are reported to be out $750 million in their own funds on the project. General Dynamics, a member of the winning team for the ATF, still lost out in the A-12 cancellation, and is also saddled with long-term debt that rose from $18 million in 1984 to $636 million at the end of 1990. With these high debt burdens and with declining profits in the past few years, defense companies are not highly regarded in the stock market; aerospace stocks were selling at 5 to 8 times earnings in late 1990, versus 13 to 14 for all companies on the Dow Jones index.[44] Entering a risky new commercial venture takes money, which many of these big defense companies cannot easily raise.

The fact remains that many defense companies have military technologies they developed for military use that they recognize as possessing commercial, or at least nonmilitary, promise. The easiest move is into nondefense sales to governments. Westinghouse Electronics Systems, for example, has long supplied advanced electronic systems to DoD. Prompted by the defense build-down, the group is expanding in complementary civilian markets, including air traffic control and drug traffic interdiction (both having government purchasers) but is also reaching out to home security systems, which is a purely commercial market. The group's non-DoD market grew from 23 to 27 percent of sales in 1990, and is projected to reach 50 percent by 1995. Drawing on its experience in C^3I systems, Westinghouse is already a leading supplier of sensors for drug interdiction. TRW is pursuing a similar strategy. It has sold to the New York Stock Exchange a computer-based security system that guards access to the building and its various parts, such as the trading floor. Possible future customers for a TRW security system include embassies and airports.[45]

These examples, and others discussed above, make another point: defense companies that are interested in conversion have begun with products, as well as markets, that they know best. Two kinds of products that seem promising are information management systems and monitoring systems that rely on remote sensing devices. The latter might find application in environmental programs, as well as in security systems. Also, defense technologies that have achieved high performance in hostile environments might find uses by commercial companies that operate under similar conditions (e.g., in the deep sea, the desert, or the polar regions).

The same factor, product similarity, also makes it feasible for many companies in the aircraft business to shift from military to commercial work. None of the dedicated defense companies that do final assembly of military airplanes (Lockheed, Grumman, Northrop, General Dynamics) plan to become Ml-scale commercial airframes but, as noted above, all are doing subcontract work for the commercial companies or plan to do so. Some have gone into repair and rework of commercial aircraft on a fairly large scale. At the subsystems and components level, the opportunities to shift to the commercial side are still greater. For example, the Sundstrand company of Rockford, IL, a supplier of actuators, constant speed drive generators, and other hardware for aircraft, shifted from as much as 60 percent defense work to 25 percent in the 5 years 1985-90.

What major defense companies are now disinclined to do is embark on large-scale production of big hardware systems with which they have no familiarity--e.g., subway cars. The transit business was frustrating to aircraft companies in the 1970s not only because of their technological inexperience, and consequent false starts or failures, but also because of inconsistent government policy (i.e., the abandonment of uniform national standards for light rail car, and the decline in subsidies for mass transit

[43] Anthony L. Velocci, Jr., "Third-Quarter Results Mask Defense Industry Weakness," *Aviation Week and Space Technology, Nov. 12, 1990,* p. 20.

[44] Ibid.

[45] Glenn Zorpette, "Suppliers Are Challenged To Downsize Gracefully as They Seek To Diversify," *IEEE Spectrum,* vol. 27, No. 12, November 1990, p. 33.

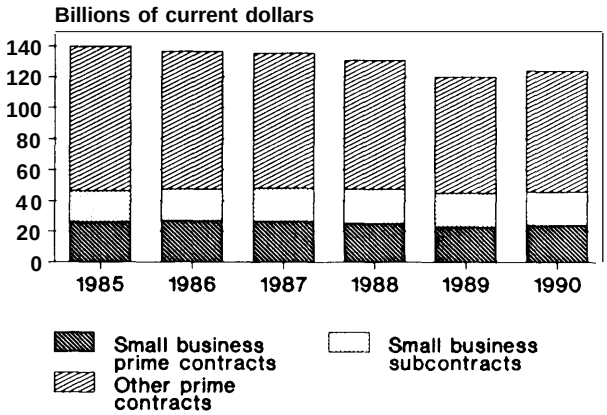
in the 1980s). However, there could be a new opportunity in the 1990s for some defense companies to use their technical expertise in developing certain challenging new transportation technologies, for example, electric vehicles. Support by States, especially California, for developing advanced transportation technologies makes the prospects more attractive. Box 7-E describes some of the possibilities.

SMALL BUSINESS AND THE DEFENSE INDUSTRY

Small and medium-size firms--collectively, "small business"[46]—are important players in defense production, accounting for over one-third of DoD purchases. Over the last decade, small business received $18 to $27 billion in annual DoD prime contract awards, or about 16 to 17 percent of all awards and 19 to 20 percent of awards to U.S. business firms.[47] Complete figures on subcontracts are not available, but reports by large firms to DoD indicate that small businesses have received $13 to $22 billion, or 37 to 40 percent, of military subcontract dollars over the last decade .48 The sum of prime contract awards and subcontracts from large firms to small business was on the order of $46 to $48 billion per year in the 5 years 1986-90, and amounted to 35 to 37 percent of awards to U.S. business firms[49] (figure 7-5).

The small and medium-size firms selling goods and services to DoD or its prime contractors are a diverse lot. Under Small Business Administration (SBA) definitions, these firms might range from a 10-person machine tool shop, to a semiconductor producer with nearly 500 employees, to a manufacturer of missile engines with just under 1,000 workers.[50] SBA oversees several congressionally mandated programs that are meant to help small

Figure 7-5-DoD Small Business Prime and Subcontracts



SOURCE: Department of Defense, Washington Headquarters Services, *Prime Contracts Awards, Fiscal Year* 1990 (Washington, DC: 1991).

firms compete for government contracts, both for procurement and for R&D.

Some small defense firms were started up for the purpose of selling to DoD, frequently by people who previously worked for large DoD contractors and understand the intricacies of the defense business. Often these firms are niche producers of sophisticated or specialized military goods and have little experience in commercial production and marketing. Some of them may simply close up shop if defense contracts or subcontracts dry up, but many are strongly motivated to survive by converting to commercial production. Other small companies that produce military goods, either as prime contractors or as subcontractors, already sell some of their output to commercial customers; many are looking to expand those sales.

Although information about small defense companies is limited, there is evidence that most have both military and commercial customers. For exam-

46A small business is defined by Small Business Administration regulations (FAR 19.101) as one that is independently owned and operated, is not dominant in its field of operations, and with its affiliates does not employ more than a specified number of employees (usually not more than 500,750, or 1,000, depending on the type of product called for by the contract). For construction and some service industries, the criterion is a specified annual dollar volume of sales or receipts, rather than the number of employees. This definition is drawn from DoD, Washington Headquarters Service, Directorate for Information Operations and Reports, *Prime Contract Awards.' Fiscal Year 1990*, DIOR/PO3-90 (Washington, DC: U.S. Government Printing Office, n.d.), p. 60.

47Ibid., table 3, p. 11. "Awards to U.S. business firms" are for work in the United States done by U.S.-owned firms. Other awards went to other government agencies, educational and nonprofit institutions, and foreign-owned companies.

48Ibid., p. 57.

49In the 5 years 198 1-85, prime contracts plus reported subcontracts to small business amounted to about 33 percent of the total awards to U.S. business firms, but the data are probably better for the later period. The number of large defense firms reporting to DoD the value of their subcontracts to small business rose continuously from 1,133 in 1981 to 1,664 in 1990.

50For construction and some service industries, the SBA criteria are specified dollar volume of receipts rather than number of employees.

Box 7-E-Opportunities for Defense Contractors in Advanced Transport

The state of land transport today is comparable in some ways to that of aviation 30 years ago. A physical infrastructure is in place, carrying a growing volume of passengers and goods, but the field barely incorporates any of the advanced electronic communications technology that supports modem aviation. Defense firms kinking to apply resources elsewhere might find some opportunities in advanced transportation technologies. An added attraction is that California, where many defense firms have their home, is in the forefront of promoting new transport technology.

California's Department of Transportation (Caltrans) is developing the State's transport infrastructure in several ways, guided by the goals of economic prosperity, environmental quality, energy conservation, equity, and mobility.[1] commuter rail transport, financed by a doubled State gasoline tax and a rail bond issue approved by California voters, is getting more emphasis. Although rail cars for the California systems are now made by foreign companies, the State's long-term, reliable financial support for commuter rail systems might attract U.S. companies into the field. Some American firms already make components and subsystems and some do the final assembly for largely foreign-made cars.[2] However, a more promising area for U.S. defense contractors might be in development of new technologies rather than expansion of existing systems.

Electric Vehicles

The California Clean Air Act of 1988 identified a range of strategies for arresting the decline of the State's air quality.[3] These included the use of low-emission vehicles, with annual targets that require an increasing fiction of an automaker's fleet to meet progressively tighter standards. In November 1991 the governors of nine northeastern states and the mayor of Washington, DC signed a memorandum of understanding agreeing to support adoption of the California rules in their States.[4] If all these States, and three others in the region that seem likely to join, adopt the California standards, 36.7 percent of the vehicles in the Nation would be affected providing a considerable encouragement to manufacturers of alternative fueled vehicles. California alone has an 11.5 percent share of the national market.

Various improved and new technologies based on alternative fuels could satisfy the standards. The strictest category, "zero-emission vehicles" (mcaning no measurable quantities of hydrocarbons, carbon monoxide, and nitrogen oxides), are first required in 1998 for 2 percent of an automaker's new models. 'he fraction grows to 5 percent in 2001 and 10 percent in 2003.[5] The only existing vehicles that meet these standards are electric vehicles (EVS). Hydrogen-burning internal combustion engine vehicles could also satisfy the emission requirements, but very few of these have yet been built, so that most potential manufacturers regard them as a longer term option.

The skills available in southern California including many in the aerospace and defense communities, are well-suited to EV production. However, the first EVs built in response to California's public policy initiatives will be foreign-made. In 1989, the Los Angeles City Council staged a competition for proposals to develop and build 10,000 EVs over 3 or 4 years.[6] The city offered the winner financial support in the form of long-term loans on favorable terms; by late 1991 they had amounted to $7 million: The city also agreed to buy some of the vehicles for its fleets, although most were intended to be sold to private customers.

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[1] California Department of Transportation, "California Transportation" Direction" Draft, Nov. 15, 1989.

[2] Under Federal "Buy American" requirements, which apply when Federal funds are involved in purchase of the ears, assembly of ears must take place in the United States and 51% of theeomponentsmust be made in America. Several foreign companies have opened final assembly plants in the United States in order to meet these requirements.

[3] University of California, Los Angeles, Lewis Center for Regional Policy Studies, *Prospects for Alternative Fuel Vehicle Use and Production in Southern California: Environmental Quality and Economic Development,* Working Paper No. 2 (UCLA: May 1991).

[4] The nine States were Delaware, Maine, Maryland, Massachusetts, New *Hampshire, New* Jersey, New York, Pennsylvania, and Virginia, with Washington, DC also party to the agreement. Connecticut, Rhode Island, and Vermont are also likely to adopt the new standards. Jim Henry and Kristine Stiven Breese, "Calif. Air Rules May Cover Northeast," *Automotive News, Nov. 4, 1991,* p. 1.

[5] *Automotive News*, Feb. 25, 1991.

[6] Material drawn from "Los Angeles Initiative Request for Proposals" and personal communication with Glenn Barr of Councilman Marvin Braude's office, Sept. 9, 1991. Councilman Braude was the author of the initiative.

Although General Motors is developing an EV, it did not put in a bid, nor did any large U.S. company. A Swedish/British company, Clean Air Technology (CAT), won with a proposal for a hybrid vehicle equipped with an electric motor and batteries for stop-and-go city driving and a small, precisely tuned gasoline engine for highway cruising. The four- or five-passenger vehicles will probably sell for about $25,000, a price that reflects the city's low-cost loans. The estimated launch date for the first 3,000 vehicles is the spring of 1992. The frost vehicles will be produced in Worthing, UK. Los Angeles representatives are exploring with CAT the possibility of setting up a manufacturing plant in southern California if the vehicle is successful, but nothing has been settled.

Another source of encouragement for production of EVs could be the Federal Government. The Surface Transportation Act of 1991, passed by Congress in November 1991, authorized $12 million for fiscal year 1992 to support at least three EV consortia.[7] The consortia are to design and develop EVs and advanced transit systems, related equipment, and production processes. At least one-half of the funds for the consortia must come from non-Federal sources; the act encourages them to include small businesses and defense and aerospace firms.

A group that aims to use the high technology talents in southern California for making EVs is Amerigon, of Los Angeles.[8] Founded in 1990, the company is coordinating small and medium-sized aerospace and other high technology firms in the area to produce subsystems for an EV, the prototype to be ready in early 1992. According to Lon Bell, Amerigon's founder, the technology of EVs is so different from that of vehicles powered with internal combustion engines that the established automobile manufacturers, with their tremendous resources sunk in one sort of production technology, are not the natural suppliers of EVs. Bell's approach was to match lists of customer or user requirements with available skills, breaking down the EV into 45 subsystems that can be developed independently, and seek the appropriate local engineering firm to work on each of them.

Many of those involved in the enterprise believe that major aerospace companies are no more likely than the big auto companies to become successful EV producers, in part because the aerospace managers and engineers are accustomed to a business in which product cycles are at least 15 years. Aerospace subsystem producers, on the other hand, might be the source of skills that could forma supplier base for a new kind of vehicle industry. Also, marketing to mass consumers is not a strong point of defense and aerospace fins, but marketing will obviously be an important factor in launching widespread EV use. Although California's Clean Air Act requires that a certain fraction of autos be zero-emission vehicles, it is not clear that consumers will want to buy them. Today's EVs are expensive and limited in driving range. By 1998, the price and other qualities may be more appealing, but they will still be unfamiliar. The first purchasers may well be companies or agencies with specialized needs (e.g., utility companies, the Postal Service), but if they ever are to make a big difference in air quality and oil consumption, a mass market of consumers will have to develop.

Smart Cars and Highways

Some quarters of the defense and aerospace business see promising conversion opportunities in the range of technologies termed "smart cars and smart highways. " Although the technologies do offer some potential for application of the skills of defense firms, the potential has rather narrow limits.

Smart cars and highways--or, more formally, intelligent vehicle and highway systems (IVHS)--are meant to ease the increasing congestion on American roads by employing many of the technologies widely used in defense and aerospace: communications, sensors, electronic controls, and systems integration. IVHS technology uses computerized signals, driver information systems, and automatic vehicle control for traffic management. The most advanced form of IVHS is an automated highway network, in which cars are controlled by signals from the road. Such a system would require expertise in the integration of many complex subsystems of communication, sensors, information processing, and so forth-similar to what major defense contractors do for other purposes.

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[7] H.R. 2950, the Intermodal Surface Transportation Infrastructure Act of 1991. No funds have yet been appropriated for the EV program at this writing. Funds maybe reprogrammed from elsewhere in the Department of Transportation's budget, or an appropriation may be sought in the second session of the 102d Congress. Other bills relevant to EVs included S. 324, the National Energy Strategy Act of 1991, which included as a short title the Electric Vehicle Technology Development and Demonstration Act of 1991, and authorized a total of $60 million of R&D and demonstration programs. It failed to pass, however. H.R. 1538, the Electric Vehicle Act of 1991, which also provided R&D support, was reported to the House in September 1991, but has gone no further.

[8] Lon BeChairman of Amerigon, personal communication Sept. 23 and 24 and Oct. 17, 1991.

(continued on next page)

Box 7-E-Opportunities for Defense Contractors in Advanced Transport --Continued

The trouble **is that the opportunities for defense companies are probably greatest in advanced IVHS systems, and these are the farthest from realization. The technologies need further development, and installing them would not only be expensive but would require sophisticated cooperation among many public and private institutions. For example, establishing an electronic toll and traffic management system in a large metropolitan area, where Federal, State, local and city jurisdictions adjoin and overlap, would involve negotiating daunting institutional barriers. Furthermore, some of these systems might encounter strong consumer resistance; drivers may object to ceding control of their cars to an electronic system.**

In the near term, the most promising commercial applications of IVHS technologies are less complex, e.g., computers in cars to give drivers continuously updated information on traffic conditions and routes. The manufacture of such devices demands the kind of experience and knowledge possessed more by producers of consumer electronics than by firms making defense and aerospace equipment. In this market, companies will be left behind if they lack abilities for rapid design, volume production, and effective marketing of cheap, reliable items that are easy to use without special training or continual maintenance.

The more advanced forms of IVHS are unlikely to develop without strong government backing. Federal spending for IVHS has been small, but could increase greatly in the next few years. Federal funding for the technology was about $2.3 million in fiscal year 1990 and $20 million in 1991. The highway bill passed by Congress in November 1991 authorized $660 million for IVHS research over the next 5 years. According to the General Accounting Office, a program to develop IVHS might require total government R&D funding (State and local as well as Federal) of as much as $34.4 billion over the next 20 year[9] While this is a substantial amount, it does not compare to the sums of about $30 billion per year that the Federal Government has paid defense contractors for research, development, testing, and evaluation in recent years.[10]

IVHS could be one component in the Nation's response to its transportation needs. It may offer some defense companies the chance to apply their skills, but it probably will not amount to much of their business in the near to medium term, and entry to the field will not be easy.

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[9]U.S. General Accounting Office, *Smart Highways:* An Assessment *of Their Potential To Improve Travel*, GAO/PEMD-91-18 (Washington, DC: May 1991).

[10]In fiscal year 1990, DoD contracts to private industry 'or research, development, testing, and evaluation amounted to $192 billion (Department of Defense, *Prime Contract Awards, Fiscal Year 1990*, DIOR/PO3-90 (Washington, DC: DoD OSD Directorate for Information, Operations, and Reprints, 1990)). In addition, DoD reimbursed private companies $3.6 billion for defense-related independent R&D and bid and proposal spending (Dr. Joe Golden, staff specialist for special technology program, Office of Deputy Director of Defense Research and Engineering for Research and Advanced Technology, personal communication, Nov. 25, 1991); the Department of Energy spent $3 billion in de.rmsc-related Contract R&D, some of which went to private companies (Department of Energy Defense Programs, *Multi-Year Program* Plan, December 1990).

pie, a 1989 survey of 97 small and medium-size prime DoD contractors and subcontractors in Ohio found that in 57 percent of the firms, half or fewer of employees worked on defense contracts; and 65 percent of the firms reported that half or less of their profits came from defense contracts.[51] A 1990 survey of prime defense contractors (mostly small) in New England showed that 40 percent of sales were to DoD.[52] Interestingly, manufacturing firms (286 of the 355 firms responding) were less defense-dependent than service sector firms; 37 percent of their sales were to DoD, compared to 52 percent for all the service firms, and 69 percent for business service companies. In St. Louis, 152 prime defense contractors (again, mostly small) responding to a survey reported that 27 percent of their sales were defense-related companies to 62 percent in the private domestic market.[53] A 1991 survey of prime defense contractors in Pennsylvania found that,

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[51]Marketel Info-Systems, Inc., Taratec Corp. and Lorz Communications, Inc., *Ohio's Changing Defense Procurement Patterns: A Company Perspective,* report to the Ohio Department of Development, Small and Developing Business Division, Jan. 8, 1990, app. C. The questionnaire did not ask what percentage of sales were due to defense contracts.

[52]Bank of Boston, Economics Department, "Swey of New England Defense Contractors," October 1990.

[53]St. Louis Economic Adjustment and Diversification Task Force, "Suxvey of Defense Prime Contractors in the St. Louis Metropolitan Area," September 1991, table 5. Although McDonnell Douglas responded to the survey, most of its responses were omitted from the statistical analysis.

overall, sales to DoD averaged 13 percent of all sales.[54] Large firms (over 500 employees) were just about average in defense dependence. The highest rates of defense dependence were found in the very smallest manufacturing firms (under 20 employees), with 45 percent of sales to DoD, and in medium-size manufacturing firms (250-499 employees), with 30 percent DoD sales.

Adjustment Plans of Small and Medium-Size Defense Firms

It seems reasonable to expect that small companies already making commercial as well as military sales are in position to increase their commercial sales. Although these firms must keep separate accounts for their defense work, their managers and work force, very often their production equipment and sometimes the product itself are the same for their military and commercial customers. Unlike major companies that are in both defense and civilian business, small companies rarely have separate defense divisions. Small metalworking companies, in particular, are inherently dual use.

While it may be technically feasible for these companies to substitute commercial work for declining defense contracts, it is not necessarily easy. There may not be enough commercial work to go around. In a Maryland survey of small defense contractors and subcontractors, respondents cited competition as their number one problem in getting new commercial customers .55 OTA found the same concern in interviews with several small custom machine shops in Massachusetts in May 1991. At one shop, which has four computer numerically controlled (CNC) machine tools, 17 well-trained employees, and an excellent reputation, the owners were spending most of their time chasing new commercial customers, without much success. This interview took place at a low point in the recession, which hit central Massachusetts especially hard; times may improve. However, many of the owners doubted that commercial customers could make up for loss of defense contracts in the custom machine business. Some voiced fears that job shop work would go overseas.[56]

Aside from the critical flaw of too few commercial customers, and despite their success in recent years in getting defense contracts, all of these Massachusetts shops much preferred commercial to defense business. The owner of one explained that there is no loyalty in DoD contracting and little repeat business, which means there is a new learning curve on each order, which in turn lowers profits. DoD business also involves waste of time-in waiting for contracts, waiting for clarification of drawings, extra paperwork, and the incredible detail of military specifications. With commercial customers, the shop can develop long-term relationships and trust; take orders or ask for clarifications over the phone; and get orders for many different parts or long runs of particular parts without going through new bids and new competition.

Managers of several machine shops emphasized that their equipment and people are dual use. In fact, high-tech production and quality inspection equipment bought for defense work has made them more versatile and competitive in commercial markets. For example, one pointed to the precision capabilities in his shop as allowing him to produce bearing housings for fine graphics printing presses, where tolerances are extremely exacting, and to build tools for the manufacture of semiconductor chips. Another shop makes block-and-pin type universal joints for everything from bowling alley cleaners and garbage compactors to machine gun drives, tank turrets, and missiles. The president of this firm thought that loss of defense business, with its low profit margin and administrative hassles, was a real opportunity to go out for more commercial work. The firm recently bought a 4-year-old shop with all CNC machines, highly trained workers, a broad sales base, and a manager who is a Jehovah's Witness and will not do defense work.

Still another Massachusetts firm makes small hand-held borescopes--remote optical viewing equip-

[54] Pennsylvania Industrial Resource Centers and KPMG Peat Marwick, "Survey of Department of Defense Contractors in Pennsylvania," n.d. The survey was sent to 1,705 establishments in Pennsylvania% responses were received from 187 manufacturing and 144 nonmanufacturing firms. Sales data were for 1989.

[55] Preliminary results of a survey by Maryland's Department of Economic and Employment Development reported to a symposium of the National Governors' Association Apr. 5, 1991. Complete report is forthcoming.

[56] Both Pratt and Whitney—a major customer for New England machine shops—and GE Aircraft Engines were said to be sending job ShOp orders abroad. This may reflect the increasing frequency of offset agreements in sales of aircraft engines to foreign customers (i.e., agreements to subcontract some of the work to the country of the purchaser).

ment for looking into areas normally inaccessible to the human eye. The company started up in the early 1970s, making devices for looking into reactor cores for the then-thriving nuclear power industry. In the 1980s, the company turned to DoD as a customer, making equipment for inspecting aircraft engines and gun barrels. But in the later 1980s company managers decided to rely less on DoD sales, with its tight regulation, low profits, and unreliable repeat orders. They moved into medical applications, which is the biggest and fastest growing market for borescopes. It was easy for them to meet Food and Drug Administration quality requirements since they were already meeting tough DoD standards for quality and durability. Ohio firms also reported that equipment and skills they acquired for precision machining of military goods could be applied to health care products, where close tolerances are also demanded.[57]

Although some of these firms have found new commercial customers with considerable success, the main worry of most small to medium-sized defense firms in shifting to more commercial business is in sales and marketing. Surveys of New England, and Ohio firms pointed to marketing as the top concern.[58] The companies mentioned availability of financing as a second major constraint in getting into new or expanded commercial production.

The Pennsylvania and St. Louis surveys found similar results although the questions were framed differently .59 Asked to rank kinds of business assistance that interested them, the St. Louis firms rated market research and marketing strategies first and second. Access to financial assistance was ranked third. As in Ohio and New England, the St. Louis firms evinced considerable interest in export markets. In Pennsylvania, over half the firms reported that they were developing domestic markets in response to anticipated DoD cutbacks; about one-third said they were developing new products, revising marketing plans, or developing international markets. Over one-third of manufacturing firms were interested in financial assistance for machinery and equipment or for new product development; about 20 percent were interested in technical assistance for new product development.

If small firms that already have a mix of defense and commercial sales find difficulties in the way of expanding their commercial business, the problems would seem to be still greater for companies that concentrate on defense production. Even here, however, there are success stories. One of the best-known examples of conversion to commercial production, dating from the 1970s, was of a relatively small company, Rolm Systems.[60] Rolm's conversion effort began in 1974, in the aftermath of the Vietnam War, but it was not so much a response to loss of military business-military sales were still holding up-as a desire to continue the company's rapid growth.

Rolm Systems was founded in 1969 to produce rugged computer equipment under license from Data General. The market was largely military, both U.S. and foreign, but also included some oil and paper companies that used computers in the field. Rugged computers remained the company's entire business until 1974, when management began to explore getting into production of telecommunications equipment, in particular private branch exchanges (PBXs) for businesses. Managers calculated that the company was reaching the limits of the market for rugged computers (at around $20 million a year), and sought to diversify in order to continue the rapid growth of their first 5 years. The choice of the business telephone market was a natural one; PBXs have much in common with computers, and 80 percent of the technology needed was already available within the company. New people were brought in for sales and marketing, and for aspects of telecom technology that diverged from computers. Rolm's first telecom offering was in 1976; by 1982 PBXs were half of the company's business. At that point, IBM bought the company but later sold the military computer business to Loral, at the behest of the Justice Department on antitrust grounds. Both descendants of the original company were doing well in 1991.

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[57] Marketel Info-Systems, Inc., et id., Op. cit.

[58] Bank of Boston, op. cit.; Marketel et al, op. cit.

[59] Pennsylvania Industrial Resource Centers and KPMG Peat Marwick, op. cit.; St. Louis Economic Adjustment and Diversification Task Force, op. cit.

[60] Material for this section comes from interviews with company officials of Loral Rolm Mil Spec (Loral now owns the Rolm military computer business) and IBM's Rolm Systems (IBM now owns the Rohn PBX business).

A more recent example of conversion of a small defense company is the Frisby Airborne Hydraulics company of Freeport, NY. This company, long a captive of the military airframe companies on Long Island, has deliberately reduced its defense dependence from **90** to **25** percent. Frisby had the advantage that some of the products for its military and commercial aircraft company customers were very similar; but it also found new commercial applications and customers for a technology (a heat resistant, leak-proof solenoid valve module) it had developed for the military, and it is now starting production of a wholly new product in the commercial field. The transformation was not easy. It took vigorous efforts to sell to new customers, improve productivity and lower costs, and adopt a new management style based on improved worker training and labor-management collaboration.

Government Programs To Help Small Companies' Adjustment

Several government programs that are designed to assist small business generally could be suitable for helping small defense firms expand their commercial business. At the Federal level, many laws give special breaks to small business. For example, the ''Buy American' laws that affect U.S. Government purchases of many items give a price advantage of 6 percent to U.S. firms generally (i.e., the government must buy American unless the price offered by a foreign firm is at least 6 percent lower), but small businesses get a 12-percent advantage.

There is special Federal financial help to small business, mostly in the form of government-guaranteed loans; these amount to about $3.5 billion a year ($3.6 billion in fiscal year 1990). In addition, the Small Business Investment Corporations and the Minority Small Business Investment Corporations, private companies licensed by SBA, are subsidized by the Federal Government to the tune of about $84 million in 1990. These corporations make equity investments as well as loans to small firms, amounting to $629 million in fiscal year 1990, Many States have financial assistance programs of various kinds for small business,[61] and though figures on the total available from these programs do not exist, they are probably bigger and almost certainly more varied and accessible than federally guaranteed loans. For a small example, two of five Massachusetts small metalworking firms interviewed in depth by OTA had built their plants and bought machinery using low-interest financing from the Massachusetts Industrial Finance Authority; none had used a federally guaranteed loan from SBA for the purpose.

The SBA also operates a few programs that offer business management and marketing advice to small firms--most often, small retail or service establishments. The Small Business Development Centers (SBDCs) are mostly located on college campuses, provide advice from faculty or students on particular problems firms bring to them, and get half their funding from their home college or university (the other half comes from SBA). Fifty-three SBDCs, located in 46 States, were supported by $55 million in Federal funds in fiscal year 1990. SBA has recently begun efforts to strengthen the SBDCs' ability to serve small manufacturing firms with technical and managerial advice.

Volunteers in the Service Corps of Retired Executives (SCORE) offer brief workshops and counseling on business management to small fins. According to some who have received their services, their greatest benefit is entree to networks in which the SCORE volunteers are well established members.

A Federal program that could prove especially useful to small defense companies is the Small Business Innovative Research (SBIR) program, which set aside $460 million of Federal R&D money for small businesses during fiscal year 1990. Under this program, established by Congress in 1982, Federal agencies with R&D budgets of more than $100 million a year must set aside 1.25 percent of their contract money for small and medium-sized firms. In 1989, 3,183 awards were given to small companies to do R&D work for Federal agencies. The program is in two stages: first, feasibility studies of promising ideas (2,346 awards in 1989, for a totaI of$118 million); second, development of the ideas with the greatest potential (837 awards, $341 million).

The General Accounting Office has issued several reports on the SBIR program, generally giving it

61 For a description of a highly varied and innovative pro-of financial aid to business in the State of Michigan, see Letitia L. Oliveira, "Digging Out From Hard Times: Economic Recovery in Michigan and Pennsylvania,' contractor report prepared for the Office of Technology Assessment August 1990.

high marks for effectively funneling R&D money to small firms and helping young companies develop advanced technologies.[62] A possible major shortcoming of SBIR, from the point of view of companies' converting to commercial production, is that DoD is the biggest funder (since it has far more R&D contract money than any other Federal agency).[63] However, for this very reason the program could offer real opportunities to adapt military technologies to civilian use. Frisby Airborne Hydraulics did just this in forming a partnership with a North Carolina firm that won an SBIR award from the Air Force for a heat exchanger to cool airplane engines. Frisby intends to market the technology to a variety of commercial customers, not only in aircraft but possibly also in electronics (see box 7-F).

Another kind of program that offers promise to small defense companies intending to convert to commercial production is technology extension assistance.[64] Technology extension has real potential to raise the performance of America's 350,000 small manufacturing firms (not just defense fins), but such programs are still quite few and scattered. They exist at both the State and Federal levels, but the States are ahead. In early 1991, 16 States had genuine extension programs (defined as those setup to give one-on-one technical advice to individual fins, with field agents as part of the program), and another 7 had technology demonstration or assistance centers. Most of these centers are fairly new, but a handful have several years' experience and one (Georgia Tech's highly regarded Industrial Extension Service) has existed for nearly 30 years. A rough estimate of what States spend on these programs is $50 million a year. Congress established a Federal program in the 1988 trade act; by 1991 it included five Manufacturing Technology Centers and was funded at about $10 million. Congress has shown considerable interest in strengthening and expanding technology extension. The **FY92** funding for Manufacturing Technology Centers was increased to $15 million, but several other bills that received serious consideration in the 102d Congress would broaden the present program and authorize spending of as much as $50 to $75 million a year.[65]

The contribution technology extension can best make to small firms is not so much state-of-the-art products straight out of the R&D lab, but rather acquaintance with best practice in manufacturing. Many small defense firms are at the cutting edge technically, and some may be prepared to enter commercial markets at the high end.[66] However, many can use help in getting their productivity up and costs down by such things as organizing work to get rid of waste, acquiring the right machinery for the job and using it efficiently, training workers in techniques for in-process quality control, and encouraging worker participation in production improvements.

Learning how to sell in the commercial world is a particular challenge for small defense fins. Some States include in their range of services to small firms assistance in finding customers. For example, in the late 1980s Michigan developed its Market Scout program to help auto suppliers move into new markets. On the basis of input-output tables, the program generated a detailed list of industries that buy from particular supplier industries and have the potential to be good customers (e.g., declining industries were pruned from the list). Market Scout also developed data on what alternate products a supplier might be able to make, given certain specific kinds of machinery and workers in certain occupations, and what industries would be likely to buy them. Like many other States, Michigan was in dire financial straits in 1991, and it cut out funding for Market Scout and several other innovative business support programs.[67]

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[62] Comptroller General of the United States, General Accounting Office, *Implementing the Small Business innovation Development Act—The First Two Years,* GAO/RCED-86-13 *(Washington DC: 1986); A Profile of Selected Firms Awarded Small Business Innovation Research Funds,* GAO/RCED-83-113D (Washington, DC: 1986); *Effectiveness of Small Business Innovation Research Program Procedures,* GAO/RCED-87-63 (Washington, DC: 1987); *Small Business Innovation Research Participants Give Program* High *Marks,* GAO/RCED-87-161BR (Washington, DC: 1987); *Federal Research: Assessment of Small Business Innovative Research Programs,* GAO/RCED-89-39 (Washington DC: 1989).

@With declines in defense spending, DoD R&D funds could be cut; however, it was one part of the national defense budget.

@For detailed discussion of technology extension programs in the United States, see OTA, *Making Things Better,* op.cit., chs. 2 and 7.

[65] See ch. 2.

66 Even firms that make highly sophisticated products may not be prepared to sell in commercial markets, however. They may need to redesign their product, get manufacturing costs down and reliability up, and strengthen their marketing.

[67] The nonprofit Industrial Technology Institute (which had developed the program under State grants) took over *the* program on a pay-for-mice basis.

Box 7-F—Frisby Airborne Hydraulics: Conversion in a Small Defense Company

Frisby Airborne Hydraulics, with about 100 employees, was a "captive" Long Island subcontractor to Grumman and Fairchild-Republic for over 30 years.[1] According to its co-owner, Greg Frisby, the 1987 cancellation of the T46A trainer program after production of only two planes was "devastating." Since DoD had planned for 400 T46As, the company assumed that the trainer was a long-range military commitment Frisby spent $300,000 developing the required advanced hydraulic control system, with a heat-resistant, leak-proof solenoid valve module that could be placed close to the engine. When DoD canceled the contract, the company received a government check for $40,000 in compensation.

Nevertheless, Frisby managed to survive and prosper while reducing its dependence on military contracts from 90 to 25 percent-and at the same time, keeping to a primary goal of no worker layoffs. It did so through a combination of aggressive marketing, changing its management style, and increasing worker participation in production decisions.

Frisby hired a sales team who agreed to work on commission and were familiar with the needs of the aerospace industry, and it backed up the sales effort with extra responsive customer service. About this time, Boeing (already a Frisby customer) announced "Operation Eagle," in which all its suppliers were to reduce prices 25 percent and freeze them at that level for 5 years. Frisby, with some trepidation, signed the contract. This prompted the company to add a major push for increased productivity to its marketing and service efforts.

Frisby moved to "participative management" in improving product design and production efficiency. It eliminated a layer of management, setup an employee committee on cost-cutting, instituted profit-sharing, offered flexible work shifts, encouraged hourly workers to contribute to production improvements, and held monthly financial statement review meetings with all employees. It cross-trained employees, all of whom now have a second skill, and paid for employees' education, based on grades. It taught English to non-English speaking employees (everyone from porters to operators).

According to Frisby's owners, the results of these efforts include:

- **50-percent reduction of scrap over each of 3 years 1987-90;**
- **20-percent reduction of rework costs;**
- **no employee turnover in 1989-90;**
- **improved profit margins;**
- **30 percent growth in sales volume; and**
- no layoffs-in **fact, increased employment.**

[1]This account of the conversion of Frisby Airborn Hydraulics from a predominantly defense company to a mostly commercial company is drawn mostly from Linda Kravitz, "Wages of Peace: Community and Industry Experience With Military Cutbacks," contractor report prepared for the Office of Technology Assessment, August 1990, and is baaed on an interview with Greg Frisby, co-owner, May 16,1990 and on "Economic Adjustment After the Cold War," testimony by Greg Frisby before the Joint Economic Committee, Us. congress, Mar. 20,1990.

(continued on next page)

Some States are making explicit efforts to target their existing business assistance programs to defense contractors. For example, Ohio recently held a conference bringing together small defense contractors to help identify new markets. Connecticut Innovations Inc., a quasi-public State financing agency, has set aside $2 million to invest in defense-dependent firms to help them fund new product and market development.

A few State and local governments are creating new programs for the specific purpose of helping firms convert from defense to commercial production. For example, the California Aerospace Supplier Improvement Program is working with small aerospace subcontractors to help them modernize their production processes, in response to defense spending reductions as well as tougher international competition.[68] Jointly administered by California's

[68]The program's promotional materials state: "Faced with reductions in defense spending as well as international competition, there is mounting pressure for many fins, particularly suppliers to aerospace companies, to explore more efficient manufacturing techniques."

[69]California's Employment Training Program is funded by an employers' payroll @x similar to the unemployment insurance tax; it can be used to retrain displaced workers or active employees who need remaining in order to avoid displacement.

Box 7-F—Frisby Airborne Hydraulics: Conversion in a Small Defense Company--Continued

Frisby is now producing hydraulic actuators, micro pump packages, and valves of varying complexity for Boeing, McDonnell Douglas, Beech, and Cessna. Boeing now represents 40 percent of Frisby's sales. Frisby has evidently become a favored supplier, since Boeing does not 'compete' the company, that is, solicit bids from other companies. Frisby still has military sales on the C-17, and while it values these sales, Frisby's co-owner comments that "the paperwork requirements for the C-17 couldn't fit into the airplane."

While improving its sales, service, management, and productivity, Frisby also found another market for its heat-resistant and leak-proof solenoid valve developed for the T46A; i.e., in deep hole oil drilling. A new plant in Clemmons, NC will be home for assembly, repair, and overhaul of Frisby's solenoid manufacturing operations. Moreover, Frisby has entered into a partnership with an R&D firm to commercialize a Small Business Innovative Research (SBIR) Phase II winning system for advanced cooling of avionics and electronics. The R&D firm, from North Carolina, had won 34 SBIRs. Its heat transfer technology, developed with funding from the Air Force, provides a better way to cool avionic systems. The system can cool radar engine systems 40 times better than air or water. Large aerospace braking systems contractors are interested in this technology; it might also be used to cool semiconductor circuit boards. This production too is scheduled for North Carolina

Frisby's owners believe that their successful transition was largely due to the flexibility inherent in smaller companies, and to products readily adaptable to commercial in the aircraft business. They "do not believe that it is impossible for large contractors to make similar transitions. ' However, in noting the disinclination of some large contractors, Frisby's owners noted that they had received no response from one big company to their proposal for a joint undertaking to produce a major hydraulic system needed for the Boeing 777 airplane. Frisby looked elsewhere, and has found a more commercially oriented prospective partner.

According to Greg Frisby, "What is urgently needed [for company conversion] is unprecedented communication and cooperation between labor and management. Employees must be willing to cross-train, cost-share through concessions and do whatever else is necessary to aid in the transition. Management, though, must work hand in hand with labor and include employees in all restraining, productivity and cost savings decision making.

Department of Commerce, Employment Training Program,[69] and community colleges, the program provides training in total quality management, including statistical process control, just-in-time procurement, and teamwork/communications, through workshops at four Centers for Applied Competitive Technologies and through onsite training. In the program's frost 2 years, employees from more than 1,600 companies are expected to attend the seminars, and 200 companies are expected to enroll in the more in-depth, onsite training.

At the Federal level, there is scarcely any assistance specifically targeted to defense firms wishing to convert. However, DoD's Office of Economic Adjustment (OEA), a small agency whose experience lies mostly in helping communities plan for adjustment to military base closings, is involved in a demonstration project for that purpose. The OEA is working with the State of New York and local communities to provide technical assistance to nine defense contractors on Long Island, to help them move into commercial markets. A technical consultant is working with the firms to develop strategic plans and help them apply for assistance from local, State, and Federal Government programs to implement the plans. OEA provided $100,000 for the project, the State $70,000, and the nine firms $120,000; local governments and the Chamber of Commerce will provide another $50,000 to $70,000 in-kind support. The nine firms selected are in three size categories and three categories of defense dependency (75 to 100 percent defense, 50 to 75 percent, and up to 50 percent).

[69]California's Employment Training Program is funded by an employers' payroll @x similar to the unemployment insurance tax; it can be used to retrain displaced workers or active employees who need retraining in order to avoid displacement.