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NAVIGATING THE WAVES: ASSESSING AND ADDRESSING KEY ISSUES IN U.S. SHIPBUILDING AND REPAIR

ES 6774: INDUSTRY STUDY: MARITIME DOMAIN

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SEMINAR #15

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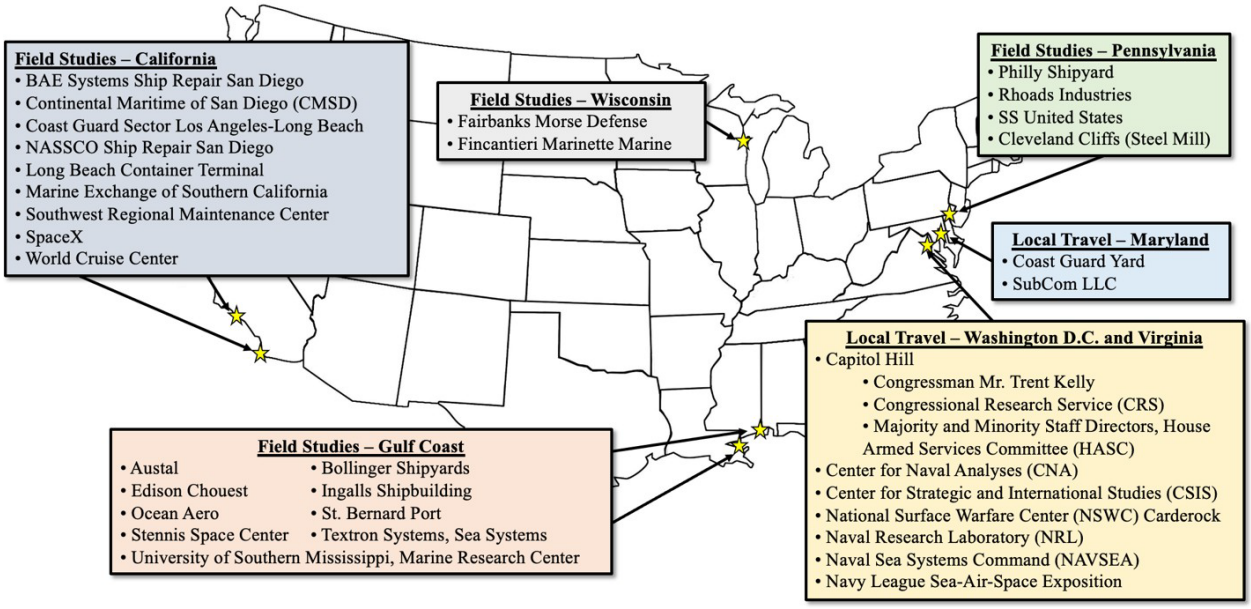
In-Class Guest Speakers

• Baffer, Bruce; Senior Vice President Global Government, American Bureau of Shipping
• Geurts, James "Hondo"; former Assistant Secretary of the Navy for Research & Development (ASN RDA)
• Taffer, Bruce, Ph.D. (Tufts University); Research Fellow, Center for the Study of Chinese Military Affairs, Institute for National Strategic Studies (INSS), National Defense University
• Wetherald, Tom; former Director of Business Development and Strategic Planning for General Dynamics-NASSCO; served on Executive Committee of the Shipbuilder's Council of America (SCA)

CONUS Industry Study Field Studies Hosts



Field Studies – Washington D.C., Maryland, Virginia – Local Travel

• Capitol Hill
  - U.S. Representative Mr. Trent Kelly, First District of Mississippi, serves on the House Armed Services Committee, serves as Chairman of the Seapower and Projection Forces Subcommittee
  - Mr. Ronald O'Rourke, Congressional Research Service (CRS), Washington D.C.
  - Mr. Chris Vieson and Mr. Brian Garrett, Majority and Minority Staff Directors, House Armed Services Committee (HASC), Washington D.C.
• Center for Naval Analyses (CNA), Arlington, VA
• Center for Strategic and International Studies (CSIS), Washington D.C.
• National Surface Warfare Center (NSWC) Carderock, Bethesda, MD
• Navy League Sea-Air-Space Exposition, Washington D.C.
• SubCom LLC, Baltimore, MD
• U.S. Coast Guard Yard, Baltimore, MD
• U.S. Navy, Naval Research Laboratory (NRL), Washington D.C.
• U.S. Navy, Naval Sea Systems Command (NAVSEA), PEO Submarines, Washington D.C.

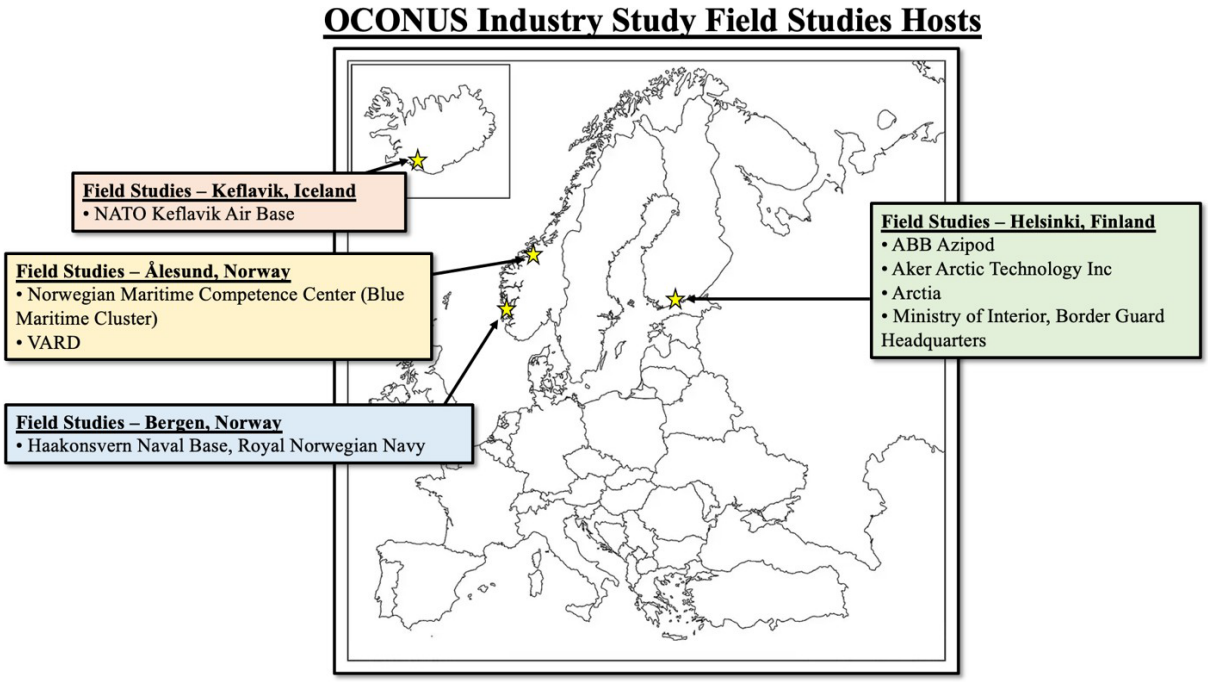
- Mr. Matt Sermon, Program Executive Officer (PEO) Submarines
- Captain Kevin Smith, Program Manager for Constellation Class Frigate

Field Studies – Pennsylvania
• Cleveland-Cliffs, Coatesville, PA
• Philly Shipyard Inc, Philadelphia, PA
• Rhoads Industries, Inc. Philadelphia, PA
• USS United States, Philadelphia, PA

Field Studies – Wisconsin
• Fairbanks-Morse Defense, Beloit, WI
• Fincantieri Marinette Marine, Marinette, WI

Field Studies – California
• BAE Systems Ship Repair San Diego, San Diego, CA
• Continental Maritime of San Diego, San Diego, CA
• Coast Guard Sector Los Angeles-Long Beach, San Pedro, CA
• General Dynamics NASSCO Ship Repair San Diego, San Diego, CA
• Long Beach Container Terminal, Long Beach, CA
• Marine Exchange of Southern California, San Pedro, CA
• Southwest Regional Maintenance Center, San Diego, CA
• SpaceX, Hawthorne, CA
• World Cruise Center, San Pedro, CA

Field Studies – Gulf Coast
• Austal, Mobile, AL
• Bollinger Shipyards, Lockport, LA
• Edison Chouest Offshore Companies (ECO), Houma, LA
• Ingalls Shipbuilding, Pascagoula, MS
• Ocean Aero, Gulfport, MS
• St. Bernard Port, Chalmette, LA
• Stennis Space Center, Kiln, MS
• Textron Systems, Sea Systems, New Orleans, LA
• University of Southern Mississippi, Marine Research Center, Gulfport, MS



Field Studies – Finland, Norway, Iceland – OCONUS

- ABB Azipod, Helsinki, Finland
- Aker Arctic Technology Inc, Helsinki, Finland
- Arctia, Helsinki, Finland
- Ministry of Interior, Border Guard Headquarters, Helsinki, Finland
- Haakonsvern Naval Base, Royal Norwegian Navy, Bergen, Norway
- Norwegian Maritime Competence Center (Blue Maritime Cluster), Ålesund, Norway
- VARD, Vestnes, Norway
- NATO Keflavik Air Base, Keflavik, Iceland

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Executive Summary

For over seven decades, the United States has championed a rules-based global order, allowing international commerce to flourish. The 2022 National Security Strategy (NSS) reaffirms this vision, specifying the United States' commitment to "an open, prosperous, and secure international order…free from aggression, coercion, and intimidation."[1]

Critical to fulfilling this ambition is ensuring the United States has the military capacity to protect its territory and project its global power. To achieve this, the United States Government must dedicate time and resources to modernize and strengthen its military, equipping it to successfully prevail in great power competition with the People's Republic of China (PRC) while addressing acute threats such as Vladimir Putin's Russia.

Realizing this ambition, however, requires addressing significant deficits in the U.S. military's readiness and capabilities, particularly deficiencies in the nation's ability to efficiently build and repair vital U.S. Navy and U.S. Coast Guard vessels. Successfully addressing these deficits will, in turn, require cooperation and commitment among the key actors involved in United States ship production and repair: the U.S. Navy, Congress, and the defense industrial base, as well as collaboration with allies and partners. In approaching this challenge, the United States should focus on *increasing the readiness of the current fleet* and *building the future fleet.*

Increasing Readiness of the Current Fleet: Maintenance and Repair

As the Government Accountability Office (GAO) wrote, "[the] U.S. Navy's [and U.S. Coast Guard's] ability to repair and maintain its ships plays a critical role in sustaining readiness during both peace and times of conflict."[2] During peacetime, the U.S. Navy and U.S. Coast Guard should prioritize communicating a consistent, reliable shipbuilding and repair demand signal to the industry. To aid this, the Department of Defense (DoD) should maximize the

additional acquisition authorities previously provided in National Defense Authorization Acts (NDAA), including block buys, multi-year procurement, and other transactional authorities (OTA), and delegate approval authority for small value dollar growth (SVDG) changes.

In combat conditions, the need for prompt repair is even more urgent. As one analyst writes, "In any future conflict in the Pacific against China, the U.S. fleet will experience battle damage on a scale not seen since World War II—a situation today's Navy is woefully unprepared to handle."[3] Today's fleet "lacks the parts, processes, plans and—perhaps most critically—the shipyard capacity to fix ships fast and send them back into battle."[4] This makes improving the U.S. Navy's ability to conduct maintenance and repairs at sea and overseas, leveraging our allies' and partners' talent and industrial bases, a critical national security concern.

Building for the Future: Shipbuilding to Prevail in Great Power Competition

In addition to maintaining and repairing the current arsenal of U.S. Navy and U.S. Coast Guard vessels, there is an urgent need to build the future fleet. A vibrant domestic, commercial shipbuilding and repair industry will only benefit the U.S. military. To improve the U.S. commercial shipbuilding sector, the U.S. government should authorize a subsidy to scrap and replace the aging U.S. Jones Act fleet, modify the Jones Act to authorize importing commercial hulls, and seek out more opportunities to directly collaborate with the commercial sector (e.g., by investing in a government-owned/contractor-operated (GO/CO) shipyard) and with allies and partners. These actions will free up U.S. labor to execute the high-value portion of shipbuilding, where the United States has a competitive advantage, bolster the economies of allies and partners, and strengthen and diversify the supply chain. By taking prompt action now, the United States can reach the Congressionally mandated goal of a 355 ship Navy, enabling U.S. forces to effectively counter the People's Liberation Army Navy (PLAN) alarming rise.[5,6]

Framing Statement

The 2022 National Defense Strategy identifies Russia as an acute threat to U.S. national security interests, but the People's Republic of China poses "[t]he most comprehensive and serious challenge to U.S. national security" and is the "pacing challenge" for the Department of Defense (DoD).[7] The Department describes this in noting, "The PRC has expanded and modernized nearly every aspect of the [People's Liberation Army (PLA),] with a focus on offsetting U.S. military advantage."[8]

As Beijing seeks to rewrite the rules underpinning the international order in the Taiwan Strait, South China Sea, and East China Sea, the U.S. Navy and U.S. Coast Guard will be called on with even greater frequency to deter Chinese aggression and ensure the free flow of commerce, communication, and seafaring navigational freedom.

To realize its strategic goals, by the end of this decade, the PRC is expected to have a battle force fleet of some 440 ships, nearly 150 more than that of the United States.[9] Against this backdrop, it is critical to consider how the United States can effectively respond to Beijing's naval expansion and ambitions. Among the most urgent issues is how the United States can build and maintain a Navy fleet that is able to deter, and if necessary, prevail against, China's military and ensure the effective continuation of the global order the United States has championed and sustained for seven decades.[10]

Strategic Environment

The United States as the Guarantor of the Modern Maritime Order

With over 95,000 miles of coastline, the United States relies on the sea for commerce, natural resources, and modern communications.[11] Beyond protecting its interests, the United States has been the de facto guarantor of global maritime security for over 75 years. This order—

benefiting allies and foes alike—advances respect for national sovereignty, rule-based trade, and open navigation of the seas, allowing 90 percent of modern trade to take place by large ocean faring vessels.

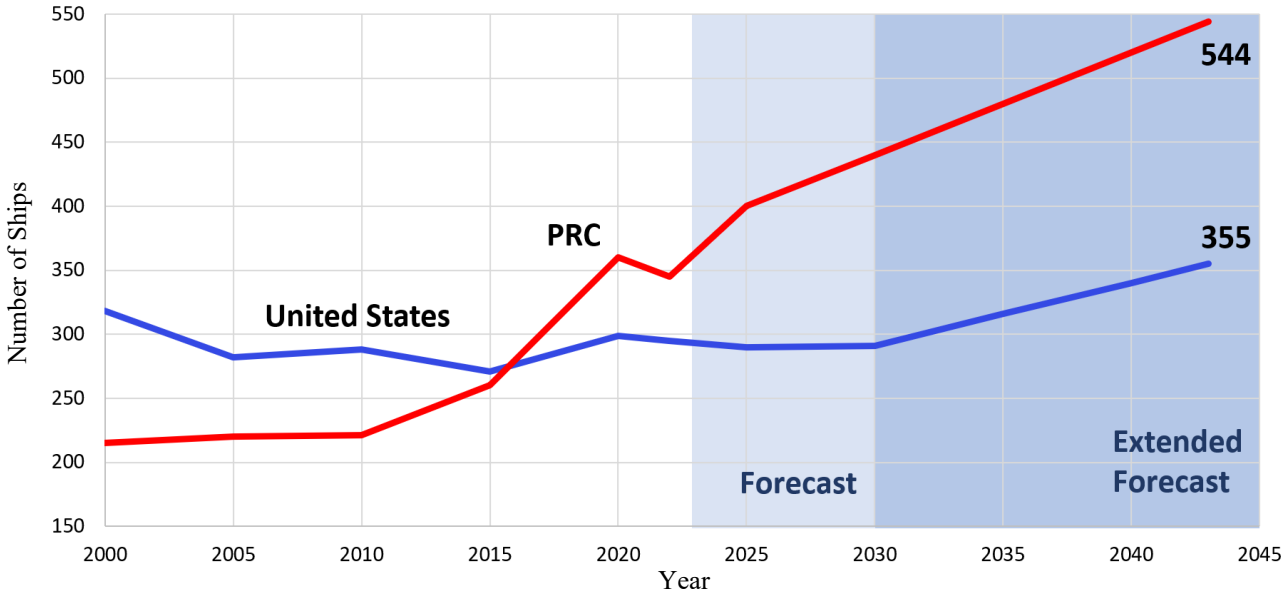
To secure these vast maritime interests, the United States has worked vigorously, over decades, to build and maintain a U.S. Navy capable of protecting its territory at home and prevailing in a conflict far from its shores. This modern maritime order, however, is under unprecedented threat from a bold, belligerent, and increasingly capable PRC. [12]

The PRC Expanding Maritime Ambitions and Capabilities

Multiple U.S. government statements and strategic guidance documents make Washington's concerns over Beijing's maritime ambitions and capabilities plain. The 2022 National Security Strategy identifies the PRC as the only competitor with the intent and the economic, diplomatic, military, and technological power to reshape the international order.[13] The White House describes Beijing as pressuring Taiwan and bullying its neighbors across the East and South China Seas.[14] The Department of State notes that the Chinese Communist Party is "using military and economic coercion to advance unlawful maritime claims."[15] And lest there be any doubt, the PRC Chairman, Xi Jinping himself, has repeatedly articulated the need to urgently build a powerful navy capable of missions far from its shores.[16]

Beijing's navy modernization program, begun in the 1990s, has dramatically expanded the quantity and quality of PLAN platforms to increase its capabilities. The PRC's volume of vessels already exceeds that of the U.S. Navy. And many analysts believe the PRC's 13 active shipyards will allow the PLAN to reach 440 battle force ships, or 150 more vessels than the United States by 2028.[17] At its current growth rate, it is feasible that by the end of the next

Figure 1: U.S. vs PRC Naval Fleet End-Strength



decade, 2040, the PRC could have close to a 550-ship navy (see Figure 1).[18]As the Secretary of the Navy, the Honorable Carlos Del Toro aptly put it, "one [PRC] shipyard has more capacity than all of [the U.S.] shipyards combined. That presents a real threat."[19] In addition to surface combatants, Beijing is growing its submarine capabilities, uncrewed undersea vessels, and missile technology, giving the PLAN alarming qualitative depth.[20]

These advancements are made possible due to the PRC's massive 30-year investment in commercial, military, and dual use shipbuilding capacity. Indeed in 1993, the PRC controlled just three percent of the global commercial shipbuilding market, compared to producing nearly half of all vessels in the world today.[21] In addition to building massive capacity to build naval vessels, the PRC is increasing its maritime interests and assets worldwide through its Belt and Road Initiative (BRI). Now in its tenth year, the BRI has invested in more than 150 countries, with analysts believing Beijing could invest as much as $8 trillion in projects.[22] Many of these initiatives are directed toward maritime assets and in strategic locations throughout the Indo-Pacific. This includes building infrastructure, such as deep-water ports, positioning Beijing to leverage these investments for military use. Public reporting suggests the PRC has a toehold in at

least 100 ports in 63 countries. Finally, the PRC is racing to sell its naval hardware to willing buyers to expand its defense ties and increase PLAN's interoperability. A recent example is the April 2023 delivery of a Chinese-built amphibious assault ship to Thailand.[23]

A Prompting for Urgent Action

The prospect of Beijing reaching parity, or even surpassing, American maritime capabilities has led concurrent U.S. administrations to demand improvements in U.S. naval assets. The 2022 National Defense Strategy responds to this direction, emphasizing the need to counter the PLAN's ambitions by sustaining and strengthening U.S. maritime deterrence. To this end, the U.S. Navy has committed to "building and maintaining a dominant naval force to keep the sea lanes open and free, deter conflict, and when called upon, decisively win the nation's wars."[24]

In support of the U.S. Navy's assessment of the appropriate battle force goal, Congress codified the 355-ship goal in the Fiscal Year 2018 (FY18) NDAA.[25] This ship count would be a roughly 18 percent increase over the 270 to 300 ships the U.S. Navy has maintained in recent decades.[26] More aggressive plans, meanwhile, aim to have the U.S. field upwards of 500 manned and uncrewed naval vessels.[27]

Before further exploring the current context and potential solutions, it is critical to understand the history of U.S. naval shipbuilding, including why and how domestic shipbuilding and repair have dramatically declined.

The Deterioration in American Shipbuilding

Emerging victorious from World War II, U.S. shipbuilding was the world's envy.[28] By the war's end, America had produced almost 7,000 major navy vessels, employing thousands of workers in over 50 major shipyards.[29,30] As Loren Thompson of Forbes Magazine explains, the

United States remained a significant, if not dominant, shipbuilder in the postwar period. American marine manufacturing benefited from government subsidies on the commercial end and Cold War spending on the military side. By the 1990s, however, the combined forces of cheap labor abroad and robust foreign subsidies, paired with the termination of federal grants to American shipbuilders and declining defense spending, initiated a dramatic deterioration in American ship construction.[31]

Today, more than 90 percent of global ship manufacturing occurs in the PRC, the Republic of Korea (ROK), and Japan, with the United States ranking 19th in commercial shipbuilding—less than one percent of the worldwide market.[32,33] To the extent the United States retains a shipbuilding industry at all, it is primarily due to military contracts.[34] What does remain in non-naval ship construction is attributable to the century-old Merchant Marine (Jones) Act which restricts the transportation of cargo between U.S. ports to ships that are U.S.-built, U.S.-owned, U.S.-registered, and U.S.-crewed.[35]

Over the past 60 years, 14 shipyards capable of building U.S. Navy and U.S. Coast Guard ships have closed. This dramatic decline leaves just seven able to build large warships today.[36] Public maintenance and repair shipyards have shrunk from eight to four, with these facilities maintaining limited functional dry docks and aging equipment.[37] More recently, the wars in the Middle East exacerbated this by orienting military resources to these conflicts instead of investing in deteriorating naval vessels and the production facilities needed to make and repair them.

The aggregate result is an anemic 21st-century American shipbuilding and repair industry controlled by a handful of companies, most notably General Dynamics and Huntington Ingalls Industries, whose viability depends entirely on government contracts. The corollary consequence

is limited production capacity, a shallow pool of available skilled labor, shrinking institutional knowledge, limited innovation, and weak domestic supply chains. In one illuminating example, the United States has gone from more than 17,000 suppliers supporting submarine construction programs to less than 5,000. [38]

Based on the planned annual rate of naval procurements and the current capacity of U.S. shipyards, the Congressional Research Service estimates that U.S. shipbuilders will only be able to produce roughly eleven naval vessels per year – depending on the class and type of ship – allowing the U.S. Navy to reach approximately 385 ships by the 2060s.[39] This leaves no room to immediately surge U.S. shipbuilding to meet the PRC's rising capabilities. Nor does it allow for reducing the months-long ship maintenance and repair delays confronting today's U.S. Navy.[40]

COVID-19 and Ukraine Highlight and Exacerbate Weaknesses

Two contemporary and seminal global events – COVID-19 and the War in Ukraine – offer timely and vital considerations for shipbuilding and naval readiness. Across every sector of the economy, COVID-19 revealed the nation's vulnerability to supply chain shocks and the over-reliance on foreign-made parts. In the shipbuilding and repair industry, the over-reliance on foreign-made parts led to shortages that delayed ship construction by months.

The war in Ukraine, meanwhile, exposes negatives and positives as it pertains to military and naval readiness, which strategic planners should consider. On the negative side, the conflict has further stressed already fragile supply chains, and depleted U.S. weapons stockpiles to troublingly low levels. On the positive side however, the war has highlighted the indispensability of strong partnerships in providing military support and leveraging allied cooperation to deter and defeat aggression. A clear example of this is the expansion of the North Atlantic Treaty Organization (NATO) to include Finland, whose entry grants the United States an expanded

partnership with a democratic and geographically critical nation that rich in naval expertise, including Navy and Coast Guard vessel construction.

Stakeholder Interests

In evaluating key stakeholders in U.S. shipbuilding and repair, several groups emerge as the most critical actors. These are the U.S. Congress, the Executive branch (to include the Defense Department and Homeland Security), the domestic shipbuilding and repairing industry, shipyard workers, the American public, and allied nations and partners.

United States Congress

Constitutionally empowered with making laws, appropriating funds, and declaring war, Congress is the most critical actor in ensuring the success of the U.S. Navy.[41] Several long-standing and more recent laws significantly impact the U.S. shipbuilding industry. Examples include the Jones Act of 1920, supporting constituents and special interest groups, 10 U.S.C §§ 8679 & 8680, generally limiting armed forces vessels from being built and repaired abroad.[42,43] Members of Congress also respond to, and advance the interest of, their constituents, including companies located within their districts or which may make political contributions.

Executive Branch

The Executive branch, headed by the President, is responsible for commanding the military and protecting the security of the United States, and honoring legally binding treaties with allies.

Current U.S. foreign and domestic policy priorities of the Biden Administration include enhancing military readiness, creating blue-collar jobs, reducing carbon emissions, revitalizing U.S. manufacturing, and increasing employment in disadvantaged communities. The three Executive branch departments most linked to the U.S. shipbuilding and repairing industry

meanwhile, are the Department of the Navy, which includes both the U.S. Navy and the U.S. Marine Corps, the U.S. Coast Guard within the Department of Homeland Security (DHS), and the Maritime Administration (MARAD) within the Department of Transportation (DOT). These Departments execute appropriated funds according to Congress' direction and develop and implement civilian leadership strategies impacting the maritime industry.

Looking more specifically at the interests and vantages of these Executive branch entities, the U.S. Navy's primary interests lie in procuring and maintaining a battle force fleet of surface and subsurface vessels capable of deterring the Nation's threats and competitors. The Marine Corps' interests are to have enough amphibious ships to enable the execution of their Force Design 2030, which has recently been at odds with the Department of the Navy as indicated in the FY24 President's Budget request.[44] The Coast Guard meanwhile, relies on the maritime industry for the constant stream of cutters to support their numerous mission sets along our nation's shores and abroad, and their interests have recently centered on procuring at least three Polar Security Cutters to increase their presence in the Arctic. As the Coast Guard acquires newer and larger vessels, they are further challenged as they outgrow current shipyard facilities and are now competing with the larger and better funded Navy for the few shipyard repair facilities capable of handling larger vessels. Finally, the MARAD "maintains a fleet of cargo ships in reserve to provide surge sealift during war and national emergencies."[45] These Departments compete for limited dollars and yard capacity to accommodate their procurement requirements.

U.S. Ship Building and Repairing Industry

The U.S. shipbuilding and repairing industry represent the third leg (along with Congress and the Executive) in the so-call Iron Triangle of the industrial base. A small number of U.S.

defense companies dominate the U.S. Navy prime contracts market. These primes and numerous small to medium-sized companies pursue a steady stream of U.S. government shipbuilding and repair contracts to maintain and grow their businesses by increasing efficiencies to lower costs and increase profitability. The industry regularly interacts with its customers within the executive branch and Congress to emphasize their special interests.

U.S. Shipyard Workers

Shipyard workers are another critical stakeholder since their low aggregate supply is in high demand for increasing U.S. Navy shipbuilding capacity. Shipyard workers are interested in long-term stability and better wages to incentivize the physically demanding work instead of numerous customer service career opportunities with less demanding work conditions. Shipyard workers, predominately in the northeast and California due to industrial composition, are frequently also represented by a labor union, adding another layer to this stakeholder group.

The American Public

Although Congress is elected by and represents the interests of the American public, legislator and constituent interests may not always align. For example, the public may be interested in short-term priorities like lower taxes and government spending that impact and can reduce the cost of fuel and consumer goods. Expensive, longer-term capital investments, such as in shipyards or military equipment that is not ready for years, can be harder to sell to taxpayers.

Allied Nations and Partnerships

The interests of the United States' allies are to protect the global maritime ecosystem and security. Ocean-going ships transport nearly 90 percent of all trade and commerce. Nations depend on the security and prosperity of this ecosystem to generate "economic opportunity and enable critical commercial and military activity."[46] Partnerships such as the North Atlantic

Treaty Organization (NATO), the Quad (India, Japan, Australia, and the United States), and, most recently, the Australia-United Kingdom-United States Security Partnership (AUKUS) have solidified these interests. Signed in 2021, AUKUS provides a transformative framework for increasing naval ties that enhance allied interoperability, share weapons platforms, enable the forward deployment of U.S. vessels in the Indo-Pacific, and lead to joint production and use of Australian shipyards.[47] As AUKUS matures, it may become the most impactful partnership in the U.S. shipbuilding and repairing industry and may serve as a model for similar mini-lateral partnerships between the United States and allies and partners with maritime industrial base capacity.

Structure, Conduct, and Performance

Evaluating the current U.S. shipbuilding and repair industry for the U.S. Navy and U.S. Coast begins by understanding the market size. According to analyses by IBISWorld, U.S. shipbuilders employ more than 100,000 people and generate yearly revenue of roughly $35 billion, with an anticipated six percent annual growth rate over the next five years. These numbers closely match estimates by the Congressional Budget Office, which has the Defense Department's spending on naval vessels between $30 and $33 billion annually over the next 30 years.[48]

Like the industry's heavy focus on the defense sector, firm participation is also highly concentrated. General Dynamics holds 35 percent of the market, followed closely by Huntington Ingalls Industries at 33 percent and BAE Systems, a distant third at eight percent. Applying Porter's Five Forces Model helps illustrate why just three firms will continue to maintain 75 percent of the market.

Porter's Five Forces

1. *Threat of new entrants*: The threat of new entrants to U.S. shipbuilding is very low due to the high levels of capital investment required to build and maintain shipyards. Other significant barriers include low profit margins, the limited pool of skilled labor, and the specialized technology and intellectual property needed to construct advanced naval vessels. Incumbency advantages add complexity as there is limited affordable and accessible land to build or expand shipyards. The work requires highly specialized expertise, and firms need past performance to work with the U.S. Navy. Despite these steep hurdles, there are a handful of examples of new entrants into the market, such as Fincantieri, which purchased Marinette Marine in Wisconsin, and invested millions to be able to conduct U.S. Navy contracts.
2. *Bargaining power of suppliers*: In assessing the bargaining power of suppliers, "the relevant factors are the ease with which the firms in the industry can switch between different input suppliers and the relative bargaining power of each party."[49] Suppliers play a vital role in the shipbuilding industry because of the magnitude of costs for inputs and unionized labor. According to IBISWorld, shipbuilders spend 41 percent of their revenue on inputs, including purchasing finished equipment and raw materials, and 24 percent on skilled labor.[50] In industries like shipbuilding that rely on "suppliers of complex, technically sophisticated components," suppliers are "able to exert considerable bargaining power."[51] Key industries in the shipbuilding and repairing supply chain include hardware manufacturing, sheet rolling and drawing, engine and turbine manufacturing, navigational instrument manufacturing, aluminum manufacturing, and

iron ore mining, which are complex, require technical precision, and physically demanding.[52]

Additionally, "shipbuilding and support services are very labor-intensive, with large ships often requiring over 1,000 workers to complete. Laborers tend to have specialized skills (heavy equipment operation, welding, and naval engineering). This leads to high industry wages, which are made even higher by the degree of unionization among workers."[53] The prevalence of labor unions in an industry is another source of supplier power.[54] The bargaining power of suppliers is a key force that firms in the shipbuilding and repair industry should thoughtfully address in their strategies.

3. *Bargaining power of buyers*: The bargaining power of buyers is moderately low. The customers for the military segment include the U.S. Navy and U.S. Coast Guard. Though there are few customers, Congress has reduced much of its bargaining power because it sets the number of ships in the appropriation legislation and stringent regulations bound price that the U.S. Navy can accept. Shipbuilders are also aware that legislation requires the hull and superstructure of vessels for the armed forces to be built domestically, making the opportunity for the U.S. Navy and U.S. Coast Guard to look internationally illegal. Further, Congress sometimes increases ship buys over what the U.S. Navy is prepared to purchase, which again lowers the U.S. Navy's bargaining power.
4. *Threat of substitutes*: The threat of substitutes for shipbuilding is very low. U.S. naval vessels are essential to our national security and perform unique functions. The FY18 NDAA cements a 355-ship U.S. Navy into law.[55] This legislation ensures there is limited ability for the U.S. Navy to substitute ships for something else, though the U.S. Navy, with the consent of Congress, does have discretion in the types of ships they buy.

5. *Intensity of competitive rivalry*: Rivalry amongst existing competitors is moderate. There are few competitors in the market overall and even fewer with the expertise and capacity to take on specific work for the U.S. Navy, many of which are competing for the same contracts. While some work will nearly certainly go to a specific supplier(s), like aircraft carriers and nuclear work, there is other work for which firms compete intensely.

Factor Conditions

Before providing actionable recommendations on ways the United States can improve its ship construction and repair capabilities, it is vital to understand the key 'factor conditions' affecting the industry: labor challenges, resource decision and allocation, lackluster infrastructure, cultural contributors, and the innovation and technology edge.

Labor Challenges

Commercial and military shipbuilding in the United States both suffer from labor constraints. Most U.S. shipyards need help to recruit workers from skilled trades in sufficient numbers due to the erosion of a skilled workforce, an aging workforce, and an educational shift. Furthermore, due to higher shipbuilding standards, which require a more skilled labor force, and a labor force primarily composed of U.S. citizens, defense shipbuilding (U.S. Navy and U.S. Coast Guard), has an even smaller pool of labor from which to draw.[56]

In his testimony to the House Armed Services Committee, President of the Shipbuilders Council of America, Matthew Paxton, affirmed: "The single most critical factor in the capacity of the shipbuilding and repair industrial base today is people. From the perspective of those in the industry, the creation of additional shipyards will not create additional capacity but rather dilute the manufacturing workforce among all shipyards and drive-up unit costs of labor […]."[57]

The total shortage of shipyard workers fluctuates with the work cycles, but public and

private yards still require additional labor. Considering only the four public shipyards, Naval Sea Systems Command (NAVSEA) Commander VADM Galinis said they were short 1,200 workers at the end of 2022 after a massive investment in the workforce.[58] Likewise, the President of the Hampton Roads Workforce Council estimated his shortfall in the local area to be 10,000, with a projection of 40,000 by 2030.[59] Other unions and companies nationwide have emphasized shortages in recruiting and retaining skilled labor.

The Acquisition Research Program at the Naval Postgraduate School commissioned an assessment of labor force dynamics in the Gulf Coast Region for four trades critical to the industrial base: electricians, metal fabricators, and fitters, inside machinists, and riggers.[60] The findings proved there was an erosion to the labor force even as the demand for these trades increased in the region, but not because of U.S. Navy shipbuilding.[61] The assessment identified two threats to the labor force. The first is the surge of skilled workers switching to lucrative Gulf industries such as the oil and gas market and the growing wind turbine market.[62] The second issue is the progressing age of the workforce, with the majority of workers being over 45.[63] A former U.S. Navy official explained that the ratio of master shipbuilders to new entrants is askew, which inhibits optimal productivity, oversight, and mentorship of less experienced workers. Similarly, a manager of BAE Systems Ship Repair yard indicated that the average age of his workforce is 55 years old, with his most skilled workers retiring.[64] An aging workforce and the upcoming number of retirements of many shipbuilders are problematic.

The U.S. culture prizes individuals who attend college and thus is partially responsible for shifting many young Americans away from learning skilled trades. A recent *Jobs for the Future* survey found that only eight percent of high school students enroll in trade classes.[65] Even though shipyards try to promote the industry within the educational system, some high

schools no longer welcome shipyard recruiters in an attempt to persuade students to attend college instead.[66] Furthermore, numerous senior shipyard managers revealed the starting wages for skilled trades in the shipbuilding industry are nearly equivalent to easier and safer work in other industries, which might prevent successful recruiting.

Resource Decision and Allocation

The DoD and DHS budget should not drive operational requirements. Instead, leaders must prioritize needs, coupled with a risk assessment, and then Congress must appropriate adequate funding to fund the top requirements to achieve the ends of the strategy. Over the past few decades, fiscal constraints have become a significant limitation to maximizing ship maintenance and repair capacity. Five key elements should be considered here.

Appropriation Migration to Mitigate Financial Burden:

No matter what course of action the U.S. Navy decides to take within its 30-year shipbuilding plan, Congress must remain flexible and fully fund ship maintenance and repair requirements to stay fully mission-capable in the fight against the PRC and/or Russia. Congress and the U.S. Navy have evolved over the past few years by migrating a portion of the one-year ship repair operations and maintenance Navy (OMN) appropriation to a three-year other procurement Navy (OPN) appropriation. In FY20, the U.S. Navy appropriated $1 billion in OPN to fund 17 availabilities through a pilot program to help "shipyards to manage the complexities of funding ship maintenance more effectively" by extending the obligation timeframe by two years.[67] The program increased to $1.2 billion in FY21 for 20 availabilities, and then in FY22, expanded further to include Fleet Forces Command and NAVSEA by funding 22 private availabilities worth $1.3 billion.[68]

This shift in appropriation, and thus fiscal execution timeframe, was envisioned to create a stable and predictable demand signal through more efficient contract strategies. The program was supposed to increase workforce and dry dock capacity, optimize shipyard capacity, and create a more accurate schedule; however, per the Southwest Regional Maintenance Center (SWRMC) and shipyards, that was only sometimes the case.[69] The multi-year appropriation assists with bridging fiscal years and alleviating some of the negative ramifications of a continuing resolution, but there are still issues with funding contract modifications for in-scope repairs. These modifications may lead to upward adjustments to incur new obligations; however, the SWRMC needs help fulfilling the upward adjustments as the U.S. Navy must find dollars in specific FYs to award the contracts.[70] If the original pilot program was successful in the eyes of the U.S. Navy and private shipyards, the remaining $10 billion OMN funds should be transferred to OPN to increase the budget authority within ship maintenance and repair.

Post-Award Change Management Process Hinders Progress:

Financial resourcing issues continue beyond the source of funding. Congress, DoD, and U.S. Navy must work with private shipyards to restructure and streamline the post-award change management process to increase decision-making efficiency and reduce idle time during the availability. Shipyard managers stated the Administrative Contracting Officer (ACO) at the SWRMC approve all change orders, whether pre-priced or small dollar value growth (SDVG). There are usually no delay issues concerning pre-priced changes; however, there are issues with the special agreement for SDVG on repairs less than $25 thousand. This agreement also limits how many change occurrences can happen for any given availability. Often, when SDVG repairs arise, the shipyard could complete the repair within a few days; however, according to various shipyards, with all the documentation and time needed for all the ACO approvals, it may take

weeks or months to get the final approval causing idle time and schedule creep. At one shipyard, 80 percent of authorized changes took up to six weeks to process the change request instead of the planned one to two weeks. The Program Manager leading the availability should hold the approval responsibility, which may lead to overall schedule efficiencies, and ships may be returned to the fleet sooner.

Investment in Distributed Maritime Operations Offers a Critical Consideration, as it Will Play a Vital Role in Conflict:

Today's naval fleet "lacks the parts, processes, plans and—perhaps most critically—the shipyard capacity to fix ships fast and send them back into battle."[71] This makes improving the U.S. Navy's ability to conduct maintenance and repairs at sea and overseas, leveraging our allies' and partners' talent and industrial bases, a key national security concern. In a step in the right direction, the U.S. Navy will be buying its first new floating dry dock in 40 years, and five T-ATS Navajo-class towing, salvage, and rescue ships are under construction, with construction authorized on another four.[72] Additionally, the U.S. Navy requested $1.7 billion in its FY24 budget proposal for an AS(X) submarine tender replacement, which would significantly accelerate the new tender, as only $15.5 million was requested in FY23 for research and development of the submarine tender replacement.[73]

Furthermore, in a war against the PRC, the United States may only have its domestic shipyard repair capacity to rely on, as foreign ports and shipyards may not be viable options either because they are located within the Chinese weapons engagement zone, or the host nation does not want to become involved in the conflict for political reasons.[74] Similar to past battles, access to overseas ports and/or territorial waters closer to the anticipated conflict but outside the Chinese weapons engagement zone will be important. The United States must negotiate with the

private sector for additional repair capacity needed in a fight with the PRC (e.g., private shipyards, partner and ally industrial base to increase the stocks and availability of spare parts).[75] Additionally, acquiring float-on/float-off (FLO/FLO) ships domestically or from allied nations must be pursued as they will serve as ship transport vessels or floating dry docks.[76] U.S. allies own only 17 of the 41 FLO/FLO ships in the global inventory. However, their availability should not be assumed, especially during a conflict.[77] These investments are hopefully not too little, too late, as the U.S. Navy's at-sea logistics force still lags in capabilities and capacity to support distributed maritime operations.[78]

Assistance from the Defense Production Act:

The U.S. Navy and the maritime industry have benefitted from long-term supplemental help through the Defense Production Act (DPA) Title III authorities. DPA assistance has supported strategic and critical material and enabled sub-tier and industrial maritime resources. It has also reinforced moving ahead with new missile programs faster, including hypersonic weapons for U.S. Navy ships.[79] The DPA has also been used to sustain and strengthen the defense industrial base in the shipbuilding industries. These investments are critical in keeping pace with aggressive PRC construction. It has been a tool to scale production and attain the parts and workforce training needed to support the Virginia-class subs.[80] DoD also used it as an instrument to establish a $22 million agreement with Rolls-Royce in Pascagoula, Mississippi, to maintain, protect, and expand the capacity needed for propellers essential to U.S. Navy shipbuilding.[81] Austal's shipyard in Mobile, Alabama, secured a $50 million DPA grant to build a $100 million facility. The company needed these funds to shift from aluminum-only to aluminum and steel ship construction. A major benefit is that Austal plans to employ 1,000 additional workers and utilize the facility to build different steel ship classes, components for

Virginia- and Columbia-class submarines, and aircraft elevators for the Ford-class aircraft carriers.[82]

The Backbone of the Commercial Shipbuilding and Repair Market Hinges Upon Subsidies:

The lack of U.S. shipbuilding subsidies has caused a decline in the industry. Today, only a few U.S. prime contractors can build U.S. Navy and U.S. Coast Guard ships due to the high barrier to entry, which often results in large companies with a competitive advantage winning contracts over smaller firms.[83] Legislation and subsidies profoundly affect the structure of the shipbuilding and repair industry in which the firms operate. Through the early 1980s, the United States paid construction differential subsidies (CDS) to assist and balance U.S. industry amongst other heavily subsidized countries, especially in the ROK, Japan, and Europe.[84] The U.S. shipbuilding industry suffers severely without the CDS program and global enforcement of fair market practices.[85]The CDS program must be re-instated to compete with the PRC. Legislation and subsidies profoundly affect the industry structure in which the firms operate.

Dilapidated Shipyard Infrastructure

Ten of the 17 shipyards that built warships in WWII have closed, leaving only seven in 2023.[86] These shipyards rely on building ships for the U.S. Navy as the lifeblood of the industry. Unfortunately, the Jones Act and the high cost of U.S. labor have left an anemic commercial shipbuilding market, inhibiting innovation across the U.S. Navy fleet that might otherwise happen if the United States had a booming commercial industry. In contrast, the PRC and the Republic of Korea's robust commercial shipbuilding markets make it less expensive to develop their navies by taking advantage of knowledge and volume to lower costs. The industry conditions in the PRC and the Republic of Korea also decrease the cost of naval research and development (R&D) because so many advancements happen in the commercial sector and

translate into downstream savings for the countries' navies. The United States must heavily invest in the infrastructure of the public shipyards and private shipyards.

Modernization of the Maintenance and Repair Shipyard Infrastructure:

The number of in-service maintenance and repair shipyards decreased from 65 to 26 between 2003 and 2020.[87,88] Notwithstanding a few outliers, such as Austal USA, which just created a new shipyard adjacent to Naval Base San Diego, shipyards are not being developed in the United States due to financial, geographic, and environmental constraints. Even though personnel at the SWRMC stated the current workload at the shipyards had yet to reach the total available capacity of the private shipyards in the surrounding area, they still had not completed a recent availability on time. Furthermore, they did not factor in that the U.S. Navy still suffers from a backlog of 4,200 maintenance days. To absorb the excess maintenance capacity, the internal infrastructure capacity of the shipyards must increase to become leaner, more efficient, and more productive.

Due to the lack of competition within the U.S. shipbuilding industry, even the most modern U.S. shipyard needs to be updated compared to shipyards in other shipbuilding nations. To increase shipyard capacity, shipyards must repurpose existing infrastructure and improve through facility modernization, procurement of new technology and equipment, development of covered warehouse space, or even dredging necessary to optimize shipbuilding and repair workloads. However, in discussions with the shipyards, they must take a section of the shipyard offline to accomplish this. With razor-thin margins, shipyards are rarely willing to sacrifice near-term productivity for long-term improvements.

Shipyards must depreciate any funding spent on the facility or capital improvements, increasing fixed overhead costs. Shipyards not only have to come up with the financing to source

the infrastructure project but will also increase overhead expenses, thus affecting how competitive they can be on future new builds and maintenance availabilities. Some shipyards have stated they have yet to reach maximum footprint capacity and would bid on more availabilities if the U.S. Navy or U.S. Coast Guard appropriately scheduled the work. Management at Fincantieri Marinette Marine, the builders of the newest class of surface combatants, the FFG-62 Constellation guided missile frigate, described their shipyard as a generation behind those in the Republic of Korea, Japan, Europe, and the PRC. This statement came after Fincantieri's recent $300 million capital investment in the shipyard.[89] Shipyards must expand infrastructure to maintain maritime domain superiority over the PRC and Russia through increased throughput of ship maintenance and repair availabilities.

SIOP and MARAD Grant Programs Assist but Do Not Go Far Enough:

The U.S. Navy has modestly invested in improving shipyard infrastructure and the industrial base. Since 2018, the U.S. Navy has attempted to modernize its four public shipyards by introducing the Shipbuilding Infrastructure Optimization Plan (SIOP). The SIOP is a "once-in-a-century commitment" calling for $21 billion over 20 years to reconfigure and modernize the Navy's public shipyards.[90,91] Even though the U.S. Navy recently completed a three-year, $191 million renovation of a 100-year-old Norfolk Naval Shipyard dry-dock under the SIOP program, many faults remain.[92] According to the GAO's testimony to Congress, the U.S. Navy's cost estimate for SIOP is "wildly off," requiring billions more to meet the U.S. Navy's needs.[93] It was estimated $4 billion would fix 17 dry docks; however, there was a $4 billion increase to fix just three of them. Through the program, three of the four public shipyards have seen improvement, but there is still a lot of work to be done at the RMCs and private shipyards to improve the readiness of the fleets positively.

Unfortunately, the SIOP investment does not promote infrastructure growth at private shipyards. Most private shipyards do not have the economies of scale from the commercial sector to justify extensive capital improvements as seen overseas. At the 2023 Navy League Sea-Air-Space Exposition, Rear Admiral (ret) Ann Phillips, MARAD Administrator, stated MARAD awarded over 300 grants totaling $282 million since 2008 in a commitment to invest in the shipyard physical infrastructure and labor force.[94] The grants focus on improving shipyard facility infrastructure and operations and training workers in shipbuilding and repair. In the future, the U.S. government and MARAD must make a concerted effort to invest in developing and advancing the RMCs and larger maintenance and repair shipyards. One example of talking to industry partners was the need for an updated dry-dock at Naval Base San Diego. The shipyard relied on the dry-dock to actively bid on availabilities; however, Naval Facilities Engineering Systems Command did not adequately maintain the dry-dock infrastructure. If this larger shipyard could participate in the grant program, it would have the financial means to expand current operations, thus ensuring no ship maintenance and repair capabilities degradation.

More Competition is Needed to Reduce Cost of U.S. Coast Guard Maintenance Availabilities:

In discussions with senior officials, the U.S. Coast Guard deferred fleet maintenance over the past few years due to fiscal constraints and dry-dock availability. The deferred maintenance diminishes predictive analysis as equipment failure predictability directly links to an availability not being skipped. Furthermore, pushing the critical maintenance and repairs into the out years increases the availability cost as there could be compounding effects on the repairs. Since the single public shipyard for the U.S. Coast Guard cannot maintain its entire fleet, they award contracts to private shipyards. However, the small-dollar size of the U.S. Coast Guard contracts

cannot compete with the larger U.S. Navy repair contracts. Rear Admiral Nathan Moore stated, "As the Navy has pushed out into the commercial shipyard industry now in the last couple of years, they have sort of blocked out the sun in terms of [the U.S. Coast Guard's] availability of using those commercial yards that [they] relied on."[95] As a result, the lack of competition means only one shipyard will bid on a U.S. Coast Guard repair contract, thus driving up the overall cost.

Cultural Contributors

The U.S. Navy and U.S. Coast Guard must change the culture when sending their shipbuilding and repair demand signals to Congress and the defense industrial base. Specifically, they must improve the transparency surrounding their shipbuilding plan, predictability in scheduling maintenance and repair availabilities, and reliability of the battle damage repair plan in times of war. Furthermore, Congress must remain flexible to allow changes to occur within the acquisition process.

Transparency:

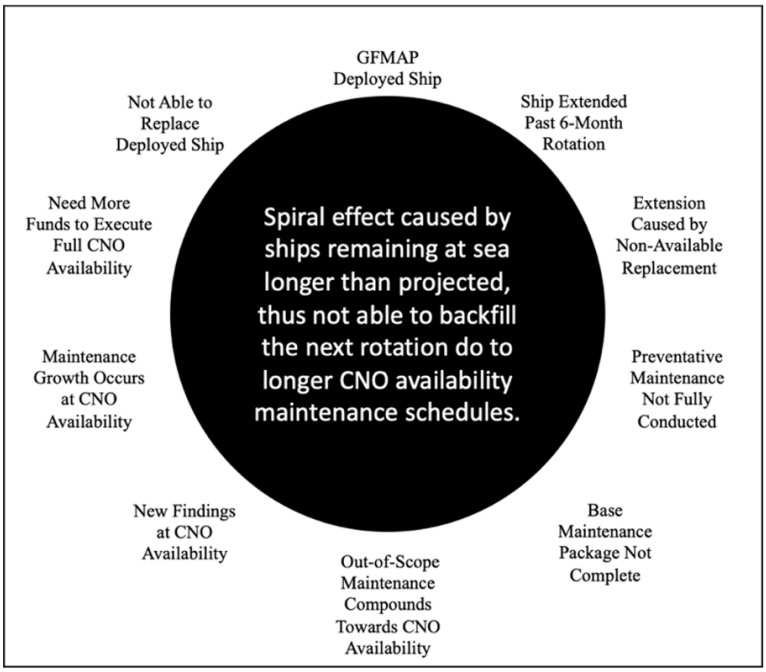
The perception of the U.S. Navy's culture concerning shipbuilding is that they are risk averse, requirements serve as the independent variable, and shipbuilding expertise resides within NAVSEA. Combined with a track record in which recent ships have been delayed, over-cost, or found not to be operationally relevant, the U.S. Navy struggles to create a dominant voice. The U.S. Navy's perception is that they are an organization that lacks a demand signal for the U.S. shipbuilding industry despite having numerous Congressional authorities that enable them to create that signal. First, the FY18 NDAA put into law the fleet goal for the U.S. Navy will be 355 ships.[96] Second, the U.S. Navy's FY23 30-year shipbuilding plan submitted three courses of action, with the most rigorous calling for 300 ships in FY33 with a growth potential of 367 ships by FY52.[97] Lastly, the congressionally mandated Battle Force Ship Assessment and Requirement

report conducted in mid-2022 suggests the U.S. Navy fleet size should consist of 373 ships.[98] In conjunction with the U.S. Navy, Congress, and the DoD must decide on the overall end strength of the fleet and engage with the defense industrial base (DIB) to execute. If not, the strategic risk to the United States will soon become insurmountable, as the PRC has well over 400 ships and is currently producing around 20 per year into its inventory.[99]

Predictability:

Both public and private shipyards must have a solid demand signal from the U.S. Navy and U.S. Coast Guard to properly plan for intermediate- and depot-level maintenance and repair availabilities. A consistent demand signal has not been possible with the post-9/11 tempo of operations. More recently, the pivot to the Indo-Pacific to deter the PRC further divided the U.S. Navy and U.S. Coast Guard with freedom of navigation operations, regulating illegal fishing, and protecting international trade near and around Taiwan. Additionally, a robust U.S. Navy and U.S. Coast Guard presence in the Middle East was a critical component to executing the Trump Administration's maximum pressure campaign against Iran. Furthermore, the heightened tensions caused by Russian aggression in the Arctic and the Baltic and Mediterranean Seas have allocated U.S. Navy surface ships to participate in more joint operations with U.S. allies and partners. These additional operations have forced combatant commanders to extend ships past the planned deployment timeframe for operational needs, thus prolonging the entry date into an availability (see Figure 2).

Figure 2: Availability Spiral Effect



The U. S. Navy and U.S. Coast Gard must project and articulate a maintenance and repair battle rhythm, even when simultaneous operations are being conducted, to allow the defense industrial base adequate time to allocate resources against the availabilities. In a 2020 GAO report, private shipyards stated that "two key considerations drive their decisions on workforce and facilities investments: visibility regarding planned workloads within a given port and their assessment of the share of that work they are most likely to win."[100]

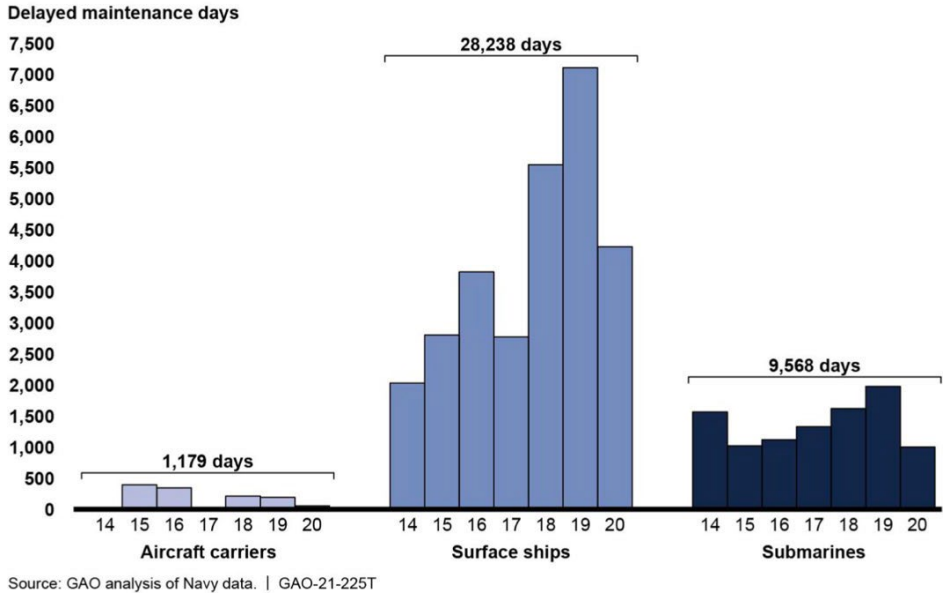
The maintenance and repair shipyards will ramp up and down their workforce based on the U.S. Navy and U.S. Coast Gard demand signals. A shipyard may hire upwards of 1,000 personnel based on a two-year projection of availabilities. Some shipyards have excess workforce capacity to perform more availabilities but need a defined plan that does not change. One example from BAE Systems was when the U.S. Navy pulled two Guided Missile Destroyers (DDG 1000) scheduled for an availability to upgrade the hypersonic weapon systems and recategorized it as a "new build repair," and awarded them to a shipyard in the Gulf states. This

decision further hindered BAE as the U.S. Navy canceled two Littoral Combat Ships' availabilities to reprogram funding for the DDG 1000 repair.

Shipyard managers stated an inconsistent demand signal creates havoc when pricing future availabilities, especially when the initial request for proposal (RFP) may lack the details necessary to scope the availability properly. Furthermore, when the initial RFP isn't delivered 120-150 days out from the availability but 30-60 days out, the shipyard will need more lead time to order the repair parts; thus, the availability timeline will be off schedule from the start.

Per a 2020 GAO report, and illustrated in Figure 3, the U.S. Navy incurred over 38,900 days of maintenance delays as it could not complete scheduled ship maintenance availabilities on time between FY14 and FY20.[101] The report stated that "this equated to the loss of 15 ships on average each year."[102]

Figure 3: Number of Days Maintenance was Delayed, Fiscal Year 2014-2020



Reliability:

It has been decades since the U.S. Navy has needed to implement battle damage repair at scale; thus, it has not updated its doctrine, tactics, techniques, and procedures. More

consequential is the lack of command-and-control guidance, which risks the U.S. Navy's ability to weigh warfighting needs and triage multiple, near-simultaneous repairs quickly.[103] There are eight organizations responsible for 15 U.S. Navy-led battle damage repair planning efforts, "[h]owever, the Navy has not formally identified an organization to coordinate these multiple efforts, thereby avoiding overlap and ensuring the efforts collectively produce the required capability needed to prevail during a great power conflict."[104,105] Since battle damage repair would likely occur in an active combat zone, subjecting ships, salvage operations, and repair facilities to attack, the U.S. Navy will have to rely on resources close to the conflict and multiple repairs occurring at once.[106] The U.S. Navy must develop and implement command-and-control guidance or risk severe failure within battle damage repair during a great power conflict.

Leverage Additional Authorities:

Generally, the U.S. Navy portrays a culture of risk aversion within the acquisition process. Leaders must continue to encourage, accept, and implement additional acquisition authorities granted by Congress each year for shipbuilding. These authorities include block buys, advanced procurement for long lead items, multi-year procurement, and OTAs. These authorities provide cost savings for the government, enable the industry to implement capital expenditures to respond to the demand signal, and reinforce the alignment of priorities between the U.S. Navy and Congress. Furthermore, during posture season, thank Congress for the additional authorities and highlight ways the U.S. Navy is exercising the additional authorities.

Innovation and Technology Edge

Productivity enhancements are one method that U.S. shipyards have reduced labor input costs. Many U.S. shipyards have introduced technology that makes work more productive, including optimal layouts, additive manufacturing, digital design, robotics, and automated

material inspection. In August 2022, during the inaugural Repair Technology Exercise, various robots crawled in, on, and below a decommissioned destroyer to install additively manufactured replacement parts on-site. The U.S. Navy convened this exercise to assess whether new technology could tackle real-world fleet maintenance and battle damage repairs in an operational environment.[107] However, productivity improvements appear uneven across shipyards, and even worse, the United States lacks a numeric assessment of U.S. labor productivity within those given shipyards.

In addition, small profits and financialization hinder sufficient infrastructure and R&D investment. By most measures, the United States spends more on R&D than any other nation; despite the magnitude of U.S. R&D, there is insufficient investment in the shipbuilding industrial base. In 2019, the United States spent about 27 percent of R&D globally, but its relative share of R&D is declining.[108] The U.S. Navy, responsible for over 80 percent of the U.S. shipbuilding industry's revenue, spends about $23 billion on R&D annually.[109,110] The U.S. Navy obligates approximately 80 percent of its R&D budget to advanced component development, systems development and demonstration, and operations systems development for sea and air assets.[111] In other words, most of the U.S. Navy's R&D funds are to develop specific combat capabilities and not to advance the efficiency and productivity of the industrial base. Two factors exacerbate this problem: financialization trends in publicly traded companies like General Dynamics and the anemic commercial market in the United States is insufficient to offset the development costs of warships as it does in other countries.

Supporting Industries

The U.S. shipbuilding industry is a critical component of national security, providing the U.S. Navy with the naval vessels necessary to protect the country's interests.[112] The U.S.

shipbuilding industry supply chain vulnerabilities must be identified and rectified. In addition to its supply chain, the defense shipbuilding industry relies on commercial shipbuilding and must pivot to offshore partnerships to provide the materials, equipment, and services required to build high-quality naval and coast guard ships.

Supply Chain

The lack of demand in defense and commercial shipbuilding in the past five decades caused the U.S. maritime industrial base to atrophy, forcing many supply vendors out of business or into other commercial sectors. This atrophy had similar effects on the skilled workforce, which was laid off at record levels causing career changes and disenfranchisement of the force that could no longer rely on the U.S. shipbuilding industry. Whether a coincidence or a consequence of this atrophy, the U.S. Navy had a series of failed ship acquisition efforts over the last two decades. The U.S. Navy was "building warships that either [didn't] work, cost too much to build in large numbers, or whose designs [were] fundamentally flawed on a conceptual level. Or all three."[113]

External events such as the COVID-19 pandemic, the war in Ukraine, natural disasters, and geopolitical tension between the United States and the PRC have compounded supply chain shortages. Now Congress has provided funding and legislative reform to address these issues. From FY19 through FY22, Congress authorized and appropriated $615 million to support industrial base expansion for submarines. The funding allowed the U.S. Navy to expand support to 180 suppliers in 30 states.[114] Then the FY22 NDAA required defense shipbuilders to source supplies and materials from U.S. companies as well as allies and partners.[115] Moreover, defense contracts emboldened the industrial base by requiring contractors to source materials from domestic vendors.

Shrinking Supply Base:

Another challenge facing the U.S. shipbuilding supply chain is the shrinking supply base. The defense industrial base raised concerns about this issue and began investing in supply chain management to seek multiple sources of suppliers. The U.S. Navy has also invested in improving the domestic supplier base, but prime contractors still rely on the global supply for parts. To mitigate this risk, contractors must better understand their suppliers' vulnerabilities and production process risks.

Price volatility is the biggest risk and can make it challenging for suppliers to manage costs and maintain profitability. In addition, geopolitical tensions or supply chain disruptions can affect the availability of these materials and create uncertainty for suppliers. For example, some rare earth minerals used in producing electronics and magnets are primarily sourced from the PRC, which creates supply chain risks for U.S. shipbuilders. There have been efforts to protect the manufacturers and providers of these materials and, at the same time, increase domestic production.

Numerous manufacturers and providers play a crucial role in the supply chain. Marine equipment and systems manufacturers provide specialized equipment and systems such as propulsion systems, navigation and communication systems, and weapons systems. Advanced materials manufacturers are another critical component of the shipbuilding industry, specializing in composites, ceramics, and high-strength alloys. Electrical and electronic component manufacturers produce a range of components, such as wiring, circuit boards, and control systems. Moreover, software and technology providers have developed more efficient, interoperable, and upgradable design process solutions for ship design, simulation, and analysis.

Finally, logistics and transportation providers deliver the transportation and logistics services necessary to move materials and components to and from shipyards.

These supporting industries are critical to the success of the shipbuilding industry. Any supply chain disruptions can have serious consequences, including delays in shipbuilding or ship repair availabilities. Close collaboration and coordination between these industries are essential. These organizations play a critical role in ensuring the U.S. shipbuilding industry remains competitive while continuing to provide the U.S. Navy and U.S. Coast Guard with the ships necessary to protect the country's interests.

Raw Material:

A critical challenge facing the supply chain is the over-reliance on foreign rare earth minerals. In 2022, the U.S. Geological Survey released a list of critical minerals essential to U.S. national security, renewable energy development, economy, and infrastructure.[116] The list includes 50 necessary minerals used to produce steel, aluminum, batteries, semiconductor chips, and electronics, all essential materials for building ships. Critical minerals such as chromium, cobalt, and manganese are essential to producing two graded steel types, high yield (HY) 80 and HY100 strength, used in building U.S. Navy ships.[117] Any supply disruptions to these minerals will harm U.S. steel-making companies in the defense and commercial sectors.

The demand for raw materials has increased significantly over the last two years, causing an increase in market prices."[118] The Chinese acquisition of mineral mines and rapid infrastructure investments in the late 1990s to early 2000s allowed the PRC to dominate and set the world's mineral prices and has a stranglehold over its production.[119] Moreover, the PRC can restrict and influence the export of minerals to other nations. The PRC's foreign direct

investment in the mining industry and significant investment in ports and infrastructure in Africa as part of the BRI creates an alarming concern for U.S. access to rare earth minerals.

The demand for these minerals will only increase as the world adopts advanced technologies. This dependency poses a significant risk to the supply chain, as mineral production delays can impact naval contract cost, schedule, and performance. Ship suppliers know the importance of strategic raw materials and access to minerals. They will likely monitor these factors closely to mitigate potential risks or disruptions to their supply chains. The shipbuilding industry uses strategic raw materials such as copper, steel, and rare earth minerals, often in limited supply. Limited access to these materials can cause supply chain disruptions and delay shipbuilding projects.

Commercial Shipbuilding Capacity

Commercial shipbuilding is a dual-use capability. The labor force for commercial shipbuilding and military shipbuilding is mostly interchangeable. However, some differences are that military shipbuilding requires workers to be U.S. citizens and have higher welding and other trades skills due to more stringent military specifications than commercial ships. In addition, commercial shipyards compete for the same dock space, raw materials, and in some cases, engines, shafts, propellers, and environmental control systems. Growing the commercial shipbuilding sector will be a net positive benefit to military shipbuilding as it will drive more capital investment, grow the labor force, and strengthen the supply chain by decreasing the number of sole-source suppliers.

A compounding problem not aided by law or policy is the lack of interoperable shipbuilding design tools utilized throughout the industry. Companies use separate non-interoperable ship design systems that hinder the holistic shipbuilding process, funneling work to

a few specific companies in the U.S. shipbuilding industry. Integrated and interoperable digital ship designs can speed up U.S. shipbuilding and provide a more dependable product.[120] Integrated digital ship designs offer a platform for shipyards, designers, engineers, and other stakeholders to collaborate on shipbuilding projects. This collaboration reduces delivery delays by identifying potential design flaws and manufacturing issues before mass production and without any degradation to quality. Products become one-off proprietary solutions instead of modular plug-and-play packages without integrated digital ship designs.

Harnessing Foreign Partnerships and Alliances in Shipbuilding and Repair

U.S allies and partners offer tremendous capacity, infrastructure and expertise that can be leveraged in building and maintaining the U.S. Navy and U.S. Coast Guard fleets.

- Extending Naval Ties with the Republic of Korea: Signed in 1953, the U.S.- South Korea mutual defense treaty is one of America's most consequential defense pacts. Korea's advanced shipbuilding industry offers tremendous collaborative opportunities for the United States. This is already taking place in supply chain management and through cooperation in ship design. But more ambitious opportunities should be forged by partnering with Korean companies to construct and repair U.S. naval vessels.
- Deepening Naval Ties with Japan: Like Korea, the United States enjoys enduring and substantive defense ties to Japan, codified in the U.S.-Japan Treaty of Mutual Cooperation and Security. Relations are particularly robust in the naval realm. The U.S. Seventh Fleet is stationed in Japan, and the U.S. maintains three prominent bases in the country: Sasebo, Yokosuka, and Atsugi. This offers a solid foundation to leverage Japanese capacity and capabilities in shipbuilding and repair.

- Leveraging the Maritime Strengths of America's Oldest Allies – Europe: For 75 years, U.S. partners in the NATO have shared technology, infrastructure, and operations. Broadening this collaboration in the naval sphere is an obvious step to improving U.S. maritime capacity and readiness in the Atlantic. European shipbuilders already offer promising, practical – and proven – prospects to deepen collaboration in ship design, construction, and repair—a well-known example of this is the above-mentioned U.S. defense partnership with Fincantieri, which is building the Navy's newest Constellation-class frigate, modeled on the FREMM (Fregata Europea Multi Missione), a ship built for both the Italian and French navies.
- Strengthening the partnership with Mexico: With a change to the Jones Act, Mexico is an ideal candidate for hull construction within the commercial shipbuilding sector. Its labor rates are favorable; as of January 2023, on average, a Mexican welder is one-third the cost per hour of a U.S. welder, $7.10 per hour versus $20.65 an hour.[121] Mexico has a strong shipbuilding capacity along the Gulf of Mexico that can provide hulls to the many U.S. shipbuilders on the Gulf.[122] The hulls can also easily be towed up the East Coast to either Newport News Shipbuilding or Philly Shipyard. Off-shoring hull construction to Mexico does introduce risks to the supply chain; however, due to the location of the industry, on the Gulf of Mexico, and the strong relationship between the United States and Mexico, this risk is minimal.[123]

Recommendations

The U.S. shipbuilding and repair industry is critical in supporting the country's national security and economy. The nation needs a bigger navy to keep pace with the PRC and deter

Chinese and Russian aggression. The following recommendations are designed to maximize the ability of the current fleet to fight tonight and to start building the future fleet now.

Current Fleet

#1: Maximize Existing Authorities to Increase Capacity

Congress authorizes additional acquisition authorities each year for shipbuilding. These authorities include block buys, advanced procurement for long lead items, and multiyear procurement. These authorities provide cost savings for the government and enable industry to implement capital expenditures to respond to the demand signal. If applicable, the U.S. Navy should also continue to use OTAs to acquire and test unmanned vessels, encouraging the growth of nontraditional defense contractors and adding capacity to the fleet.

At the local level, and to improve the readiness of the current fleet by driving down scheduling delays that accrue during maintenance and repair availabilities, U.S. Navy leadership should delegate approval authority for SDVG change orders from the ACO to the Program Manager leading the availability. Relatedly, the U.S. Navy should plan for a change request budget of $1 million to $2 million for each ship's availability. These steps will result in overall schedule efficiencies, returning ships to the fleet sooner and available for combatant commander taskings.

#2: Provide a Predictable, Reliable Shipbuilding Demand Signal

In conjunction with Congressionally authorized additional shipbuilding acquisition authorities, the U.S. Navy needs a long-term plan to send a consistent demand signal to the defense industrial base (DIB) to keep the shipyards and suppliers fully employed. Each year, concurrent with the President’s budget submission, the U.S. Navy is statutorily required to provide Congress with a 30-year shipbuilding plan.[124] However, in discussions with U.S. Navy

officials, industry leaders, and professional congressional staff members, they all agree that the 30-year shipbuilding plan in its current form serves no one.

Instead, the U.S. Navy should produce a strategy-based plan that identifies a fleet mix consistent with the Battle Force Ship Assessment and Requirement (BFSAR) report. The 2022 National Defense Strategy DoD Planning Scenario lays the foundation for the BFSAR report. Using the BFSAR report as the anchor document to identify ship requirements will ensure coherence between all force structure reporting requirements and reduce the three alternatives within the 30-year shipbuilding plan into a single path. This consistency and predictability will allow shipyards and suppliers to forecast to meet shipbuilding demands on time and at scale.

#3: Improve the U.S. Navy's Ability to Repair Ships at Sea and Overseas

Congress also plays a key role in how the U.S. Navy conducts ship repair. Generally, vessels homeported in the United States or Guam may not be overhauled, repaired, or maintained in a foreign shipyard except for voyage or battle damage repairs.[125] Statutory limits on the U.S. Navy's ability to use overseas shipyards result in fewer opportunities to strengthen partnerships with shipbuilding nations and assess other nations' abilities to assist with maintenance and repairs during peacetime, leaving too much to chance during the conflict. These limitations merit reconsidering allowing ships homeported in the United States or Guam to undergo repair or maintenance in a foreign shipyard, especially when it will result in improved readiness and potential taxpayer cost savings.

Additionally, since many key allies' shipyard facilities are within a potential adversary's weapons engagement zone (e.g., the Republic of Korea, Norway, Finland), the ability of the U.S. Navy to conduct battle damage repairs afloat is critical. Successful battle damage repairs require increasing the size of the expeditionary logistics fleet to support distributed maritime operations.

The current inventory of two aging submarine tenders and a few fly-away repair teams is insufficient. Accelerating the acquisition of the AS(X) submarine tender replacement is a good start.[126] The U.S. Navy should also request Congressional approval to acquire additional T-ATS Navajo-class towing, salvage, and rescue ships and a FLO/FLO ship, which may serve as a ship transport vessel or a floating dry dock.[127] A larger expeditionary logistics fleet requires a larger Merchant Mariner force to operate these ships. However, the Merchant Mariner force has been declining, with a shortage is anticipated during a contingency.[128] Correcting this anticipated shortfall requires a holistic government effort to grow and retain the force needed to operate mission-critical ships in potentially hostile environments.[129]

Future Fleet

#4: Leverage our Allies' and Partners' Expertise and Industrial Bases

"Mutually beneficial Alliances and partnerships are an enduring strength for the United States and are critical to achieving our objectives," including growing a bigger U.S. Navy and U.S. Coast Guard.[130] For example, the Republic of Korea is a world-class shipbuilding nation and ally. If the U.S. Navy were to partner with Korean shipyards to understand best practices, it could take those lessons learned and adapt the processes and tools to U.S. shipyards, leading to greater domestic efficiency. To ensure the Republic of Korea finds mutual benefit in the relationship, the United States can work with them in areas where the United States has a comparative advantage, such as with advanced combat systems (e.g., AEGIS). The United States has a track record of successfully leveraging allies for cooperative development and technology transfer, with AUKUS as a prime example, as Australian citizens will soon be working alongside U.S. citizens in nuclear shipbuilding facilities. Additional potential opportunities include the

development of unmanned subsurface technologies, over-the-horizon radars, and resilient communication networks.

A strong network of alliances and partnerships also allows the United States to diversify supply lines and ensure access to key strategic materials, found largely in Africa and Brazil, in the event of increased competition or conflict with the PRC. The Partnership for Global Infrastructure and Investment, established by G7 leaders in 2022 to "deliver game-changing projects to close the infrastructure gap in developing countries, strengthen the global economy and supply chains, and advance U.S. national security," is an ideal vehicle for these initiatives.[131]

#5: Implement a Scrap and Build Subsidy

To mirror Korean shipyard efficiencies and advances achieved through dual market shipyard production, the United States must revitalize the domestic commercial shipbuilding market. Following the 2008 financial crisis, the PRC implemented a scrap and build subsidy to keep its shipbuilding industry solvent. The United States should consider doing the same, implementing a scrap and build subsidy to replace the entire Jones Act fleet. Such a subsidy would provide the demand signal needed to revitalize the commercial shipbuilding sector and have the advantage of turning over the United States' aging commercial fleet. Older ships are more expensive to operate and less fuel efficient than modern-built ships.

#6: Modify the Jones Act

Complementing a scrap and build subsidy for the commercial shipbuilding industry, Congress should seek to amend the Jones Act to allow increased production of parts and materials outside of the United States. Specifically modifying U.S. Coast Guard regulations to change the definition of "U.S.-built." The requirement for "major components" of the hull and fabrication of the superstructure in the United States should be deleted, while the requirement for

vessel assembly in the United States should remain. These changes would allow the U.S. commercial shipbuilding industry to adopt the model employed by the Norwegian shipbuilder Vard. Vard outsources manufacturing its ship hulls to Romania, where, in 2019, labor rates were one-seventh of Norway's.[132] Once the hull and early outfitting are complete, the ship is towed to Norway to complete the outfitting and the finishing requirements. The hull typically accounts for about 20-30 percent of the overall shipbuilding cost.[133] Employing this strategy in the United States would reduce costs, bolster allies' and partners' industrial bases, free up U.S. vendors in the supply chain to produce parts and equipment for U.S. military ships, and require fewer commercial shipyard workers, who would then be available to transfer their skills and work at shipyards building U.S. military ships.

#7: Invest in a Government-Owned/Contractor-Operated (GO/CO) Shipyard

To capitalize on the efficiencies gained by amending the Jones Act and implementing a Vard shipbuilding model, the U.S. government should pursue acquiring a GO/CO shipyard. The principle behind the GO/CO strategy is that shipbuilding and ship repair are critical U.S. Navy readiness capabilities. Therefore, the government should be more active than in other industries to ensure there will always be a shipbuilding and ship repair industrial base in the United States. The government benefits from its modernization and recapitalization projects, regardless of who wins the contract. A state-of-the-art GO/CO shipyard will be largely automated, requiring fewer workers and improving build quality since automated welds are more precise than human welds. It will also introduce more competition into the shipbuilding and repair industry as a company will no longer need to own a shipyard to compete on a shipbuilding or repair contract.

Appendix A: People's Republic of China-Taiwan Question

Question: "People's Republic of China-Taiwan: Short and long-term implications; levers US and others have to address them?"

The only obstacle preventing the People's Republic of China (PRC) from unilaterally terminating the "one country, two systems" policy and invading Taiwan is the deterrent effect created by the strength of the U.S. Navy and its incomparable network of allies and partners. The PRC has shown that it plays the long game, thinking not in years but by decades. The United States does not just need to deter the PRC today; it needs to deter the PRC for as long as Beijing aspires to unite Taiwan with mainland China. This requires a U.S. Navy that is strong today and strong tomorrow. Without taking bold action, the force that deters the PRC today will likely not be of sufficient strength to deter them tomorrow.

"The PRC has expanded and modernized nearly every aspect of the [People's Liberation Army (PLA),] with a focus on offsetting U.S. military advantage."[134] The PRC is our most consequential strategic competitor, and the Department of Defense's (DoD) "pacing challenge."[135] In 2021 the People's Liberation Army Navy's (PLAN) fleet comprised 355 ships and submarines; the U.S. Navy's deployable battle force comprised 296 ships. By the decade's end, the PLAN fleet will reach 440 ships and submarines, while the U.S. Navy will shrink by five ships to 291.[136,137]

Deterring the PRC today

The PRC has two significant advantages over the United States regarding invading Taiwan. They get to choose the day the invasion commences and have a home-field advantage. The PRC will make operational surprise a strategic imperative. In the open-source war gaming conducted by the Center for Strategic and International Studies (CSIS) on a Chinese amphibious invasion of Taiwan, in most iterations of the wargame during the opening three weeks of the

invasion, the U.S. Navy lost two carriers and more than a dozen surface ships as well as four submarines.[138] Surface ships forward deployed within the PRC defensive zone are especially vulnerable to large salvos of modern anti-ship missiles that effectively exhaust the ships' magazines of interceptors.[139] While the projected losses represent approximately 15 to 25 percent of all U.S. Navy surface combatants, they include nearly all large surface ships in the Western Pacific.[140] Since the wargame covers only the first three weeks of the conflict, the number of losses represents a floor, not a ceiling.[141]

These numbers are drawn from a conflict in 2022, not 2030, when the PLAN will have an additional 100 ships in its fleet. Repairing ships and returning them to the fight rapidly is one way the U.S. can overcome its lack of numbers. Unfortunately, building the maintenance, repair, and expeditionary logistics capabilities needed to reconstitute a damaged fleet competes for many of the same resources needed to maintain readiness and build warships – limited shipyard space, a shrinking labor force, a stressed supply chain, and an inconsistent demand signal as to what the nation's and the U.S. Navy's priorities are. A ship unable to return to the fight or deploy does not help build U.S. deterrence credibility.

Deterring the PRC in the future

It will take a resolve the United States has shown it lacks to grow the U.S. Navy. If the size of the U.S. Navy's battle force fleet does not rapidly grow, it is hard to imagine the PRC perceiving the U.S. Navy as a credible threat, especially in the 2040s, when it could easily have a 2:1 advantage. The U.S. Navy can only expect to be perceived as a credible threat if the DoD, Congress, and the defense industrial base are working cooperatively to ensure that all aspects of the military shipbuilding and ship repair industries are strong and fully resourced, including construction, maintenance, and battle damage repair.

Fortunately, unlike the PRC, the United States has strong allies in the Indo-Pacific region. By working closely with these allies – including shipbuilding and repair powerhouses, Japan and the Republic of Korea, both with sizable blue-water navies; and Australia, a long-time ally with whom the United States is authorized to share nuclear submarines and other maritime-related technology, and located largely outside the PRC's weapons engagement zone – the United States can leverage their capabilities and expertise to maintain the military advantage of credible deterrence.

Notes

[1] "Biden-Harris Administration's National Security Strategy," accessed April 17, 2023, https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf.
[2] GAO, "Navy Ships: Timely Actions Needed to Improve Planning and Develop Capabilities for Battle Damage Repair," GAO 21-246, June 2021,
[3] Liam Nawara, "Revive Expeditionary Battle Damage Repair Squadrons," Proceedings, March 2022, Vol. 148/3/1,429.
[4] David Axe, "The Day Might Come When Chinese Missiles Strike American Warships. The U.S. Navy Isn't Ready," Forbes, June 4, 2021, https://www.forbes.com/sites/davidaxe/2021/06/04/the-day-might-come-when-chinese-missiles-strike-american-warships-the-us-navy-isnt-ready/?sh=407abdb44529.
[5] Terry McKnight, 2018 Defense Budget Restores Hope for 355-Ship Navy, December 2017, https://www.usni.org/magazines/proceedings/2017/december/2018-defense-budget-restores-hope-355-ship-navy.
[6] Bruce Jones, "Order from Chaos, Navigating Great Power Competition – A Serious Planning Start," Brookings, August 3, 2022.
[7] U.S. Department of Defense, 2022 National Defense Strategy of the United States of America, October 27, 2022, 4-5 , https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF.
[8] Ibid., 4.
[9] Sen. Marco Rubio, "Sea power is essential to countering communist China," Defense News, April 11, 2023, accessed April 17, 2023, https://www.defensenews.com/opinion/commentary/2023/04/11/sea-power-is-essential-to-countering-communist-china/, and Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China*, (Washington, DC: DoD, 2022), 52.
[10] Bruce Jones, "Order from Chaos, Navigating Great Power Competition – A Serious Planning Start," Brookings, August 3, 2022.
[11] National Oceanic and Atmospheric Administration US Department of Commerce, "How Long Is the U.S. Shoreline?," accessed April 28, 2023, https://oceanservice.noaa.gov/facts/shorelength.html.
[12] Evan S. Medeiros et al., "A New Direction for China's Defense Industry" (RAND Corporation, September 19, 2005), https://www.rand.org/pubs/monographs/MG334.html.
[13] The White House, "FACT SHEET: The Biden-Harris Administration's National Security Strategy," The White House, October 12, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/10/12/fact-sheet-the-biden-harris-administrations-national-security-strategy/.
[14] "U.S.-Indo-Pacific-Strategy.Pdf," accessed October 8, 2022, https://www.whitehouse.gov/wp-content/uploads/2022/02/U.S.-Indo-Pacific-Strategy.pdf.
[15] "China's Military Aggression in the Indo-Pacific Region," *United States Department of State* (blog), accessed October 8, 2022, https://2017-2021.state.gov/chinas-military-aggression-in-the-indo-pacific-region/.
[16] "How Is China Modernizing Its Navy?," December 17, 2018, https://www.csis.org/analysis/how-china-modernizing-its-navy-0.
[17] "Preparing for War With China, U.S. Shrinks Its Navy | Opinion," accessed April 19, 2023, https://www.newsweek.com/preparing-war-china-us-shrinks-its-navy-opinion-1792231.
[18] "US Ship Force Levels," Naval History and Heritage Command, accessed May 10, 2023, https://www.history.navy.mil/research/histories/ship-histories/us-ship-force-levels.html#1951; "China v America: how Xi Jinping plans to narrow the military gap," The Economist, May 8, 2023, accessed May 9, 2023, https://www-economist-com.nduezproxy.idm.oclc.org/china/2023/05/08/china-v-america-how-xi-jinping-plans-to -narrow-the-gap; Diana Stancy Correll, "Navy's 30-year shipbuilding plan offers three options to increase the size of the fleet," Navy Times, April 21, 2022, accessed May 9, 2023, https://www.navytimes.com/news/your-navy/2022/04/21/navys-30-year-shipbuilding-plan-offers-three-options-to-increase-the-size-of-the-fleet/.
[19] Lendon, Brad, and Haley Britzky, "Us Can't Keep up with China's Warship Building, Navy Secretary Says," CNN, February 22, 2023, https://www.cnn.com/2023/02/22/asia/us-navy-chief-china-pla-advantages-intl-hnk-ml/index.html.
[20] David Axe, "Yes, The Chinese Navy Has More Ships Than The U.S. Navy. But It's Got Far Fewer Missiles.," Forbes, accessed April 19, 2023, https://www.forbes.com/sites/davidaxe/2021/11/10/yes-the-chinese-navy-has-more-ships-than-the-us-navy-but-its-got-far-fewer-missiles/.

[21] Elisabeth Braw, "Shipping Lines Are Getting Worried About Dependence on China," Foreign Policy (blog), April 3, 2023, https://foreignpolicy.com/2023/04/03/global-shipping-china-dependence-korea-japan-britain/.
[22] "China's Massive Belt and Road Initiative," Council on Foreign Relations, accessed February 7, 2023, https://www.cfr.org/backgrounder/chinas-massive-belt-and-road-initiative.
[23] Mike Yeo, "Thailand Receives Chinese-Made Amphibious Ship," Defense News, April 25, 2023, https://www.defensenews.com/naval/2023/04/25/thailand-receives-chinese-made-amphibious-ship/.
[24] "2022 Chief of Naval Operations Navigation Plan Update," *USNI News* (blog), July 26, 2022, https://news.usni.org/2022/07/26/2022-chief-of-naval-operations-navigation-plan-update.
[25] Terry McKnight, 2018 Defense Budget Restores Hope for 355-Ship Navy, December 2017, https://www.usni.org/magazines/proceedings/2017/december/2018-defense-budget-restores-hope-355-ship-navy.
[26] "Report to Congress on Navy Force Structure and Shipbuilding," *USNI News* (blog), October 10, 2022, https://news.usni.org/2022/10/10/report-to-congress-on-navy-force-structure-and-shipbuilding-2.
[27] "Improving the Shipbuilding Industrial Base," accessed April 19, 2023, https://www.nationaldefensemagazine.org/articles/2022/1/21/improving-the-shipbuilding-industrial-base.
[28] "United States Navy in World War II," in *Wikipedia*, December 8, 2022, https://en.wikipedia.org/w/index.php?title=United_States_Navy_in_World_War_II&oldid=1126353821.
[29] "War Production," The War | Ken Burns | PBS, accessed November 30, 2022, https://www.pbs.org/kenburns/the-war/war-production.
[30] "Wartime Builders of Large Ships," accessed April 28, 2023, http://shipbuildinghistory.com/shipyards/emergencylarge.htm.
[31] Loren Thompson, "U.S. Shipbuilding Is At Its Lowest Ebb Ever. How Did America Fall So Far?," Forbes, accessed February 25, 2023, https://www.forbes.com/sites/lorenthompson/2021/07/23/us-shipbuilding-is-at-its-lowest-ebb-ever-how-did-america-fall-so-far/.
[32] Scott Mall, "FreightWaves Classics: America's Commercial Shipbuilding Industry Is Nearly Gone," FreightWaves, January 22, 2021, https://www.freightwaves.com/news/freightwaves-classics-americas-commercial-shipbuilding-industry-is-nearly-gone.
[33] Mall.
[34] "America Doesn't Need More Shipping Protectionism | Cato Institute," September 15, 2022, https://www.cato.org/commentary/america-doesnt-need-more-shipping-protectionism.
[35] "The Jones Act: A Burden America Can No Longer Bear | Cato Institute," June 28, 2018, https://www.cato.org/publications/policy-analysis/jones-act-burden-america-can-no-longer-bear.
[36] "To Provide and Maintain a Navy: Understanding the Business of Navy Shipbuilding," U.S. Naval Institute, July 7, 2021, https://www.usni.org/magazines/proceedings/2021/july/provide-and-maintain-navy-understanding-business-navy-shipbuilding.
[37] "Improving the Shipbuilding Industrial Base."
[38] "Industry Perspectives on Options and Considerations for Achieving a 355 Ship Navy | United States Senate Committee on Armed Services," May 24, 2017, https://www.armed-services.senate.gov/hearings/17-05-24-industry-perspectives-on-options-and-considerations-for-achieving-a-355-ship-navy.
[39] "Product Details RL32665," accessed April 19, 2023, https://crsreports.congress.gov/product/details?prodcode=RL32665.
[40] "Navy's Ships Spend Less Time at Sea amid Persistent Maintenance Delays, Report Says," Stars and Stripes, accessed April 29, 2023, https://www.stripes.com/branches/navy/2023-01-31/navy-warships-maintenance-delays-report-9003989.html.
[41] United States Constitution. Article 1, Section 8. accessed online 23 April 2023 at https://constitution.congress.gov/browse/essay/artI-S8-C13-1/ALDE_00013363/.
[42] "10 USC 8679: Construction of vessels in Foreign Shipyards: Prohibition," accessed May 12, 2023, https://uscode.house.gov/view.xhtml?req=granuleid%3AUSC-prelim-title10-section8679&num=0&edition=prelim.
[43] "10 USC 8680: Overhaul, repair, etc. of vessels in foreign shipyards: restrictions," accessed May 12, 2023, https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title10-section8680&num=0&edition=prelim
[44] The Department of the Navy's FY24 Budget Request includes decommissioning three amphibious ships without requesting additional amphibious ships, thus placing the total number of amphibious ships below the mandated 31 from the FY23 NDAA.

[45] U.S. Department of Transportation, Maritime Administration, About Us, accessed online on 9 May 2023, https://www.maritime.dot.gov/about-us.
[46] "Biden-Harris Administration's National Security Strategy," accessed April 17, 2023, https://www.whitehouse.gov/wp-content/uploads/2022/10/Biden-Harris-Administrations-National-Security-Strategy-10.2022.pdf.
[47] "AUKUS Plan Looks to Shore up Deterrence, Promote Stability," U.S. Department of Defense, accessed April 23, 2023, https://www.defense.gov/News/News-Stories/Article/Article/3328430/aukus-plan-looks-to-shore-up-deterrence-promote-stability/https%3A%2F%2Fwww.defense.gov%2FNews%2FNews-Stories%2FArticle%2FArticle%2F3328430%2Faukus-plan-looks-to-shore-up-deterrence-promote-stability%2F.
[48] "An Analysis of the Navy's Fiscal Year 2023 Shipbuilding Plan." accessed May 14, 2023, https://www.cbo.gov/system/files/2022-11/58447-shipbuilding.pdf?emci=41658a7a-2b65-ed11-ade6-14cb65342cd2&emdi=fba3b36b-aa65-ed11-ade6-14cb65342cd2&ceid=201657.
[49] Robert M. Grant, *Contemporary Strategy Analysis*, 9th Edition (West Sussex, UK: Wiley, June 2016), 76.
[50] Shahool Al-Bari, Ship Building in the U.S., IBISWorld, January 2023, https://my-ibisworld-com.nduezproxy.idm.oclc.org/us/en/industry/33661a/about.
[51] Ibid.
[52] Ibid.
[53] Ibid.
[54] Robert M. Grant, *Contemporary Strategy Analysis*, 9th Edition (West Sussex, UK: Wiley, June 2016), 76.
[55] Terry McKnight, 2018 Defense Budget Restores Hope for 355-Ship Navy, December 2017, https://www.usni.org/magazines/proceedings/2017/december/2018-defense-budget-restores-hope-355-ship-navy. [56] "Frequently Asked Questions," HII, accessed April 26, 2023, https://jobs.hii-tsd.com/content/FAQ/?locale=en_US.
[57] *State of the Defense Industrial Base*, 118 Cong. (2023), (statement of Matthew Paxton, President Shipbuilders Council of America).
[58] Laura Heckman, "JUST IN: Parts, Labor Shortages Continue to Plague Navy," National Defense, January 2023, https://www.nationaldefensemagazine.org/articles/2023/1/30/parts-labor-shortage-continue-to-plague-navy.
[59] Mike Gooding, "Hampton Roads Maritime Industry Facing Manpower Shortage of 10,000 Workers," 13NewsNow, February 2023, https://www.13newsnow.com/article/news/national/military-news/shipbuilding-manpower-shortage/291-336368de-9088-4fc8-8db3-aeb572e0fb60.
[60] "Acquisition Research: Creating Synergy for Informed Change," Excerpts from the Proceedings of the Nineteenth Annual Research Symposium, May 2, 2022, available at https://dair.nps.edu/bitstream/123456789/4567/1/SYM-AM-22-054.pdf.
[61] Ibid.
[62] Ibid.
[63] Ibid.
[64] Otto Kreisher, "Shipbuilding Industry Struggles to Recruit and Retain Workforce," USNI News, June 2019, https://news.usni.org/2019/06/21/shipbuilding-industry-struggles-to-recruit-and-retain-workforce.
[65] Natalie Hayek, "All Hands on Deck," GIJobs.com, February 2021, https://mydigitalpublication.com/publication/?i=691642&m=60085&p=12, 14.
[66] Otto Kreisher, "Shipbuilding Industry Struggles to Recruit and Retain Workforce," USNI News, June 2019, https://news.usni.org/2019/06/21/shipbuilding-industry-struggles-to-recruit-and-retain-workforce.
[67] "Highlights of the Department of the Navy FY22 Budget," accessed April 18, 2023, https://www.secnav.navy.mil/fmc/fmb/Documents/22pres/Highlights_Book.pdf.
[68] Ibid.
[69] Ibid.
[70] Ibid.
[71] David Axe, "The Day Might Come When Chinese Missiles Strike American Warships. The U.S. Navy Isn't Ready," Forbes, June 4, 2021, https://www.forbes.com/sites/davidaxe/2021/06/04/the-day-might-come-when-chinese-missiles-strike-american-warships-the-us-navy-isnt-ready/?sh=407abdb44529.
[72] Gregory R. Trauthwein, "Heger Dry Dock Gets to Work on AFDM for U.S. Navy," Marine Link, January 18, 2023.

[73] Michael Fabey, "Pentagon Budget 2024: U.S. Navy Proposal Accelerates Submarine Tender Acquisition," Janes, March 14, 2023.
[74] GAO, "Navy Ships: Timely Actions Needed to Improve Planning and Develop Capabilities for Battle Damage Repair," GAO 21-246, June 2021.
[75] Trevor Prouty, "Forward Battle Damage Repair Keeps Ships in the Fight," Proceedings, Vol. 148/1/1,427, January 2022.
[76] Timothy A. Walton, Ryan Boone, Harrison Schramm, "Sustaining the Fight Resilient Maritime Logistics for a New Ear," Center for Strategic and Budgetary Assessments (CSBA), 2019.
[77] Ibid.
[78] Ibid.
[79] Lipton, Eric, "From Rockets to Ball Bearings, Pentagon Struggles to Feed War Machine," The New York Times, March 24, 2023, https://www.nytimes.com/2023/03/24/us/politics/military-weapons-ukraine-war.html.
[80] "Memorandum on the Presidential Determination Pursuant to Section 303 of the Defense Production Act of 1950, as Amended," The White House, The United States Government, December 21, 2021, https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/21/memorandum-on-the-presidential-determination-pursuant-to-section-303-of-the-defense-production-act-of-1950-as-amended/.
[81] "DOD Announces $36.9 Million in Defense Production ACT Title III Covid-19 Actions," U.S. Department of Defense, July 17, 2020, https://www.defense.gov/News/Releases/Release/Article/2278475/dod-announces-369-million-in-defense-production-act-title-iii-covid-19-actions/.
[82] Staff, Naval News, "Austal USA Celebrates Opening of Steel Facility," Naval News, April 12, 2022, https://www.navalnews.com/naval-news/2022/04/austal-usa-celebrates-opening-of-steel-facility/.
[83] David Axe, "The U.S. Navy Has a Big Shipyard Problem," Text, The National Interest (The Center for the National Interest, July 31, 2021), https://nationalinterest.org/blog/reboot/us-navy-has-big-shipyard-problem-190958.
[84] Aaron Klein, "Decline in U.S. Shipbuilding Industry: A Cautionary Tale of Foreign Subsidies Destroying U.S. Jobs," Eno Center for Transportation, September 2015, https://www.enotrans.org/article/decline-u-s-shipbuilding-industry-cautionary-tale-foreign-subsidies-destroying-u-s-jobs/#:~:text=16%20That%20number%20has%20fallen,in%201980%20are%20gone%20today.
[85] Ibid.
[86] Jack Reed, Jim Inhoff, "To Provide and Maintain a Navy: Understanding the Business of Navy Shipbuilding," Proceedings, vol 147/7/1,421, (July 2021), https://www.usni.org/magazines/proceedings/2021/july/provide-and-maintain-navy-understanding-business-navy-shipbuilding.
[87] Eckstein, Megan, "Coast Guard Struggling to Get Ships Repaired as Navy Expands Use of Smaller Yards," USNI News, March 16, 2020, accessed April 3, 2023, https://news.usni.org/2020/03/16/coast-guard-struggling-to-get-cutters-repaired-as-navy-expands-use-of-smaller-yards.
[88] "U.S. Private Shipyards – Major Shipbuilding and Repair Base Overview – 2003 Update," Maritime Administration, accessed April 3, 2023, https://www.maritime.dot.gov/ports/national-maritime-resource-and-education-center/us-private-shipyards-%E2%80%93-major-shipbuilding-an-2.
[89] Mallory Shelbourne, "Major Shift Comes to Fincantieri Marinette Marine as Freedom LCS Line Ends," USNI News, April 25, 2023, accessed April 27, 2023, https://news.usni.org/2023/04/25/major-shift-comes-to-fincantieri-marinette-marine-as-freedom-lcs-line-ends.
[90] Naval Sea Systems Command, "Shipyard Infrastructure Optimization Program," accessed April 2023, https://www.navsea.navy.mil/Home/Shipyards/SIOP/.
[91] "Naval Shipyards: Ongoing Challenges Could Jeopardize Navy's Ability to Improve Shipyards," GAO-22-GAO-22-105993, Government Accountability Office, accessed April 4, 2023, https://www.gao.gov/assets/730/720454.pdf.
[92] Baylor, Kaicey, "Multi-Million-Dollar Dry Dock Renovation Completed at Norfolk Naval Shipyard," April 19, 2023, accessed April 22, 2023, https://www.13newsnow.com/article/news/local/mycity/portsmouth/norfolk-naval-shipyard-renovated-dry-dock-4/291-462a9f6c-587c-4422-ab94-e4e2a7ae8169.
[93] John Grady, "Navy Cost Estimates on Shipyard Modernization 'Wildly Off,' GAO Tells Congress," USNI News, May 2022, https://news.usni.org/2022/05/11/navy-cost-estimates-on-shipyard-modernization-wildly-off-gao-tells-congress.
[94] Phillips, Ann, Rear Admiral (ret) U.S. Department of Transportation Maritime Administration Administrator, 2023 Navy League Sea-Air-Space Exposition, https://seaairspace.org/.

[95] Eckstein, Megan, "Coast Guard Struggling to Get Ships Repaired as Navy Expands Use of Smaller Yards," USNI News, March 16, 2020, accessed April 3, 2023, https://news.usni.org/2020/03/16/coast-guard-struggling-to-get-cutters-repaired-as-navy-expands-use-of-smaller-yards.
[96] Terry McKnight, 2018 Defense Budget Restores Hope for 355-Ship Navy, December 2017, https://www.usni.org/magazines/proceedings/2017/december/2018-defense-budget-restores-hope-355-ship-navy.
[97] "Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress," RL32665, Congressional Research Service Reports, accessed April 16, 2023, https://crsreports.congress.gov/product/pdf/RL/RL32665/383.
[98] Ibid.
[99] Lendon, Brad and Britzky, Haley, "Us Can't Keep up with China's Warship Building, Navy Secretary Says," Cable News Network, February 22, 2023, accessed April 16, 2023, https://www.cnn.com/2023/02/22/asia/us-navy-chief-china-pla-advantages-intl-hnk-ml/index.html.
[100] "Navy Ship Maintenance: Evaluating Pilot Program Outcomes Could Inform Decisions to Address Persistent Schedule Challenges," GAO-20-370, Government Accountability Office, accessed April 4, 2023, https://www.gao.gov/assets/710/707354.pdf.
[101] "Navy and Marine Corps: Services Continue Efforts to Rebuild Readiness, but Recovery Will Take Years and Sustained Management Attention," GAO-21-225T, Government Accountability Office, accessed April 4, 2023, https://www.gao.gov/assets/720/711029.pdf.
[102] Ibid.
[103] GAO, "Navy Ships: Timely Actions Needed to Improve Planning and Develop Capabilities for Battle Damage Repair," GAO 21-246, June 2021, 25.
[104] Ibid., 19, 21.
[105] Ibid., 21.
[106] Ibid., 10-11.
[107] Teri Carnicelli and Thomas McMahon, "Inaugural Navy Exercise Tests Dozens of Ship Maintenance Technologies Aboard Decommissioned Destroyer," Naval Surface Warfare Center, Port Hueneme Division, Public Affairs, September 13, 2022.
[108] National Science Board, *Science and Engineering Indicators 2022: The State of U.S. Science and Engineering*, NSB-2022-1, (Alexandria, VA: National Science Foundation, 2022), https://ncses.nsf.gov/pubs/nsb20221.
[109] Shahool Al-Bari, Ship Building in the U.S., IBISWorld, January 2023, https://my-ibisworld-com.nduezproxy.idm.oclc.org/us/en/industry/33661a/about.
[110] Department of the Navy, *Resources Blog*, May 2021, https://www.navy.mil/Resources/Blogs/Detail/Article/2638885/department-of-the-navy-fy-2022-presidents-budget/. [111] Ibid.
[112] United States, White House, The National Security Strategy of the United States of America, February 2022, https://www.whitehouse.gov/wp-content/uploads/2022/02/NSS-Final-2022-2.pdf.
[113] David Axe, "The U.S. Navy Wasted A Whole Decade Building Bad Ships," Forbes, accessed April 27, 2023, https://www.forbes.com/sites/davidaxe/2021/01/05/the-us-navy-wasted-a-whole-decade-building-bad-ships/.
[114] Submarine Industrial Base Council, "Protect the President's Budget Request For Submarines," accessed on April 25, 2023, http://submarinesuppliers.org/wp-content/uploads/2023/03/SIBC-Issue-Papers-2023.pdf.
[115] United States. White House. The National Security Strategy of the United States of America, February 2022. https://www.whitehouse.gov/wp-content/uploads/2022/02/NSS-Final-2022-2.pdf.
[116] Communications and Publishing, "U.S. Geological Survey Release 2022 List of Critical Minerals," USGS, February 22, 2022, https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals.
[117] American Alloy Steel "HY 80, HY 100," accessed on April 19, 2023, https://www.aasteel.com/hy-80-100/.
[118] U.S. Geological Survey, "Mineral Commodity Summaries, January 2023: Chromium," accessed on April 19, 2023, https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-chromium.pdf.
[119] Institute of Developing Economics Japan External Trade Organization, "China in Africa, Chapter 8: China's Mining Footprint in Africa," accessed April 19. 2023, https://www.ide.go.jp/English/Data/Africa_file/Manualreport/cia_08.html.
[120] "Digitalisation Driving Change in Shipbuilding.," Lloyd's Register, accessed April 27, 2023, https://www.lr.org/en/insights/articles/digitalisation-driving-change-in-shipbuilding/.

[121] Gregory R. Trauthwein, "Heger Dry Dock Gets to Work on AFDM for U.S. Navy," Marine Link, January 18, 2023.
[122] Michael Fabey, "Pentagon Budget 2024: U.S. Navy Proposal Accelerates Submarine Tender Acquisition," Janes, March 14, 2023.
[123] Timothy A. Walton, Ryan Boone, Harrison Schramm, "Sustaining the Fight Resilient Maritime Logistics for a New Ear," Center for Strategic and Budgetary Assessments (CSBA), 2019, 111.
[124] "10 U.S.C. §231: Budgeting for construction of naval vessels: annual plan and certification," accessed May 12, 2023, https://www.govinfo.gov/content/pkg/USCODE-2021-title10/pdf/USCODE-2021-title10-subtitleA-partI-chap9- sec231.pdf
[125] "10 USC §8680: Overhaul, repair, etc. of vessels in foreign shipyards: restrictions," accessed May 12, 2023, https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title10-section8680&num=0&edition=prelim.
[126] Michael Fabey, "Pentagon Budget 2024: U.S. Navy Proposal Accelerates Submarine Tender Acquisition," Janes, March 14, 2023.
[127] Gregory R. Trauthwein, "Heger Dry Dock Gets to Work on AFDM for U.S. Navy," Marine Link, January 18, 2023, and Timothy A. Walton, Ryan Boone, Harrison Schramm, "Sustaining the Fight Resilient Maritime Logistics for a New Ear," Center for Strategic and Budgetary Assessments (CSBA), 2019, 63, 67-68.
[128] Timothy A. Walton, Ryan Boone, Harrison Schramm, "Sustaining the Fight Resilient Maritime Logistics for a New Ear," Center for Strategic and Budgetary Assessments (CSBA), 2019, 26.
[129] Ibid., 113.
[130] U.S. Department of Defense, "Fact Sheet: 2022 National Defense Strategy," March 28, 2022, https://media.defense.gov/2022/Mar/28/2002964702/-1/-1/1/NDS-FACT-SHEET.PDF.
[131] The White House, "Fact Sheet: President Biden and G7 Leaders Formally Launch the Partnership for Global Infrastructure and Investment," June 26, 2022, https://www.whitehouse.gov/briefing-room/statements- releases/2022/06/26/fact-sheet-president-biden-and-g7-leaders-formally-launch-the-partnership-for-global-infrastructure-and-investment/.
[132] "Hourly labor costs ranged from €5.4 to €43.5 across the EU Member States in 2018," *Eurostat*, April 11, 2019, accessed April 26, 2023, https://ec.europa.eu/eurostat/documents/2995521/9720156/3-11042019-BP-EN/3240675b-5513-41a4-8b28-3f5e24c55b70.
[133] *Study on Competitiveness of the European Shipbuilding Industry, Directorate-General Enterprise & Industry* (Rotterdam, Netherlands, Directorate-General Enterprise & Industry, 2009) 121.
[134] U.S. Department of Defense, 2022 National Defense Strategy of the United States of America, October 27, 2022, https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR- MDR.PDF, 4.
[135] Ibid., 1.
[136] Sen. Marco Rubio, "Sea power is essential to countering communist China," Defense News, April 11, 2023, accessed April 17, 2023, https://www.defensenews.com/opinion/commentary/2023/04/11/sea-power-is-essential-to-countering-communist-china/.
[137] Department of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China*, (Washington, DC: DoD, 2022), 52.
[138] Mark F. Cancian, Matthew Cancian, Eric Heginbotham, "The First Battle of the Next War, Wargaming a Chinese Invasion of Taiwan," CSIS, January 2023, 101-02.
[139] Ibid., 88, 132.

[140] Ibid., 132.
[141] Ibid., 119.