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Industry Study**

**Final Report
*Shipbuilding***



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SHIPBUILDING INDUSTRY 2015

ABSTRACT: Increasing globalization demands the ability to move raw materials, components, and finished products across the world’s waterways. The shipbuilding industry that makes this possible is mature, fairly stable, and increasingly concentrated. Barriers to entry are high, and the health of the industry depends on relatively few key external drivers. While it dominates the military segment of the industry globally, the United States is a minor player in the commercial segment. Foreign government subsidies and other financial incentives provided to industry have caused U.S. yards to lose market share in a competitive industry. The negative impacts to naval construction come from reduced defense spending and lack of contract predictability. Recommendations focus on changes to budgeting and acquisition policies, and to planning methodologies used in the U.S. Navy, Department of Defense, and Congress.

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PLACES VISITED

Domestic:

Newport News Shipbuilding, Newport News, VA
U.S. Coast Guard Yard, Curtis Bay, MD
Carnival Corporation and PLC, Miami, FL
MS Noordam, Holland America Lines, Fort Lauderdale, FL
Bollinger Shipyard, Lockport, LA
Edison Chouest Offshore, LaRose, LA
Huntington Ingalls, Pascagoula, MS
VT Halter Marine, Inc., Pascagoula, MS
Waterman Steamship Corporation, Mobile, AL
Austal USA, Mobile, AL
General Dynamics/National Steel and Shipbuilding Company (NASSCO), San Diego, CA
BAE Systems San Diego Ship Repair, San Diego, CA

International:

Joint U.S. Military Advisory Group, Korea (JUSMAG-K), Seoul, Republic of Korea
Hyundai Heavy Industries, Ulsan, Republic of Korea
Hyundai Motors, Ulsan, Republic of Korea
Daewoo Shipbuilding and Marine Engineering, Okpo, Republic of Korea
Samsung Heavy Industries, Geoje, Republic of Korea



INTRODUCTION

The United States needs to embark on a long-term campaign to improve the nation's shipbuilding capacity and infrastructure to mitigate risks to national security.

When we originally wrote this thesis, seminar members agreed the risks to national security from a weak shipbuilding industry were both economic and military. After examining the major issues in the industry we concluded the health of the commercial sector was a factor, but not critical, to the naval shipbuilding sector's health. This reduced the importance of revising protectionist statutes as this would have little impact on naval shipbuilding. Examination of the remaining key issues led us to revise our thesis: *The United States needs to modify Department of Defense (DoD) acquisition policy and planning to increase predictability in Navy shipbuilding.*

This paper will demonstrate the strengths and weaknesses of the U.S. shipbuilding industry, as well as potential threats to national security and opportunities to ensure a robust industry in the future. While we do survey the commercial side of the industry and provide recommended actions that could help regain some of its lost market position, more weight is given to the naval shipbuilding segment in both discussion and recommendations.

The United States is unequivocally a maritime nation, with powerful defense and economic interests. Our ability to dominate the seas during World War II and emerge as a superpower was enabled by a focused industrial surge. This, in turn, was enabled by a large number of ship yards capable of rapidly capitalizing the Navy. That surge capacity no longer exists as the number of shipyards has diminished while the complexity and expense of new ships slows production to a barely sustainable rate. Today, the U.S. commercial sector enjoys <1% of global market share.¹

A market definition of shipbuilding is straight forward if somewhat inelegant: "Companies in this industry operate shipyards or boatyards. Shipyards are fixed facilities with dry docks and fabrication equipment capable of building ships, including barges, cargo ships, container ships, ferryboats, fishing boats, passenger ships, patrol boats and sailing ships."² This definition is useful as a description of what shipyards can produce, but it falls far short of describing how the "critical infrastructure in this vital section of our nation's economy is key to sea power,"³ or why shipbuilding is a "strategic national (asset) essential to U.S. national security interests."⁴

To illustrate the linkage between shipyards and national security, we will first define the industry and discuss current conditions, including the economic health, strategies, and challenges that signal long-term outlook. We will survey the role governments have played in building and maintaining shipyards, and consider a proper role for the U. S. government. This will introduce four essays addressing major issues facing the industry, and each will include recommendations for future action to ensure the domestic shipbuilding industry remains a viable strategic national asset.

Throughout the report, we describe the shipbuilding industry using standard economic and industry terms. All monetary figures are in U.S. dollars. Analysis will employ both objective and subjective methodologies. Charts and graphs that support statistical analyses are illustrated in appendices as referenced in the body of the report. Subjective analyses are based on personal interviews of government and industry leaders, class interactions with domestic and foreign shipyards and ship operators, and studies of published works.

THE INDUSTRY: DEFINITION AND CURRENT CONDITION

The global ship and boat building industry's projected 2014 revenue is \$258.1 billion. This industry includes construction of boats for consumers, ships and specialized vessels for commercial and government customers, and repair activities. This represents an average annual growth of 1.1% over the past five years. With a five-year projected 1.2% annualized growth,



revenues are expected to be \$274.5 billion in 2019.⁵ Globally, exports account for \$156.6 billion. Repair, the least capital intensive and time-consuming activity, provides only 6.9% of revenues to the industry. Boat building revenues are much larger, accounting for 29.3% of revenues, while shipbuilding accounts for 63.8% worldwide. The greatest concentration of business is in North Asia, with these business earning 60.2% of industry revenues. Second-place Europe is far behind at 16.0%.⁶ The industry is in the mature phase of its life cycle, and barriers to entry are medium and increasing with government assistance and high capital investment costs deterring new entrants.⁷

The U.S. share of the shipbuilding industry is \$25.5 billion in revenue, or a 9.87% share of the global ship and boat building market.⁸ This represents an average annual growth of -1.8% over the last five years. The five-year projected annualized growth rate is expected to be 2.2%, indicating renewed health. U.S. exports of \$1.7 billion account for only 7.8% of its revenue due to lack of penetration and the inability to compete in the global market.⁹ This is a result of Asia's competitive advantage.¹⁰ Clearly, the United States is a minor player in the global shipbuilding market. Annual output accounts for less than one percent of the worldwide order book for new construction. The industry is characterized by well-established products that are split into three market segments.¹¹ Military shipbuilding makes up the largest segment that includes naval ships, patrol ships, and submarines.¹² Activities in this segment, including repair, account for nearly 69% of domestic ship production and repair.¹³ The commercial segment includes bulk-shipping companies and cruise ship operators.¹⁴ Lastly, the consumer segment consists of leisure boats that have a higher sales volume and faster turnaround time.¹⁵ The U.S. shipbuilding industry's 2014 revenue represents <0.1465% as a share of the nation's \$17.4 trillion GDP.¹⁶ As a measure of direct impact this is not an economically vital industry nationally, but there are indirect and induced impacts that make it a dominant engine for some local and regional economies.

Among the small number of key external drivers are federal spending on U.S. Navy ships, and oil and gas exploration and production, which has increased in the United States following a moratorium in the aftermath of the April 2010 Deepwater Horizon spill in the Gulf of Mexico. The "competition protection provided by the Jones Act,"¹⁷ more properly the 'Merchant Marine Act of 1920,' provided opportunities for U.S. shipyards to monopolize production of offshore platforms, drilling ships, and tankers for domestic operators.¹⁸ Additional external drivers are the price of steel, which impacts profitability, and the effects of consumer spending on demand for goods and related delivery systems.¹⁹

Market share concentration is high, and has decreased in the commercial segment in the last five years due to energy industry expansion. This has also eroded the market share of shipyards engaged in defense production. As of August 2014, General Dynamics (29.2%) and Huntington Ingalls Industries (27.6%) hold a combined 56.8% of U.S. industry market share.²⁰ Huntington Ingalls Industries acts as a monopoly in building aircraft carriers for the U.S. Navy. Because the Navy is a monopsony in this very narrow market, however, oversight and cooperation between builder and customer are essential to keep costs down and contract changes to a minimum.

Barriers to entry are high domestically. Capital costs to establish shipyards, and the retooling necessary to remain competitive as new classes of ships and innovative methods and materials are introduced, "makes it very difficult for new operators to enter the industry."²¹ Due to increased energy exploration, it's estimated there were 569 industry enterprises including smaller yards and repair facilities, and 111,905 employees²² in the United States, representing annualized five year increases of 0.7% and 1.05% respectively.²³ The industry is concentrated in the Southeastern United States because of proximity to oil and gas production, and large naval facilities in Virginia and



Florida.²⁴ Because of this high concentration and capital requirements that act as barriers to entry, competition is low in this industry.²⁵

Asia, led by South Korea, dominates the cost-competitive commercial shipbuilding segment. South Korea overtook Japan to achieve the top spot in the 1990s.²⁶ Now both countries continue to invest and use technology to delay China's meteoric rise.²⁷ Inevitably, China's state-owned shipyards will take the lead due to the government's substantial investment and significant low-cost advantage permitted by cheap labor that represents 31.8% of the industry's costs.²⁸ The United States remains very uncompetitive with 2014 revenue of \$6.87 billion and an inconsequential single-digit market share.²⁹ Moreover, Asia's competitive advantage of increased efficiencies, substantial government subsidies, and supportive trade practices will suppress the United States' growth.³⁰ This drives U.S. shipyards to remain focused on the smaller domestic market that is protected by the Jones Act.³¹ This, in turn, results in a domestic industry that has less investment in productivity and capacity than its Asian counterparts.³²

The military shipbuilding segment is critical to a nation's defense and ability to project its interest overseas.³³ Current global revenue in this segment is \$38.1 billion, and is anticipated to increase at an annualized rate of 3.9% to \$46 billion in 2019.³⁴ Profit margins are expected to rise from 8.6% in 2014 to 9.1% in 2019.³⁵ The U.S. Navy's planned spending of \$15.23 billion in 2014 represents approximately 40% of global military shipbuilding and 69% of total U.S. shipbuilding industry revenue.³⁶ Most of this spending is for low production volumes of highly specialized, sophisticated, and expensive vessels.³⁷ However, U.S. government fiscal constraints may reduce these procurements and exert more pressure on an unstable industry.³⁸ Globally, nations enjoying increasing economic growth and in the midst of rising geopolitical tensions may be increasingly interested in procuring more advanced naval products from other countries.³⁹ The U.S. shipbuilding industry may benefit from this interest if it can design and build the kinds of vessels foreign navies want for an acceptable price.

However, governments often protect and support their domestic industries to maintain technological advantages and to prevent dependence on foreign nations.⁴⁰ This makes the military shipbuilding segment heavily reliant on government policies, economic forces, and security considerations.⁴¹ Yet, multinational collaboration has increased as countries become more willing to outsource and transfer technology to increase exports.⁴² This will increase the segment's trade at an annualized rate of 4.1% to \$5.7 billion by 2019, with Russia, China, the United Kingdom, and France representing the largest exporters.⁴³ Europe generates as much as 60% of its industry revenue from exports while some countries, such as Russia, rely on them to maintain shipyards.⁴⁴ The United States derives only about 15% of revenue from exports, relying instead on its domestic monopoly.⁴⁵

An effort to grow U.S. exports could offset diminishing domestic demand caused by fiscal constraints that will delay starts, reduce quantities, or even cancel projects.⁴⁶ An unwillingness to do this could result in a diminished share of global sales as other nations increase naval defense spending and production.⁴⁷ Failure to take advantage of a growing global demand could create opportunities for emerging economies to increase competitiveness as they become more sophisticated at design and leverage their lower costs, efficiencies, and commercial shipbuilding advantages.⁴⁸ These new competitors could also bridge entry barriers through increased joint ventures to ease associated costs and enhance their manufacturing capabilities.⁴⁹ In addition, they could further build state-owned naval corporations and provide large subsidies to heavily invest in productivity improvements and low-cost strategies.⁵⁰



In the next two sections, we will discuss and analyze industry challenges and outlook. To help us do that, we first evaluated industry strengths, weaknesses, opportunities, and threats (SWOT). The result is the below “SWOT analysis” (*see Appendix I*). Here we not only tighten our focus on naval shipbuilding, but look at internal and external factors in a deliberate way that signals trade-offs we might make to improve the government-industry relationship and enhance national security.

We have identified four key strengths that show where the industry has its greatest advantages. Warship design and technology is a significant strength in our domestic industry. Innovations in design, development, and manufacturing have allowed the United States to build a navy of uncontested strength and presence. The U.S. Navy is only one of a few navies that have the technological capabilities to undertake advanced large-scale construction, such as aircraft carriers.

The United States also has a large defense budget, allowing the Navy to fund new shipbuilding and support services. This includes the construction of extremely expensive and sophisticated products such as nuclear attack submarines. The industry’s largest players and their suppliers have benefited from this by supporting the demand for multi-ship contracts and long project lead times. This has kept military shipyards and work stable during a time when commercial shipyards were impacted by recessions. U.S. government purchases account for the majority of the broader shipbuilding industry’s revenue.

The third strength is the Navy’s size. With the world’s largest Navy, the United States builds nearly every type of military vessel used by modern navies. The U.S. Navy has more aircraft carriers than all other nations combined, and it operates daily on all of the world’s oceans.

The last strength is the workforce. The United States has the world’s most skilled and experienced naval shipbuilding work force. In this labor intensive industry, over 1,000 highly skilled technicians might be required to work on a single large ship at one time. The size and complexity of these ships means labor costs account for an estimated 25% of industry revenue.

We also identified four weaknesses that show industry disadvantages relative to competitors. The first weakness is high industry concentration. This industry has high barriers to entry, largely due to the enormous capital costs associated with acquiring manufacturing equipment and land, particularly waterfront properties, and upfront manufacturing process costs. Combined with relatively low volume, this has resulted in a highly concentrated industry.

The next weakness is low competitiveness. A shipbuilder’s ability to win large-scale shipbuilding contracts depends on the size and capacity of its shipyard, its design and development engineering techniques, reliability of products and services, reputation for integrating complex systems, and ability to respond to changing customer needs. Combined with high concentration, this creates a low competition level between remaining firms within the industry. High market-entry risk, capital investment requirements, and specialization promote stability in the industry, but consequently lowers competition levels.

Shipyard constraints and inefficiencies are another industry weakness. A number of variables determine the distribution of shipbuilding and repair operations throughout the United States, to include proximity to port facilities and to naval facilities. This constrains shipyard enlargement because of the high capital investment and restraints in expanding to adjacent land areas. Additionally, because each ship class is unique, shipyards would need to constantly retool in order to increase efficiencies of existing and new contracts. Reduced military and commercial orders restrain ship construction, and that pressures shipyards to reduce capacity and the labor force.



Exports are the last weakness we identified. U.S. military shipbuilders are more competitive in the international defense market than their commercial counterparts, with small and medium sized shipyards often selling vessels to foreign governments. Nevertheless, foreign military sales account for a small share of defense contracts. On average, major U.S. defense contractors derive roughly 15% of total revenue from international sales.

We identified three opportunities, or areas where the industry could exploit its advantages. There is an opportunity through foreign military sales to increase the industry's customer base. If the United States could increase total revenue from international sales to that of its European competitors (as much as 60%), it would make a significant positive impact on shipyard volume.

Infrastructure investment and modernization represents another opportunity. As the U.S. Navy attempts to meet its objective of creating a fleet to meet anticipated challenges in the coming years, there is an opportunity to develop policy that focuses on a strong financial structure and modernization and that supports long lead times in the design, construction, and delivery of ships. In return, military shipbuilders would have confidence to continue investing in restructuring their operations to increase efficiencies and industry competitiveness.

Industry cooperation provides an opportunity to increase industry competitiveness. Concentration within the industry has led to increased cooperation among companies. Some shipbuilders act as subcontractors on one project, while simultaneously competing against the prime contractor for another contract. This benefits smaller companies and the industry at large. In addition, encouraging cooperation between domestic and foreign entities will provide benefits to adopt best-case processes that improve efficiencies and decrease shipbuilding costs and time.

Finally, we identified three threats that could create challenges in the industry if not addressed. The first threat is budget uncertainty. Withdrawal from conflicts in the Middle East, combined with the government's attempts to reduce the fiscal deficit through broad spending cuts, could derail the Navy's procurement plans with delays, reductions, or even cancellations. This budgetary uncertainty poses a potential threat to an industry that requires long-lead times and stability.

The next threat is that the constrained defense budget will compel the Navy to increasingly compete with other Pentagon programs, such as the F-35 stealth fighter. This may threaten the Navy's support for the Asia rebalance, and will impact the military shipbuilding industrial base.

The last threat is globalization. Larger foreign companies, such as BAE Systems and Austal, have developed market penetration strategies intended to grow, develop, and export their products. Quality foreign products at lower prices could create threats to U.S. foreign military sales.

The elements identified in this analysis must be kept in mind as we review the industry's challenges and outlook and again consider our thesis that the United States needs to modify DoD acquisition policy and planning to increase predictability in Navy shipbuilding.

CHALLENGES

Economist Michael Porter's "Five Forces" model⁵¹ (*see Appendix 2*) illustrates the competitive landscape, provides good insight into the overall workings and health of the industry, and is a useful tool to identify industry-wide challenges. The factors described here apply, to varying degrees, to the commercial side of the industry, but our focus is on naval ship construction.

We assess rivalry among existing competitors as medium. There is a small number of firms, each familiar with its competitors and industry innovations. Industry consolidation has reduced the number of firms competing for contracts where delivery times, quality, and reputation



add to the competitive environment. While there are multiple shipyards that could theoretically compete to build the different types of naval vessels, specialization has become the norm in this industry segment. As an example, General Dynamics NASSCO in San Diego specializes in support ships, such as the T-AKE class of cargo vessels and the Afloat Forward Staging Base. Because of steps they have taken to drive down the cost of producing commercial vessels, the company is optimized for support ships. Conversely, Huntington Ingalls Newport News shipyard is specialized for nuclear vessels – aircraft carriers and submarines. This specialization limits both the intensity of, and basis for, competition, but does not mean there is no competition in the industry. Austal USA and Marinette Marine competed to build the Littoral Combat Ship (and are each building a variant), and the Navy is pushing Ingalls Shipbuilding and GD-NASSCO into competition for the T-AO(X) fleet oiler and LH(X) amphibious assault ship platforms, and each will be contracted to build one of these. The trend for naval construction is that two companies, at most, will compete for new contracts.

The threat of new entrants to the market is low. The shipbuilding industry has very high barriers to entry. The costs of needed equipment, real estate, and the carrying costs for initial production are all prohibitively high. Land space with ocean access, tools, cranes, and other heavy equipment all require an extremely high upfront investment, in addition to the special certifications required to build for the government. To paraphrase a congressional staff member we met, “imagine a new ship yard trying to get certified to do nuclear reactor work right now.” Labor costs can be a barrier as well. Shipbuilding requires a very diverse and highly trained workforce with much of the construction still done by hand. This is blue-collar work, but highly specialized blue-collar work, which adds significantly to costs if the firm either cannot or chooses not to take advantage of the high-priced technological innovations that reduce the amount of labor required for some tasks. This threat of new entrants can be slightly higher when existing firms choose to expand into building ships of different types where competition is already low. That is, recapitalization and expansion are less cost-prohibitive than new starts. Finally, quality and reputation matter in this industry where the product is expected to operate for anywhere from 20-50 years, which works to the disadvantage of new entrants. These factors and low profit margins lead us to conclude the bigger threat is a rapid contraction of the industry, not too many new entrants.

The threat of substitute products is either medium or low, depending on the application. As examples, for commercial vessels that transport petroleum products, pipelines represent an attractive and safe option that can deliver goods as needed or available at relatively low cost. Conversely, for the transport of bulk goods or containers, ships have an advantage in cost and capacity over air transport. Costs of acquisition and operation are high, however, and provide incentives to pursue innovation and alternatives. Currently, the Navy and the shipyards are in danger of pricing themselves out of the ship business. The extremely high cost of building naval vessels threatens to boost innovation of alternative platforms or products. The next generation of ballistic missile submarine, or Ohio-class replacement, is a good example. The price of the Ohio replacement is so high that it has driven a discussion on reducing the nuclear triad. Although the U.S. government concluded this is not an option, the overall price tag will continue to force consideration of potential strategic substitutes for the triad.

The Naval Shipbuilding Industry is a monopsony. The U.S. government is the sole buyer for many of the products and acts as a price setter, but we assess the bargaining power of buyers as medium. The Navy is in the unenviable position of wanting competition and the ability to set prices, but also has to weigh that against the fact it has to protect its industrial base. The Assistant



Secretary of the Navy for Research, Development and Acquisition, Mr. Sean Stackley, recently stated in the press that a few of the primary Navy ship suppliers were “one contract away from shutting down.”⁵² Driving a hard bargain must be offset by the realization that there could quickly be no U.S. shipyard capable of building what the country needs.

The bargaining power of suppliers is high in this industry. The price of raw materials is based on competition with outside industries (i.e., steel is used in buildings, automobile manufacturing, infrastructure, etc., adding to price volatility), as well as within (e.g., fittings and pipes used for naval construction must be more robust than commercial versions, so they come at a much higher price). The amount of specialized labor that goes into building ships is high, and labor accounts for over 25% of costs in this industry, as compared with 10.5% in the broader maritime sector.⁵³ Naval ships are built individually or in small groups over periods of years, which creates more leverage for suppliers throughout the supply chain. Down chain suppliers want long-term and large-quantity contracts that shipyards cannot offer. The manufacturer of a pipefitting used on a ship built five years ago, for example, may be out of business or have no desire to perform government work anymore. Not being able to buy in bulk hurts the bargaining power of the shipyards. One Gulf Coast shipyard told us they sometimes have to accomplish the paperwork for parts suppliers because the burden is something the smaller suppliers either do not want to accept or cannot afford. Being a sole supplier, the shipyard has no choice but to use its own manpower to accomplish the task for its supplier.

Porter’s Five Forces suggest an industry with little incentive for costly innovation, threatened by contraction, and reliant on a single customer for the majority of its revenue. Challenges to profitability and survival are represented by other cost drivers.

Protectionist statutes that eliminate competition from foreign builders create upward pressure on prices for some ship types, which has the added effect of reducing competitiveness to attract foreign buyers. Skilled labor requires investments in training and certification, as well as continuing education to keep pace with innovation. Coupled with union involvement and increasing demand due to growing off-shore oil and gas exploration, skilled labor is a significant cost driver. Shipyard facilitation and technical innovation require capital investments for limited and highly-desired waterfront real estate, as well as new tooling and equipment and the training that goes with them. Predictability in orders (demand), quantities, and funding streams are all cost drivers. Each of these will be discussed in greater detail in the essay section of the paper, along with proposals to mitigate these drivers while creating efficiencies and adding to profitability (*see “U.S. Shipbuilding Cost Driver Mitigation Strategy” essay below*).

In addition to these domestic cost drivers, the shipbuilding industry must contend with the effects of subsidies paid by foreign governments that create advantages for foreign shipyards. Subsidies seem to be the one advantage some international shipbuilders have that enable them to compete. The Chinese government has provided shipyard subsidies of up to 20%, and has likewise subsidized the steel industry, a critical supplier for shipbuilders. Myrto Kalouptsidi of Princeton University conducted a study comparing shipyard efficiencies and quality in relation to the price of ships produced in each country. China was known to have inefficient shipbuilding practices and substandard quality, yet sold ships cheaper than Korea and Japan. Comparing these factors helped determine the effect subsidies had in offsetting prices.⁵⁴ Kalouptsidi provides a graphic illustration (*see Appendix 3*) of the impact such subsidies have on production and competitiveness in the global market.

The Shipbuilding Council of America (SCA) collected subsidy information from the top shipbuilding countries. SCA has estimated that South Korea provided an average \$2.4 billion in



aid annually to its shipbuilding industry between 1988 and 1993; Germany provided \$2.3 billion; Japan, \$1.9 billion; Italy, \$940 million; Spain, \$897 million; and France, \$634 million.⁵⁵ Even if all other factors were equal, it's clear the United States would be at a competitive disadvantage in this market.

Another fiscal advantage enjoyed by foreign shipbuilders is they do not pay shipping taxes, which puts U.S. firms at a disadvantage when it comes to building or replacing ships. Among the ways the United States mitigates this disadvantage is through use of the Construction Reserve Fund (CRF). The CRF is authorized by 46 U.S.C. Chapter 533, and provides financial assistance to modernize the aging maritime fleet. Its purpose is "to promote the construction, reconstruction, reconditioning, or acquisition of merchant vessels built and documented under the laws of the United States for purposes of national defense and the development of U.S. commerce."⁵⁶

Similarly, the Capital Construction Fund (CCF) was created to assist owners in modernizing and expanding the U.S. merchant fleet. "The program encourages construction, reconstruction, or acquisition of vessels through the deferment of Federal income taxes on certain deposits of money or other property placed into a CCF."⁵⁷ Last September, the National Oceanic and Atmospheric Administration noted "there are 1,634 CCF Agreements with a total of approximately \$263M on deposit. Many of these CCF Agreements were established years ago and identify scheduled projects that are no longer viable."⁵⁸ Because these programs provide tax deferrals or relief, the impact is less robust than the kinds of subsidies we see in other nations.

Government subsidies create a price advantage. While it's tempting to say the United States should put its considerable weight behind building and maintaining a dominant navy and leave the commercial sector to founder, that's a recipe for disaster. Alfred Thayer Mahan, author of *The Influence of Sea Power Upon History: 1660–1783*, provides a cautionary tale. He wrote that strong, wealthy countries, such as 18th-century France, have attempted to achieve maritime pre-eminence via large standing navies while ignoring the merchant marine, and succeeded only in bankrupting the national treasury and causing a subsequent decline in world influence.⁵⁹

Enhanced and more aggressive U.S. laws and policies might provide effective mitigation to these challenges. A growing China continues to exert pressure in East and South Asia, requiring a strong maritime commitment from the United States and partner nations in the region. An increasingly belligerent Russia poses a threat to Western Europe and to oil and gas supplies in the region. Such potential disruptions to global trade and security create an imperative to maintain a healthy and profitable shipbuilding industry to support possible growth in domestic shipping capacity.

OUTLOOK

Worldwide, military shipbuilding through 2019 is expected to accelerate as naval budgets increase. This anticipated increase is a response to rising regional tensions and the growing demand for maritime resources to respond to those pressures. In Western nations, where debt burdens continue to put downward pressure on government spending, defense budgets will remain relatively stable because of increased geopolitical tensions and the need to replace or modernize aging naval fleets. BRIC nations (Brazil, Russia, India, China), conversely, are generally experiencing economic growth. Spending in these nations is expected to continue growing as well just as economic and territorial rivalries with neighboring countries intensify. Global spending in the naval shipbuilding segment is expected to grow at an annualized 3.9% to \$46 billion in 2019. Industry Value Added, a measure of industry's contribution to the economy, is expected to grow at an annualized rate of 2.3% over the next five years, while GDP will outpace it at an expected annualized growth rate of 3.6%.⁶⁰



In the next five years, because of increased global spending, the military shipbuilding segment can expect to see continued strong demand and increased profit margins. The outlook is for profits to grow from 8.6% of revenue to 9.1% in 2019.⁶¹ The steel industry is expected to see an increase in prices, which will drive down profits in the broader shipbuilding industry. These pressures, and the costs of labor and facility maintenance, are expected to lead to industry consolidation in European countries. This, in turn, is expected to increase industry concentration, efficiencies, and competitiveness with Asian builders of naval vessels. It's also expected to increase international collaboration in design, component production and quantity purchases. As efficiencies create upward pressure on output and demand, the forecast is for increased labor employment in the global military shipbuilding segment.⁶²

Overall, the outlook for domestic shipbuilding is favorable. The demand for naval vessels is increasing, and funding requests support this growth. Demand in the commercial segment is likewise increasing. As demand for energy continues to increase, orders for new vessels, to include exploration vessels, drilling rigs, and oil transport ships, have increased. This plays to the benefit of companies protected by the Jones Act. A caution here is that energy prices could drop and remain low, reducing both demand and production with attendant negative impacts to the commercial segment. In the five years to 2019, revenues in the domestic shipbuilding industry are expected to rise at an annualized rate of 3.1% to \$29.7 billion.⁶³

As noted, debt burdens and slow economic growth will drive cuts in general defense spending in Western nations. However, the maritime nature of current and expected conflict means that spending on shipbuilding should remain fairly stable. Due in large part to the "Asia pivot," with a growing Chinese naval fleet and regional uncertainty, the United States is expected to increase spending to modernize its naval fleet. Sequestration is a concern as it may create downward pressure on defense spending. This uncertainty means there may be stagnant growth in the military shipbuilding segment to 2020, and this could cause delays, reductions, or cancellations of planned buys. Because there exists a defense-wide need for modernization and recapitalization, naval spending may be reduced to make room in the budget for other strategic priorities in the next five to ten years.

Exports in this segment are expected to increase at an annualized rate of 4.5% to \$1.2 billion in 2020. Increasing tensions in the Middle East and in the Asia-Pacific drive increased demand for ready naval products. This, in turn, is driving up profit expectations from 5.3% of revenues in 2015 to 6.8% in 2020. Between now and 2020, Industry Value Added is expected to increase at an annualized rate of 3.6%, while GDP is expected to increase at an annualized rate of 2.5%.⁶⁴

Budget uncertainty and shifting demand for energy and energy-related products introduce risk to the domestic shipbuilding industry generally. Naval shipbuilding is particularly affected as sequestration may drive purchasing decisions that impact yards and suppliers already at risk in a low-quantity, high-cost industry. Recapitalization has long-term benefits for national security, but it requires increased budgets, new ways of structuring long-term purchasing plans, or both.

It's clear that, without significant government intervention, the U.S. commercial shipbuilding industry will not become a giant on the world stage. While the United States dominates the military shipbuilding segment, that position is by no means permanent given the growing capabilities of competitor nations. Increased Foreign Military Sales (*see "Using Foreign Military Sales to Maintain the Naval Shipbuilding Industrial Base" essay below*) would help to sustain and grow this segment. With an influx of revenue, industry players could recapitalize aging shipyards, improve efficiencies, and stabilize the supply chain.



GOVERNMENT GOALS AND ROLE

At its height, U.S. shipbuilding boasted approximately 1,000 shipyards. Today, there are only 350 shipyards, and these are mostly small machine shops with few employees.⁶⁵ There were once 35 shipyards that could build naval ships and now, with the recent termination of naval shipbuilding in the Avondale yard in Louisiana, only seven remain. By 1970, the pattern of multiple builders was gone and fierce competition over a few contracts saw most shipyards close or consolidate under major corporations.⁶⁶ The Navy's Fiscal Year 2016 30-year shipbuilding plan calls for a fleet of 308 ships. Right now, at 275, the naval fleet is the smallest it's been since 1917,⁶⁷ and this reduced capacity will make it difficult to maintain the pace of construction required to build and sustain such a technologically advanced fleet.

To secure a military industrial base to meet our national security needs, we must have a competitive shipbuilding industry. The result of years of instability and the erosion of government financial support is an industry that has lost shipyards, has few suppliers, and has consolidated remaining shipyards under a small number of large companies. This has severely reduced competition, raised the cost of ships, and hindered innovation and effectiveness.⁶⁸ There are several actions the government might take to secure the future of a robust shipbuilding industry. Some are likely to have greater impact than others, but all are worth considering.

First, to be competitive globally, state and federal governments should seek to expand programs that remove land purchases and shipyard capitalization as barriers to entry. Subsidies, grants, or long-term interest-free loans will spur growth and employment in this industry, help shipbuilders transition to broader markets, and encourage investment in modernization. This growth would encourage innovation and competition, and would positively impact the supply chains that support the industry.

Second, reform the protectionist laws governing U.S. shipbuilding. There has long been debate on whether the Jones Act should be scrapped. Those who oppose repealing the law believe it will kill the shipbuilding industry and put our national security at risk as we will not have the maritime industrial base to build naval ships.⁶⁹ Recently, Senator John McCain of Arizona called for its repeal. In a floor statement on January 22, 2015, he characterized the Jones Act as “an archaic 1920s era law that hinders free trade, stifles the economy and hurts consumers – largely for the benefit of labor unions.”⁷⁰ It's unclear what the impacts of repeal would be, and arguments on both sides are compelling. The effects would be most keenly felt in the commercial sector, though there would be some residual benefits to military shipbuilding through growth in the supplier base. Many of the successful foreign shipbuilders enjoy significant economies of scale from commercial market share dominance. The Jones Act does not deliver the market share necessary for the United States to achieve competitive economies of scale and, therefore, the United States will likely never be competitive in the global commercial market. We should seriously consider repeal of the Jones Act only after incentives and subsidies such as those described above are in place and the effects are known.

Today, there are concrete examples, such as in South Korea, that shipyard survival rates increase in proportion to the amount of government subsidies received. This makes it clear that it's impossible for shipyards that do not receive government support to compete in the global shipbuilding arena.⁷¹ Hans-Jakob Kruse, Chairman, Hapag Lloyd AG, Hamburg, West Germany, said it best in an editorial published in *The Journal of Commerce* (Aug 12, 1988).⁷²



The idea of removing competitive anomalies by reducing subsidies to zero is quite appealing... However, things are not quite that simple. Although there are many differences in political and commercial systems, countries nowadays are closely intertwined commercially, leaving little room for positive unilateral actions. It would certainly be a bold gesture if a country were to abolish all its subsidies, but the only result would be that its industry would henceforth be at a competitive disadvantage vs. its subsidized competitors.⁷³

A third key action is repeal of the 2011 Budget Control Act (BCA). The cuts proposed in the BCA do not allow for sufficient orders for naval shipbuilders to keep their shipyards profitable and efficiently manage flow.⁷⁴ Fourth, Congress must pass the annual budget on time. The use of continuing resolutions causes delays in ship deliveries and increases costs, creating wasteful and harmful down-chain effects.⁷⁵ A fifth action is to agree on the size of the naval fleet, create a responsive and sustainable shipbuilding plan, and lay in long-term funding accordingly. The size of the Navy and Coast Guard has great consequence to the shipbuilding industry and to national security.

The stability these actions generate is illustrated by the Canadian National Shipbuilding Procurement Strategy (NSPS). For years, Canada had followed a ‘boom and bust’ cycle for recapitalization of its government-owned and -operated fleets. That is, once vessels were built, shipyards would shut down, skilled labor would move to other industries, and the cost of repair and sustainment increased. This was repeated often and to the detriment of the national economy and local communities. “To minimize the risk to all parties, the government needs to understand that a long-term, phased approach is needed while the industry develops the physical and intellectual sinews for this challenge.”⁷⁶ A continuous build program of the kind NSPS provides would offer stability in the age of the fleet and in the shipbuilding industry. As Royal Canadian Navy Vice Admiral (ret) Peter Cairns stated, a continuous build strategy offers benefits to both the Navy and the shipbuilding industry. “Assuming a navy of 16 destroyer / frigate vessels, as it is constituted today, building one of these ships every two years would ensure no ship was ever older than 32 years.”⁷⁷ A more detailed discussion of NSPS is in the essay portion of this paper, but it’s worth noting here that such a strategy would require significant political will to pursue.

Mr. Stackley recognizes the need to minimize risk to the industrial base. He is “structuring the competition to build the new T-AO(X) fleet oiler and LHA 8 amphibious assault ship” to ensure the bidding yards “both get enough work to remain viable.”⁷⁸ This competition structure is a sound approach to the problem the industry faces, and may prove to be a test case that drives a strategy similar to NSPS for the U.S. shipbuilding industry.

In an era of shrinking and uncertain defense budgets, we see that risk conveys to suppliers as well.

Risk in the [defense] supplier base has already begun to materialize. History has shown that as defense budgets fall, the government squeezes the primes to produce at lower cost. The primes in turn squeeze their suppliers to produce at lower and lower costs. There are already emerging signs that this pressure has caused a further shake-out in the supplier base. Such providers may find commercial markets more attractive and opt to abandon the defense sector completely.⁷⁹

Government needs to push naval shipbuilders to continue to explore deeper, more adaptive and collaborative partnerships with their suppliers. These relationships benefit the builder, the



supplier, and the customer (government), so government involvement early on will surely provide long-term benefits to all parties, including the taxpayer. A competitive and vibrant commercial industry is vital to a healthy defense segment, and it's clear that government action can work to create a favorable environment.

Shipbuilders also have a role in improving the industry's viability as well. The impact of labor unions is an area for concern and must be addressed. If the Jones Act is repealed, labor unions will shrink as we have seen in other industries that are not protected by this kind of legislation. This will provide shipbuilders the ability to set wages based on market value and use a larger margin of their profits to reinvest in the company and increase their ability to compete in the market.⁸⁰ The industry already recognizes it needs to invest in a skilled workforce to reap the benefits of innovation and efficiencies. Newport News Shipbuilding, for example, has a robust apprentice program and offers associates degrees to retain workers.⁸¹ The industry has developed centers of excellence to nurture innovation.⁸² If production rates are allowed to stabilize, shipbuilders will be able to recruit and retain the next generation workforce. If the industrial base continues to shrink and workers are lost, they are not easily replaced.⁸³ In short, greater competition will create a labor-friendly environment making union influence less disruptive while giving the labor force more of a stake in economic outcomes.

ESSAYS ON MAJOR ISSUES

Using Foreign Military Sales to Maintain the Naval Shipbuilding Industrial Base

As the nation struggles with mounting debt and increasing costs of healthcare programs, appropriations for major weapons systems cannot be assured. Fiscal constraints and automatic cuts built into the Budget Control Act of 2011 (BCA) will disrupt the acquisition of large weapons systems. With the 'feast or famine' appropriation cycles that see major weapons programs funded and cut in surges, these on-again/off-again appropriations will have a disruptive effect on the manufacturing capacity of the major naval shipyards. As the Chief of Naval Operations, Admiral Jonathan Greenert, said at a 2014 speech at the Brookings Institution, "I worry about the shipbuilding industrial base. . . . But more importantly, there's some likelihood we lose one or two [ship] builders, and we only have five."⁸⁴ These are the 'Big Five': Newport News, Ingalls, Bath Iron Works, Electric Boat, and NASSCO. Of these, only NASSCO has any meaningful customer base outside of the Department of Defense.

If the Navy does not order a ship from these yards for a year or more, the yards will be forced to close or lay off significant portions of their skilled workforce due to lack of work. To reopen or develop that skilled labor for the next rearmament cycle may take years and many more millions of dollars. This is time that will diminish flexibility in naval shipbuilding and add to the cost of each ship. What can be done to maintain this naval shipbuilding capacity if the Navy is forced to halt new ship construction at one or more of these yards for any period of time? Foreign military sales (FMS) provide an opportunity to offset potential cuts.

The Navy's current 30-year shipbuilding plan runs from 2015 until 2044. The Navy states its goal of building and maintaining a battle force of 308 ships, a combination of combatants, combat logistics force ships, and support vessels that are routinely requested by the combatant commands.⁸⁵ This translates into 264 battle force ships to be built during this period.⁸⁶ The Navy's new ship construction shortfall through 2024 will be an average of \$2.7 billion per year.⁸⁷ This is the approximate cost of a Virginia class SSN or the projected cost of one-and-a-half Flight III Arleigh Burke class destroyers.⁸⁸



During the years from 2025 through 2035, when the Navy will simultaneously build the Ford class aircraft carriers and the new ballistic missile submarine, shipbuilding costs will jump to an average of \$19.7 billion (in 2014 dollars) per year, \$6.7 billion above historical average annual shipbuilding expenditures.⁸⁹ This projected shortfall represents the approximate cost of a Virginia class SSN and the projected cost of two Flight III Arleigh Burke class destroyers.⁹⁰

In order to meet the fiscal constraints of the Navy's new ship construction budget under the BCA caps, a significant curtailment of some classes of ships will be necessary. During the first ten years, the Navy can either cut SSN construction from two to one per year, or curtail destroyer construction to one every other year. During the second ten-year period, when fiscal constraints are the most severe, attack submarine construction may have to be reduced by one per year to make only one every other year, and destroyer construction will have to be suspended. This period will last while the new class of SSBNs is being built, and it's in this environment where the impact to the shipyards becomes clear.

The shipbuilding plan calls for an average of one destroyer built per year each for Ingalls and Bath Iron Works. Ship classes planned to be built in the 30-year shipbuilding plan are illustrated in the table at Appendix 4 and are projections for where the planned classes will likely be built in the next twenty years without any significant change to the industrial base. With the likely suspension of destroyer construction, that will leave Bath Iron Works with no ships to build for almost ten years. While this also affects Ingalls, the amphibious ships can offset the loss of the destroyers. To ensure the survivability and capacity of Bath Iron Works, FMS may be the answer.

Foreign military sales provide equipment to approved nations as government-to-government sales.⁹¹ "FMS allow foreign governments to purchase defense articles and services as well as design and construction services, from the U.S. Government. Under FMS, the Department of Defense procures defense articles and services for the foreign country using the same acquisition process used to procure for its own military needs."⁹²

For naval ships, FMS can be new construction or refitting retiring U.S. Navy or Coast Guard ships. This program has benefits beyond employing a shipyard. "International programs contribute to cooperation between military forces, enhancing interoperability between U.S. forces and those of their friends and allies."⁹³ Allies in possession of U.S. ships require training from their U.S. counterparts to operate the equipment. This provides opportunities for standardized doctrine, enhanced working relationships and an allied fleet that has the ability to operate together. The fleet a competitor navy may see would be much stronger with partner nation's ships within the formation or screening for the U.S. carriers – a picture of unified purpose.

Many of the ships the U.S. has sold through the FMS programs return to U.S. shipyards for overhaul or other forms of maintenance or upgrade throughout their service life. This can represent a long-term source of revenue for the yard that is awarded this business. Currently, about \$1.5 billion per year is spent through naval FMS. Four Fast Missile Craft were built over three years for the Egyptian Navy at a total value of \$1.1 billion.⁹⁴ Many other corvette-sized ships are built every year for the FMS program. These sales provide an excellent opportunity to fill the excess capacity in critical shipyards.

The U.S. Navy can manage the workload for each of the critical shipyards and shift the work as necessary. This is similar to the process that has each Virginia class submarine built in two places at once and Arleigh Burke class destroyers built in two yards. When the shipyards reach the point where they are bidding on foreign contracts, the U.S. Navy can determine which yards are eligible to bid, just as the Navy does with domestic military shipbuilding contracts.



Foreign military sales provide an option for the ‘Big Five’ shipyards to produce classes of ships for customers outside of the Department of Defense. This independent revenue source can take the place of U.S. Navy orders during periods of low demand. This keeps the shipyards, their workforce, and the naval architects gainfully employed. If this is done successfully, the shipyards can become a viable competitor in the international marketplace. By competing for foreign contracts, the shipyards are forced to innovate to remain competitive. This will carry over to long term benefits for U.S. Navy contracts.

Allied nations do not doubt that the U.S. can build warships as well or better than other nations. Many of our retired or surplus vessels are very popular and serve longer in other navies than in our own. The difference is the ships that are popular and sought after are the frigates. Of the 55 U.S.-built Oliver Hazard Perry class frigates built, more than twenty are either in service or in the process of transferring to the service of foreign navies.⁹⁵ This class of ship was also built new for allies to include Australia. In today’s naval market, a successor to the Perry class would have likely buyers in NATO and the Pacific region. The smaller classes of ships are most relevant to foreign navies and represent the greatest potential for sales volume and scheduling flexibility.

Since budgetary constraint is likely to impact the U.S. Navy and the shipbuilding industry for the foreseeable future, FMS provides an opportunity to improve capacity and survivability for the shipbuilding industrial base, spur innovation in design and manufacturing processes, enhance allied interoperability, and strengthen U.S. national security economically and militarily.

- *Charles M. Bartenfeld*

A Showdown with Strategy: Rebuilding the Triad and the Shipbuilding Industry

Seventy years after the United States detonated the first atomic device at the Trinity Site, the nation still must bear the costs of the nuclear age. As the long-range bombers, intercontinental ballistic missiles, and ballistic missile submarines that compose the nuclear triad increase in age, the U.S. faces a strategic choice of how to structure this force for the future. This choice has far-reaching consequences, and the path chosen will have major impacts on the national shipbuilding industry. Of particular importance, acquiring a new Navy ballistic missile submarine (SSBN) in a fiscally constrained environment will result in reduced procurement of other ship classes for the Navy. Unfortunately, the Navy’s current thirty-year plan for shipbuilding does not offer any alternatives to this situation other than “additional topline relief.” If this relief is not attained, it’s likely a U.S. shipyard will close, further reducing an already fragile industrial base.

The President’s nuclear employment guidance states that the United States will maintain a nuclear triad in order to maintain strategic stability and hedge against technical problems and unforeseen vulnerabilities.⁹⁶ The report emphasizes the critical role of U.S. nuclear strategy in maintaining strategic stability with the world’s major nuclear powers, strengthening regional deterrence, and reassuring U.S. allies and partners.⁹⁷ In the face of a resurgent, belligerent Russia with intent to modernize its military (including its nuclear arsenal), a rising China with a growing nuclear arsenal, and the threat of nuclear proliferation in the Middle East and Asia, re-vitalizing the U.S. nuclear triad rises to the level of a strategic imperative.

However, whether the U.S. can afford the triad is questionable. Current estimates to modernize the arsenal are as high as \$1 trillion over 30 years,⁹⁸ and \$350 billion in the next 10 years. Costs include the proposed replacement ballistic missile submarine (SSBN(X)), which is needed to replace the current Ohio class SSBNs. The current fleet of SSBNs was launched



between 1983 and 1996 and will be retired at a rate of approximately one boat per year between 2027 and 2040.⁹⁹ Additionally, the Trident II missile requires a life extension program. The combination of these programs would cost an estimated \$100 billion.¹⁰⁰ Other costs to modernize the triad include the Air Force's Long Range Strike Bomber (LRS-B) and Minuteman III life extension or replacement. Furthermore, the Department of Energy's National Nuclear Security Administration plans to spend \$60 billion to upgrade five different nuclear warheads in the inventory.¹⁰¹ In total, considering the entire Department of Defense budget is currently around \$500 billion, nuclear triad recapitalization could absorb seven percent of the budget over the next 10 years.

Examination of the SSBN recapitalization plan reveals how much budget it absorbs alone. The Navy's 30-Year Shipbuilding Plan calls for 12 Ohio Replacement SSBNs to replace the 14 Ohio class subs now in commission, with the lead boat procured in FY21.¹⁰² A second submarine would be purchased in FY24, followed by one per year from 2026 to 2035.¹⁰³ The Navy estimates the first sub will cost \$12.4 billion in 2014 dollars, and follow-on subs will cost \$6 billion, for a total cost of \$79 billion.¹⁰⁴ With higher per-boat cost estimates and the inclusion of research and development costs, Congressional Budget Office estimates exceed \$100 billion.¹⁰⁵

The effect of these costs is dramatic when examined in the context of the Navy's annual shipbuilding budget (*Appendix 5, Fig. 1*). With the addition of SSBN(X), the average annual shipbuilding budget balloons from \$13.9 billion to an average of \$17.5 billion per year (*Appendix 5, Fig. 2*). This represents an average of 35% of the annual shipbuilding plan budget once in serial production. When the Navy begins procurement of SSBN(X), it also plans to continue production of three Littoral Combat Ships, two DDG-51 destroyers, and 1-2 attack submarines per year. Additional requirements call for a new aircraft carrier every five years, new amphibious assault ships, a replacement oiler, and other auxiliary ships. Clearly, this is not an executable plan.

Priority will undoubtedly be given to SSBN(X) and aircraft carrier procurement over the next 20 years. Attack submarines (SSN) and large surface combatants (destroyers), are the two serial production, high-cost programs that span the entire "30 Year Plan." As such, they will likely be among the first targets if cutbacks are needed to pay for SSBN(X). Procurement reductions for these vessels would realize cost savings, but would introduce risk to the Navy's operational requirements for critical capabilities (Figure 1). To avoid these deep cuts in the shipbuilding plan, with accompanying decrements to required inventories, it might be attractive to scale back the SSBN(X) program itself, but the Navy maintains it is essential to keep 4-5 SSBNs deployed at a time, and according to Navy calculations only a fleet of 12 guarantees this deployment rate.¹⁰⁶ Without adjustments to historical funding levels, there will be winners and losers in shipbuilding, and those will be chosen from both strategic necessity and budget reality.

General Dynamic-Electric Boat (GD-EB) and Huntington Ingalls-Newport News Shipbuilding (NNS) are sure to be winners. GD-EB could lose from a reduction of Virginia class SSNs, production of which is already spread thin in a sharing arrangement with NNS in which each company builds particular parts of the ship, alternating final construction, sea trials and delivery.¹⁰⁷ However, this loss would be offset by an SSBN(X) contract. GD-EB led Ohio class SSBN production and would likely lead the SSBN(X) program. NNS is a winner because the company is the sole source for U.S. aircraft carriers. A sharing arrangement for SSBN(X) with GD-EB (like exists for Virginia class subs) could further benefit NNS.

Shipyards producing destroyers are the likely losers in the budgetary crunch caused by SSBN(X) as illustrated in Appendix 4. Even if the "30 Year Plan" was followed and destroyer production was split between the General Dynamics Bath Iron Works (GD-BIW) and Ingalls



Shipbuilding, it's questionable whether GD-BIW could maintain operations at a production rate of one per year. Any further reduction to the destroyer orders would halt destroyer production at one of these two yards. Either Ingalls Shipbuilding would be left with amphibious warships alone, or Bath Iron Works would be left with nothing.

So what are the alternatives to this scenario, one in which SSBN(X) production leads directly to further collapse of the shipbuilding industrial base? The first option is to alter the structure of the triad to balance the shortfall. Although some changes to the size of each leg may be possible, recapitalization cannot be delayed due to the age of the respective systems, and the legs must be sized to ensure their deterrence value. The life of a current SSBN is limited by the age of its nuclear core (i.e., life extension is not possible). Reduction of the SSBN(X) fleet to budget-balancing levels (eight subs) does not support deterrence requirements. The need for the LRS-B is just as dire as the need for SSBN(X). B-52s averaged 44 years old in 2008. Parts availability and survivability against modern air defenses plague this fleet of bombers.¹⁰⁸ The B-1B is no longer equipped for the nuclear mission, and the B-2 is facing aging airframe and interoperability issues that threaten its survivability. The Minuteman III force has gone through several life extension programs, including propulsion and guidance replacement, which are intended to make it viable through 2030.¹⁰⁹ The Air Force is faced next with further investment in life extensions or procurement of a replacement system during planned SSBN(X) serial production. In other words, the requirement to procure LRS-B and to maintain the ICBM leg of the triad will offer no relief to the large budgetary pressures of SSBN(X) on the shipbuilding budget.

Another option that would protect the Navy's other ship classes and the nation's shipyards is to fund SSBN(X) above the Navy's shipbuilding budget (i.e., make it a "DoD bill"). Although appealing to the Navy, the funding would still come out of DoD's shrinking budget. In the current, budget-constrained environment, with the earlier described need to invest in all legs of the triad, it will be difficult for Congress to make an appropriation to a separate account for SSBN(X) (even though this account, the National Sea-Based Deterrence Fund, was created in NDAA 2015, it is not funded).¹¹⁰ The Fleet Ballistic Missile (FBM) program, which consisted of nuclear powered submarines and the Polaris missile, is a valuable historical precedent.¹¹¹ Proposed in the 1950's, the Navy had doubts about the expense of the program, fearing the effects it would have on the budget.¹¹² Three programs were cancelled as a result: two missile programs competing with Polaris, and one aircraft program.¹¹³ Although other shipbuilding continued on pace, the Navy paid FBM bills in other areas, including fleet maintenance and new development.¹¹⁴ Unless the Navy makes similar decisions in the SSBN(X) era, it will have to pay for the system in *force structure and national shipbuilding infrastructure*. Unfortunately, the nation's and the Navy's need to build SSBN(X) will likely lead to both – a Navy smaller than the 308 ship fleet currently envisioned, and a shipbuilding industry with fewer yards.

The long-term effects of losing a shipyard are not limited to fewer ships and the inability to meet fleet size requirements. It would also mean a loss of competition, increased costs for new ships, and further strain on the Navy shipbuilding budget. Compounding the problem, losing shipyards means losing the skilled workforce along with them. The combined result of all of these effects is a weakened industry, unaffordable ships, and a diminished national security.

The time has come for the Navy to move beyond admitting it has a problem to offering a solution. The DoD and Congress should be able to look to the "30 Year Plan" as an executable long-term plan, not as the Navy's position going into budget negotiations. Whereas "additional



topline relief” would certainly solve the problem, it is not a reasonable resourcing strategy, and a showdown with strategy is ill-advised, unless national security is worth the bet.

- Lt Col Scott A. Cain, USAF

Learning From the Commercial Shipbuilding Industry

Just as we rely on our Navy for security and the freedom to operate in the global commons, the global economy relies on fleets of commercial ships to move approximately 90% of all world trade. Without shipping, the intercontinental, intra-regional, and domestic bulk transport of raw materials, food, and manufactured goods would simply not be possible.¹¹⁵ The commercial shipping industry is a key enabler of the global economy and one of the most cost effective means of transporting large amounts of materials over great distances. Building and maintaining these vessels, whether for commercial or military applications, requires a skilled workforce, dedicated infrastructure, and significant capital investments. While naval vessels are built for different purposes and to different standards, it’s worth looking to the commercial industry for techniques, procedures or business practices that could be applied to improve the Navy’s shipbuilding capacity and infrastructure.

The shipbuilding industry is a global venture with the vast majority of ships built in North Asia and Europe. Europe dominated the shipbuilding market over a century ago with 80% of the global market share. Today, the market is primarily dominated by the North Asian countries. In the 1950s, Japan challenged Europe’s position and by the 1970s had moved ahead due mainly to rapid economic growth and a coordinated shipbuilding program.¹¹⁶ In the early 1970s Japan and Europe had the lion’s share of the world market until South Korea emerged as a competitor. While labor costs were rising in Japan, South Korea combined low labor costs with a deliberate campaign to position shipbuilding as a strategic industry for the country.¹¹⁷

By the mid-1990s a carefully planned industrial program enabled South Korean builders to increase their global market share to 25%, and by 2005 they had overtaken Japan.¹¹⁸ Today, the biggest mover in the international shipbuilding market is China. China already had an active shipbuilding industry, but growth resulted from the country’s industrial expansion strategy in conjunction with strong rising demand as a result of China’s economic boom. China surpassed Japan in 2006 as the second-largest shipbuilding nation,¹¹⁹ then overtook South Korea in 2010 to become the largest shipbuilding country in the world. A coordinated effort and commitment on the part of government and industry led to rapid growth and dominance in a competitive market.

Over the past five years through 2014, China’s shipbuilding industry has been growing at an annualized rate of 2.5% to \$79.4 billion (USD).¹²⁰ The Chinese government classifies shipbuilding as a strategic sector and has limited foreign shareholdings in Chinese shipyards, marine diesel, and crankshaft factories to 49%.¹²¹ China’s rapidly growing industry focuses primarily on commercial vessels such as bulk cargo carriers, container ships and oil tankers. These are relatively easy to build and it’s simple to comply with construction standards. By building a limited number of types with limited variation enables builders to flatten their learning curves and gain efficiencies.

China primarily uses the efficient hull-block construction method of shipbuilding, used by Japanese and South Korean shipbuilders for decades. The primary benefits of hull-block construction are optimization of resources, shorter build times and greater overall throughput



capacity for a shipyard, translating into greater productivity and profit.¹²² This method is one U.S. builders have adopted in some, but not all, shipyards.

China holds a significant cost advantage over its rivals due in a large part to cheap labor.¹²³ South Korea and Japan continue to hold a technological and perceived quality edge over the Chinese manufacturers, and emphasize these aspects in order to attract customers.¹²⁴ This technological advantage has seen these countries focus on more complicated (and higher value-added) vessels such as Liquefied Natural Gas carriers, while the Chinese have gained a large market share in building container vessels.¹²⁵ Quality, based on research and development, design, raw materials, and construction practices, as well as labor costs are drivers in this market.

Shipbuilding, whether for military or commercial purposes, is a complex process. One of the major challenges the U.S. Navy faces with its shipbuilding program is quality control. Accepting ships with deficiencies has both operational and fiscal impacts. According to the U.S. Government Accountability Office Report, *Navy Shipbuilding - Opportunities Exist to Improve Practices Affecting Quality*, there have been several cases of poor quality in newly constructed ships. Many of the problems were attributed to issues with basic elements of shipbuilding, such as welding, installation of key systems, and electrical work.¹²⁶ The commercial industry places emphasis on quality control during the shipbuilding process using trained inspection teams on site to monitor the build from start to finish. Building warships for the U.S. Navy is much more complex than building a commercial tanker or container ship; however, quality control is a universal imperative.

It's important to note the Navy and commercial industry operate in different environments. Commercial industry generally has several shipyards to choose from and benefits from competition. Conversely, competition for naval vessels is limited and is sometimes monopolistic, as with aircraft carriers. Another difference is with contracting. The Navy generally uses cost-reimbursement contracts, especially for new builds since the full scope of costs associated with building is unknown. This places more cost risk on the government. For some ships, where it has a better idea of expected costs, the Navy will use a fixed-price incentive contract where cost overruns are shared by the government and the contractor. Commercial ship buyers, on the other hand, maintain strict control over design changes and primarily use firm-fixed-price contracts where the shipbuilder accepts the full costs of any identified quality issues or required rework.

U.S. Navy shipbuilding has had its share of issues and setbacks that have either delayed the delivery of a ship, cost the government enormous amounts of money, or had operational impacts due to poor quality control. While the Navy cannot control labor costs, there are practices the U.S. government can employ to bring costs down. A campaign to position shipbuilding as a strategic industry with both military and economic importance would create economies of scale and competition in the commercial sector. This would, in turn, enlarge the pool of skilled labor for naval construction. Employing contract vehicles that place greater risk for cost overruns on the builder might also force a dramatic reduction on the number of changes to requirements during the build. This implies a commitment from the Navy to clearly define requirements up front and to minimize changes. Finally, quality control practices used in the commercial sector rely on technical expertise, inspection and reviews from the start of construction and throughout the build process. The Navy would benefit from a similar approach to keep the costs of rework to a minimum. By placing much needed emphasis in these areas, Navy shipbuilding could reduce the costs associated with shipbuilding and enhance national security in the process.

- COL John A. Redinger, USA



U.S. Shipbuilding Cost Driver Mitigation Strategy

America's shipbuilding industry is not optimized for any stakeholder, and will not provide a long-term sustainable commercial and military maritime capability to the United States. The Navy has an aging fleet and a shipbuilding industry ill-prepared to meet future shipbuilding requirements in an effective and efficient manner. Stakeholders, be they builders or buyers, argue the other is to blame for cost overruns, capability deficiencies, and schedule delays. It appears to be an intractable problem with little chance of improving without major changes.

Fundamental to a sustainable shipbuilding industry strategy is predictability and long-term value to the U.S. citizenry. The predictability required to significantly change the current course of the shipbuilding industry cannot be achieved in the government's current Planning, Programming, Budgeting and Execution (PPBE) process. Value can be measured many different ways, but here the focus will be as a measure of return on investment.

There are a variety of cost drivers that impact the military shipbuilding industry. Not every relevant cost driver can be mitigated, and when this occurs the cost driver will be considered a constraint that will likely endure. Below are ways to mitigate many of these cost drivers, followed by a broad strategy recommendation for future military shipbuilding requirements. This strategy will provide both predictability for all stakeholders and value to the U.S. taxpayer.

Statute – Protectionist statutes governing American shipbuilding were largely beneficial for the industry during the WWI, WWII, and post-WWII eras, and drove innovation in commercial and military shipbuilding when the federal government was committing huge resources to maritime vessels.¹²⁷ Without resources these statutes rarely achieve the desired effect, which has often been the case from 1850 to the present. Rather than ensure a healthy industry, the Merchant Marine Act of 1920, more commonly known as the Jones Act, has resulted in an industry that gets by on building smaller boats, repair facilities, and oil rigs. Over the last 20 years the lack of demand for naval vessels and U.S.-built commercial ships has made these laws less effective.

The Jones Act creates an environment where the U.S. government must pay a premium to buy a world-class navy. There does not appear to be any legislative appetite to reverse this law anytime soon and no mitigation is available unless it's changed. Drastic changes would only further jeopardize the industry and their first- and second-tier suppliers. For the purposes of developing a Navy shipbuilding strategy, current laws have little impact except for the potential demand for skilled workers. No Jones Act would quickly reduce the demand for skilled ship workers in the U.S. and the labor issues may be mitigated.

Labor Costs and Skills – The average shipbuilding employee at Huntington Ingalls shipyard in Newport News earns more than \$70k annually.¹²⁸ This is approximately \$20k more than the average American household and a significant cost driver when ships require hundreds of thousands of man hours to complete.¹²⁹ Building an aircraft carrier involves approximately 40-million skilled-worker hours.¹³⁰ A recent spike in off shore oil expansion has increased demand for skilled labor common to both industries. The demand increase and labor union involvement have driven labor costs up. Even when demand flattens it will take time for labor costs to stop rising.

The cost of skilled labor is difficult to mitigate and can only be addressed over time as the demand for such workers normalizes. Oil exploration drives a demand increase for experienced welders and pipefitters. Predictable long-term labor needs would allow industry to grow and maintain the workforce required to meet the Navy's demands. A portion of the workforce could



be federalized in order to prevent instability or high turnover in the industry. Training centers already exist and a similar approach is used to support our public shipyards mentioned previously.

Shipyards Facilitation and Technical Innovation – With the exception of Austal USA, U.S. shipyards are decades old and some over a century old. Urban sprawl and growth has consumed available space for expansion or facility improvements. Significant modernization needs to be done to gain long-term efficiencies in both private and government-owned yards. Four of the Navy's maintenance shipyards recently required over \$4 billion in repairs and modernization to ensure infrastructure-related safety, health, and quality-of-life issues are properly addressed.¹³¹ The Huntington Ingalls Newport News shipyard has had some recent infrastructure upgrades, but requires still more. In contrast, competitive foreign shipyards have room for efficient shipyard activities, modern facilities, and necessary equipment to build ships on schedule and at the contracted price. As U.S. shipyards close it's difficult for shipbuilders to consolidate capability. What is left is an aging and disparate group of shipyards usually optimized for only one type of navy ship. The lack of tailorable and scalable shipyards with modern facilities and equipment drives inefficiency and remains a cost driver that must be addressed in any forthcoming strategy.

Advanced and mature technologies can bring about significant efficiencies and cost savings especially when they become widely available. Such advances are very limited in shipbuilding. Much of the work is still done manually by skilled workers or technicians. Shipbuilding is a process that simply cannot be automated on a large scale. Still, there have been innovative evolutionary improvements. Most ships are built using the hull-block process. The advent of aluminum hull Navy ships has led to significant advances in aluminum welding. Additionally, advancements in ship design and modeling tools have led to more efficient designs and build plans. The lack of shipbuilding innovation has forced the Navy to look crew size reductions as a viable option for to lower life-cycle costs.¹³² These manpower cost savings are often not realized for many years due to the higher procurement and maintenance costs of highly automated equipment to account for the crew reduction. This lack of real innovation is another cost driver.

Mitigating facilitation and technical innovation requires industry and the government to look for ways to partner for improved technology transfer opportunities and seek ways to incentivize efficiency and cost reductions. The government pays for this capacity either through the inefficiencies that drive up cost and schedule delays, or, as it has over the last century, it pays significant sums to private corporations to build manufacturing capacity and improve manufacturing efficiencies.¹³³ Industry would be more willing to share the burden of this cost if the government continued to seek future partnership opportunities. This improved partnering would also enable technology transfer between government and industry partners, and would maximize investment dollars and the pooling of resources to solve joint problems.

Predictability – Risk is the measure of uncertainty in an effort and always drives cost. Quantity changes and funding uncertainty *vis-à-vis* the PPBE process do not properly incentivize companies to innovate or invest in infrastructure and facilities. The Navy's early requirement for the LCS was 55 ships, and in 2008 there was serious consideration to increasing that number.¹³⁴ Six years later, the Secretary of Defense capped contracted quantities to 32.¹³⁵ That reinforced the message to industry that the government is an unpredictable partner. Predictability is the most important cost driver that must be addressed in an effective Navy shipbuilding strategy.

Mitigation requires consensus with the Navy and our political leaders. As unlikely as this condition may be it is the only way to correct a problem that only appears to be worsening. An exception to the current PPBE and Fiscal Year Defense Plan is required to optimize the military



shipbuilding industry and provide the required capability to the DoD. The strategy must translate into a long-term acquisition strategy that encompasses all of the Navy's shipbuilding requirements.

Proposed 30 Year Hybrid Strategy: Canada had an opportunity to restart their shipbuilding industry from scratch as they had shut down their Canadian Navy shipbuilding capacity in the 1990's. In 2010 the Canadian government announced their National Shipbuilding Procurement Strategy (NSPS), which they developed in partnership with industry. The NSPS has five phases:

1. Developing the Strategy: *completed* and announced in June 2010.
2. Selecting the shipyards: *completed* on October 19, 2011.
3. Establishing the relationship with the shipyards: *commenced* with the signing of overarching Umbrella Agreements with the shipyards in February 2012; will continue through various shipyard interactions with NSPS governance committees and project teams.
4. Preparing the yards and finalizing the designs – *currently underway*.
5. Constructing the ships.¹³⁶

Ultimately, the Canadians developed a strategy that enabled competition, provided for long-term predictability, achieved bipartisan political support, and constructively partnered with the commercial shipbuilding industry.

The U.S. can no longer compete with countries that have chosen to nationalize or semi-nationalize their shipbuilding industry without partially doing so ourselves. The investment in corporate facilitation must be a part of this solution. We should adopt Canada's approach. We may not be able to follow Canada's plan precisely, but if the Navy has a sound strategy to meet current and emerging threats for next 20-30 years then the U.S. government should be able to make a long-term commitment with our nation's shipbuilders to produce and maintain a fleet capable of meeting that requirement. Shipbuilding is a unique procurement problem, and the procurement strategy should have the flexibility to be equally unique. This strategy encourages shipyard consolidation and consolidation of existing and future contracts as much as possible. The short-term cost of this strategy may not provide any immediate cost savings, but if managed properly should yield significant capability and industrial security at a reasonable price.

Shipbuilding will always be expensive but it does not have to be inefficient. Without a comprehensive procurement strategy for our Navy's requirements we will continue to trade capability for cost overruns and schedule delays, ultimately placing the security of our nation at risk. Predictability in the military shipbuilding industry will create value. The above strategy is a possible mechanism to enable our stakeholders to reach this goal.

-LTC Christopher D. Schneider, USA

CONCLUSION

Our objective was to understand the nexus between the shipbuilding industry and national security. After initially focusing on the Jones Act as a potential driver of industry health, we began to realize naval shipbuilding was only residually impacted by the health of the commercial segment. This reduced the importance of revising protectionist statutes, so we will not provide a recommendation on preservation or repeal of the Jones Act, but will simply acknowledge the benefit of the Jones Act for preservation of the U.S. mariner base.

Our recommendations are means to improve the health of this industry and enhance national security. Providing predictability through long-term contracts in the naval shipbuilding sector would address the majority of identified industry concerns and produce many corollary benefits.



First, predictability would provide stability in the labor force by creating a less disruptive hiring and layoff cycle. This would increase the desirability of shipbuilding jobs, leading to improved recruiting and retention. It would further incentivize infrastructure improvement because of the surety of recouping investments. The same is true of process improvement and innovation investments that would increase industry profitability. Finally, predictability would stabilize supply chain confidence and allow shipbuilders to increase order quantities.

In order to increase predictability, we recommend the Navy pursue policy and planning changes with the Defense Department and engage with Congress to address possible solutions. Policy remedies include changes to DoD acquisition regulations and the Federal Acquisition Regulation, and revisions in National Defense Authorization Act language that acknowledge the unique timeframes required for achieving the goals of the Navy's 30-year Shipbuilding Plan. Together, these changes would work to achieve fleet-wide planning and acquisition in a responsive and responsible way that benefits the Navy and the shipbuilding industry.

We recommend DoD Instruction 5000.02, "Operation of the Defense Acquisition System," be revised to include specific guidance for ship acquisition emphasizing the importance of predictability and considerations to improve long-term stability of shipbuilding programs. Despite the unique nature of ship acquisition, DoDI 5000.02 provides little special guidance for ships.

In addition, we recommend modifying Federal Acquisition Regulation (FAR), Part 17, *Special Contracting Methods*, to include long-term contracting options unique to shipbuilding. Currently, Subpart 17.1, *Multi-year Contracting*, offers a five-year contracting option, but the Navy should determine if a longer period would provide desired predictability without undue inflexibility in budgeting. Of note, Subpart 17.1 outlines the benefits of multi-year contracting, which include lower costs, reduced administrative burden, stabilization of contractor workforce, and incentives to improve productivity through investment in capital facilities and advanced technology.

Finally, as an alternative to FAR changes, we recommend the Navy consider working with Congress to include provisions in the National Defense Authorization Act to secure shipbuilding funds for periods up to 10 years. In addition to guaranteed funding, the Navy should pursue a "block buy" approach when committing to new ship classes. If Congress funds the start of construction, it should commit to building a fleet of ships, with the option to cancel or curtail only after the block is complete. Awards of small numbers such as DDG-1000 or LHA-8 do not inspire investment in innovation or research and development.

We recommend the 30-Year Shipbuilding Plan be written to comply with DoDI 5000.02, Enclosure 8, *Affordability Analysis Guidance*. Such changes to current planning processes could also improve predictability in naval shipbuilding. Any variations to this guidance based on changed defense strategy, changed force structure, or the need for industrial base expansion would require specific justification within the document. This guidance tells component leadership to conduct affordability analyses by portfolio. It also states that following the guidance "provides a nominal versus optimistic foundation for the future." This guidance further states that the topline portfolio budget beyond FYDP be based on average of the last two years of FYDP and OSD cost inflator. Finally, it states that total cost across portfolios cannot be above projected future budget. This drives a trade-off analysis among shipbuilding and other Navy procurement portfolios.

In summary, we recommend the Navy promote predictability in naval shipbuilding by developing proposals for consideration by the Defense Department and Congress. These should include the policy and planning recommendations outlined above. Further, the Navy should perform a comprehensive review of shipbuilding guidance to determine if other policy or statutory



mechanisms are available to promote predictability. Inefficiencies, concentration, and budget uncertainty make the future health of this industry ambiguous. Action by the U.S. government could add stability to the industry, enhance its long-term outlook, and enhance national security.



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ACRONYMS

BCA – Budget Control Act
BRIC – Brazil, Russia, India, China
CAPT – Captain
CCF – Capital Construction Fund
CDR – Commander
COL – Colonel
CRF – Construction Reserve Fund
DSME – Daewoo Shipbuilding and Marine Engineering
DoD – Department of Defense
DoDI – Department of Defense Instruction
FAR – Federal Acquisition Regulation
FBM – Fleet Ballistic Missile
FMS – Foreign Military Sales
FYDP – Future Years Defense Program
GD-BIW – General Dynamics Bath Iron Works
GD-EB – General Dynamics Electric Boat
GD-NASSCO – General Dynamics National Steel and Shipbuilding Company
GDP – Gross Domestic Product
ICBM – intercontinental ballistic missile
LCS – Littoral Combat Ship
LHA – amphibious assault ship
LH(X) – amphibious assault ship (planned)
LRS-B – Long Range Strike Bomber
Lt Col – Lieutenant Colonel
NATO – North Atlantic Treaty Organization
NDAA – National Defense Authorization Act
NNS – Newport News Shipbuilding
NSPS – National Shipbuilding Procurement Strategy
OSD – Office of the Secretary of Defense
PPBE – Planning, Programming, Budgeting, and Execution
SCA – Shipbuilding Council of America
SSBN – nuclear-powered ballistic missile submarine
SSBN(X) – replacement ballistic missile submarine
SSN – attack submarine
T-AKE – dry cargo vessel
T-AO(X) – fleet oiler (replacement)
U.S. – United States
USA – United States of America
USD – United States dollar



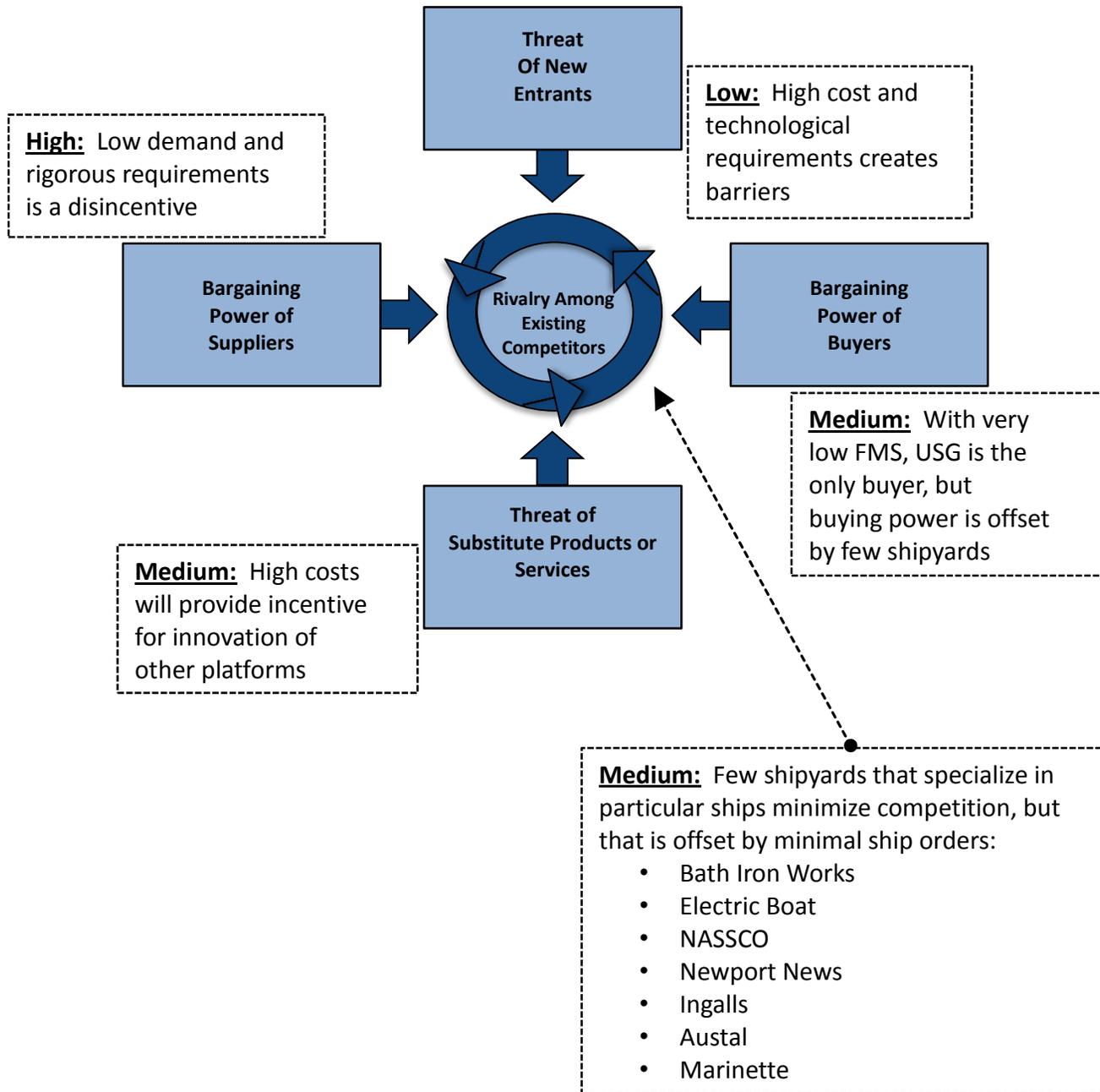
APPENDIX 1

“SWOT” Analysis, U.S. Navy Shipbuilding

<p>STRENGTHS</p> <ul style="list-style-type: none"> • Warship design and technology • Defense budget • Size of industry • Skilled workforce 	<p>WEAKNESSES</p> <ul style="list-style-type: none"> • High concentration • Low competitiveness • Shipyard constraints and inefficiencies • Exports 	INTERNAL FACTORS
<p>OPPORTUNITIES</p> <ul style="list-style-type: none"> • Increase customer base • Infrastructure investment and modernization • Increase domestic and foreign cooperation 	<p>THREATS</p> <ul style="list-style-type: none"> • Budget uncertainty • Inter-service competition • Globalization 	EXTERNAL FACTORS
<i>POSITIVE FACTORS</i>		<i>NEGATIVE FACTORS</i>

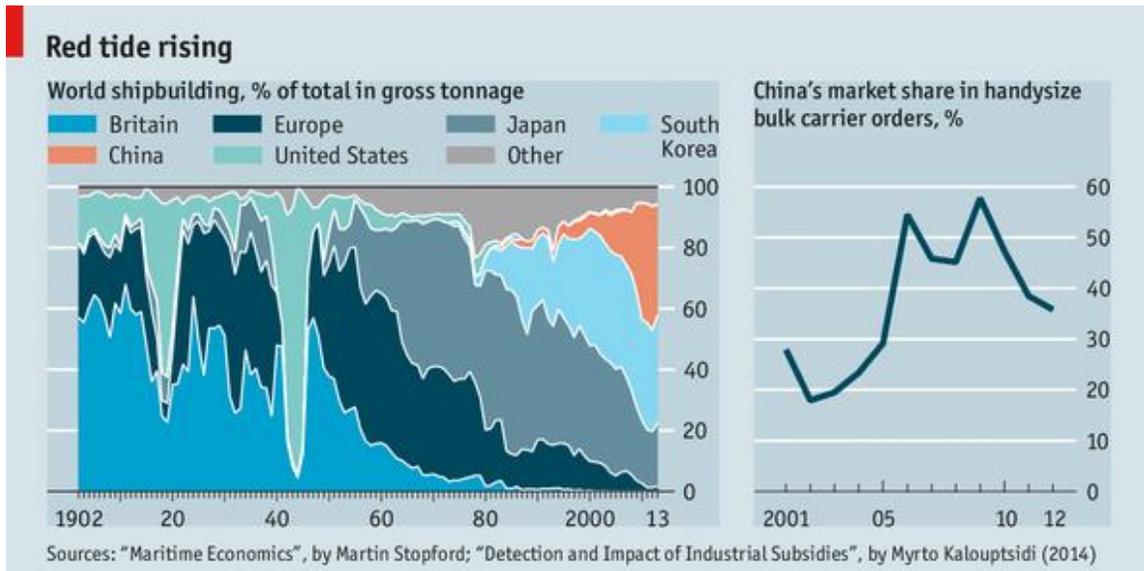


APPENDIX 2

Five Forces Model¹³⁷

APPENDIX 3

Impact of Subsidies on Shipbuilding¹³⁸



APPENDIX 4

U.S. Navy Ship Construction: Planned Vessels by Type and Contracted Shipyards

	Newport News	Ingalls	Bath Iron Works	Electric Boat	NASSCO	Marinette	AUSTAL
CVN	X						
DDG		X	X ¹				
LCS						X	X
SSN	X			X			
SSBN	X			X			
LPD		X					
LX		X					
LHA		X					
MLP/AFSB					X		
T-ATF					X		
T-AO					X		

¹ With the likely suspension of destroyer construction, Bath Iron Works will have no ships to build for nearly ten years starting in 2025.



APPENDIX 5

	SSBN(X)	SSB	DDG-51
Shipbuilding Budget (Historical Annual Average)	\$13.9 B	\$13.9 B	\$13.9 B
Cost per Unit (Projected)	\$12.4 B; \$6 B*	\$2.8 B	\$1.4 B - \$1.8 B
Shipbuilding Budget (Annual Average with Changes to Production)	\$17.5 B	\$16.6 bn	\$15.4 bn (incl SSB reduction)
Production Rate by Type (Planned)	1/year*	1-2/year	2/year
Production Rate by Type (Reduced)	N/A	1/year	1/year
Total Required by Type	12	48	88
Total Production by Type	12	36	72

Figure 1: Impacts to Shipbuilding Budget with Changes to Production by Ship Type

*12 Ohio Replacement SSBNs to replace the 14 Ohio class subs now in commission, with the lead boat procured in FY21.¹³⁹ A second submarine would be purchased in FY24, followed by one per year from 2026 to 2035.¹⁴⁰ The Navy estimates the first sub will cost \$12.4 billion in 2014 dollars, and follow-on subs will cost \$6 billion, for a total cost of \$79 billion.¹⁴¹

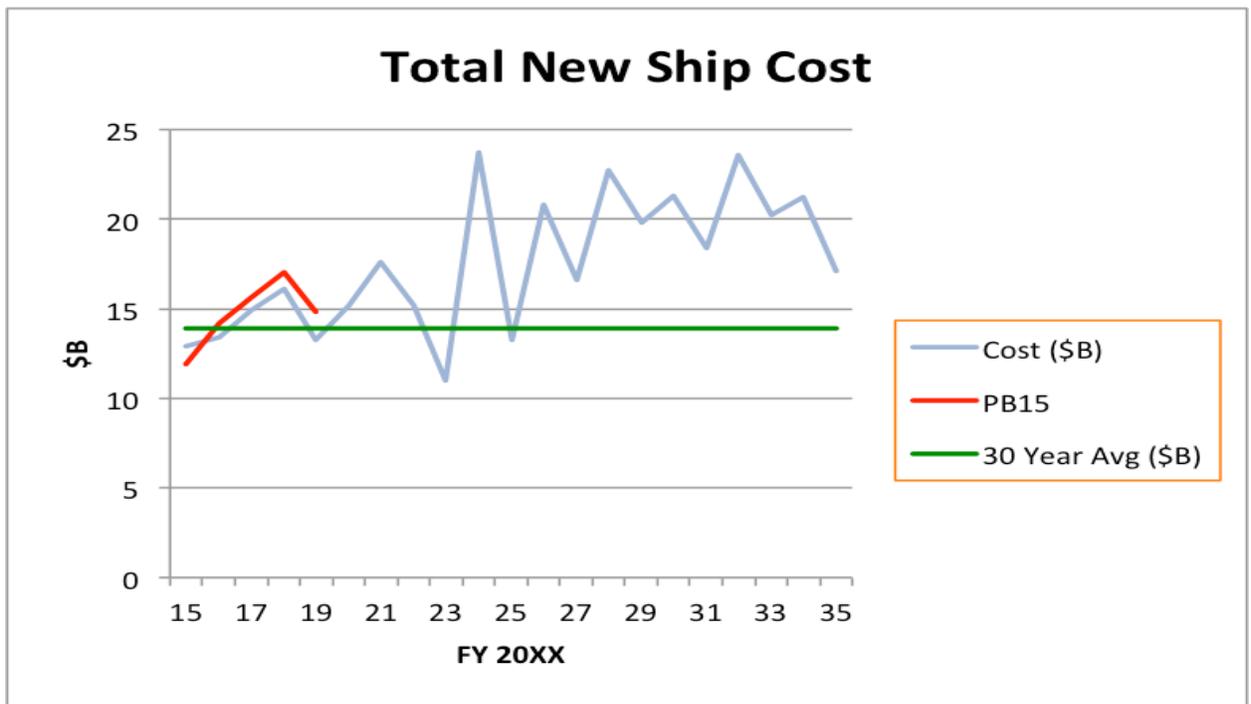


Figure 2: Total New Ship Cost Over a 20-year Period

