SHIPBUILDING

ABSTRACT

The United States produces the best military warships in the world but remains uncompetitive in the production of large commercial vessels. As a maritime nation, continued preeminence in military warship construction is an essential element of the National Security Strategy. The lack of a viable commercial shipbuilding industry does not directly impact the National Security Strategy. However, the cost of maintaining excess military shipbuilding and repair capacity and the costs associated with maintaining a non-competitive commercial shipbuilding industry do impose increasingly high opportunity costs on national security resources.

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PLACES VISITED

Domestic:

Austal, Mobile, AL
Avondale Shipyard, Northrop Grumman Ship Systems, New Orleans, LA
Bath Iron Works, General Dynamics Corporation, ME
Bollinger Shipyards, Lockport, LA
Electric Boat, General Dynamics, Quonset Point, RI
Ingalls Shipbuilding, Northrop Grumman Ship Systems, Pascagoula, MS
Knight and Carver, San Diego, CA
Kvaerner Philadelphia Shipyard, Inc., Philadelphia, PA
National Steel and Shipbuilding Company, General Dynamics, San Diego, CA
Naval Surface Warfare Center, Carderock Division, Carderock, MD
Newport News Shipbuilding, Northrop Grumman Ship Systems, Newport News, VA
North American Shipbuilding, Larose, LA
Portsmouth Naval Shipyard, Kittery, ME
Rolls-Royce, Walpole, MA
Southwest Marine, San Diego, CA
SPAWAR, San Diego, CA
Textron Marine and Land Systems, New Orleans, LA
US Navy Supervisors of Shipbuilding: Bath, ME; Pascagoula, MS; and Newport News, VA

International:

US Embassy, Seoul Korea
Daewoo Shipbuilding and Marine Engineering Co. Ltd., Seoul, Korea
ALSTOM Korea Co., Ltd., Seoul, Korea
Daewoo Shipbuilding and Marine Engineering Co., LTD, Koje-City, Kyungnam, Korea
HSD Engine Co., Changwon-City, Kyungnam, Korea
Automobile and Shipbuilding, Industry Division, Ministry of Commerce, Industry and Energy, Republic of Korea
SAMSUNG Heavy Industries Co.,Ltd., Koji Shipyard, Koje City, Kyungnam, Korea
Ministry of Defense-DCN (Direction des Constructions Navales), Paris, France
THALES Naval France, Meudon la Foret Cedex, France
Kockums, Malmo, Sweden
US Embassy, Helsinki, Finland
US Embassy, Paris, France
Confederation of Finnish Industry and Employers, Helsinki, Finland
Kvaerner Masa-Yards, Turku New Shipyard, Turku, Finland
Aker Finnyards Oy, Rauma, Finland

INTRODUCTION

The United States builds the highest quality and most technologically advanced warships in the world. Ironically, it ranks fifteenth in the world in construction of commercial ships, accounting for only about one percent of gross tonnage. Consequently, the US Navy is the domestic shipbuilding industry's largest customer and the source of over 85 percent of the total revenue of the largest six shipbuilding yards.

The drastic reduction in US Navy orders for new ships since the end of the Cold War has affected profitability and has resulted in general overcapacity in the industry. Shrinking demand sets up a circular problem. With less demand, there are fewer profits and less incentive to invest in modernization. Without modernization, the cost to build a ship increases. With increased costs and tighter budgets, the Navy can afford fewer ships.

Because ships are essential to national security, the US Navy will continue to buy and repair ships regardless of the cost. But the reduction in demand also led to downsizing of the shipbuilding industrial base, resulting in less competition. And competition has been the traditional mechanism for the Department of Defense to get the best product for the lowest price. The principal challenge for Defense therefore, is how to get the highest quality military ships at the most reasonable cost.

THE INDUSTRY DEFINED

The shipbuilding and repair industry comprises some 240 shipyards and facilities, with more than 90,000 employees engaged in building and repairing ships, barges and miscellaneous vessels, including offshore drilling platforms.[1] Shipyards can generally be categorized as building and/or repairing military ships or commercial ships. Some yards compete in both sectors but this is not widespread. The US Navy operates four publicly owned shipyards for repair work only, although some have a history of new construction.

Table 1. Numbers of shipyards by category

All Shipyards	Builders				Repairers		
	Large Vessels (> 400 feet in length)	Small Vessels (< 400 feet in length)	Barges	Aluminum Boats	Large Vessels (Panamax beam or larger)	Small Vessels (less than Panamax beam)	Topsides Only
238	15	82	25	29	28	136	12

Source: www.coltoncompany.com (May 02)

Few private shipyards are capable of building and repairing large vessels, commercial or military. Of these, the largest six shipyards (known as the 'big six') are subsidiaries of just two large defense industry corporations – General Dynamics and Northrop Grumman. Their work, which is almost entirely defense related, accounts for

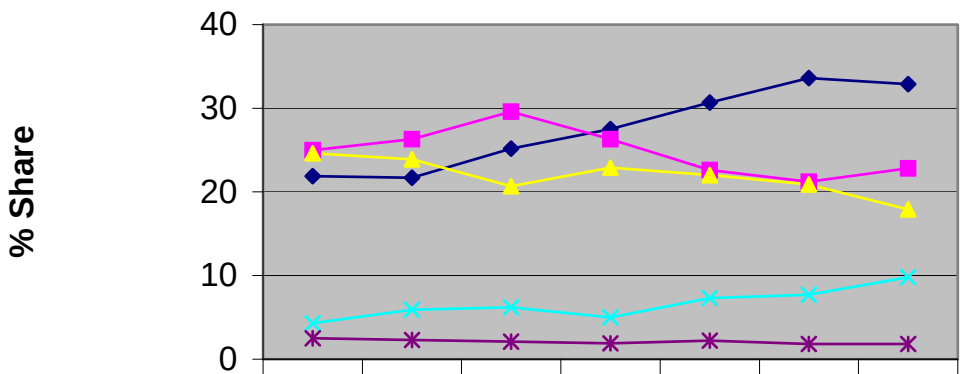
two-thirds of the shipbuilding and repair industry's $11 billion annual revenue. Of these big six, only Newport News is capable of building nuclear aircraft carriers, and only Newport News and Electric Boat are certified to build nuclear powered submarines. Further, only Bath Iron Works and Ingalls build highly complex major surface combatants, and both retain excess building capacity. In contrast, over 100 of the smaller firms have annual revenues of less than $5 million, representing less than two percent of the industry's total revenues.[2]

US shipyards build less than one percent of the world's total construction of commercial vessels over 1,000 gross tons.[3] Exports account for less than two percent of the US shipbuilding industry's revenue. Commercial ship construction in US yards is generally for the US market from which foreign competition is barred by the Passenger Vessel Services Act of 1886 (PVSA) and the Merchant Marine Act of 1920 (Jones Act). Various US regulations also result in construction of all defense vessels in US shipyards.

CURRENT CONDITION

The US shipbuilding industry is not competitive globally, as the following chart shows. In 2001, the United States ranked 15th in the world with a 1% market share, based on compensated gross tonnage.[4]

Figure 1. World Shipbuilding Comparison



	1995	1996	1997	1998	1999	2000	2001
Korea	21.9	21.7	25.2	27.5	30.7	33.6	32.9
Japan	25	26.3	29.6	26.3	22.6	21.2	22.8
EU	24.6	23.9	20.7	22.9	22	20.9	17.9
China	4.3	5.9	6.2	5	7.3	7.7	9.8
N/S Am.	2.5	2.3	2.1	1.9	2.2	1.8	1.8

Source: Organization of Economic Cooperation and Development – Mar 02

The US Government has taken various measures over the past century to protect and nourish the commercial shipbuilding industry. Strong advocacy for continued government economic protection for domestic shipbuilders through the restriction of foreign competitors retains significant appeal on many levels. But the long-standing protective and supporting provisions of the PVSA, the Jones Act and Title XI funding maintain a US shipbuilding capability that is not competitive internationally.

Other government measures that offer limited benefits to the US shipbuilding industry are the Buy American Act and the Oil Pollution Act of 1990 (OPA 90). The Buy American Act was not aimed specifically at the shipbuilding industry but it contains provisions that direct the industry toward a specific and limited set of US suppliers. OPA 90 is an environmental measure designed to reduce the potential for oil spills by requiring the construction of double-hulled tankers. The Jones Act will require tankers for use in the US to be constructed in the US. These measures are not presently providing the level of construction expected however, as operators move to a smaller fleet of larger ships and delay ordering OPA 90 compliant tankers.

While lack of commercial competitiveness does not affect the industry's ability to build military ships, it does affect the cost of these ships. With no commercial market, domestic shipbuilders rely on defense contracts. Current defense requirements do not fully use domestic shipbuilding capacity. While underutilized shipyards compete for defense orders, Defense is required by legislation to use only a limited and inefficient US domestic market for its supply of new ships. This co-dependent relationship is substantially less efficient in resource allocation than a truly competitive market.

Additionally, recent consolidation of the defense sector of the shipbuilding industry and the practice of teaming arrangements between shipyards further reduces the effectiveness of competition as a means to control production costs. Although direct comparison of the public and private yards is difficult, in the opinion of the authors, the US Navy compounds the inefficiency of the market by maintaining its own shipyards for repair work that the private sector could undertake more efficiently, and by using contracting procedures that promote inefficient processes, such as cost based contracts.

Productivity

In its May 2001 report entitled *National Security Assessment of the US Shipbuilding and Repair Industry*, the Dept of Commerce used two elements to measure productivity in the shipbuilding industry – value-added per employee and output per employee. The report used the automobile and aircraft assembly areas as a basis of comparison because these are the most closely related "heavy" industries. These industries have also experienced and recovered from productivity challenges.[5]

During the 1970s and early 1980s, many of the leading US industrial sectors were thought to be in decline, largely because of the proliferation of superior production techniques in East Asia. The US auto and steel sectors were particularly hard hit during that period. In the 1990s, however, these traditional manufacturing sectors showed

adaptability and largely recovered by embracing new technology and increasing labor productivity.

In the area of value-added per employee, the Dept of Commerce report[6] indicated that during the late 1980's, shipbuilding and repair employees added less value to finished products per person than automobile or aircraft assembly business. Indeed, during the two decades up to 1998, shipyards lost ground to all manufacturing industries and in aggregate have been consistently below the national manufacturing average in value-added per employee.

In the area of output per employee, shipbuilding and repair is also failing to keep pace with the automobile and aircraft industries. In the two decades between 1977 and 1998, shipbuilding and repair employee output rose by only 45% while automotive and aircraft assembly improved over 210 and 185 percent respectively.[7]

Again, using the Dept of Commerce report as a basis, among shipbuilding nations, US shipbuilders rank near the bottom in terms of productivity, and the gap is widening. The report indicates that labor, material, and overhead cost in the US shipbuilding industry are substantially higher when compared to the rest of the world. European and Japanese shipyards produce vessels more efficiently (with far fewer labor hours than the US) and continue to adopt new and proliferate superior production techniques while embracing new technology and increasing labor productivity.

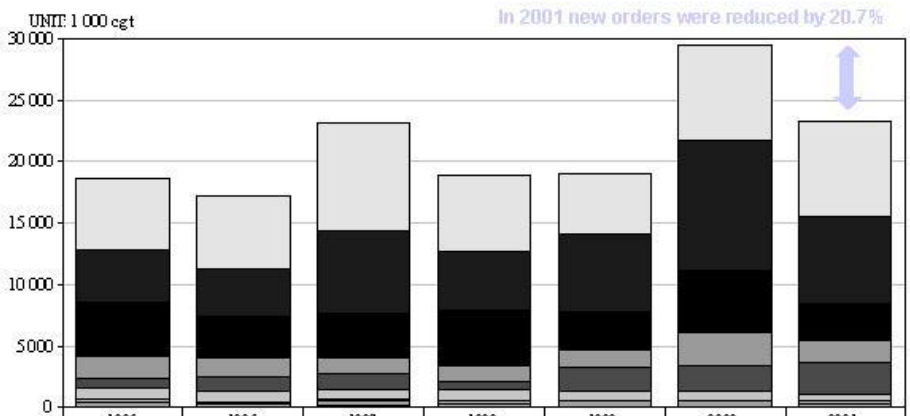
Information Technology

Information technology has changed the nature of shipbuilding more than any other single technology. It provides the means for Northrop Grumman and General Dynamics, the owners of the big six shipbuilding yards, to reduce management and administrative overhead across their geographically dispersed shipyards. By eliminating redundancies, gaining better supplier leverage, and transferring technologies and processes, they can reduce costs. By coordinating marketing and sales functions, sharing research and development, distributing knowledge, and managing external relations they can increase revenues. The US Navy can benefit from this management and production streamlining with better ships at lower cost.

Global Overcapacity

As depicted in the following figure, trends in sales and shipments of vessels worldwide indicate a sharp rise up to the year 2000. This is followed by a downturn in orders in 2001. Excess capacity in world shipbuilding is expected this decade. Such a surplus capacity will put pressure on international shipyards to cut costs, making US shipyards even less competitive.

Figure 2. Changes in world new ship orders



	1995	1996	1997	1998	1999	2000	2001
Japan	5 858	5 900	8 790	6 225	4 934	7 686	7 764
Korea	4 228	3 843	6 764	4 682	6 325	10 559	7 088
EU	4 362	3 333	3 567	4 460	3 060	5 050	3 028
Other Europeans	1 887	1 601	1 385	1 332	1 391	2 743	1 770
China	801	1 191	1 213	668	1 928	1 981	2 657
Asia & Pacific	820	836	785	920	786	838	570
NIS	246	179	174	174	69	84	248
North & South America	411	272	397	349	480	472	208
Africa & Middle East	32	9	120	12	20	18	9
Unknown	0 0 2 1	1 0 0					
WORLD TOTAL	18 643	17 165	23 197	18 823	18 993	29 431	23 341

Source: Lloyd's Register

CHALLENGES

US policymakers, concerned about the viability of the US shipbuilding industry, face four significant challenges in the coming decade. They are:

1) Managing overcapacity in the industry, exacerbated by duplicative and costly public yards;
2) Increasing productivity within the US industry to maintain its viability and reduce the cost of building ships;
3) Developing niche capabilities to compete in the global marketplace; and
4) Providing acquisition reform and incentives to promote innovation within the industry.

Overcapacity

The US shipbuilding and repair industry has significant excess capacity, both in commercial and military ship production. In the case of military ships, this is the result of an industrial base sized to meet the needs of a 600-ship Cold War Navy. Despite significant defense industry consolidations, the current big six shipyards possess an industrial capacity that far exceeds the demands of the current low rate of US military ship production. While the US shipbuilding industry possesses sufficient capacity to meet the requirements of military shipbuilding for the foreseeable future, the overcapacity represents an overhead that is costly and that may not be necessary.

In the case of commercial ship production, US shipyards possess significant unused capacity, despite substantial shipyard closings and consolidations. The US commercial shipbuilding industry lacks competitiveness internationally in the construction of large ships (crude oil tankers, bulk tankers, liquefied natural gas carriers and container ships). US commercial ship production is limited to the niche markets and markets protected from international competition by the Jones' Act. The challenge for US shipbuilding is to develop a competitive advantage in technologically advanced commercial shipbuilding, as it has in military shipbuilding.

Overseas shipyards face similar challenges created by unused capacity. This state of affairs will further reduce the ability of US shipyards to compete internationally. The rapid ascent of Korea as a world leader in commercial ship production and increasing Chinese shipbuilding market share has reduced profit margins and resulted in a world-wide industrial overcapacity in the international shipbuilding industry. The Organization for Economic Cooperation and Development (OECD) estimates international overcapacity will range from 16 to 29 percent by 2005.

The resulting high levels of world production in 2001 and 2002 further depressed price levels. Additionally, because of the high level of construction in 2000, orders for container ships, bulk carriers and cruise ships have dropped significantly. Increasingly, Japanese and Korean shipbuilders are focusing on the higher technology shipbuilding, such as liquid natural gas carriers, for future growth and market share.

Productivity

Productivity within the US industry lags because of its lack of investment in new technologies and its inability to retain skilled production workers. US shipyards vary in standards of cleanliness and condition and organization of materials. Overseas shipyards generally have a higher degree of automation.

Information technology is used to varying degrees in different shipyards. Many still rely on a wide range of hardware, software and operating systems that store data in disparate databases. Different information systems are used for different aspects of design and manufacturing as well as for administrative functions such as personnel and financial management. Automated manufacturing processes are mostly stand-alone

systems with no digital connectivity to overall process. In most cases, suppliers of components use different systems with no connectivity to the shipyard. Great scope exists for increasing productivity through investment in information technology.

The industry also has inadequate workforce skills required for job productivity. In some areas, there is surplus labor, in others shortfalls. More than two thirds of the US shipbuilders reported labor shortfalls, primarily in their production workforce. The industry has a high turnover rate, particularly amongst the newcomers, and is facing a major exodus of baby boomers in the near future. As demands for new ships are inconsistent, it is difficult for managers to keep employees working fulltime. The work is dull, dirty and dangerous and requires intensive training. The high turnover rate increases production costs as managers recruit and train new employees and accommodate their learning curve on the job.

Globalization

As the US progressed its transition from the industrial age to the information age, its steel production, automobile manufacturing, and other traditional heavy industries were among the first victims of the transition. Poor productivity through lack of innovation and investment made these industries uncompetitive internationally. The US shipbuilding industry is in a similar situation today.

While the US commercial shipbuilding industry sector is not competitive internationally, the military sector leads the world in advanced technology warships and submarines. Value adding at the high technology end of shipbuilding provides the US shipbuilding industry an advantage in combatant construction. A similar strategy needs to be applied to commercial construction if this sector is to remain viable.

Acquisition

Typically, a naval ship is funded from a single fiscal year's construction budget. When the Navy orders a new aircraft carrier for example, Congress allocates all the construction costs from a single year's appropriation. This severely affects the Navy's ship construction resources. It limits flexibility. Shipbuilders are unable to predict workloads. Funds are invested in potential assets that will not be operationally employed for 5 to 6 years.

Estimating costs for incorporating advanced technology later in the production timeline is difficult. Cost overruns are more likely because the actual cost of the technology is significantly higher by the time it is installed. The Navy is left with prior year shipbuilding bills and overruns that must be absorbed in the current year's naval construction budget. Unlike current policies requiring full funding of major capital projects, incremental or multiyear funding smoothes out the construction costs over the life of the project. It permits concurrent construction of more ships and optimizes available funding for maximum new ship construction.

OUTLOOK

The US shipbuilding industry has sufficient capacity to produce the military ships required to support national security. The industry has adequate workforce and facilities to meet current demand with additional capacity available to increase production when required. In addition to a trained workforce, the industry has the requisite engineering and design capability to produce technically complex, high value-added warships. Access to research and development facilities, both public and private, permit technology insertion and innovation to retain comparative advantage in constructing the most technologically advanced warships.

US shipyards are not competitive internationally in the commercial ship market and lag behind foreign shipyards in design, construction processes and shipyard layout. Protection from overseas competition has resulted in inefficiency and reduced incentive to adopt world best practices. However, this lack of competitiveness does not adversely affect national security because for the most part the shipyards that build military ships do this as their primary business. Lack of commercial orders will therefore not affect the viability of the industry to build warships and submarines.

Lack of commercial competitiveness could however, lead to further consolidation or closure of shipyards that primarily build commercial ships or military ships that are commercial in nature, such as tankers and transport ships. This in turn could affect future capability to meet Defense orders for these ships. But this should not be a concern in terms of national security because the global industry for building this type of low value-added ship is sufficiently robust to complement US domestic production.

Consolidation of the independent big six shipyards under two large defense industry corporations provides significant opportunities for achieving production efficiencies and cost control. Further efficiency in the industry can be achieved if the Navy plans, over time, to close its repair yards and outsource repair work to the private sector. Defense will reduce its costs by outsourcing and industry will have an additional source of revenue to help maintain their viability.

While in the short term, the US shipbuilding industry has the capacity to meet demand as determined in recent defense studies, the cost to maintain this capacity remains high. Within Defense, other high cost major end items compete for funding and this can delay procurement of new ships. Because of overcapacity, the US shipbuilding industry can support delayed construction in the short term. However, in the long term, delaying construction means that the Navy will have significantly fewer ships than required and, if delayed too long, the industry will not be able to make up the shortfall.

The US produces the most sophisticated and capable combatant ships in the world, and is preeminent in this field. US industry however, is a minor participant in the global military shipbuilding marketplace, selling only some aspects of advanced combatant technology to some allies. While the current combatant building program is inadequate to meet the projected needs for the Navy to maintain the numbers of ships

proposed in the QDR, it will not diminish the pre-eminent position of the US as the world's best combatant shipbuilding nation.

For commercial shipbuilding, the US industry produces less than one percent of the world's new construction while its exports account for less than two percent of the industry's total revenue. The ill fated 1994 OECD agreement,[8] designed to eliminate world shipbuilding subsidies, held promise to achieve a more level playing field. But even with such an agreement in place, the US is extremely unlikely to become a pre-eminent player in the world commercial shipbuilding marketplace. The US does however, have the ability to lead in high-end value-added technology in the shipbuilding manufacturing process.

America's need to project power and support a littoral defense strategy will provide continuing political support for the Navy and Coast Guard. The make-up of the US fleet will depend on the perceived threat but the shipbuilding industry is capable of adapting as necessary to design and build the high technology warships required for national security. Political will is likely to support a strong Navy, despite the excess cost that may be required to maintain excess capacity, either in public or private shipyards. Policymakers who would otherwise be reluctant to close public shipyards may see a viable opportunity for this as the aging workforce nears retirement.

GOVERNMENT GOALS AND ROLES

The government's role in industry should be to provide only that amount of regulation and assistance that allows the marketplace to drive the engine of economic growth. Further involvement may be required to enable industry to support specific needs of national security. For the shipbuilding industry then, the government should provide sufficient incentive for the industry to build the best military ship at a reasonable price.

The US government intervenes in the shipbuilding industry in a number of ways that distort market forces and prevent competition from forcing innovation and productivity improvements. Specifically US law requires vessels used for US domestic passenger and freight trade to be built in the US and to be owned and operated by US citizens. The Government also provides loan guarantees to encourage US operators to modernize their fleets and US shipbuilders to upgrade their yards.

Proponents of intervention generally label it as necessary to maintain a US capacity to build commercial ships that support a merchant fleet that could be used for defense purposes. Some also argue that a commercial shipbuilding industry will provide the skill base that enables warships to be built in the US. In reality though, the US merchant fleet is inconsequential in US world trade and of limited use to mobilize for support of military operations. The capability to build warships is self-sustaining rather than reliant on the commercial shipbuilding capability. In fact, US military shipbuilding is so technologically advanced that many skills have no equivalent in merchant ship construction.

Indeed existing government intervention is actually a cost to the economy in general and Defense in particular as the US Navy and US commercial operators pay a hefty premium on global market rates for purchasing US built commercial ships – costs that operators pass onto to customers and costs that Defense must take from other capital investments.

The role of Government in the US shipbuilding industry must be compatible with the Government's overall desire to promote economic growth and prosperity through global trade. The Government needs to continue to fund development of highly capable warships in the US and to have them built in the US. Not only is this prudent for national security, it is leveraging a genuine US capacity for high technology value adding that distinguishes US industry from that in most other countries. There is nevertheless scope for the Government to encourage innovation and productivity improvements in warship construction by the nature of contracts used.

To control costs, Defense acquisition policy must provide incentives for lowering production costs. This includes restructuring contracts to assure a return to defense contractors when savings are realized and could take the form of tax breaks and accelerated depreciation. Policy reforms must take into account free market forces. While controlling costs, private industry must maintain its profitability. Low and unstable rates of production are not incentives for private industry to control costs. Stabilizing build rates will even work load and allow shipbuilders to use resources more efficiently.

The Government also needs to review its continued involvement in the ship repair industry by examining the cost effectiveness of the public shipyards. Publicly owned operations are generally not as efficient as private operations. And in light of industry overcapacity, the public yards reduce the potential to make the private sector more efficient and viable.

For simple commercial ships, where US industry is not competitive, the Government should allow Defense and US commercial operators to purchase ships in the global market. The role of Government in this process will be to phase out protective measures, supported by appropriate economic measures that can assist those most severely affected to transition to other industries.

ESSAYS ON MAJOR ISSUES

ESSAY ONE - CONSOLIDATION AND REDUCED COMPETITION

At the end of the Cold War, there was a worldwide trend towards consolidation in defense industries. Today, after significant mergers and acquisitions in the United States, only two major defense shipbuilding companies remain and yet there is still overcapacity within the industry. This essay examines how downsizing affects the US shipbuilding

industrial base to determine if competition is still an effective mechanism for procuring the best ships at the best price.

Today almost all the US Navy's Shipbuilding and Conversion (SCN) funds go to the big six shipyards. Until 1995, these six yards were separately owned. Since 1995, there has been a steady move towards consolidating multiple yards under a few owners culminating with Northrop Grumman's acquisition of Newport News Shipbuilding in November 2001. The big six private shipyards are now owned by two Defense industry corporations - General Dynamics and Northrop Grumman.

Factors Influencing Cost

In general, the cost of a ship comprises the cost of resources used and the value that is added in the construction process. Resources are the factors that go into production and include material, labor, and overhead. Value-added is the increased value of the finished product above the value of its component parts. Simple ship designs have low value-added, and their costs are based primarily on the amount of resources used to produce them. Conversely, complex ships have high value-added and require extensive investment in research and development in addition to the cost of resources. Because only a few shipbuilders have the technological expertise required to produce ships that perform highly specialized functions, the law of supply and demand sets a high price for technologically advanced ships.

Comparative Advantage

Shipbuilders in countries that have access to cheap resources can be competitive in the low value-added shipbuilding market. For this reason, industries in the Republic of Korea were able to enter commercial shipbuilding in the 1970s and are now leading competitors. Today, China's industries are entering the market and they have the potential to capture a large market share of low value-added ships because of their low cost of land and labor.

Shipbuilders in countries that have higher production costs are not price competitive on low value-added ships and must rely on high value-added construction to be profitable. Recognizing that China can be more competitive in the low value-added market, Korean shipbuilders are refocusing their efforts from building low technology bulk carriers and container ships to higher technology liquefied natural gas carriers and offshore production facilities. For the same reason, countries such as Finland, France, Germany, and Italy build specialized ships such as cruise liners, offshore supply vessels, and ice breakers.

An exception to this generalization is Japan's shipbuilding industry. Japanese industries entered shipbuilding when the cost of resources was low. Today, Japan's labor rate is high relative to other countries and yet Japan is the leading producer of low value-added ships. The reason for this apparent inconsistency is that Japanese shipbuilders made heavy capital investment in automation and efficient production processes. While

European shipbuilders maintained their competitiveness by adding value, Japanese shipbuilders maintained price competitiveness by keeping production costs low.

The US shipbuilding industry's comparative advantage is in building technologically advanced warships. Some of the features that provide added-value to US built warships include integrated electronics and weapons systems, advanced sensors and weapons, redundant systems, survivability features, and advanced signature reduction. Additionally, technologies that reduce the total lifecycle costs of ships can be another form of value-adding. US shipbuilders can add value by introducing technologies that reduce manpower requirements in ships or lower the cost of maintenance over the life of the ship.

Competition within the US Industrial Base

For a number of reasons, competition for US military ship construction has always been within the US industrial base. During the Cold War, US shipbuilders focused almost exclusively on developing the most technologically advanced warships in the world and paid relatively less attention to controlling production costs. Capital investment was made in developing technology because the added-value created by technology provided a higher rate of return than investments made to keep production costs low. As a result, US shipbuilders are so technologically advanced today that even if competition were opened to foreign industry, no other shipbuilder could add the same value to a high-end combatant as US shipbuilders.[9] At the same time, production inefficiencies have increased the cost of a US built ship above the cost of its added technology. The challenge to Defense is how to maintain technological advantage and at the same time control production costs.

Competition is one means of controlling costs. But recent consolidation in the industry has reduced competition. Only Northrop Grumman builds nuclear aircraft carriers (at Newport News shipyard) and large deck amphibious ships (at Ingalls shipyard). While submarines are produced by Northrop Grumman and General Dynamics, production is under a teaming arrangement between subsidiaries Electric Boat and Newport News in which each yard divides the work roughly in half. Major surface combatants, amphibious transports, and auxiliary ships are built by in shipyards owned by both corporations to a common design.

In the current low-rate production environment of US military shipbuilding, a traditional competitive environment may not be in the best interest of national security. Such a competition would most likely result in the losing competitor being forced to close the shipyard that lost the bid. Without an understanding of the long-term shipbuilding requirements of the Navy, this outcome would be undesirable. In light of these considerations, competition is not an effective means to reduce production costs.

Potential for Production Cost Savings

Consolidation does provide potential cost savings in production. Companies can realize savings through combined material procurements, combined marketing, common financial and engineering tools, shared work and stable work force, optimal use of geographically close facilities, sharing of best practices, and a combined approach to capital improvements and sharing lessons learned. To maximize cost savings through these mechanisms, government policy should provide incentives to reduce production costs by passing on some of the benefits of cost savings to the shipbuilders. Contracts based on price instead of cost will encourage production efficiencies and will pass on savings to Defense in the long term.

Competition to Improve Value-adding

Even though competition in a consolidated industry has limited effectiveness for controlling production costs, competition is still an effective means for promoting innovation. In approving recent mergers, Defense supported acquisitions that preserved design, engineering, and research and development capability within each of the consolidated shipbuilding corporations.

Because of competition for design, Newport News Shipbuilding and General Dynamics both submitted a significant number of design changes for improvements in the Virginia Class submarine at the time mergers were under consideration. Maintaining submarine design and construction capability by two separate owners preserves competition that can lead to improvements.

Similarly, Northrop Grumman and General Dynamics competed for the design of the future surface combatant in the DD(X) program. Although both companies will participate in construction of the final design, competition for design is an effective means to promote innovation. Not only will innovation lead to increased capability, it will also lead to lower total ownership costs.

Conclusions

Although consolidation has reduced the role of competition in controlling production costs, economies gained through consolidation can reduce costs. At the same time, competition for design of future combatants ensures that the US maintains its technological advantage. By the nature of its value-added, the cost of a US warship will remain high but, through the opportunities provided by consolidation, Defense should promote production cost control so that the price of a warship is reasonable considering its value-added.

ESSAY TWO - THE IMPACT OF LABOR ON SHIPBUILDING PRODUCTIVITY

The shipbuilding industry remains challenged when it comes to productivity. As US shipbuilding is a labor-intensive industry, manpower will have a direct impact on its productivity. During the past twenty years, automation and lean manufacturing practices, mergers and acquisitions, as well as reduced demands have had a direct impact on shipbuilding personnel. The number of US workers in commercial shipyards declined from 180,000 in 1980 to 89,000 in 1998.[10] In some areas, the industry has labor shortfalls, in others, surplus labor.

Labor Shortages

The Dept of Commerce 'National Security Assessment of the US Shipbuilding Industry' found more than two thirds of the corporations it surveyed reported labor shortfalls, primarily in their production workforce. Managers felt these labor shortages "reduced their profitability, increased construction costs and delayed project completion."[11]

In the Dept of Commerce survey, shipbuilders expressed concerns about their ability to recruit and maintain an adequate workforce. One company estimates a thirty percent turnover every three years. Another reported a 200% turnover during a single year. Managers feel they have "high turnover due to uneven workload, harsh work environment and competitive labor market."[12]

One of the issues managers did not consider in the Commerce survey is pay. Although workers are paid slightly more than others are in manufacturing industry (except automobiles and airline industries), hourly wage rates have remained constant since 1977. Wages of automobile and airline workers have increased thirty percent.[13] Workers in US shipyards are paid the lowest hourly rates of shipyard workers in developed nations.[14]

Shipyard managers must also plan for the eventual turnover of their aging workforce. Depending on the particular regions, 50% to 70% of the workforce is over 40, and 20% to 38% is over 50. As all companies have seniority policies, the newest employees have been the first to be laid-off. Employees under the age of 30 working for the six largest shipbuilders range between 5% and 22% of the total population of the workforce.

Labor Surplus

Specialization of the workforce also affects productivity in some shipyards. "Narrowly defined job classification/titles can cause idle time and reduce a shipyard's flexibility to utilize its workforce effectively." Many of the local unions will not allow their employees to cross to other trades, arguing that this practice constitutes a safety issue. Military procurement practices indirectly reinforce the practice by paying rates

based on an individual's years of experience in a trade. The industry considers skill certification a primary predictor of quality. An employee's skills may only be required on a short-term basis, particularly if the worker is trained in a single trade.

Developments

Shipbuilding work is in the main dull, dangerous and dirty. Shipbuilding companies are beginning to address personnel issues. Some are offering signup bonuses for new recruits and referral bonuses to the employees who bring them in while others are encouraging employees to cross train in other skill areas.[15] Most have initiated aggressive recruiting campaigns with local high schools, trade schools, and/or colleges. Co-op programs (work while in school) are particularly successful. Many of the larger corporations have instituted some type of in-house training (on-the-job training or apprenticeships) to ensure necessary skills can be developed.

In the area of improving morale, employers are addressing availability of meals, physical fitness opportunities and cleaning up the shipyards. With computer-aided manufacturing and robotics, they have improved safety conditions. Still, new employees seem unwilling to stay and employee productivity related to output has lagged when compared to other industries.

ESSAY THREE – EFFECTS OF GLOBALIZATION

The US has utilized many incentives to protect its shipbuilders from overseas competition and to encourage competition within the US market. With globalization providing the basis for future US economic prosperity, many of these Government programs need reviewing to ensure they support overall growth and prosperity in the US economy.

The Jones Act

The Jones Act provides that vessels built for the US coastwise trade be built in the United States and be manned, flagged and operated by US crews. The Jones Act has shielded the domestic shipbuilding industry from global competition. This has had the effect of delaying improvements, automation and best practices within shipyards producing commercial ships. US shipbuilders often have antiquated manufacturing and production processes, nominally higher labor costs, considerably higher man-hours required to build a vessel and higher material costs.

Supporters of the Jones Act will argue that commercial shipbuilding defrays some of the overhead at shipyards that construct both military and commercial ships. But it is defrayed within US industry by the premiums US commercial shipping operators pay for US built ships. Without the Jones Act, supporters argue, US shipbuilders would not be price competitive with foreign shipbuilders and new orders for commercial ships would go to overseas shipyards. When this happens, only military ships will be built in US

yards. Shipyard overhead will then be passed on to the US government as a premium on the cost of a new ship.

Opponents of the Jones Act will point out that in the long run eliminating the Jones Act will force US shipbuilders to become more competitive. The two US shipbuilders that build both commercial and combatant ships have invested heavily in acquiring their shipyards. With more advances in project management and production automation efforts, both could become more competitive in the international market.

By phasing out industry protection under the Jones Act, shipyards will be forced to be more efficient or to stop building ships. The likely scenario in the event the Jones Act is phased out is that one of the two shipyards that build both commercial and military ships will be forced to close. But the surviving yard will be more efficient and will fill more of its order book with military ships. For Defense, any requirements for commercial standard ships that cannot be met by the reduced number of US shipyards can be sourced on the international market.

Antitrust Issues

Shipbuilding today is in a very different environment from the economic situation that existed when antitrust laws were enacted. Military and commercial shipbuilding occurs in a worldwide market that is undergoing heavy consolidation. The sole US customer for military ships is the US government. The Government is reviewing mergers in order to promote stability and support the industrial base.

The Government also seeks to structure mergers in a way that encourages competition in key competitive advanced technology fields related to shipbuilding. The Government is also looking at mergers from the standpoint of personnel recruitment and retention. In the new global environment opportunities may arise to engage other countries in partnerships and joint ventures, and antitrust law should take this development into account.

In the post-cold war, competitive, and globalized world of the twenty-first century, the US has secured a place as the world's premier economy and sole superpower. One area in which the US has secured a solid foundation for future growth and opportunity is manufacturing, particularly high technology value adding. But, according to a Dept of Commerce report, "despite overall growth in manufacturing in the US, shipbuilding and repair continues to contribute a small and declining percentage of the national total." This indicates not just that the industry must improve if it is to survive, but that its demise would have little long-term economic impact on GDP.

ESSAY FOUR - ACQUISITION & INNOVATION

The business of shipbuilding has traditionally been a time-consuming process, combining the considerable engineering challenges of designing, assembling, machining,

and fitting as many as a million parts within a single structure. Shipbuilders must increase their competitiveness by delivering high-quality products within compressed development schedules at very low costs. These needs are even more urgent because the shipbuilding industry in the United States has experienced significant downsizing following the end of the Cold War and the accompanying reduction in defense budgets.

Enablers like innovative procurement procedures, increasing emphasis on interoperability and jointness, and use of digitization and other information technology advancements can leverage capabilities and obtain the best possible value for our limited resources.

Innovative Procurement Procedures

Common practices between commercial and military contracts will help make industry more efficient in both markets. A metric other than man-hours must be used to calculate the cost of ships and encourage the industry to move away from less efficient manpower intensive practices. A fixed price contract, which allows shipbuilding firms to keep cost savings achieved because of investing in automation and lean manufacturing techniques, would provide incentives to modernize.

Multi-year procurement contracts are one example of fixed price contracts currently being utililized by the Navy to procure AEGIS destroyers with significant cost savings. Multi-year procurement contracts identify a specified number of ships to be built at a single yard over five years. This policy enables employers to plan several years at a time, which allows them to provide workforce stability and purchase materials through better economies-of-scale. Within multi-year procurement contracts, design changes need to be considered carefully as they can add considerable costs to the project. The challenge with change orders is to develop a procedure that can incorporate a contingency for changes at the start of the contract.

Coast Guard Deepwater Project

In developing the Integrated Deepwater System, the Coast Guard broke with the traditional federal acquisition approach in favor of an innovative mission-based performance acquisition methodology. Key to the project's philosophy is the need to leverage commercial and military technologies and innovation to develop a completely integrated, multi-mission, and highly flexible operating system at the lowest possible total ownership cost—including funds for research and development, design and engineering, acquisition, and life-cycle operations and support.

Rather than focusing on specific hardware—e.g. a specific class of cutter or aircraft—the Coast Guard has developed performance specifications that describe the fundamental capabilities the service needs to perform all of its maritime security missions in the Deepwater operational environment. Source selection is based on four criteria - operational effectiveness, technical feasibility, managerial capability of the team, and total ownership cost of the system. The principal benefit of using the mission-based

performance acquisition approach is that it gives industry great flexibility to leverage proven as well as leading-edge technologies to provide optimal operational effectiveness at the lowest total cost.

The acquisition strategy is innovative but concerns among legislators are that reliance on a single contractor could potentially lead to cost overruns and delays. By giving industry scope to design a system of systems, the Coast Guard is encouraging innovation and cost effective delivery of capability.

Future Destroyer - DD(X)

In April 2002, the Navy selected Northrop Grumman (Ingalls) as the lead design agent for the DD(X) ship program. This includes the award of a cost-plus award-fee contract for design agent activities such as the systems design of the DD(X) destroyer, and the design, construction and test of its major subsystems. The approach adopted for the DD(X) program recognizes the strength of the US shipbuilding industry in developing advanced combatant technology. Design competition within the US shipbuilding industry allowed Defense to leverage innovation in research and design concepts.

The team of contractors included Raytheon Systems as the combat systems integrator. The team's proposal also incorporated "Blue Team" member Bath Iron Works (BIW) as a subcontractor to perform DD(X) design and test activities, which will ensure BIW will have the ability to produce a detailed DD(X) design and build these ships in the future. By sharing the eventual building of this class of ships between two competing shipyards, Defense is maintaining a redundant capacity for advanced surface combatant construction.

The award of the DD(X) Design Agent contract signals the start of a revolution for the Navy's surface combatant fleet, with the development of transformational technologies that will create new capabilities while reducing crew size and yielding significant combat advantage.

Information Technology Digitization

Shipyards in Europe are leading a trend to convert to digitized applications that integrate the entire shipbuilding process from design to production. It allows shipyards to devise build strategies that focus on earlier production start, minimum building dock time, extensive pre-outfitting, accurate work content estimates and specific production information for each stage of production.

IBM/Dassault's Computer-Aided Three-dimensional InterActive (CATIA) is such an application. General Dynamic's Electric Boat, and Northrop Grumman's Newport News Shipbuilding selected CATIA to construct the Virginia Class attack submarines. Howaldtswerke-Deutsche Werft (HDW), the German shipbuilding giant also converted its entire development, engineering and product data management to CATIA. The design itself is embodied in three-dimensional drawings of individual components,

systems and major deck assemblies that replace paper-based drawings and reduce reliance on wooden mockups. These electronic representations can be manipulated by "virtual walk-throughs" and "what-if?" iterations that validate design and engineering decisions before any metal is cut. When manufacturing actually begins, the computer-based design elements are linked directly to digitally controlled machinery on the manufacturing floor where metal is cut to exact specification.

In the Virginia class attack submarine program, the result has been a 90 percent reduction in construction problems over the Seawolf class at comparable points in construction. Digitized systems like CATIA allow shipyard engineers and designers to work both internally, sharing critical design data in real-time, and externally with major suppliers through the Internet. Digitization allows simultaneous engineering and better and quicker access to information to forge closer ties with suppliers.

CONCLUSION

American shipbuilders produce the best military warships in the world. They are state of the art high value added vessels designed for deepwater operations and power projection missions that support our national security strategy. As a maritime nation, continued preeminence in military warship construction is essential for national security.

In the commercial sector, the United States continues to remain globally uncompetitive in the production of large commercial vessels. Government intervention in commercial shipbuilding via the Passenger Vessel Safety Act and the Jones Act has resulted in a lack of competition, promoting inefficiency and reduced incentive to adopt world best practices.

Lack of commercial orders will not affect the viability of the industry to build warships and submarines but could lead to further consolidation of shipyards that primarily build commercial ships or military auxiliary ships. This could affect future capability to procure these ships domestically, but the global industry for these lower value added ships is sufficiently robust to complement US domestic production should the need arise. A viable commercial shipbuilding industry is therefore not an essential requirement for national security.

The US must continue to build its own warships and submarines because this is both a key element of our national security and it offers the best opportunity for the US to maintain its pre-eminent position in advanced technology military shipbuilding while developing a commercial edge in niche commercial shipbuilding. Defense can drive productivity improvement by using contracts that encourage innovation and efficient production processes, by stabilizing build rates, and by requiring builders to consider total life cycle costs in design and construction. Programs like the DD(X) and Coast Guard Deepwater programs are promising examples of these acquisition reforms.

The cost of maintaining excess military shipbuilding and repair capacity and a non-competitive commercial shipbuilding industry impose increasingly high opportunity costs on national security resources. These costs can be reduced by closing public shipyards and outsourcing repair work to the private sector, and by allowing international competition for the construction of naval auxiliary vessels.

While costs and overcapacity remain concerns for the foreseeable future, America's shipbuilding industry will continue to provide the nation with the necessary warships and support vessels needed to meet America's national security objectives.

ENDNOTES

[1] Description of the shipbuilding and repair industry is drawn from the definition used in the US Dept of Commerce, Industry and Trade Outlook 2000, pp 22-1/22-2

[2] US Dept of Commerce, National Security Assessment of the US Shipbuilding and Repair Industry, Washington DC, May 2001, p7

[3] ibid, pxiv

[4] Compensated Gross Tonnage (CGT) is a numeric coefficient that is intended to account for vessel complexity. For a more detailed description refer to the National Security Assessment of the US Shipbuilding and Repair Industry, May 2001, p60

[5] US Dept of Commerce, National Security Assessment of the US Shipbuilding and Repair Industry, Washington DC, May 2001, p97

[6] ibid, p103

[7] ibid, p104

[8] OECD Council Working Party on Shipbuilding, 1994 Agreement Respecting Normal Competitive Conditions in the Commercial Shipbuilding and Repair Industry, (available online at www.oecd.org/dsti/sti/industry/ship/act/wp7.htm)

[9] Other nations build advanced combatants such as diesel submarines, small aircraft carriers and frigates but their technical complexity is generally at a lower level than the most advanced US combatants.

[10] Bell & Howell; Training Funds will Help Area Shipyards Build Workforces, *Info & Learning Business Dateline*, Vol. 22, No 3, 15 Mar 01.

[11] Op cit, National Security Assessment of the US Shipbuilding and Repair Industry, May 2001, p ix.

[12] ibid p x

[13] ibid p 100

[14] National Shipbuilding Research Program, Shipbuilding Technologies – State of the Art Assessment, North Charleston SC, Aug 00 (www.nsrp.org)

[15] Bell and Howell; Worth their Weight in Gold, *Info & Learning Business Dateline*, Vol. 22, No 17, 22 Oct 01, p 33

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