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Root Cause Analysis of Labor Shortages in the Skilled Trades Supporting Navy Shipyard Maintenance and Modernization

March 2023

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Prepared for the Naval Postgraduate School, Monterey, CA 93943.

Disclaimer: The views expressed are those of the author(s) and do not reflect the official policy or position of the Naval Postgraduate School, US Navy, Department of Defense, or the US government.



The research presented in this report was supported by the Acquisition Research Program of the Department of Defense Management at the Naval Postgraduate School.

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ABSTRACT

The U.S. Navy is experiencing significant delays in ship and submarine maintenance periods. A major factor in these delays is the lack of skilled trades engaged in the shipyard industry, both in the public and private sectors. Often referred to as “blue-collar,” these trades include electrical, welding, piping, mechanical, machining, and others. This thesis is a research-based root cause analysis aimed at understanding and addressing the fundamental reasons for this labor shortage. Utilizing the Ishikawa method adapted for this application, including a fishbone diagram, a multitude of root causes are identified, touching on topics such as economics, public policy, federal government contracting, education, and national security. Recommendations for actions to be taken include recruiting and training initiatives, while topic areas like government contracting are recommended for future research.



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ACKNOWLEDGMENTS

We would like to thank our professor and advisor, Dr. Robert Morlock, for his valuable guidance and unwavering support. His dedication to students and infinite knowledge made us better civil servants to the Department of the Navy and was instrumental in completing our thesis.

First, I would like to thank my wife, Maurin, for hanging in there and supporting me throughout this graduate school journey. Without her, this would not have been possible. Secondly, I would also like to thank my parents for their love and support during this time. To my daughter, Julia—you were my inspiration to keep going. I love you!

—Anthony Cirone

I would like to thank my husband, Zak, for supporting me on this journey. He took care of me for two years of late nights and long weekends while I focused on schoolwork. Achieving this accomplishment would not have been possible without his love and support.

—Nancy Glaeser

To all of my friends and family that pitched in to help me to get through this program—I cannot thank you enough. To the unsung hero of my whole college career, my wife—I had the easy job, you had the hard job. I was reading articles and writing papers while you got dinner ready and took care of the poop diapers. I would not have been able to do this without you.

—Christopher Kadlec



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LIST OF ACRONYMS AND ABBREVIATIONS

A&S	Acquisition and Sustainment
BIW	Bath Iron Works
CNO	Chief of Naval Operations
COVID	Coronavirus Disease
DIB	Defense Industrial Base
DOD	Department of Defense
FY	Fiscal Year
GAO	Government Accounting Office
NASSCO	National Steel and Shipbuilding Company
NAVSEA	Naval Sea Systems Command
NDEA	National Defense Education Act
NNSY	Norfolk Naval Shipyard
OSD	Office of the Secretary of Defense
PHNSY & IMF	Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility
PNS	Portsmouth Naval Shipyard
PSNS & IMF	Puget Sound Naval Shipyard and Intermediate Maintenance Facility
ROI	Return on Investment
SHRM	Society for Human Resource Management
Surgeain	Surge Maintenance
USNI	United States Naval Institute
U.S.	United States



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I. INTRODUCTION

A. PROBLEM STATEMENT

The United States (U.S.) Navy is experiencing significant delays in ship and submarine maintenance periods. Its shipyard trades labor shortage is a key contributing factor to these delays. In September 2022, an Inside Defense article stated, “a top Navy official said fewer ships are being delivered on time out of maintenance availabilities—citing workforce shortages as a ‘national crisis’” (Decker, 2022).

B. WHY THIS MATTERS

The shortage of shipyard trades labor impacts the U.S. Navy’s mission readiness and operational availability of its fleet. This results in both delaying the return of ships and submarines to service and the rate at which U.S. Navy vessels are maintained. In 2020, “the chief of naval operations gave the Navy an aggressive goal to eliminate lost operational days from overrun maintenance availabilities by next year” (Eckstein, 2020). When U.S. Navy assets are not mission ready, it ultimately impacts national security and the safety of the warfighter. According to the Chief of Naval Operations (CNO) 2022 Navigation Plan, “readiness remains the Navy’s top priority...America has always been a maritime nation. The seas are the lifeblood of our economy, our national security, and our way of life” (CNO Navigation Plan, 2022).

C. RESEARCH SCOPE

To identify the reason behind maintenance period delays, the authors first defined the scope. Research was conducted on the major drivers impacting delays in shipyards, which included funding, schedule demands, and resource constraints. The authors narrowed the scope to focus on personnel resource constraints. From there, research was refined to the blue-collar category, with an emphasis on skilled trades labor. Experience in specialized trades is essential to successfully completing industrial shipyard work on U.S. Navy vessels. Key trades include, but are not limited to, electricians, welders, pipe fitters, and mechanics. The skilled labor categories are further defined in the background section.



After narrowing the scope to skilled trades labor, the authors focused on recent maintenance period delays at both U.S. Navy-owned, also known as public shipyards, and private shipyards. The research focused on shipyards executing U.S. Navy maintenance periods across the nation, excluding work accomplished internationally. Within the U.S. Navy's maintenance windows, the authors concentrated on major overhaul efforts during maintenance periods, referred to as CNO availabilities. CNO availabilities consist of significant industrial-level work and must be executed in shipyards. Smaller continuous maintenance availabilities and windows of opportunities, accomplished pier side at U.S. Navy bases, were not part of the research.

D. RESEARCH QUESTIONS

1. **Primary:** What is the root cause of the trades labor shortages in shipyards executing CNO availabilities?
2. **Secondary:** Is there a different root cause for the trades labor shortage in public versus private shipyards?

E. METHODOLOGY

Sources for the root cause analysis come from four general areas: existing literature, official reports, anecdotal articles, and the authors' professional experience as project managers for U.S. Navy modernization. Both objective and subjective research will support the review, analysis, and conclusion of this thesis.

The process used for the root cause analysis is a modified version of the Ishikawa Fishbone and the five whys process developed by Kaoru Ishikawa in the 1960s to identify root causes in manufacturing failures while working for Toyota (Best & Neuhauser, 2008). The process of using the fishbone diagram starts with canned topic areas for brainstorming to come up with casual causes within that topic area. Originally used for manufacturing, there were five areas for consideration called the five M's: measurement, manpower, machine, material, and method. Since there are no canned topic areas for this application, the authors modified the process and jumped straight to brainstorming the casual causes based on research conducted and professional knowledge. This initial set of casual causes



was the jumping-off point for the authors' research. A few iterative rounds of casual cause refinement, followed by research to better understand and present the cause, led to a final set of casual causes laid out in Chapter IV. These were put on the initial fishbone diagram (Figure 3), wherein the problem statement is the spine, and each casual cause is a major bone stemming from the spine.

For each casual cause, a root cause analysis was performed using the five whys method. Research into each element was the basis for answering these whys, with additional investigation as new questions surfaced. This process led down multiple paths and evaluations until a root cause was identified. The fishbone diagram depicts the answers to those whys as a branch stemming from the major bone for each casual cause. Lastly, these major bones are combined into the spine, showing the connections of common root causes among the different branches.

F. THESIS STRUCTURE

This thesis is structured as follows: Chapter II lays out the background of shipyards and the trades labor needed. Chapter III provides the literature review of the research conducted. Chapter IV goes through the root cause analysis of why shipyards are seeing a trades labor shortage. Chapter V wraps up the conclusion, recommendations, and future research.



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II. BACKGROUND

A. PURPOSE OF SHIPYARDS

Shipyards are where U.S. Navy ships and submarines are built and repaired. They are essential to national defense by constructing and maintaining mission-ready vessels. Timely delivery of U.S. Navy assets is crucial to meet mission requirements. This thesis will focus on the sustainment aspect of U.S. Navy vessels at shipyards. Shipyards perform industrial work, which includes major overhauls, upgrades, and restoration. These maintenance periods are called CNO availabilities. CNO availabilities occur at pre-established periodicities, depending on the platform and expected service life of the vessel. Shipyards execute availabilities in the water or a dry dock, and the duration can range from six months to three years.

CNO availabilities occur at various shipyards across the nation and in foreign locations, where the U.S. Navy has a presence. There are only four active U.S. Navy-owned shipyards, and the rest are privately owned. The two main sustainment aspects of CNO availabilities are maintenance and modernization. Maintenance is key to ensuring vessels meet their expected service life and support mission readiness. It can include overhaul, rebuild, and restoration of shipboard systems and equipment. This includes complex structural, mechanical, electrical, and combat system repairs. Modernization is important by updating obsolete equipment and providing increased warfighting capabilities to the fleet. System improvements help maintain a tactical advantage over adversaries and adapt to changing technology. The completion of CNO availabilities drives key metrics for the U.S. Navy's mission readiness and operational availability. Figure 1 captures data from maintenance delays across all U.S. Navy platforms: aircraft carriers, surface ships, and submarines.



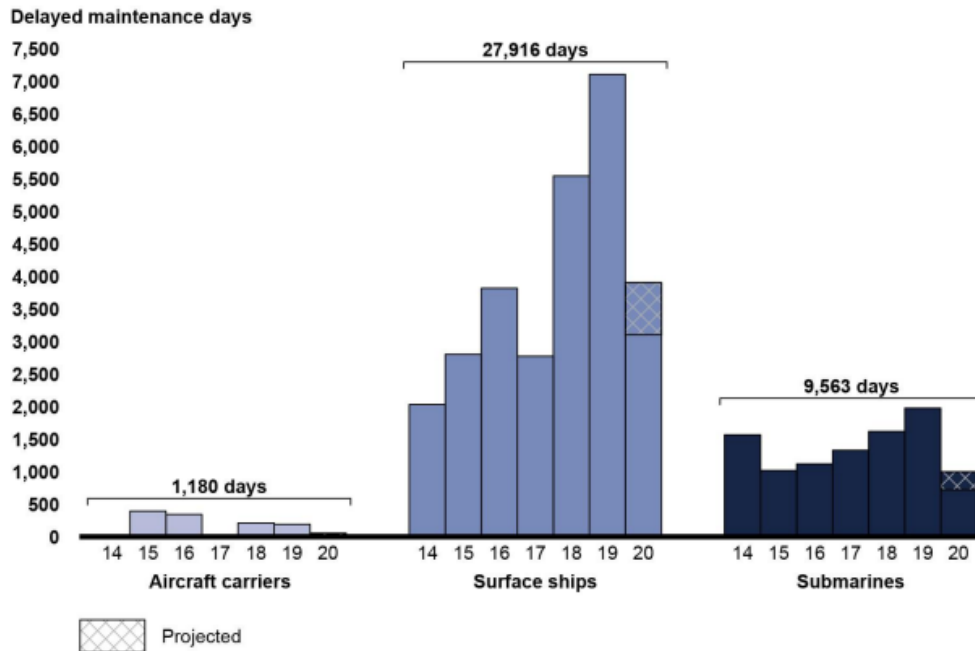


Figure 1. Days of Maintenance Delay for Aircraft Carriers, Surface Ships, and Submarines, Fiscal Years 2014–2020. Source: GAO (2020b).

The U.S. Navy owns four public shipyards that “perform a vital role in national defense by executing maintenance on submarines and aircraft carriers in order to provide combat-ready ships to the fleet” (Naval Sea Systems Command [NAVSEA], n.d.a). The location of these four shipyards is captured in Figure 2.

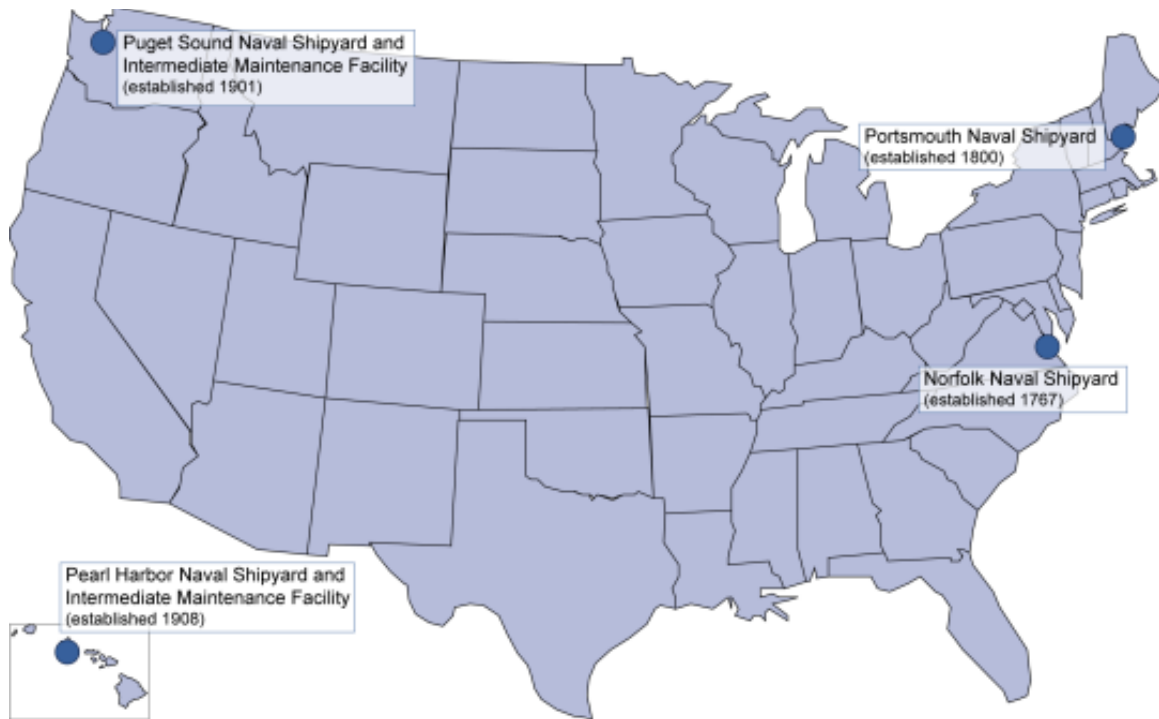


Figure 2. Map of Naval Shipyards as of 2017. Source: GAO (2017).

According to NAVSEA’s website, the mission of each U.S. Navy-owned shipyard is:

- Norfolk Naval Shipyard (NNSY): “repair, modernize, and inactivate U.S. Navy warships and training platforms” (NAVSEA, n.d.a).
- Portsmouth Naval Shipyard (PNS): “safely overhaul, repair, modernize the U.S. Navy’s nuclear-powered attack submarines” (NAVSEA, n.d.a).
- Puget Sound Naval Shipyard and Intermediate Maintenance Facility (PSNS & IMF): “maintain, modernize, and retire” (NAVSEA, n.d.a) the U.S. Navy’s fleet.
- Pearl Harbor Naval Shipyard and Intermediate Maintenance Facility (PHNSY & IMF): “repair, maintain, and modernize the Fleet” (NAVSEA, n.d.a).

B. SKILLED TRADES NEEDED IN SHIPYARDS

Like any corporation, there is a hierarchical structure within shipyard organizations. Skilled trades labor is essential because they are the ones executing the work. Shipyards can have the best project managers and planners, but that alone will not make CNO availabilities successful. Descriptions of some key skilled trades in shipyards are:

- Electrician: “installs, repairs, manufactures and tests...shipboard electrical systems and control equipment” (NAVSEA, n.d.b).
- Mechanic: “installs, removes, optically aligns, tests, overhauls and repairs ship’s...machinery and other shipboard components” (NAVSEA, n.d.b).
- Shipfitter: “plans, manufactures, installs, removes, and repairs structural assemblies” (NAVSEA, n.d.b).
- Welder: “cuts and joins all types of industrial and marine metals...using complex welding and thermal cutting processes” (NAVSEA, n.d.b).
- Machinist: “manufactures new and repairs existing parts using lathes, milling machines, boring mills, drills” (NAVSEA, n.d.b).
- Pipefitter: “removes, repairs, manufactures, installs and tests piping systems” (NAVSEA, n.d.b).
- Insulator: “applies a variety of insulation materials on hulls...to prevent loss of heat or cold, prevent condensation and reduce noise levels” (NAVSEA, n.d.b).
- Painter: “prepares surfaces and applies coatings on interior and exterior surfaces, tanks and voids” (NAVSEA, n.d.b).
- Crane Operator and Rigger: “operates portal and mobile cranes to install or remove ship components...selects, installs, and uses cables, ropes, shackles, beam clamps, strongbacks and other weight handling gear to lift, move, and position heavy loads” (NAVSEA, n.d.b).



C. SUMMARY

This chapter provides the context behind shipyards and the workforce required to execute CNO availabilities. The next chapter presents the literature review, which dives into the research conducted on the trades labor shortage in shipyards.



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III. LITERATURE REVIEW

The authors have firsthand knowledge of the trades labor shortage impact from managing projects that upgrade ship systems and equipment. In addition to their direct knowledge, the authors' research found documentation that validates the problem statement. The literature review consists of official government reports and a variety of articles regarding shipyard trades labor and maintenance period delays.

A. GOVERNMENT ACCOUNTING OFFICE (GAO) REPORTS

The GAO provides reports, at the request of Congress, to address improvements in the government. GAO reports consist of objective and non-biased information that is available to the public. Their efforts include data collection and recommendations to increase efficiency and introduce cost-saving measures across the Department of Defense (DOD).

A 2017 GAO report found that shipyard conditions are poor and contribute to maintenance period delays. "In fiscal years 2000 through 2016, inadequate facilities and equipment led to maintenance delays that contributed in part to more than 1,300 lost operational days-days when ships were unavailable for operations-for aircraft carriers and 12,500 lost operational days for submarines" (*Government Accountability Office [GAO], 2017*). Lost operational days prevent the U.S. Navy from meeting its mission and could negatively impact national security.

In 2020, the GAO conducted a study on U.S. Navy shipyards and provided recommendations to address maintenance delays for aircraft carriers and submarines. It states: "The Navy's four shipyards completed 38 of 51 (75 percent) maintenance periods late for aircraft carriers and submarines with planned completion dates in fiscal years 2015 through 2019, for a combined total of 7,424 days of maintenance delay" (GAO, 2020a). Workforce factors "such as shipyard workforce performance and capacity (having enough people to perform the work)" were identified as one of two main components for maintenance delays on aircraft carriers and submarines (GAO, 2020a). Another GAO report in 2020 identified readiness challenges across the U.S. Navy and Marine Corps. It



stated: “The Navy is frequently unable to complete scheduled ship maintenance on time and incurred over 38,900 days of maintenance delay from fiscal year 2014 through 2020” (GAO, 2020c). “The factors contributing to maintenance delays include insufficient shipyard capacity, shortage of skilled personnel, and deferred maintenance during operational deployments” (GAO, 2020c).

These GAO reports highlighted shipyard conditions and workforce factors that prevented shipyards from completing maintenance periods on time. Delays impact the U.S. Navy’s mission readiness and availability to meet operational commitments. Without addressing the problems, the U.S. will continue to face maintenance period delays that ultimately impact national security.

B. FISCAL YEAR 2020 (FY20) INDUSTRIAL CAPABILITIES REPORT

The Industrial Capabilities Report is an annual report to Congress, as required by Title 10 U.S Code, Section 2504. The Acquisition and Sustainment (A&S) organization falls under the Office of the Under Secretary of Defense and is responsible for developing this report. It analyzes the health of the Defense Industrial Base (DIB), which includes manufacturing and sustainment to provide increased capabilities to the warfighter. Part of the analysis is capturing the DIB’s risks and vulnerabilities while providing strategies for improvement.

The FY20 Industrial Capabilities Report referred to the defense industrial workforce as an endangered species. It states: “The DIB relies on a force of skilled workers to provide and support the products and services required to meet the U.S. government’s national security needs” (Office of the Secretary of Defense Acquisition and Sustainment [OSD A&S] Industrial Policy, p. 112). The report found that the same issues existed in the 2019 ICD. It states: “Candidate pools of potential workers are shrinking due to adverse demographics and persistent biases against industrial trades careers among parents and educators” (OSD A&S Industrial Policy, p. 112).

A Congressional required document is reporting that the need for skilled trades labor is imperative to our national security and highlights that its negative perception is



impacting the defense industrial workforce. Ensuring a stable DIB will provide competitive advantages to the warfighter and maintain national security.

C. ARTICLES

The authors expanded their research to various independent articles. Outside of government reports, multiple sources highlighted factors in the defense industry's trades labor shortage and its impact on maintenance period delays. The articles are lumped into general categories, which set the foundation for the root cause analysis chapter.

1. Stereotype

An article from the United States Naval Institute (USNI) News highlighted challenges with recruiting younger generations as shipyard workers are getting closer to retirement. The shipyard industry is “facing increasing challenges from an aging workforce, lack of stability in the contract workload, and a problem convincing young Americans that shipyard work is essential and well-paying” (Kreisher, 2019). Secondary schools tend to focus on students continuing education at universities and colleges versus promoting career paths that lead to the trades industry. The USNI article continues to emphasize “the policy of many high schools not welcoming industry recruiters hampers their ability to attract new workers” and it has a “problem getting the message out that shipyards provide good-paying jobs” (Kreisher, 2019). Recruitment is crucial for hiring to attrition and keeping up with the workload demand, which needs to gain traction in secondary education. Another article by the Society for Human Resource Management (SHRM) underlines the stigma behind the term “blue-collar” and its effect on trades labor shortage. It starts with parents influencing their children to earn a college degree with the expectation that after graduation they will find high-paying professional jobs. Blue-collar work is associated with being dirty and requires manual labor, which “often discourages people from applying” (Wilkie, 2019).

Efforts are being pursued to reach students in high school, specifically to garner interest in shipyard trades. Marinette shipyard in Wisconsin is doing just that. Bethany Skorik, a senior manager of public affairs noted, “We’re working with our local school systems, from elementary to middle to high school, on how we can get students interested



in shipbuilding. They can start thinking about the really satisfying careers in manufacturing and being able to make something complex like a ship from start to finish” (Lundquist, 2021). These types of programs are invaluable to helping bridge the gap in skilled labor shortages, but challenges remain. Despite the positive aspects of many of the apprenticeship programs, shipyards still face workforce challenges with the retirement rate and increased demand, especially during the pandemic.

The concept of college education for personal advancement was reserved for students who can afford to pay for college without debt. “The average student borrows over \$30,000 to pursue a bachelor’s degree...20 years after entering school, half of student borrowers still owe \$20,000 each on outstanding loan balances” (Hanson, 2021). Attending college delays earnings until after graduation, typically four years for a bachelor’s degree. In addition, “some 31 percent of respondents said their choice of major was their biggest regret from college, with 28 percent regretting taking on student debt to fund their education” (Shovelin, 2022). High school students are forced to make life-altering decisions as a teenager. It is challenging for students to know what careers they want to pursue or how student debt will affect them after graduation.

“On October 4, 1957, the Soviet Union shocked the people of the United States by successfully launching the first earth-orbiting satellite, Sputnik. During the Cold War, Americans, until that moment, had felt protected by their technological superiority. Suddenly the nation found itself lagging behind the Russians in the Space Race, and Americans worried that their educational system was not producing enough scientists and engineers” (United States Senate, n.d.). This resulted in the passing of the National Defense Education Act (NDEA) in 1958. “It established the legitimacy of federal funding of higher education and made substantial funds available for low-cost student loans, boosting public and private colleges and universities. The results were conspicuous: in 1960 there were 3.6 million students in college, and by 1970 there were 7.5 million. Many of them got their college education only because of the availability of NDEA loans, thanks to Sputnik and to Senator Hill’s readiness to seize the moment” (United States Senate, n.d.).



2. Trades Labor Training

Bath Iron Works (BIW) in Maine has seen a decrease in applicants as the manufacturing industry has declined in the area. To increase the candidate pool, BIW developed a training program with a local community college. The program is only three weeks long and comes with multiple benefits. There is no cost for enrollment, trainees receive weekly pay, and they are offered an interview upon completion. “The program has brought in hundreds of new workers” (Feinberg, 2021) and has helped bridge the gap in finding employees with the right skills. Other shipyards have been following similar efforts as BIW by establishing apprentice programs and trying to target high school students. Huntington Ingalls has an apprentice school in Virginia, which is currently in high demand. The program enrolls 200 students at a time and recently received 4,000 applicants. Additionally, they have an internship program for high school students to prepare them for apprentice school. “Apprenticeship programs not only benefit our industry, but they also provide opportunities for our local communities to learn a valuable trade and apply that skill to either our industry of defense and maritime manufacturing or other industries in our region” (Lundquist, 2021).

3. U.S. Navy Reliance on Private Shipyards

Base Realignment and Closure (BRAC) “is the congressionally authorized process DOD has used to reorganize its base structure to more efficiently and effectively support our forces” (OSD A&S BRAC, n.d.). Following World War II, the U.S. Navy owned eleven shipyards. Before the 1990s, two shipyards were ordered to close. Once BRAC was chartered, five more shipyards were ordered to close, reducing the total number of public shipyards to four and downsizing its workforce from approximately 70,000 to 22,000 employees. (Seacoast Shipyard Association, n.d.).

The four remaining public shipyards have a more consistent workload than private shipyards. This helps public shipyards strategically plan for future work and maintain the workforce required to support its demand. Public shipyards are mission funded through Congressional appropriations. “This system, designed to provide steady funding, provides an incentive to the fleet to keep a steady flow of workload at the shipyards. Under mission



funding, the Fleets play a larger role in determining schedules and workload priorities at the public depots, while NAVSEA determines the capacity of the shipyards” (RAND Corporation, 2008).

In addition, increased competition impacted the workload on private shipyards. “The Navy had previously awarded ship maintenance availabilities under a cost-plus Multi-Ship Multi-Option (MSMO) construct that prioritized a predictable workload for industry, and in 2011 it began moving towards a Multiple Award Contract/Multi-Order (MAC-MO) firm fixed price setup that prioritized cost control” (Eckstein, 2017). The U.S. Navy relies heavily on private shipyards, but prioritizing cost control upon contract award is forcing the industry to underbid. This leads to poor workmanship and availability extensions.

4. Shipyard Conditions

Shipyard conditions are often poor and require long working hours. The environment is often dirty, equipment is not properly maintained, and the workers are exposed to harsh weather. Safety can also be a factor, although most U.S. shipyards have undergone extensive safety protocol courses and implemented changes in recent years to comply with Occupational Safety and Health Administration requirements. Long hours in poor working conditions can lead to employee burnout. A survey conducted by the International Journal of Environmental Research and Public Health asked over 400 Spanish shipyard workers to rate their experiences in the past, related to burnout and the future state of their employment. The results of the study found that “shipyard workers have a higher risk of experiencing burnout (emotional exhaustion, personal-efficacy, and cynicism), which was associated with a negative past and negative future time perspective. This higher risk of experiencing burnout can have serious consequences for the sustainable employability of blue-collar workers” (Detaille et al., 2021).

5. Coronavirus Disease (COVID)

Shipyards were already facing maintenance delays due to trades labor shortages, and the pandemic only made matters worse. In 2005, the U.S. Navy established a Surge Maintenance (SurgeMain) program “to augment the Navy’s organic civilian shipyard workforce in times of need” (NAVSEA, 2020). During the pandemic, SurgeMain activated



1,629 reservists to ease the backlog in maintenance periods at its public shipyards. Since the program was created, this was the highest number of reservists activated at one time. “With up to 25 percent of the production workforce unable to report to their duty location, the shipyards have not been able to execute all their work and have built a backlog of work that, if left unchecked, would result in delays in returning ships to the fleet” (NAVSEA, 2020).

National Steel and Shipbuilding Company (NASSCO) in San Diego also highlighted the impacts of the pandemic. They were already experiencing issues with not having enough people to support the workload. “NASSCO can’t hire new workers fast enough to outpace the people leaving or retiring from the industry...national labor shortage that arrived with the coronavirus pandemic has been felt by most industries” (Katz, 2020). This had a major impact on shipyards because skilled trades labor requires substantial training before employees can begin executing work. “In the era of the coronavirus, another problem that has arisen are vaccine mandates. The tight quarters required for shipbuilding make social distancing either impractical or impossible” (Katz, 2020).

In addition, the pandemic has introduced a more widely accepted remote working environment. Employers are allowing more employees to work from home, permitting a better work-life balance. Shipyard work requires employees to work onsite and cannot offer the same flexibility as other industries. “Attrition is more than it’s ever been. People are moving from job to job. You have more options for employment, which are remote that people are jumping on. We’ve brought in a lot of people, trained a lot of people, but at the same time, we’ve seen them go out the door” (Katz, 2020). “The demand for flexibility in where and how people work has been building for decades. Before the crisis, surveys repeated showed 80% of employees want to work from home at least some of the time. Over a third would take a pay cut in exchange for the option” (Lister, 2022).

D. SUMMARY

This chapter reviewed the literature relevant to shipyard maintenance delays that laid the framework for the root cause analysis in the next chapter. The root cause analysis dives into the reasons behind the trades labor shortage in shipyards.



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IV. ROOT CAUSE ANALYSIS

This chapter describes the root cause analysis as laid out in the methodology section of Chapter I. After the literature review, the authors performed an initial brainstorming session that resulted in six casual causes. These casual causes are represented in the initial fishbone diagram shown below. The root cause analysis of each casual cause is described in sections of this chapter, starting with the casual cause statement to which the five whys process is applied. This is depicted on the fishbone diagram (displayed in Figure 3) as each line of questioning originates from its casual cause.

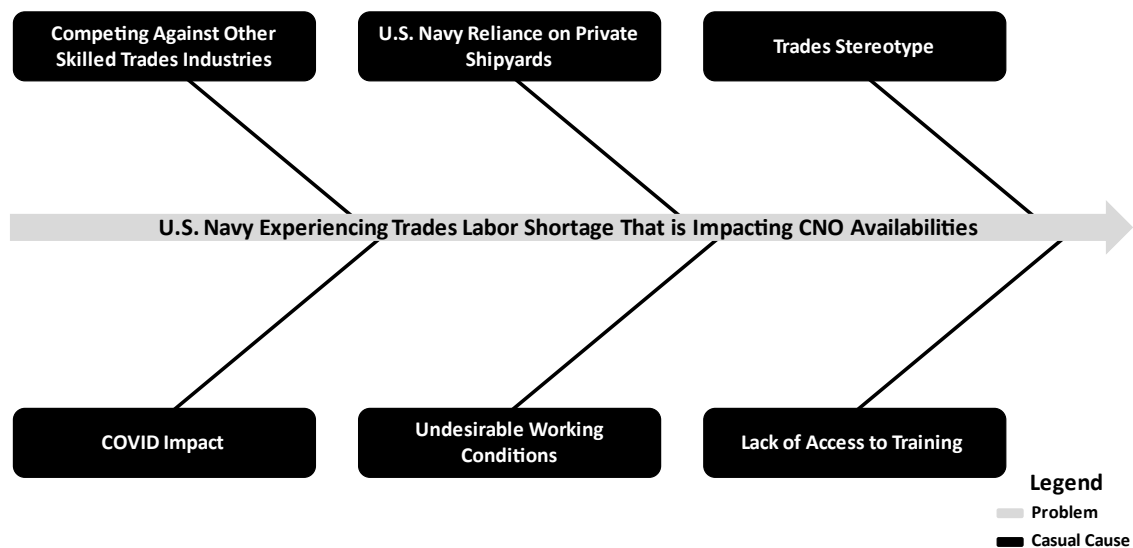


Figure 3. Initial Fishbone Diagram

A. TRADES STEREOTYPE

Casual Cause: A negative stereotype about trades labor is keeping people from entering the shipyard industry.

Prospective employees are reluctant to enter industries that come with a negative association. The first casual cause focuses on the perceptions of skilled trades in shipyards, which may or may not be valid. Both the rational and irrational aspects of this perception will be explored in the root cause analysis.

The perception that U.S. manufacturing jobs are not secure due to offshoring has its basis in a major economic shift that unfolded over the last forty years. Manufacturing was the largest economic sector in the United States, peaking at twenty million manufacturing jobs in 1979. The story of American manufacturing is one of a middle-class employed industry that no longer resides domestically. However, there is still a robust set of trades labor that cannot be outsourced. The U.S. Navy shipyard industry relies heavily on overtime and is consistently behind schedule because it cannot get enough skilled employees to perform the work. Globalization and increasing U.S. labor rates have severely gutted the U.S. manufacturing industries, and the reaction to offshoring has led to the shortage of qualified employees in a stable shipyard trades industry.

Root Cause: The U.S. overreacted to the offshoring of manufacturing jobs.

On the contrary, participation in U.S. manufacturing jobs is dwindling with the growing perception that college is a worthy pursuit. The U.S. job market requires a highly educated workforce in industries like healthcare, cybersecurity, engineering, and finance. Furthermore, traditional high-earning professions, like medical doctors and lawyers, require additional years of college before earning an income. Increased participation in college is based on significant demand. However, most of those who attend college do not graduate with a degree in these high-earning fields.

Root Cause: Over-participation in college in reaction to increased demand for a more highly educated workforce.

Although earning potential is a key driver, it is not the only benefit of attending college. Value is gained through higher education and the personal growth that comes with college experience. There is a perception that a college graduate is a well-rounded individual, with better reading, writing, and speaking skills. Highly educated individuals are generally good for society; however, it comes at great financial cost. The vast U.S. population cannot pay for higher education without student loans. In the past, college was reserved for those who could pay for it. With the number of federal and private student loans available today, more students can attend college but are in significant debt for years after graduation.



Root Cause: The idea of earning a college degree is generally more attractive than entering the skilled trades industry.

The perception of the blue-collar industry is another factor in the reluctance to get into skilled trades. Blue-collar work is often associated with a lack of intelligence sufficient to attend college. Following the USSR beating the U.S. to space, there was a push to avoid wasted brainpower and the U.S. started encouraging its citizens to attend college. Federal student loan programs were subsidized and provided more opportunities for students to attend college. After failing to be the first nation to reach space, the U.S. reinforced its global standing by being the first nation to land on the moon. The success of the moon landing helped establish a new U.S. identity characterized the ideal of a college education, an emphasis on technological advancement, and lead the free world.

Root Cause: Global events created federal incentives to increase college education across the nation.

Figure 4 displays the fishbone diagram for the trades stereotype casual cause.

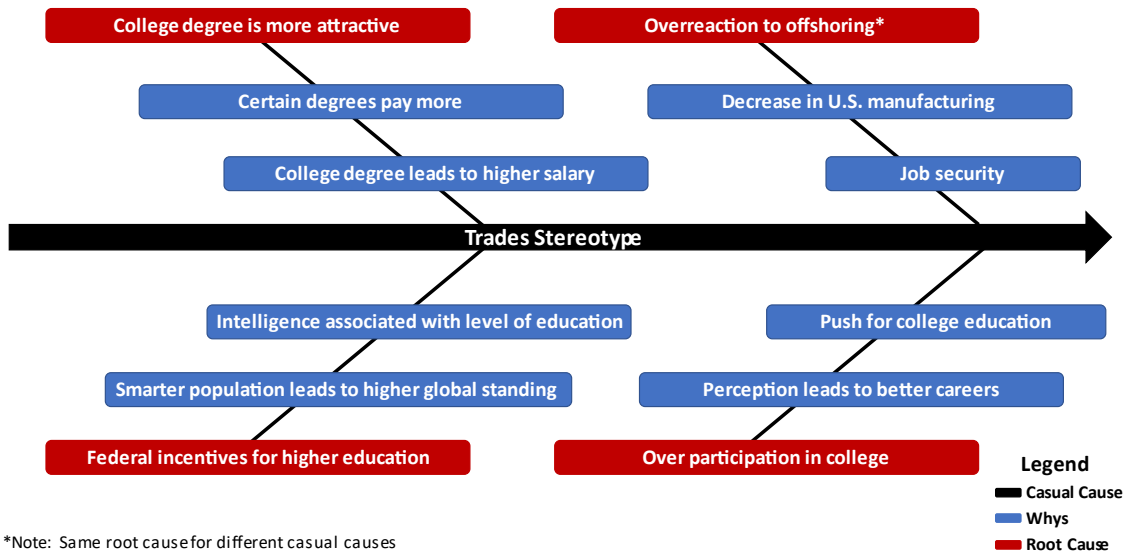


Figure 4. Trades Stereotype Fishbone Diagram

B. LACK OF ACCESS TO TRAINING

Casual Cause: Limited training opportunities are keeping shipyard workers from becoming qualified to support the skilled labor trades needed.

Training is an important aspect of any position, whether that occurs through traditional education, on-the-job training, or vocational courses. Shipyard employers, employees, and customers are all well served by adequate training. If a shipyard does not have a qualified workforce, it is less likely to perform satisfactorily and win future work. Investment in training is key to any organization's success.

The return on investment (ROI) is not immediate, as it takes time to train and cultivate proficient employees. Organizations also risk losing competent employees to other employers offering better compensation, benefits, and growth opportunities. Losing skilled employees after spending a significant amount of time and money on their development can disincentivize training programs. Apprentice programs and similar initiatives have been established to mitigate the shortage in shipyard skilled trades labor, but they simply do not train enough personnel to fill the gap needed to help shipyards complete CNO availabilities on time. If one or two companies were to offer sufficient training to new shipyard workers, there would be less incentive for other shipyards to have their own training programs. It would be easier and cheaper to simply poach trained employees from another company.

The robustness of shipyard training programs depends on the consistent workload to support its skilled workforce. While the U.S. Navy requires constant execution of CNO availabilities, there is still a large amount of fluctuation in awarding government contracts to steadily support a large workforce. This stems from the rules of government contracting laid out in the Federal Acquisition Regulation.

Similarly, skilled trades employees may leave a company to seek better opportunities. The shipyard with the next big contract may offer more overtime, a pay raise, and even promotions. Among shipyards, this is also a function of winning government contract awards for CNO availabilities. This leads back to the same root cause of government contracting rules.



Root Cause: Government contracting rules result in shipyard award fluctuations for CNO availabilities.

Public shipyards do not have the same ROI problem as private yards. There are concerns with training costs; however, U.S. Navy-owned shipyards can determine the scope of training offered to its employees. Consistent workflow and funding in public shipyards allow the government to support training efforts. They also do not face the same rate of attrition as private shipyards; employees generally remain in government positions due to increased job security. From the 1960s to the 1990s, the U.S. Navy ordered public shipyard closures, downsizing from eleven to four. The majority of these closures were a result of the BRAC to reduce costs and increase efficiencies across the DOD. This resulted in a significant reduction in the shipyard trades labor workforce and training programs.

Root Cause: The cost of operating public shipyards was too high and forced closures.

Figure 5 displays the fishbone diagram for the lack of access to training casual cause.

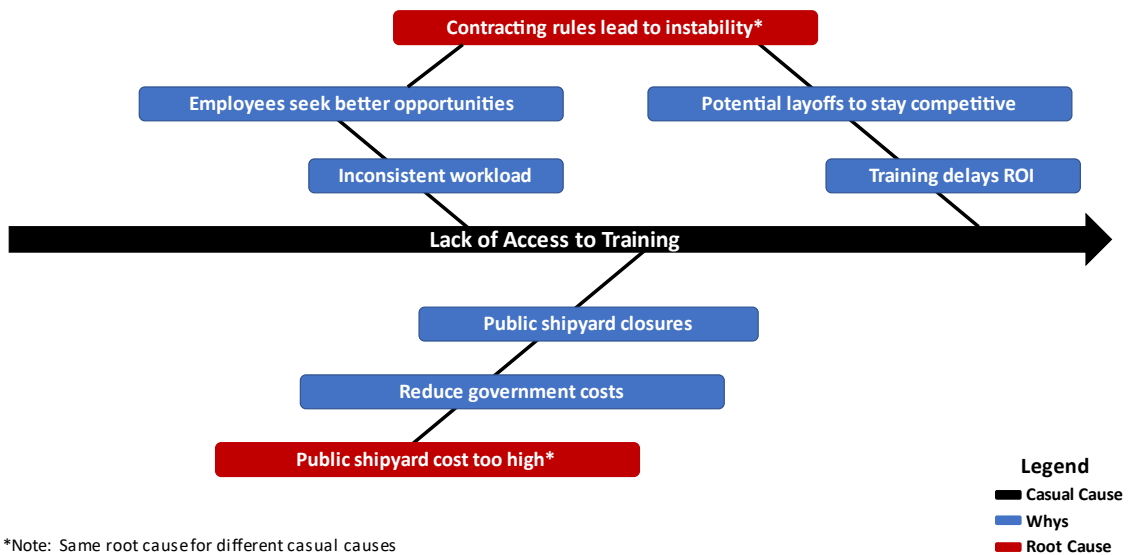


Figure 5. Lack of Access to Training Fishbone Diagram

C. U.S. NAVY RELIANCE ON PRIVATE SHIPYARDS

Casual cause: Public shipyard closures forced the U.S. Navy to heavily rely on private shipyards for CNO availabilities.

The U.S. Navy owns four public shipyards: Norfolk Naval Shipyard, Portsmouth Naval Shipyard, Puget Sound Naval Shipyard & Intermediate Maintenance Facility, and Pearl Harbor Naval Shipyard & Intermediate Maintenance Facility. In contrast, there are over twenty private shipyards that execute CNO availabilities. Private shipyards face inconsistent funding and workload planning challenges because they may not win every contract they bid on. In addition, emergent availabilities can occur, which adds to planning challenges. This workload uncertainty makes it difficult for private shipyards to staff accordingly, which can lead to layoffs.

In recent years, the shipyard industry has not been able to complete CNO availabilities on time. Without addressing workload planning and funding challenges, the issues with labor retention and hiring skilled workers will continue. Returning U.S. Navy assets to service is crucial to meeting mission requirements in support of national security. As discussed in the lack of access to training section, the U.S. Navy closed most of its public shipyards due to a perceived cost that outweighed the output. This has directly resulted in increased reliance on private shipyards.

Root Cause: The cost of operating public shipyards was too high and forced closures.

There is also the perception that federal employment is more stable than private employment within the same industry. Historically, the government does not lay off their employees at nearly the same rate as private industry. When the economy and revenues are strong, few employers are laid off. When the economy is weak, private companies are faced with potential layoffs. In contrast, federal employment doesn't typically deal with employee layoffs. Based on the authors' experience, the government will reduce the workload to maintain its workforce during budget constraints.

Root Cause: Federal employment is historically immune to economic downturns.



Similar to the ROI problem with training mentioned earlier in this chapter, private yards do not have the economic incentive to retain employees. If a shipyard fails to win a contract, there is nothing to fund its employees' salary outside of conservative management planning. Increased overhead costs impact the shipyards' ability to competitively bid on contracts. The inconsistency of contract awards can lead to layoffs instead of incentivizing shipyards to keep their workforce until the next solicitation.

Root Cause: Government contracting result in shipyard award fluctuations for CNO availabilities.

Private shipyards have inconsistent workflow and gaps between awards, which make it difficult to provide employee growth opportunities and stability. Federal employees fall under the government pay scale with set pay increases. Public shipyards also have a more consistent workload schedule with fewer bottlenecks than private shipyards. Funding is appropriated from Congress to meet public shipyard resourcing requirements and gaps in the private yards exist because government contracting encourages competition to reduce cost.

Root Cause: Government contracting rules favor competition over workforce stability.

Figure 6 displays the fishbone diagram for the U.S. Navy reliance on private shipyards casual cause.



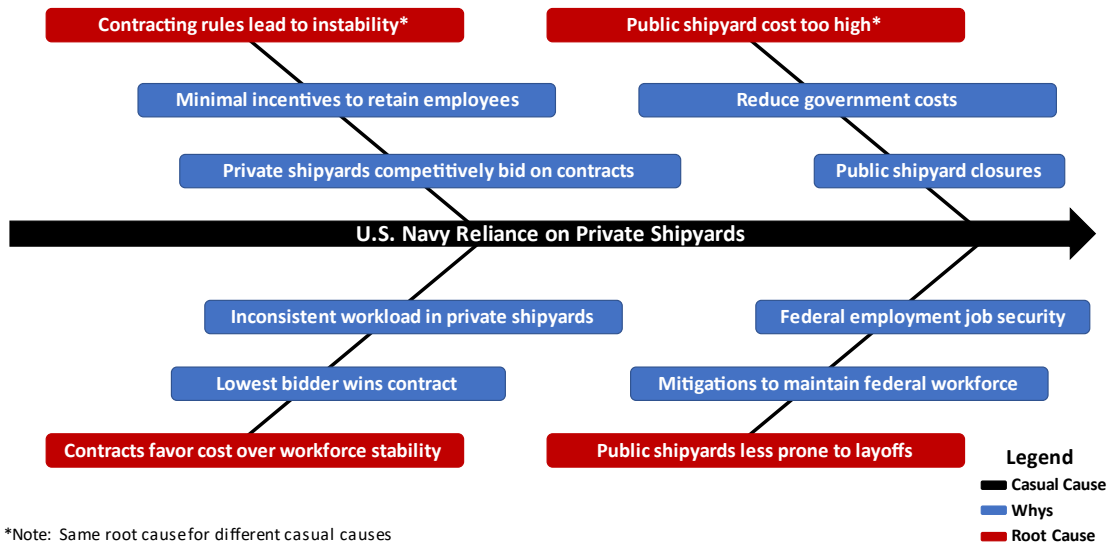


Figure 6. U.S. Navy Reliance on Private Shipyards Fishbone Diagram

D. UNDESIRABLE WORKING CONDITIONS

Casual Cause: The working conditions in shipyards are an impediment to attracting new employees.

The environmental and physical conditions in shipyards are rough. Workers are exposed to extreme elements: heat, cold, rain, and snow throughout the year. Additionally, they are completing physically exhausting tasks that can involve heavy lifting, standing for long periods, excess movement, and repeated stress on their bodies. The industrial nature of this work results in it being loud, dirty, dangerous, and demanding.

Root Cause: Shipyard work is inherently dirty and dangerous.

The environment at the shipyard often has degraded equipment, showing wear and tear, and is not an ideal place to work. The failure to implement capital improvements and needed infrastructure developments within the shipyards is negatively impacting employees who are forced to continue working in degraded conditions that continue to worsen as time elapses. If shipyards defer investing in capital improvements, the workforce will continue to lose employees who opt to find better and safer working conditions. The

departure of employees will negatively impact availability milestones, resulting in poor workmanship and schedule delays.

Root Cause: Capital investments are deferred due to budget constraints.

Figure 7 displays the fishbone diagram for the undesirable working conditions casual cause.

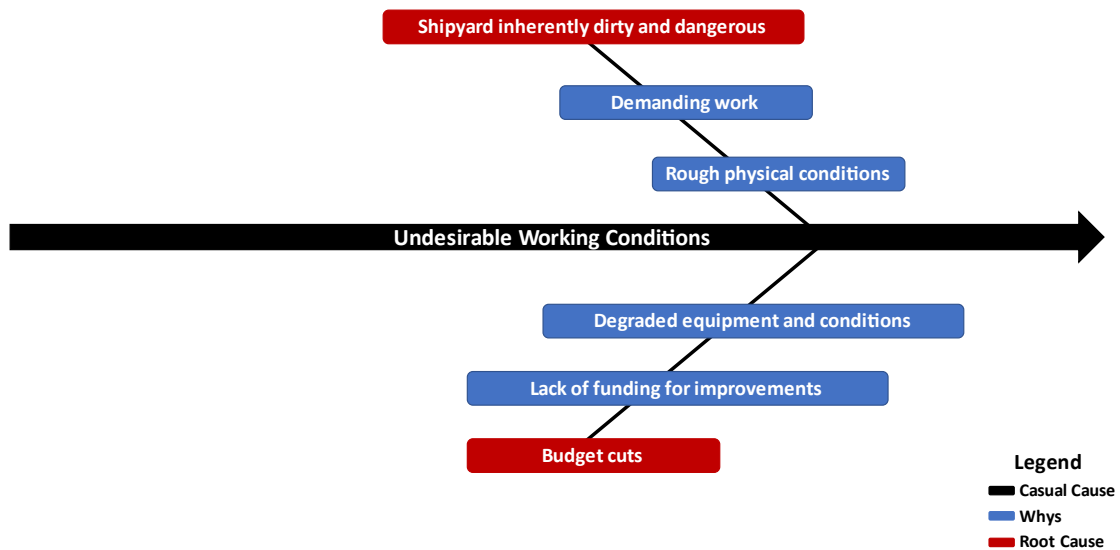


Figure 7. Undesirable Working Conditions Fishbone Diagram

E. COMPETING AGAINST OTHER SKILLED TRADES INDUSTRIES

Casual Cause: Other industries have demand for trades labor, which reduces the candidate pool to support U.S. Navy maintenance periods.

As with any industry that demands a specific trade or skill set, the U.S. Navy shipyard industry is competing for trades labor with other blue-collar industries. Currently, the demand for trades labor is higher than its supply. The lack of supply in these labor categories comes down to a lack of interest by the general population. Ever since the U.S. and global economic conditions led to the offshoring of manufacturing and trades jobs, there has been a growing perception that those types of jobs are unwise to get in. That

perception has been over-adopted, the economic principle of supply and demand shows the supply gap for well-paying jobs with consistent demand should increase supply. The flaw of this economic principle is that it assumes people are making rational decisions with complete information. A stigma exists that these trades are unworthy to pursue, as previously mentioned in this thesis.

Root Cause: Decades of U.S. manufacturing and trades labor offshoring resulted in a significant decline in the willingness to get into the industry.

Further complicating competition for insufficient labor, other trades industries do not have as many barriers to entry for potential employees. The federal employment requirements for U.S. citizenship and obtaining a security clearance means there is an inherent reduction from an already too-small pool of candidates. Potential employees can apply for U.S. citizenship and a security clearance, but both take significant time and effort. Therefore, resulting in a deterrent when there are plentiful options for employment in related fields. These requirements derive from the risk to national security of having unvetted personnel with access to sensitive information.

Root Cause: Unvetted workforce is a risk to national security.

Another obvious barrier to entry into executing U.S. Navy CNO availabilities is a geographical one. Work must be performed in a shipyard with access to waterways. This prevents much of the U.S. labor market to participate in the shipyard industry. Shipyard locations also tend to have higher populations that need to pull from the same industrial candidate pool.

Root Cause: Shipyards must be located on waterways with access to open water.

As compared to other industries, the U.S. Navy requires a higher level of technical demand on the skilled trades performing work. Specialty metals make certain welding more difficult, physical conditions make electrical cabling installations tedious, and shock and vibration requirements make mechanical fittings more complex. The U.S. Navy's need for higher reliability, performance, and survivability results in more demanding work for those skilled trades. This requires robust training and increased performance from skilled trades, which adds another barrier.



Root Cause: The U.S. Navy has strict requirements for their skilled trade labor due to national security.

Figure 8 displays the fishbone diagram for the competing against other skilled trades industries casual cause.

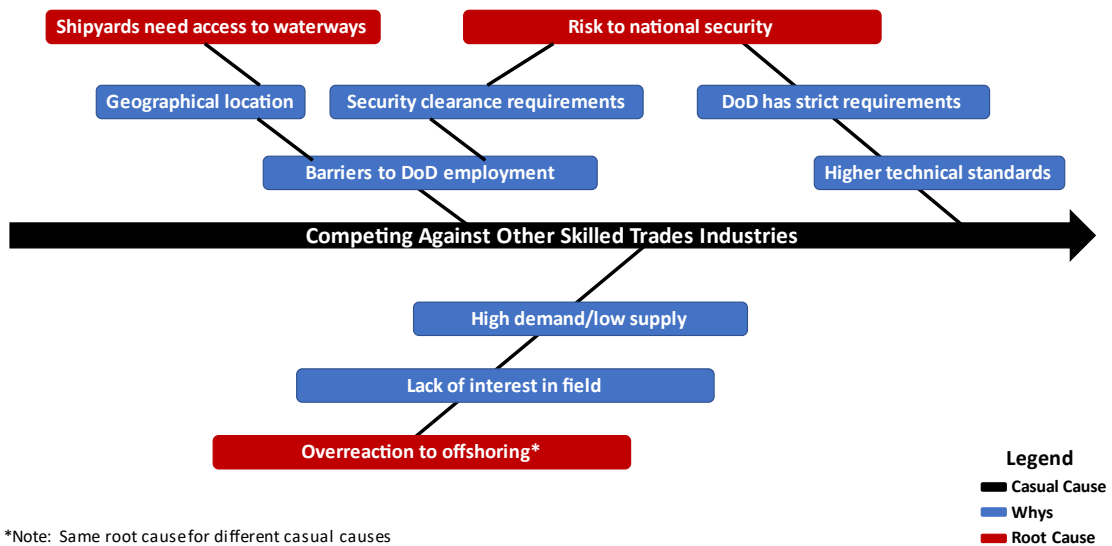


Figure 8. Competing Against Other Skilled Trades Industries Fishbone Diagram

F. COVID IMPACT

Casual Cause: COVID negatively impacted skilled trades labor supporting U.S. Navy shipyard work.

As with many industries, COVID affected the U.S. Navy and its shipyard industry’s ability to perform their work at the same pace as before. At the beginning of the pandemic, shipyards felt a significant impact due to the number of employees calling out of work. Information about COVID was constantly changing, this created fear of coming to work. Physical distance from others is not always feasible in a shipyard environment due to work conducted in small spaces. In addition, childcare facilities closed, and schoolchildren were

forced to learn from home. This led to more people staying at home to watch their kids and/or avoid getting sick.

Root Cause: Fear of getting sick.

As vaccinations became available, the risk of severe illness or death was reduced. To decrease the impact of an essential industry, vaccination requirements were implemented. In an environment that inherently requires close physical quarters, increasing people's immunity would reduce severe health risks. However, individuals took a political or moral stance against being vaccinated. The mandates further reduced the shipyard workforce, which increased the trades labor shortage.

Root Cause: Lack of immunity among the public.

There is also the impact on those who become sick or exposed and the recovery and quarantine time that goes along with that. While increased immunity can help reduce the impact of this, no vaccination prevents transmission. Until that time, COVID is here to stay, just like influenza. Because of that, there is an ongoing impact on all industries regarding their workers contracting COVID; the population will need to adopt ways to manage the impacts as with any other disease that cannot be eliminated.

Root Cause: COVID will not be eradicated.

As pointed out in the literature review, one of the COVID impacts felt by NASSCO was the demand for more flexible work by the general population. The pandemic forced companies to utilize and expand remote work to the maximum extent. Job markets that benefited most were those that could offer that flexibility to prospective new employees. Typical office jobs became more attractive since most work could be done remotely. Work that is inherently physical and must be done on location has fared the worst; there is no ability to offer a trades labor employee to perform their work from home.

Root Cause: Shipyard work must be executed on-site.

Figure 9 displays the fishbone diagram for the COVID impact casual cause.



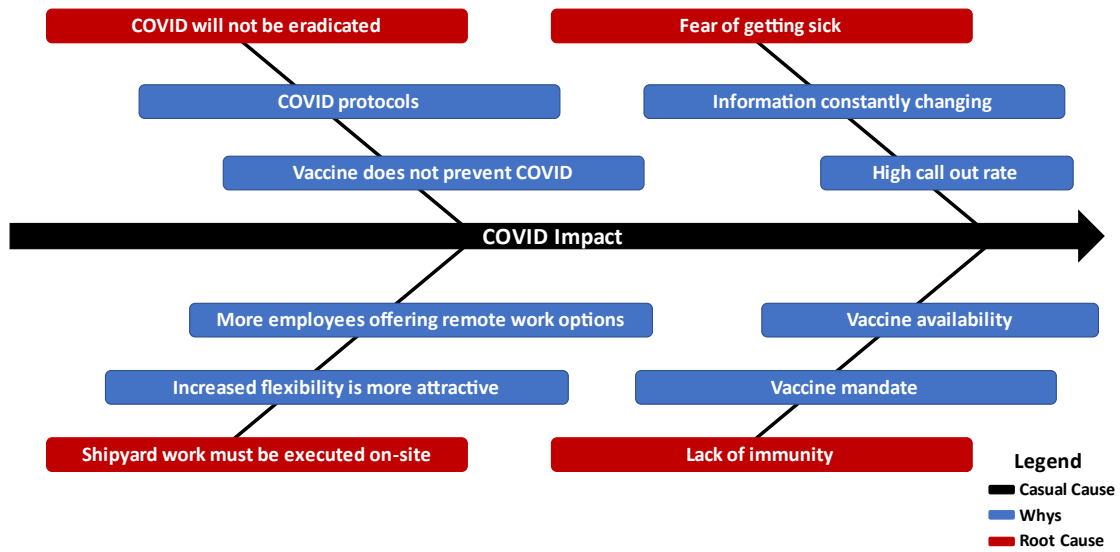


Figure 9. COVID Impact Fishbone Diagram

G. SUMMARY

This chapter laid out the root cause analysis to determine the reasons behind the trades labor shortage in shipyards. The conclusion wraps up the analysis and provides recommendations to address the shipyard trades labor shortage across the DOD.

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V. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSION

Through the root cause analysis performed in this thesis, the research questions were answered:

Primary Question: What is the root cause of the trades labor shortages in shipyards executing CNO availabilities?

In researching the reasons for shipyard trades labor shortages, several root causes were identified, which fits in with a multifaceted topic area. In some cases, there were similar root causes that were derived from different casual causes. These connections are shown in the final fishbone diagram (Figure 10). Linked root causes produced the same recommendations to address improvements across a range of contributing factors. Multiple fishbone revisions were necessary to adequately group root causes together. To address the root causes, they were broken down into two categories: recommendations and future research.

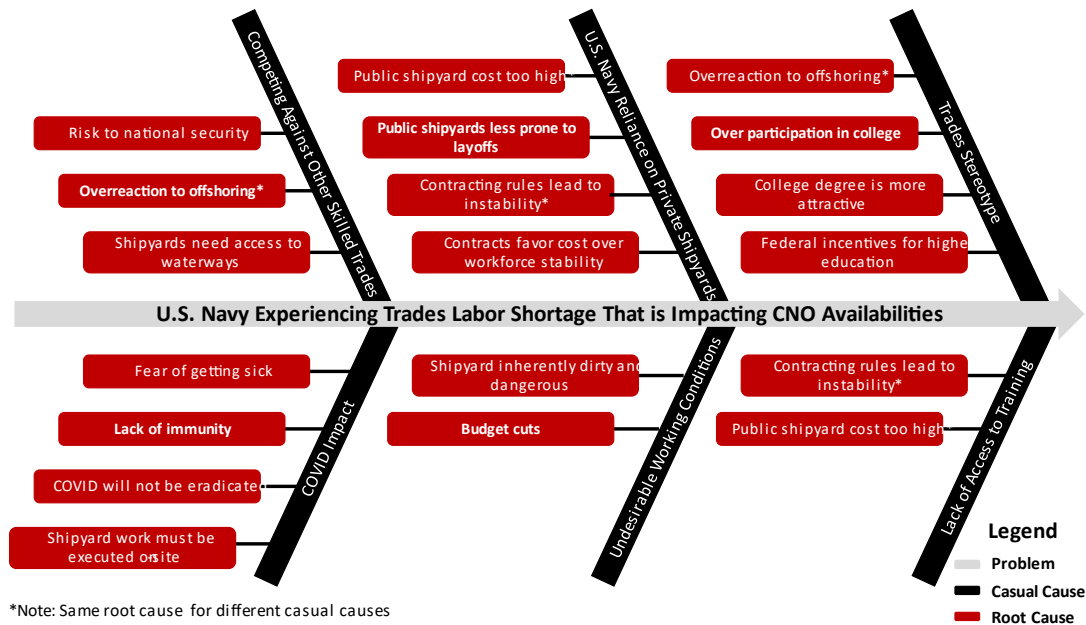


Figure 10. Final Fishbone Diagram

Secondary Question: Is there a different root cause for the trades labor shortage in public versus private shipyards?

There are different root causes for the trades labor shortages experienced in public and private sectors, but most of the root causes apply to both industries. What became apparent in the authors' research is that the U.S. Navy needs to rely on a mix of both public and private shipyard workforce to meet the demand. A follow-on question is what mix is optimal to balance reliability, sustainability, controllability, and cost efficiency while maintaining national security and benefiting from the efficiencies of market forces?

B. RECOMMENDATIONS

To identify recommendations, each root cause was analyzed individually. The goal was to implement mitigations to reduce the impact of the shipyard skilled trades labor shortage supporting CNO availabilities. The recommendations were broken down into three categories: direct actions, indirect actions, and future research (refer to Table 1). Direct actions include efforts that reduce the impact on root causes, where indirect actions are mitigations to a root cause that cannot change. The table below reflects the type of recommendation for each root cause.



Table 1. Root Cause Recommendation Categories

Root Cause	Direct Action	Indirect Actions	Future Research
The U.S. overreacted to the offshoring of manufacturing jobs	X		
Decades of U.S. manufacturing and trades labor offshoring resulted in a significant decline in the willingness to get into the industry	X		
Over-participation in college in reaction to increased demand for a more highly educated workforce	X		
The idea of earning a college degree is generally more attractive than entering the skilled trades industry	X		
Global events created federal incentives to increase college education across the nation	X		
Capital investments are deferred due to budget constraints	X		
Government contracting rules result in shipyard award fluctuations for CNO availabilities	X		X
Government contracting rules favor competition over workforce stability	X		X
Fear of getting sick		X	
Lack of immunity among the public		X	
COVID will not be eradicated		X	
Shipyard work is inherently dirty and dangerous		X	
Shipyards must be located on waterways with access to open water		X	
Shipyard work must be executed on-site		X	
Unvetted workforce is a risk to national security		X	
The U.S. Navy has strict requirements for their skilled trade labor due to national security		X	
The cost of operating public shipyards was too high and forced closures			X
Federal employment is historically immune to economic downturns			X

1. Direct Actions

Direct actions are recommended where change can directly impact the root cause. In this section, root causes are grouped when the same action applies.

a. Recruitment

Root Cause: The U.S. overreacted to the offshoring of manufacturing jobs.

Root Cause: Decades of U.S. manufacturing and trades labor offshoring resulted in a significant decline in the willingness to get into the industry.



Root Cause: Over-participation in college in reaction to increased demand for a more highly educated workforce.

Root Cause: The idea of earning a college degree is generally more attractive than entering the skilled trades industry.

Root Cause: Global events created federal incentives to increase college education across the nation.

The authors recommend changes to recruitment tactics for skilled trades labor. This includes marketing adjustments to target high schools and present opportunities for successful careers in the shipyard industry. Partnerships need to be developed between shipyards and high schools to educate students about career options that include trades labor work. An additional recommendation is for the federal government to offer incentives to those who join the shipyard trades labor workforce. These could include a signing bonus, grants for affordable housing near shipyards, or scholarships for trades school.

b. Infrastructure Subsidies

Root Cause: Capital investments are deferred due to budget constraints.

The authors recommend government tax abatements for infrastructure improvements in private shipyards. Private shipyards are more focused on profits, which led to degradation in equipment and environmental conditions. Poor shipyard conditions contribute to the workforce shortage and impact availability schedules due to increased equipment repair times.

In addition, public shipyards do not have the budget to support infrastructure improvements. Recommend the DOD consider prioritizing maintenance funding and invest in the Defense Production Act Title III. Investment in Title III allows the DOD to conduct studies for shipyard infrastructure and workforce improvements.

c. Training Initiatives

Root Cause: Government contracting rules result in shipyard award fluctuations for CNO availabilities.



Root Cause: Government contracting rules favor competition over workforce stability.

The federal acquisition regulation does not incentivize public shipyards to train and invest in their workforce. If the government continues to prioritize cost control as the primary factor in contract awards, workforce training needs to be championed by a separate initiative. The authors recommend that the federal government utilizes training programs to develop and improve the trades labor workforce. The government should open schools or partner with community colleges near shipyards to create training opportunities and increase its candidate pool. This mirrors efforts some key private industry players have already implemented.

2. Indirect Actions

Indirect actions are proposed where the root causes can only be mitigated. In this section, root causes are grouped when the same action applies.

a. Vaccinations

Root Cause: Fear of getting sick.

Root Cause: Lack of immunity among the public.

Root Cause: COVID will not be eradicated.

COVID will not be eradicated, but mandatory vaccinations were initially in place to reduce the risk. Masks were previously mandated to reduce the spread, but no longer a requirement. Additionally, medical knowledge of the disease and its effects should continue to appease public fears of contracting the disease.

b. Industrial Work Mitigations

Root Cause: Shipyard work is inherently dirty and dangerous.

Root Cause: Shipyards must be located on waterways with access to open water.

Root Cause: Shipyard work must be executed on-site.



Shipyard work is labor-intensive and often accomplished in small and crowded spaces. Personal protective equipment, such as hard hats, safety shoes, and hearing and eye protection is required. In addition, the operation of heavy machinery poses risk to the operator and anyone in the immediate surrounding area. Shipyards could invest capital funds into attracting workers, by giving them the most up to date tools and technologies to complete shipyard work. If employees knew they were operating in state of-the-art, updated, safe environments with the latest technologies, it may attract additional candidates.

CNO availabilities must be executed in a shipyard, there is no option for remote work. While there is no option for this work to be done offsite, there can be a better effort by shipyards to employ a better work-life balance for its workers. Work can be separated into various shifts or schedules, giving flexibility for workers to implement schedule changes to accommodate appointments, childcare scheduling, and other personal needs. Moreover, some routine training or certain certification classes may be able to be accomplished remotely via the computer. By giving alternate options where possible, shipyards can help to provide additional benefits to personnel.

c. Premium Pay

Root Cause: Unvetted workforce is a risk to national security.

Root Cause: The U.S. Navy has strict requirements for their skilled trade labor due to national security.

The U.S. Navy has requirements that cannot be reduced. Strict standards are required for the warfighter's safety and national security. Due to regulations, the U.S. Navy should expect to pay higher wages. This creates challenges when availabilities are awarded based on the lowest cost and shipyards cannot remain competitive while maintaining a qualified workforce.



3. Future Research

The following root causes require future research to determine recommendations for a path forward. These causes are very complex and sufficient to warrant their own research projects. In this section, root causes are grouped when the same action applies.

a. Sustaining the Shipyard Industry

Root Cause: Government contracting rules favor competition over workforce stability.

As the U.S. Navy moved away from a predominantly government-employed shipyard workforce to a private one, the dependability, reliability, and skill set of the workforce dropped abruptly, negatively affecting stability. The U.S. should more broadly look at the value of national security by encouraging the development of domestic industries that bring manufacturing and skilled trades to the nation. In a post-COVID world, where globalization is showing economic vulnerabilities, research should focus on developing all domestic industries that impact national security, not just the DOD. This is a significant topic for future research that has many facets and academic disciplines, including economics, public policy, business analysis, acquisitions, and military defense. Most vulnerabilities are currently due to the supply chain, even if the final product is assembled domestically. This warrants a look into the feasibility of a wide range of industries from raw materials and agriculture to energy and silicon chips.

b. Business Case Analysis of Contracting Impacts on the Shipyard Workforce

Root cause: Government contracting rules result in shipyard award fluctuations for CNO availabilities.

A business case analysis is needed to assess contract strategy for winning consecutive contracts. The current contracting strategies are failing to account for the trades labor workforce, which is negatively impacting schedule. Shipyard availabilities were recently switched to multi-award contracts for cost control. With the priority to reduce cost, schedule, and performance are affected. A business case analysis would show how the



current multi-award contract strategy does not support government tasking requirements, and instead, causes consistent delays, cost overruns and negative impacts on CNO availabilities. This warrants its own research project.

c. Business Case Analysis on Public versus Private Shipyards

Root Cause: The cost of operating public shipyards was too high and forced closures.

Root Cause: Federal employment is historically immune to economic downturns.

The authors recommend conducting a cost-benefit analysis to compare the operational costs of private and public shipyards. With the BRAC forcing public shipyard closures, this analysis will determine the future of public shipyards and answer some questions. Do public shipyards' operational costs outweigh the benefits? Should the DOD close the remaining public shipyards or re-open ones that were previously closed? The number of CNO availabilities will continue to grow as more vessels are constructed. A cost-benefit analysis will help determine how taxpayers' dollars should be used to invest in shipyards.

Federal employment provides increased job security. The closure of public shipyards significantly reduced the number of federal employees and increased the need for privatized employment, which is less stable. The authors recommend future research on the impacts of public shipyard closures and the U.S. Navy's heavy reliance on a contracted workforce. Specifically focusing on the cost to sustain public shipyards versus increasing the number of private shipyards and contracted employees.

C. SUMMARY

This thesis provided a thorough analysis of the reasons behind shipyard trades labor shortages. Through implementation of recommendations and future research, the authors believe improvements can be made to address the trades labor shortage. Tackling this issue will help reduce delays in on-time deliveries of naval assets and ultimately sustain national security.



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