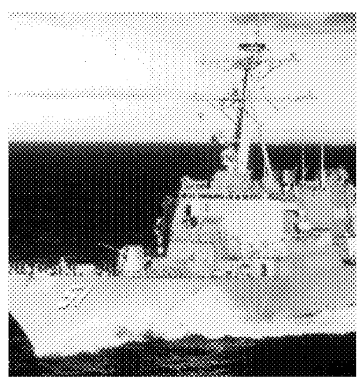
Case Study 3: Shipbuilding

The importance of an American shipbuilding industry has long been the subject of debate. A strong U.S. shipbuilding industry is considered an essential national attribute by many observers. The United States is, after all, a maritime nation, is one of the world's largest trading nations, and has the world's largest single national economy. Many of the nation's goods are shipped by sea. Further, the world's oceans are critical to U.S. military security. Indeed, every significant U.S. military engagement in the 20th century has included ocean transportation of U.S. military forces. The oceans that provide barriers to foreign threats also make deployment of American forces abroad more difficult. But while the United States has developed and deployed the largest and most technically advanced naval forces to guard its approaches and to project U.S. military power; in the post-World War II period, foreign-owned and foreign-built ships have provided most of the nation's ocean transportation.[1]

The U.S. shipbuilding industry has been in decline since the mid-19th century, when except for wartime production, it peaked. Over the years, the U.S. government has enacted many laws designed to retain shipbuilding capabilities. For example, laws passed in the late 19th and early 20th centuries granted a monopoly to U.S. shipyards to build ships for trade between U.S. ports. A 1936 law authorized a direct subsidy to shipyards building vessels for U.S. foreign trade, and U.S. naval construction, repair, and overhaul work has largely been reserved for domestic yards. Nonetheless, many argue that there is less long-term government



[1] Some of these ships have U.S. owners but foreign registry, largely to reduce costs associated with U.S. labor and safety laws

support for shipbuilding than for competing transportation technologies such as aviation.

Concern about the health of the entire shipbuilding base grew, however, as fierce global competition and a worldwide slump in shipbuilding reduced American commercial large-ship construction to zero. This situation was compounded by the reevaluation of naval requirements and the subsequent reduction in naval shipbuilding as a result of the end of the Cold War. By the end of the 1980s, the Bush Administration had concluded that "Navy shipwork alone will not sustain the U.S. Shipbuilding Industrial Base."[2]

Expected reductions in naval forces make it even more difficult for Navy work alone to maintain a viable U.S. shipbuilding industry. Critics argue that a strategy focused solely on Navy shipbuilding can neither provide the Navy with affordable ships, nor provide the basis for rapid expansion of naval construction if such an expansion is needed in the future.[3]

Two principal alternatives have been suggested to preserve a Navy shipbuilding capability. One is to shrink to a small shipbuilding base dedicated to military shipbuilding. A second alternative is to reestablish the United States as a globally competitive commercial shipbuilder and to use the renewed commercial capability, which would reside in an integrated base, to help meet future U.S. Navy needs. The Shipbuilders' Council of America for example, has stated that: "The only way a reconstitutable shipbuilding base can survive in the United States is for U.S. yards to build commercial ships."[4] During the course of OTA's civil-military integration study, the potential for an integrated shipbuilding base was examined.

In the face of the moribund U.S. commercial shipbuilding program for large ships, however, reestablishing a commercial base is indeed a challenge. In 1993, the United States, the world's largest trading nation, ranked a distant 27th in merchant shipbuilding, with two-tenths of 1 percent of the world's gross tonnage on order and only one commercial ship under construction.[5] During the course of the CMI assessment, a significant government effort aimed at enhancing U.S. commercial shipbuilding was initiated. This effort is discussed later.

This case study considers the potential for integrating the defense shipbuilding base with a reestablished commercial base. The study briefly outlines the current structure and condition of the U.S. shipbuilding base. It discusses the national security shipbuilding base that might be needed in the future and considers some market trends. It examines alternatives for reestablishing a commercial element of the base. Finally it considers factors that inhibit integration and factors that favor integration in shipbuilding.

STRUCTURE AND CONDITION OF U.S. SHIPBUILDING BASE

The shipbuilding industry includes shipyards that build, repair, and overhaul ships; component producers that develop and build critical ship parts; research organizations that explore new marine technologies; and design firms. The industry has an extensive public sector component composed of shipyards, research laboratories, supporting naval industrial centers, and the Navy's ship-acquisition organization. This public sector portion

[2] U.S. Department of Defense, *Report on the Effects of Navy Shipbuilding and Repair on U.S. Public and Private Shipyards and the Supporting Industrial Base*, January 1990.

[3] A 1992 report by the General Accounting Office, for example, noted that the costs for submarines and other ships being built by the two submarine shipbuilders would probably increase because of the amortization of overhead costs over a smaller production base; a smaller but more senior, and therefore more highly paid, workforce; and higher vendor costs. U.S. General Accounting Office, GAO/NSIAO-93-32-BR (Washington, DC: U.S. Government Printing Office, 1992).

[4] Shipbuilders Council of America presentation to Presidential Transition Team, Washington, DC., Dec. 14, 1992.

[5] U.S. Department of Commerce, *U.S. Industrial Outlook 1994: Shipbuilding and Repair* (Washington, DC: U.S. Government Printing Office, January 1994), p. 21-1. Japan led the world with 31 percent, South Korea with about 20 percent, and China with about 5 percent.

of the base is important to any strategy for integrating the commercial and defense bases. It currently does much of the repair and overhaul work and has a profound impact on military construction.

The shipbuilding base is geographically dispersed and is a major source of employment. According to Department of Labor statistics, over 109,000 people were employed in shipbuilding and repair alone in 1993 (down from 123,000 in 1992). Employment generated in the lower, or supporting, tiers is also probably significant. For example, OTA estimates of spending patterns based on Bureau of Economic Analysis input-output analysis data indicated that in calendar year 1992, defense shipbuilding purchased almost $7 billion in goods and services at the first tier (i.e., government prime contracts to firms classified under the Standard Industrial Classification under SIC 3731—shipbuilding and repairing). This spending, in turn, induced demand of almost $3 billion at the second tier (major components), over $1 billion at the third tier (subcomponents), and about $600 million at the lower tiers (materials).[6]

Research and Development

Nondefense shipbuilding research and development (R&D) in the United States was extremely limited during the 1980s (probably averaging less than $100 million per year).[7]

Shipbuilding R&D has included the National Shipbuilding Research Program (NSRP), a cooperative program between government and industry. NSRP aims to develop and implement improved shipbuilding and repair processes. The program was funded by the Maritime Administration (MARAD) at a rate of about $2 million a year between 1972 and 1985. The Navy, mostly through its MANTECH budget, provided about $2 million a year from 1982 to 1985 and between $500,000 and $1.75 million a year from 1987 through 1992. The shipyards absorbed the indirect costs and were responsible for implementation costs.

Companies also invest their own funds in R&D projects. In the recent past such spending may have been more common among so-called second tier shipyards than large shipyards. For example, the Trinity Marine Group in Gulfport, Mississippi, developed and built a vessel made of composite Kevlar that has been sold to Mexico and is being shown in the Middle East.

The low level of R&D spending is partly attributable to the industry's assessment of market prospects. A 1985 OTA report on maritime R&D, for example, surveyed U.S. ship operators and shipyards and found that expected market demand was the single most important factor in determining company R&D investments.[8] The report concluded that the low demand for U.S.-built ships during the 1980s had "forced the shipbuilding industry to be extremely conservative in devoting funds to R&D."[9] Such low levels of R&D investment have, in turn, limited American competitiveness in shipbuilding because companies that do not develop better ways to build ships or other desirable products cannot hope to compete for future sales.

Observers argue that there are few university or college programs supporting the maritime industry. Only a few American universities have pro-

[6] These estimates are based on the latest available U.S. Department of Commerce, Bureau of Economic Analysis tables: "1987 Annual I-O Tables," (unpublished), and Bureau of the Census CY 1992 spending by the federal government for national defense.

[7] In comparison, the automotive industry reportedly spends about $12 billion each year on R&D. While this figure includes much development work for new model cars, it also includes longer term research on propulsion, structures, materials and other items. Automotive Trade Association, McLean, VA (personal communication).

[8] U.S. Congress, Office of Technology Assessment, *R&D in the Maritime Industry: A Supplement to an Assessment of Maritime Trade and Technology*, OTA-BP-O-35 (Washington, DC: U.S. Government Printing Office, May 1985).

[9] Ibid., p. 6.

grams in naval architecture and naval engineering, including the Massachusetts Institute of Technology (MIT) in Cambridge, the Stevens Institute of Technology in Hoboken, New Jersey, Webb Institute of Naval Architecture and the University of Michigan at Ann Arbor. The Japanese, in contrast, appear to have a robust network of research support for their maritime industry. For example, Japan's Ship Research Institute supports research on new types of ships and addresses such topics as fuel-saving marine engines. Japan also has a Marine Technical College for vocational training and an Institute for Sea Training for on-board training for students from universities and colleges.

The outlook for increased U.S. shipbuilding R&D has brightened recently as the commercial market possibilities have improved. Several firms have reported investments in new manufacturing technologies and are studying new ship designs. Furthermore, the improving commercial market has coincided with government initiatives with heavy R&D components. The Clinton Administration's shipbuilding initiative includes the Advanced Research Projects Agency (ARPA) managed MARITECH Program aimed at developing and applying advanced technology to improve the competitiveness of the U.S. shipbuilding industry.[10]

Design

The design element of the shipbuilding base resides in both shipyards and in separate marine design firms. These separate firms often work closely with a shipyard, or with the Naval Sea Systems Command (NAVSEA) to develop new ship designs. Once a Navy design is selected, it is passed on to production yards, which do the final design.

Because no builder or prospective owner or operator has shown an interest, however, design houses have produced few new commercial designs in recent years. The industry has been forced to survive largely on Navy work and the ability to provide services other than designing ships.

Production

American shipbuilding establishments are usually classified into four basic categories: major shipyards engaged in the construction and repair of ships, major ship-repair and dry-dock facilities, smaller shipyards that service inland waterway and coastal commerce, and topside-repair facilities. In the past, the benchmark for tracking the U.S. shipbuilding industry was the active shipbuilding base (ASB), defined by both shipyard capability and business criteria. Due to the reduction in construction of new ships, especially of those 1,000 gross tons and over, the ASB has been replaced by a measure based primarily on capability. This new benchmark is the U.S. major shipbuilding base (MSB), defined as privately owned yards that are open and have at least one shipbuilding position—either an inclined way, a side-launching platform, or a building basin capable of accommodating vessels 122 meters or more in length. With few exceptions, these shipbuilding facilities are also major repair facilities with dry-docking capability. Under the new definition, there were 19 major shipbuilding facilities in the United States on October 1, 1993 (versus 14 shipyards in the former ASB).[11]

Several hundred medium- and small-sized, or second-tier, U.S. shipyards primarily support the inland waterway and coastal commerce business. These shipyards produce tugboats, ferries, fishing vessels, barges, small government-owned ves-

[10] *Strengthening America's Shipyards: A Plan for Competing in the International Market,* The White House, Oct. 1, 1993, p. 7.

[11] U.S. Department of Commerce, op. cit., footnote 5, pp. 21-1 and 21-2. MSB shipyards employ about 73 percent of all employees in the sector. The remaining 27 percent is distributed across the approximately 550 other establishments classified under SIC 3731 (shipbuilding and repairing). Not included are the nine government-owned shipyards (some now scheduled for closing) which do not engage in new construction, but do overhaul and repair of Navy and Coast Guard ships.

TABLE 10: Major Industry Sectors Supporting Shipbuilding
Fabricated plate work (boiler shops)
Condensers
Diesel engines
Steam turbines
Propellers
Reduction gears
Large shafting equipment
Electrical power equipment
Power distribution switchboards
Air circuit brakers
Gas turbines
Heating and ventilation
Periscopes
Combat systems
Electronics
Heavy handling equipment (Cranes)

SOURCE: Office of Technology Assessment, 1995,

sels, and oil-drilling equipment. Some are currently engaged in large riverboat projects as a result of legislation that allows gambling on inland waterways. These yards have generally maintained a better commercial business base over the past decade than have the large yards. Many are considered internationally competitive having built fishing trawlers, patrol craft, and other vessels for export.

Several major component sectors, each an industry in its own right, support shipbuilding (table 10). These sectors, in turn, draw on a host of subcomponent producers and material suppliers. For example, the Naval Sea Systems Command reported in 1990 that the construction of the *Arleigh Burke* class of guided-missile destroyers (DDG-51) involved over 500 primary equipment subcontractors and thousands of subcontractors in the lower tiers.[12] The supplier base has been consolidating as a result of reduced Navy spending and little commercial work. Many firms have reportedly either left the industry or have devoted most of their work to supporting military shipbuilding. A 1991 survey of U.S. marine machinery suppliers found that only 81 percent of those surveyed were at the time of the survey supporting the marine industry and that 71 percent of those supporting the marine industry were directly involved in U.S. Navy shipbuilding. Many of the firms reported that they were working at only 40 to 70 percent of full capacity.[13]

Component producers have also been hurt by the increasing use of imports by the U.S. shipyards. The U.S. Marine Machinery Association, for example, has estimated that over 70 percent (in terms of value) of components used by U.S. shipyards in repairing or building commercial ships are imported. Industry sources cite the reduction of the supplier base as one reason for higher construction and repair costs and longer ship-construction time in the U.S. shipbuilding industry.

Some of the sectors shown in table 10 support both commercial and military shipbuilding, while others, particularly combat systems and electronics, principally support the military. Some participants from component producers in the OTA shipbuilding workshops reported that they were integrated in production and could survive without government business in the future. Indeed, they argued that the current government acquisition laws and regulations encouraged many component producers to quit accepting government business, further reducing the level of CMI. The Federal Acquisition Streamlining Act of 1994, combined with changes in the use of military specifications and standards, is expected to have a positive effect on allowing firms to continue to accept both defense and commercial business.

Maintenance and Repair

Maintenance and ship conversion work is an important element of the industry. Navy maintenance and repair is split between the public and

[12] OTA, *Building Future Security: Strategies for Restructuring the Defense Technology and Industrial Base,* op. cit., footnote 1, p. 81.

[13] Ivars Gutmanis, *Analysis of the Civil-Military Integration Feasibility for Selected U.S. Industry Sectors* (Washington, DC, Hobe Corp.) August 1993, p. 32.

private sectors, with work either allocated directly to public yards or awarded to private yards under competitive bid. In 1993, Navy work was performed at eight naval shipyards, two Navy-owned ship-repair facilities, and 36 privately owned shipyards. Some repairs are also done overseas. The overwhelming amount of Navy ship repair goes to public yards.[14] Under the Navy competition program, most submarine repairs have gone to the public sector and most surface-ship repair to the private sector.[15]

Industry Trends

The large U.S. shipyards are highly dependent on U.S. government business, and military construction is falling. According to the Department of Commerce, 65 military ships greater than 1,000 light displacement tons (ldt) were on order, or under construction, as of October 1993 in 12 privately owned shipyards.[16] (See table 11.) In 1993, the Navy ordered the first of several sealift ships. Five commercial container ships were converted to meet military requirements. Eleven new sealift ships were included in the FY 1994-99 shipbuilding program. Many viewed these ships as a potential means to help shipyards make the transition to more commercial work, but the initial contract awards were controversial, with some critics arguing that the decisions paid inadequate attention to preservation of the shipbuilding industrial base.[17]

Commercial possibilities for U.S. shipbuilders remain mixed. On the one hand, the market for large commercial ships is improving and U.S. shipyards such as Newport News Shipyard have secured contracts for commercial ships from foreign owners. On the other hand, Korean shipyards have announced major expansions in shipyard capacity to meet the anticipated market demand.

Second-tier shipyards are reportedly in better shape, although they, too, have had to contend with a downturn in business because expected increases in demand for vessels to carry grain and coal failed to materialize. Nevertheless, the Commerce Department reports that Gulf Coast shipyards "continue to invest in and expand their facilities and equipment used in ship repair and conversion work."[18] Firms such as Trinity Marine Group, for example, have reported that they are applying new manufacturing technologies such as plasma arc cutting to gain higher precision in parts manufacturing, single-side welding of plate, and automated blast and paint facilities, to improve productivity and reduce the labor input.[19]

Another important trend that emerged in the early 1990s was the increased U.S. government interest in improving U.S. shipyards commercial competitiveness. The Clinton Administration's interest in strengthening U.S. shipbuilding was preceded by interest from Congress. The National defense Authorization Act for Fiscal Year 1993 (Public Law 102-484) included a number of shipbuilding initiatives including the requirement that sealift ships built under the fast sealift program be designed and constructed to commercial specifications. The law directed the President to develop a plan to ensure that domestic shipyards could compete effectively in the international marketplace.

The following year, the National Shipbuilding and Shipyard Conversion Act of 1993 included:

[14] U.S. Department of Commerce, op. cit., footnote 5, p. 21-4. The FY 1994 budget requested about 14 percent of the ship repair funds be allocated to competition.

[15] Ibid.

[16] Ibid., pp. 21-2 and 21-3.

[17] R. Holzer, "Major U.S. Shipyards Question Navy Awards," *Defense News*, Sept. 20-26, 1993, p. 6.

[18] U.S. Department of Commerce, op. cit., footnote 5, pp. 21-2 and 21-3.

[19] H.B. Walpert, Senior Vice President, Trinity Marine Group, "Vessel Technology: U.S. Shipyard Perspective," speech to the International Conference on the Maritime System of the Americas, Mar. 25, 1993.

TABLE 11: Military Ships on Order or Under Construction as of October 1, 1993

Type	Number
Fast combat-support ship (AOE)	4
Guided-missile cruiser (CG)	1
Aircraft carrier (nuclear-powered) (CVN)	2
Guided-missile destroyer (DDG)	23
Amphibious assault ship (multipurpose) (LHD)	3
Dock-landing ship (LSD)	3
Mine-countermeasures ship (MCM)	2
Attack submarine (nuclear-powered) (SSN-21)	2
Attack submarine (nuclear-powered) (SSN-688)	9
Ballistic-missile submarine (nuclear-powered) (SSBN)	4
Oceanographic research ship	1
Fast sealift	2
Ice breaker (WAGB)	1
Ocean surveillance ship (T-AGOS-23)	1
Ocean survey ship (T-AGS-60)	3
Fleet Oiler (T-AO)	4
Total	65

SOURCE: U.S. Department of Commerce, *U.S. Industrial Outlook* 7994, table 1, p 21-2.

1. a financial incentives program to provide loan guarantees to initiate commercial ship construction, encourage shipyard modernization, and support increased productivity;
2. a technology development program (subsequently carried out by ARPA in its MARITECH Program) to improve the technology base for advanced shipbuilding and encourage innovative commercial ship design and production processes and technologies;
3. enhanced DOD support for the Navy's Affordability Through Commonality Program to foster the use of common modules for military and commercial ships; and
4. enhanced support for those portions of the Navy's Manufacturing Technology and Technology Base Program that are associated with shipbuilding and ship repair technologies.[20]

The Clinton Administration's shipbuilding plan addressed many of the Congressional objectives through a combination of international negotiations, the MARITECH program, acquisition reform, loan guarantees, and international marketing support.

These government initiatives could potentially have significant impact on CMI. In 1995, the MARITECH program claimed some success from its near-term technology development projects in helping firms win commercial contracts.[21]

Market Forecast

Workshop participants and others interviewed during this case study stressed the importance of the commercial market to shipyard survival, and the need for U.S. shipbuilders to understand and address market needs in order to succeed in reentering commercial shipbuilding. Some shipyards espoused a market *niche* strategy aimed at capturing a part of the market that includes specialty ships, such as cruise ships, survey ships, one-of-a-kind ships, or few-of-a-kind ships. Other builders reportedly plan to apply advanced technologies to directly attack the global competition (e.g., the Japanese and Koreans) in high-volume sectors such as large tankers.

As noted earlier, however, the prospects for a renewed demand for large commercial ships remains a matter of debate. More than 14,000 ships from the global commercial fleet will probably

[20] National Shipbuilding and Shipyard Conversion Act of 1993, 10 U.S. Code 2501.

[21] Specifically listed were Newport News Shipbuilding's construction of a 40,000 deadweight ton (DWT) product carrier, Todd Shipyards' success in winning a contract for Washington State ferriers, and Alabama Shipyard's Inc. letter of intent to build from bulk cargo ships for Tritea Maritme Ltd. of Piraeus Greece. See MARITECH Program Fact Sheet.

TABLE 12: Estimate of Level of Work for a 400- and 300-Ship Navy

Ship category	Fleet size	Service life	Average new ships per year	Building yards	Overhaul/repair projects per year	Overhaul/repair docks needed
Aircraft Carriers	1 2/1 0	40	0.3/0.25	1/1	1 .5/1	3/2
Submarines	55/45	30	1.8/1 .5	1 to 2/1	8/7	9/8
Surface combatants	1 30/100	30	4.3/3.3	2/1 to 2	18/1 4	20/1 6
Amphibious/replenishment ships	128/95	30	4.3/3.2	2 to 3/1 to 2	18/14	20/1 6
Mine warfare/support ships	75/50	30	2.5/1 .7	1/1	11/8	12/9
Total	400/300		13.2/1 O	9 to 7/7 to 5	56.5/44	64/51

SOURCE: Office of Technology Assessment, 1995.

need to be replaced by the turn of the century. Almost 2,000 additional new ships are expected to be required to meet expanded needs. But despite the many forecasts of a commercial shipbuilding boom in the 1990s, the worldwide number of large merchant ships on order, or under construction in 1993, declined. Still, new construction is expected to develop to provide the double-hull oil tankers to comply with the Oil Pollution Act which became law in 1990. These tankers are scheduled to be phased in between 1995 and 2005, but might not be built in U.S. yards. Further, changes in environmental regulations could have an impact on the speed with which these ships are introduced. U.S. production ultimately depends on what percentage of the global market the United States is able to capture.

Other potential commercial work includes oil drilling rigs, marine structures, and large land structures demanding extensive welding or using shipbuilding techniques.

Although Navy shipbuilding, conversion, and repair activities are expected to continue to decrease, Navy work will still dominate the U.S. shipbuilding and ship-repair industry in the near term. A principal national security concern is how to preserve the capability to build nuclear submarines and aircraft carriers. But while these programs represent important defense capabilities, they appear to have limited direct CMI effects, with most CMI potential being in supporting industries such as electronics.

Other Navy programs are more directly applicable. The Navy sealift program, for example, was viewed by many of those interviewed as an opportunity to assist the transition to commercial shipbuilding business. There has been considerable debate, however, over the extent to which CMI can be achieved given the current design requirements of the sealift ships. Participants at OTA's shipbuilding workshops disagreed over whether the planned ships were too militarily unique.

The size of the Navy fleet is currently projected to fall from over 500 in 1993, to between 300 and 400 ships under the DOD's *Bottom-Up Review.* Table 12 gives an estimate of the level of work and number of shipbuilding and overhaul facilities that might support a Navy of 300 to 400 ships.

Given reasonable assumptions about service life, new Navy construction for a force of this size might range from 10 to 13 ships a year. This new construction might be supplemented with the overhaul and repair of 44 to 67 vessels, but overhaul and repair work is also decreasing as the Navy moves away from its past practice of allowing 35 percent of a ship's service life to be spent out of commission in major repair and overhaul, and toward the commercial industry's figure of about 5 percent.

Participants in OTA's shipbuilding workshops concluded that three building yards might be the minimum necessary to meet anticipated Navy shipbuilding needs for a force this size. Partici-

TABLE 13: Defense Objectives of Integrating Civilian and Military Shipbuilding
Design, develop, build, and support effective naval forces
Preserve a skill base in design, engineering, and production
Maintain key facilities
Lower the costs of naval vessels
Enhance the transfer of critical technologies

SOURCE. Off Ice of Technology Assessment, 1995.

TABLE 14: Civilian Objectives of Integrating Civilian and Military Shipbuilding
Ensure profitability
Preserve a skill base in design, engineering, and production
Maintain key facilities
Lower the costs of commercial vessels
Enhance the transfer of critical technologies

SOURCE: Off Ice of Technology Assessment, 1995.

pants argued, however, that five to six yards were preferred. Building yards and overhaul and repair docks are important not only to provide normal peacetime support but also to handle unforeseen peacetime accidents or combat damage that might disable a vessel. A future shipbuilding defense base might include the following types and numbers of building yards:

- one carrier yard
- one submarine yard
- two surface-combatant yards
- two auxiliary yards

Some of these yards could, of course, build more than one type of ship.

CIVIL-MILITARY INTEGRATION

Some CMI currently exists, particularly in the subtiers, but integration at the shipyard level is limited. Increasing CMI at all levels is made more challenging by the lack of commercial competitiveness in building large ships.

Industry and government personnel participating in the two OTA shipbuilding workshops argued that civil-military integration of the shipbuilding base demanded a clear statement of the objectives to be achieved by such integration. Five defense objectives (see table 13) were identified. The highest-priority defense objective is to preserve the capability to design, develop, build, and support the vessels needed to perform the Navy's basic missions: sea control and sea denial in war, forward presence and support of political interests in peacetime.

Workshop participants also identified five civilian objectives of integrating shipbuilding (see table 14) and noted that commercial success in building ships demands that the operations be profitable. Participants observed that the mix of skills for commercial production might differ from those needed in the defense base. For example, the skills needed for modular construction of commercial vessels might be very different from those needed for defense, with the commercial base having less demand for highly skilled electricians and electronics personnel and more demand for basic welders and assembly personnel.

Shipbuilding facilities appear to have considerable defense and commercial overlap. Although defense might demand some unique facilities (e.g., nuclear), many of the costly, fixed shipbuilding facilities can be used for military or civilian work.

Workshop participants argued that technology transfer is as important to the commercial sector as it is to defense. Certain technologies, such as the technology to produce large composite structures, may be needed in both civilian and defense work. Armaments technologies, however, have few commercial uses.

Although many of the broad defense and civilian objectives overlap, the difference between the first priority of each list underscores the fundamental difference that makes CMI difficult. Government goals stress combat performance and oversight of public funds. Commercial goals, of necessity, stress profitability, which is key to staying in business. While the differences between such objectives might be reduced, they are unlikely to be eliminated.

Factors Favoring and Inhibiting Integration

There are a number of technical, market, and policy factors favoring increased integration in the shipbuilding sector.

Technical

Although there are many acknowledged differences between defense and commercial hull designs, propulsion systems, and weapons systems on board, government and industry personnel argued that there are also many commonalities in components and that technological developments in design and manufacturing processes—if exploited—might enhance integration within the shipbuilding sector. The possibility of such integration has increased with the new DOD policy toward the use of military specifications and standards.

Both the commercial and defense sectors face many common environmental and safety problems. Research efforts in these areas, as well as in design and manufacturing processes, might be expected to provide useful information to both the commercial and defense sectors. In July 1994 the Deputy Director for Defense Research and Engineering for Laboratory Management reported on a DOD effort to determine what research and technologies might be sourced from non-DOD laboratories and which ones might be expected to remain in the more militarily unique Service laboratory environment. Increased out-sourcing potential for naval systems included: habitability and outfitting, shock, propulsion machinery, and electrical power systems.[22] In order to exploit technical developments, the Non-Government Panel studying the issue recommended that Navy laboratories establish strong collaborative programs with industry and university partners.[23]

The MARITECH Program aims to use a wide variety of technologies that appear to have application to both commercial and defense needs. These include exploiting developing technologies:

- in simulation and modeling, virtual prototyping, and advanced materials to enhance integrated product development;
- in simulation and modeling, prototyping, and communications to enhance integration in design;
- in flexible automation/robotics, real-time physical measurement, agile manufacturing and advanced methods in cutting, welding, and pasting to enhance integrated construction; and
- in communications and advanced repair to enhance integration in follow-on support.[24]

Navy studies on Affordability through Commonality (ATC) have examined concepts for modular construction, equipment standardization, and process simplification. In many cases these processes and the equipment might be confined to using standardized militarily unique items. Indeed, past standardization programs have sometimes isolated the military from commercial developments when the standardization has been to specifications not used in the commercial sector. Component producers interviewed by OTA argued, however, that standardizing to commercial specifications in areas where they appear appropriate (e.g., many of the different pumps and valves that go on ships), is feasible and can promote savings.

Civil-military integration at the shipyard level is aimed at maintaining a skilled workforce, shipyard facilities that can accommodate large naval

[22] *The Laboratory Infrastructure Capabilities Study: Non-Government Panel Meetings June/July 1994.* Summary available through DOD Laboratory System World Wide Web Services: LabLINK Home Page: Projects.

[23] Ibid.

[24] Robert Schaffran, "MARITECH," Presentation at the ARPA Seventeenth Systems & Technology Symposium, Oct. 25-27, 1994, San Francisco, CA.

vessels, and at improving U.S. shipbuilding technology. Workshop participants concluded that much of the hull work can be automated. Computer aided design and computer aided manufacturing (CAD/CAM), for example, can drive a battery of robots in welding. Much of the rest of the ship can be built in specialized factories.

Workshop participants noted that foreign technology is important and that U.S. firms may gain access to it through partnerships with international firms (such as those developed in the electronics industry) or through direct license agreements.

At the sector level, technological opportunities for integration are enhanced by the availability of public sector facilities for private sector use. This appears to make most sense when the facility investments are too costly for the private sector to make individually. For example, the David Taylor Naval Ship Research and Development Center in Carderock, Maryland, has one of the largest maritime model basins in the world. Research topics at the Center include hull-form structures, propulsion, silencing, maneuvering and control, auxiliary machinery, environmental effects, pollution abatement, logistics, computer techniques, and software for analysis and design—most of which have some commercial application. The enabling legislation for the Center specifies that experiments can be conducted for private shipbuilders if the builders defray the cost of the experiment.[25] The authority, however, has reportedly seldom been used, except for examining some hull designs.

Other possibilities exist in facilities such as the Navy Surface Warfare Center's Crane Division of Crane, Indiana, which conducts R&D on a variety of systems, including microwave devices, acoustic sensors batteries, and microelectronic technology. While these efforts are directed at fleet support, some might be exploited to enhance commercial capabilities.

National laboratories represent additional government resources available for use in shipbuilding. The use of supercomputers at Sandia National Laboratories to solve planning problems in design and manufacturing is an example of sector level integration. Both the Sandia National Laboratories and Oak Ridge National Laboratory currently have supported shipbuilding activities. Sandia, for example, has a Cooperative Research and Development Agreement (CRADA) with one of the shipyards in advanced welding techniques, and Oak Ridge has ongoing cooperative work in manufacturing.

Exploiting commonality in process technology (e.g., design, manufacturing, testing) appears fairly straightforward. The use of commercial components on combatants, however, raises questions about the durability of products manufactured under commercial standards. Critical questions about shock resistance, for example, must be addressed. Many electronic components are currently meeting such requirements through ruggedization, a process by which commercial items are placed in a rugged container that can resist the shocks and stresses of combat. In common with findings in other critical combat areas, those interviewed generally agreed that design, manufacturing processes, and components represent the greatest opportunities for integration.

Market Factors

The U.S. military and commercial shipbuilding markets have almost been mutually exclusive at the shipbuilding level. Yet many OTA workshop participants argued that this need not be the case. Workshop participants and others interviewed during the assessment stated that ship components and subcomponents are the most likely items to be purchased, but major end items might also be bought commercially. The Navy, for example, used an off-the-shelf merchant tanker, modified

[25] OTA, *R&D in the Maritime Industry: A Supplement to an Assessment of Maritime Trade and Technology*, op. cit., footnote 8, p. 35.

with defense features, to provide underway replenishment to fleet combatants in 1972.

The Navy's T-AGOS program was run "commercially" from 1981 until 1986. The commercial philosophy followed in that case reportedly allowed the program to reduce Navy oversight significantly.

More recently, the United Kingdom contracted for construction of a helicopter carrier based on a commercial, rather than a military, hull design. By modifying a commercial design rather than using a militarily unique one, the United Kingdom expects to save over $76.5 million.[26]

The French have also used a more commercial approach to meet some of their needs. An earlier OTA study reported that the French Navy, in developing a new class of frigates for routine patrol missions, decided against sophisticated and expensive warships to perform these missions.

A commercial shipyard, Chantiers de l'Atlantique (owned by the Alcatel-Alsthom GEC Group), that specializes in the design and construction of passenger liners, received the contract. In lieu of military specifications, the French Navy permitted Chantiers de l'Atlantique to use somewhat less rigorous "safety of life at sea" norms conceived for merchant-marine and passenger ships. The patrol frigates are equipped with the same weapons systems as are standard frigates, but lack a computerized battle-management system capable of integrating them into a naval task force. Because of these economies, the patrol frigates were developed and built at one-third the cost of frigates built to military specifications. The limited defensive capabilities of the patrol frigates could, however, prove problematic if they confront comprehensive threats.[27]

More market commonality may be achieved in naval transport ships, but there were mixed views on whether this will occur. As noted earlier, some participants in OTA's shipbuilding workshops expressed concern that the ships then in the Navy's sealift program had little commercial overlap, while DOD participants argued that the ships were "the least military-specified ship ever" and that the specifications that did exist were mostly performance specifications.

One argument made by those concerned about CMI was that the design's performance specification forced noncommercial solutions, and that if support for a commercially viable ship had been a consideration, a different design would have emerged. It was the opinion of some participants that the DOD could have met 90 percent of the lift requirement at 50 percent of the cost and had a commercially viable ship. Concerns were focused on the requirements for off-loading and the hazardous cargo requirements. Regardless of their views on current designs, workshop participants generally supported the idea of moving toward a more commercial vessel for most Navy purchases.

Policy Factors

The recent government shipbuilding initiatives aim not only at developing technology but also at applying that technology to demonstration vessels with the objective of reestablishing the U.S. shipbuilding industry as a self-sufficient, internationally competitive industry.[28] The MARITECH program, outlined earlier, is designed to develop and apply advanced technology to improve the competitiveness of the U.S. shipbuilding industry. According to Dr. Larry Lynn, Director of

[26] P. Felstead, "VSEL Wins Contract To Build U.K. Helo Carrier," *Janes Defense Weekly*, May 22, 1993, p. 10.

[27] U.S. Congress, Office of Technology Assessment, *Lessons in Restructuring Defense Industry: The French Experience*, OTA-PB-ISC-96 (Washington, DC: U.S. Government Printing Office, June 1992), p. 26.

[28] National Defense Authorization Act for Fiscal Year 1994, Public Law 103-160, Nov. 30, 1993, Sec. 1352. 10 USC 2501.

ARPA, "MARITECH will ensure that a domestic shipbuilding infrastructure, capable of building competitive ships, is available to procure affordable Navy ships at such time that new construction tonnage is needed."[29]

As a part of its plan for strengthening America's shipyards, the Clinton Administration has also pursued efforts to eliminate foreign shipbuilding subsidies through the Organization for Economic Cooperation and Development, provided guarantees through the Department of Transportation for ship construction, and extended loan programs to cover ships built for export.

Workshop participants raised and discussed several other near-term strategies, including building and leasing commercial ships in place of the Ready Reserve Fleet and purchasing a fleet of vehicle carriers that would be on a standby arrangement under government contract for use in an emergency. (See box 7.)

Factors Inhibiting Integration

Several factors have inhibited integration in the shipbuilding sector. The major factor has been the almost total lack of commercial shipbuilding. The dearth of commercial shipbuilding is partly a function of the technical, market, and policy factors noted below.

Technical

As discussed earlier, naval combatants have very specific tasks to perform that often have little or no overlap with commercial activities. They must be capable of withstanding damage that would not be expected in a commercial vessel. Shock tests, and special fire-fighting equipment are often essential. Because of the potential for sustaining combat damage, many observers question the capability of the new French patrol frigates to operate in a high-intensity combat environment.

Since they incorporate many technologies that are different from those used in large commercial vessels, the construction of combatants often requires different skills than do commercial ships (e.g., electronics integration and weapons systems installation). Much of the value added in combat vessels is associated with these complex electronics and weapons systems. CMI here is more likely to occur at the electronic component level. Thus, while process technology may potentially be easily integrated, the special needs of combat vessels will create some technical limits to product integration. The existence of many militarily-unique systems must be acknowledged in considering a realistic CMI strategy in this sector.

The lack of competitiveness of the American shipbuilding industry has been exacerbated by the general absence of investment in new process technology in the industry. Although smaller yards report investments, representatives from the major yards participating in the OTA workshops estimated that large U.S. shipyards are as much as 10 years behind in technology. The result is that production time per ship is two to three times as long in U.S. yards as it is in the best foreign yards. The MARITECH Program is aimed at introducing new technologies, but the workshop concensus was that outdated yards will require substantial new investment to become commercially competitive.

New technological developments in the United States are aimed at both reducing the number of workers needed to build a ship and the time needed to complete a ship. Although American wages have declined to the degree that they are slightly lower than Japan's and much lower than those in Western Europe, they remained high compared to South Korean wages or those of the People's Republic of China. Further, almost all major foreign yards can reportedly build ships faster and with fewer people than can U.S. yards. For example,

[29] Statement by Larry Lynn, Acting Director, Advanced Research Projects Agency, before the House Appropriations Committee, Subcommittee on National Security, Mar. 23, 1995.

BOX 7: Other Suggestions for Preserving a Naval Construction Base

Workshop participants generally agreed that the falling rate of Navy construction, combined with the lack of a commercial market for large ships, necessitated drastic action to reestablish a domestic shipbuilding industry. A number of alternatives were discussed in addition to integrating the commercial and defense bases. These included: ceasing to transfer ships to other nations as the Navy decommissions them because this practice eliminates potential customers; building ships directly for the export market (including diesel submarines); starting a major building program for Coast Guard ships.

Participants suggested that there should be greater support for foreign military sales. Such sales may be controversial, however, because they can potentially create threats to U.S. forces. On the other hand, they can sustain important high-level skills in the absence of commercial work. Some participants discounted the possibility of future threats to U.S. forces.

Participants also proposed changing the duration of the charter of MSC ships. Longer charters could certainly be used to facilitate sealift acquisition. Participants indicated that tankers, as well as vehicle carriers, might be built for a five-year charter. They pointed out that the production of double-hulled tankers, coupled with a focused sealift construction program built around longer charters, might create a commercially viable program.

Finally, workshop participants suggested that the Nation needs to develop incentives that support the shipbuilding industry. The Norwegians, for example, use tax policy (i.e., high depreciation rates for ships) to sustain a very modern fleet. Liberia and Bahrain are both tax-free environments. U.S. tax policy, on the other hand, was viewed as punitive to the shipbuilding industry.

SOURCE: Office of Technology Assessment, 1995.

the Japanese are estimated to have cut the percentage of labor cost in the cost of a ship from about 40 percent in 1987-88 to 20 to 25 percent in 1991.[30] A ship operator noted that the international ship market is highly dependent on the lowest price. Technology aimed at productivity improvements is essential.

Participants at OTA's shipbuilding workshops expressed concerns about the ability of shipbuilding firms to gain access to necessary financing to make technology investments. They estimated that U.S. yards would require new technology and facilities—thought to cost between $100 million and $200 million per yard—to compete effectively. Component producers complained that small firms could not get access to such financing, and they called for government guarantees. Others argued, however, that financing was available for good investments and that government loans were therefore unimportant.

Market

A number of market factors inhibit integration. One of the greatest is the uncertainty in the market for large ships. Despite the expectation of increased demand, expansion has been slow. A further problem is fierce international competition. Several Korean shipyards, for example, have announced major capacity expansions to meet the expected increased market demand. Japanese and European yards can also be expected to be competitive.

Owners, operators, and government workshop participants noted that U.S. shipyards have been very poor at marketing. Although shipyards com-

[30] *Drewry World Shipbuilding, The Next Ten Years:Can the Challenge Be Met?* (Drewry Shipping consultants, Ltd., London: April 1992) , p. 26.

plain about a lack of orders, some workshop participants argued that American shipyards lack a commitment to marketing and often fail to visit firms interested in buying new ships. Foreign builders, on the other hand, are said to visit regularly.

Market subsidies were hotly debated at the workshop. Many workshop participants argued against direct, long-term subsidies, stating their belief that federal subsidies have hurt the base by isolating it from competition.[31] A 1983 OTA report hinted at this, noting that:

> Over the past two decades the United States has only built major merchant ships when Federal subsidies were used to pay a large portion of the cost or when laws, such as the Merchant Marine Act of 1920 (Jones Act), required that the ship be built in a U.S. yard.[32]

Instead, participants generally supported a program in which shipyards would receive initial transition funding to help them convert to commercial shipbuilding. Such a program would also include a commitment on the part of the government to encourage shipbuilding through incentives.

Some workshop participants advanced a different market approach. They suggested that smaller, cheaper ships might be better suited to the new defense environment and take advantage of technology developments to retain combat capability. For example, smaller fighting ships might be built (at $250 million a copy) with an acceptable compromise in performance by capitalizing on space-based (or airborne) command-control links whose costs would be met through joint service support. Expensive, large radars and associated equipment could then be removed in favor of off-board sensors. A modular design would allow additional "tuning" of ships for particular needs in various locations around the world.[33] A small ship might also be more likely to develop an export market.

Policy Factors

Government acquisition laws and regulations that have effectively separated much of the defense and commercial bases have had a negative effect on the shipbuilding industry too. As in other sectors, special rules have driven up costs. For example, although Navy and commercial hull welding for surface ships might be similar, the costs are far higher for Navy work because of the additional testing required and the more stringent labor requirements to certify those tests. It was reported that certified welders were paid $16 an hour for Navy work and $10 an hour for commercial work. As a result, a yard doing both Navy and commercial work reportedly either had to have two labor forces with different training requirements and pay scales, or use the more highly skilled workers and pay the higher wages for commercial work as well.

Government cost-accounting and inventory requirements that differ from commercial practices have also reduced commercial competitiveness and ultimately inhibited integration. Workshop participants noted that commercial and Navy ships were once built side-by-side and that such construction was helpful; now, partly because of government acquisition rules, this does not, and cannot, occur. Integrating production processes in the shipyards will continue to be difficult if current acquisition laws are not changed. Shipyards argue that the paperwork associated with govern-

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[31] The subsidies included a construction-differential subsidy (CDS) under the Merchant Marine Act of 1936. The CDS provided for the government to pay a shipyard, contracting with an American foreign-trade ship operator, the difference between the higher American cost and the lower foreign production cost. The Merchant Marine Act of 1970 anticipated the building of 300 ships under CDS over a 10-year period.

[32] U.S. Congress, Office of Technology Assessment, *An Assessment of Maritime Trade and Technology*, OTA-O-220 (Washington, DC: U.S. Government Printing Office, October 1983), p. 85.

[33] A. Skolnick, "Sea Power, Peacekeeping, Defense Conversion and Budgets: Can They Be Balanced?" *Naval Engineers Journal*, September 1993.

ment regulations drives up the cost of commercial products.

Finally, military specifications and standards have separated shipbuilding in much the same way they have affected other defense sectors. Extensive discussions about the impact of military specifications and standards took place in both the OTA shipbuilding workshops and during interviews. Some of the component producers predicted that continuing the same level of Navy specifications and standards would drive many component producers out of the government market. Although some specifications and standards are viewed as valid, many are thought to be inappropriate. The effects of Secretary of Defense Perry's changes in the use of military specifications and standards are not yet clear, but are considered to be helpful.[34]

Many of those involved in the workshops argued that in the past, decisions to modify the use of military specifications and standards often did not filter down to those charged with writing and implementing the specifications and standards. As a result, little seemed to change despite decisions to proceed with specification *reform*.

U.S. Coast Guard safety standards for ships built and/or requested in the United States (including the use of nonflammable materials and different boilers) were cited as inhibitors by some workshop participants because of their impact on the price of U.S.-built ships. The cost of a boiler that meets U.S. Coast Guard standards, for example, was said to be twice that of one that did not meet those standards.

The actual cost impact of U.S. Coast Guard standards on new commercial construction, however, is disputed. The Coast Guard maintains that the actual cost of compliance is far below the 15 percent figure often cited by shipbuilders. The Coast Guard uses a 1973 report by the American Commission on Shipbuilding that cites a 3 to 5 percent additional "cost of a U.S. flag vessel for compliance with the technical requirements of the Coast Guard, American Bureau of Shipping (ABS), and the U.S. Public Health Service."[35]

Further, the Coast Guard argues that even in the absence of Coast Guard regulations, U.S. shipyards are not competitive and that the absence of foreign flag shipbuilding in the United States must be attributed to factors such as the long delivery schedules and corresponding high delivery costs at U.S. yards, rather than any *added* cost of compliance with Coast Guard regulations.[36] In support, several in industry noted that "what we need is *globalization of standards*" to level the production field and improve safety.

Implications of Increased Integration

Increased integration is thought by many to be essential for the preservation of a domestic shipbuilding base that can provide affordable ships for the Navy. Without increased non-defense work it will be difficult to preserve more than a very few building yards. Greater use of common components and greater use of common design and manufacturing technologies appear useful for both the defense and commercial sectors. It is in these areas that the greatest potential for CMI may exist.

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[34] Secretary of Defense William J. Perry, *Memorandum for Secretaries of the Military Departments, Subject: Specifications & Standards: A New Way of Doing Business*, June 29, 1994.

[35] *White Paper: Cost of U.S. Coast Guard Regulations to U.S. Shipbuilders and the Initiative with the Shipbuilders' Council of America To Reduce These Costs*, Sept. 6,1991 (updated December 1992), p. 2.

[36] Ibid., p. 8.