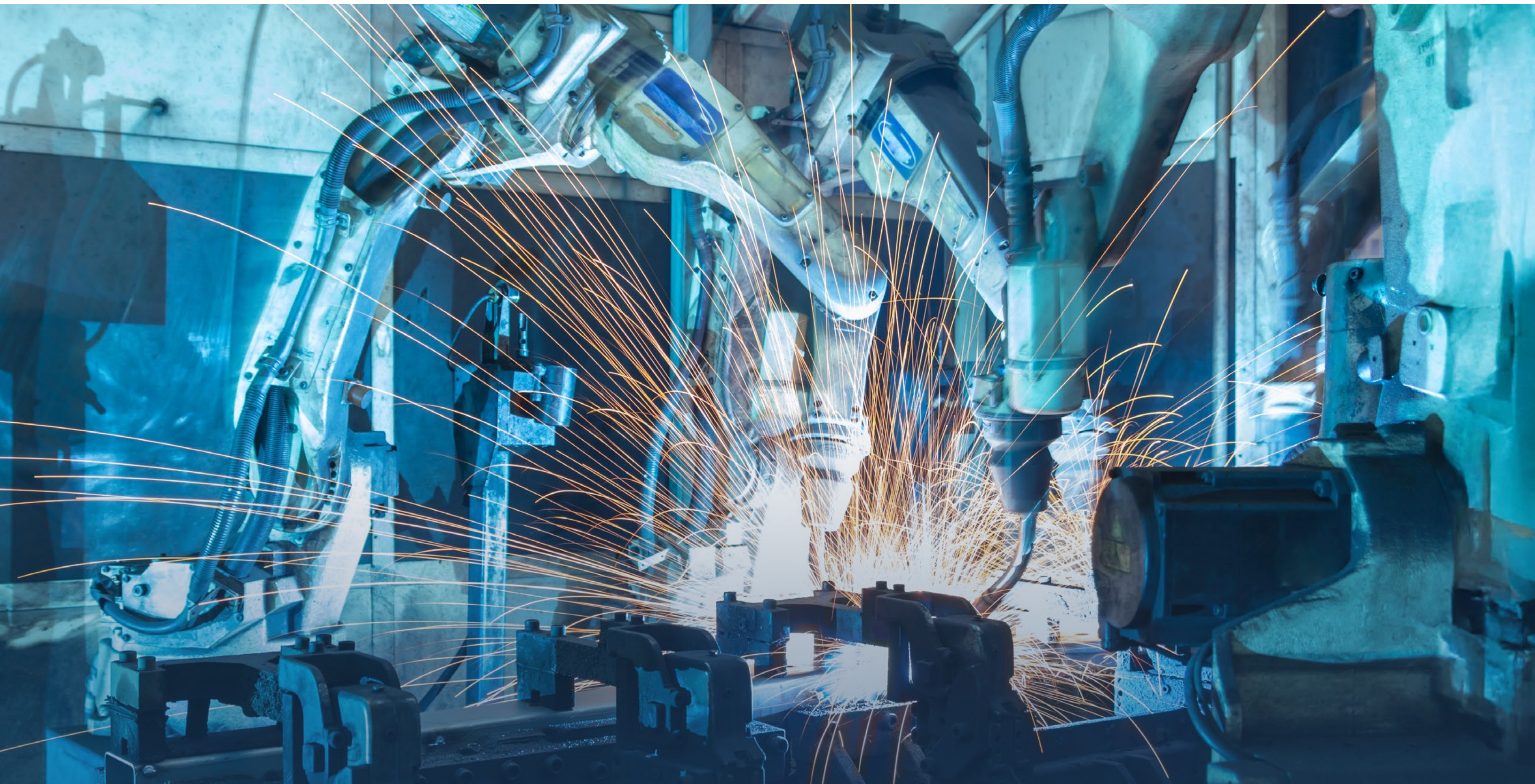

Enhancing Naval Shipbuilding Efficiency and Quality Through Robotic Welding Adoption

A Synthesis of Technical Review, Industry Survey, and Expert Interviews

NDIA Emerging Technologies Institute
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Executive Summary

The United States naval shipbuilding enterprise is facing a severe crisis characterized by multi-year schedule delays, escalating costs, and a critical shortage of skilled labor. Despite near-doubled budgets (in real terms) over the past 40 years, the Navy has struggled to grow its fleet as planned, threatening fleet readiness and power projection. Manual welding, a cornerstone of shipbuilding, has been identified as a primary contributor to these inefficiencies due to low productivity or arc-on time (the actual time a welding arc is active), human-induced quality defects, and the hazardous nature of the work.

This report by the National Defense Industrial Association's (NDIA) Emerging Technologies Institute (ETI) investigates the potential for robotic welding solutions to address these challenges. Drawing on multiple sources, including a technical paper, stakeholder interviews, and a national survey of 58 industry organizations, it assesses current adoption levels, identifies key barriers, and proposes policy measures to accelerate implementation.

Key findings indicate that the adoption of robotic welding in naval shipbuilding is currently minimal. 40 percent of survey respondents reported "minimal" use, while 22 percent reported no use at all. This slow adoption persists despite overwhelming evidence of profound benefits from other sectors: automotive, agriculture, and general manufacturing sectors have seen profound benefits, including 20 – 50 percent efficiency gains, 15 – 60 percent reductions in scrap and rework, and significant improvements in worker safety.

The most significant barriers to adoption identified by industry are the high initial cost of systems and the lack of a clear Return on Investment (ROI), the complexity of welding qualification requirements for new processes, integration challenges, and the need for specialized personnel training. To overcome these hurdles, industry stakeholders identified a critical need for pilot project funding, access to demonstration facilities, and specialized training programs. From a technical perspective, the most desired features in robotic systems are in-process weld monitoring, real-time data collection for quality assurance, and automated compliance with stringent naval welding standards.

This paper concludes with a series of recommendations for the Department of War (DOW), the Navy, and Industry. These include establishing government-backed initiatives to de-risk ROI, modernizing qualification processes, and fostering collaboration to create standardized, interoperable robotic solutions. By strategically embracing automation, the naval shipbuilding industry can transform its production capabilities, enhance vessel quality, alleviate workforce pressures, and ultimately support efforts to restore the efficiency and capacity required to build the fleet of the future.

Introduction

The United States Navy's ability to maintain maritime superiority depends heavily on a resilient and efficient shipbuilding industrial base. This sector faces deep structural challenges, including aging infrastructure, a shrinking and aging skilled labor force, and prolonged production timelines that frequently miss strategic demands.[1] Despite employing approximately 110,000 workers across about 150 shipyards and contributing $42.4 billion annually to GDP,[2] U.S. shipbuilding output (in number of ships built annually) has fallen sharply from historical levels by more than 85 percent since the 1950s, particularly in commercial production. This decline has contributed to eroding the depth of the skilled workforce and a robust supply chain, further concentrating risk within the few shipyards capable of constructing complex naval vessels.[3]

A central bottleneck in naval shipbuilding is welding. It accounts for approximately 25 – 28 percent of all shipbuilding labor hours and nearly 28 percent of manufacturing cost, underscoring its critical role in vessel strength, watertight integrity, and durability.[4] Manual and semi-automatic welding dominates current practice but is highly labor-intensive, prone to variability, and constrained by a declining workforce, with a predicted shortfall of about 330,000 welders by 2028.[5] Given that the Navy's 2025 shipbuilding plan calls for a 381-ship fleet by 2054 plus 134 unmanned platforms, for a total of 515 naval platforms,[6] the need for accelerated, high-quality ship construction is more pressing than ever.

Robotic welding offers a pathway to enhanced productivity, consistency, and safety, but adoption within naval shipbuilding has been slow. This paper synthesizes technical analysis, industry survey insights, and expert interviews to propose actionable recommendations and a roadmap for adoption. It outlines both opportunities and barriers, draws lessons from other industries, and offers phased strategies to guide successful implementation.

Current Welding Landscape in Naval Shipbuilding

The welding environment in naval shipbuilding remains heavily reliant on traditional manual and semi-automatic processes. This is a function of the industry's unique challenges, including massive, non-repetitive workpieces, the need for welding in confined or difficult-to-access spaces, and a wide variety of materials and joint types.

The primary methods used by the U.S. naval shipbuilding industry are Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW), Gas Tungsten Arc Welding (GTAW), Submerged Arc Welding (SAW), and Flux-Cored Arc Welding (FCAW).

While each has its purpose, they are all constrained by their dependence on a highly skilled human operator. This reliance creates systemic weaknesses in productivity, quality consistency, and workforce sustainability. The low arc-on time (total amount of time a welding arc is active and welding is actually occurring) inherent in manual and semi-automatic processes, coupled with the national shortage of skilled welders,[5] makes manual welding a primary bottleneck in shipyard production.

NDIA Survey Findings

To quantify the state of robotic welding automation, NDIA's Emerging Technologies Institute conducted a survey[7] targeting a cross-section of the defense industrial base. Fifty-eight (58) organizations spread across public and private shipyards, academia, equipment manufacturers, and system integrators were surveyed. The respondents represent a valuable snapshot of the ecosystem, with roles including Management (47%), Research & Development (26%), and Welding Engineering (25%). The organizations ranged from small suppliers (53% with welding departments of fewer than 10 personnel) to large prime contractors (18% with 100 or more personnel). In addition, 12 follow-on interviews were conducted with selected survey participants, including a major U.S. automotive manufacturer.

The survey results unequivocally confirm that the adoption of robotic welding in naval shipbuilding is nascent. Responses to the question "To what extent does your organization utilize this technology?" are displayed in Figure 1 on the following page.

Shielded Metal Arc Welding (SMAW)

Often called "stick welding," this process uses a consumable, flux-coated electrode that creates its own shielding gas as it melts to protect the weld. This simple and portable method is versatile for various metals and conditions, but requires chipping away a protective slag coating after welding.

Gas Metal Arc Welding (GMAW)

Commonly known as "MIG welding," this is a fast and efficient process where a continuously fed solid wire electrode melts to form the weld. An external shielding gas protects the weld pool from contamination, resulting in high productivity and clean welds with minimal cleanup.

Submerged Arc Welding (SAW)

An arc welding process where a continuously fed wire electrode joins metal workpieces under a blanket of granular, fusible flux. It is valued for producing high-quality welds at high deposition rates and for creating a safer working environment due to minimal spatter, sparks, and fumes.

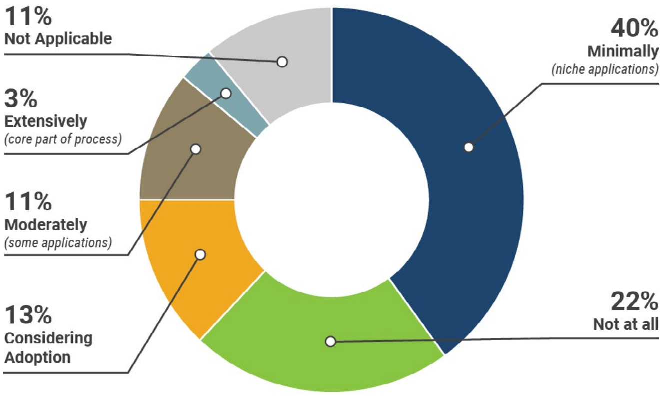
Gas Tungsten Arc Welding (GTAW)

Referred to as "TIG welding," this is a precise process that uses a non-consumable tungsten electrode to create the arc, with filler metal often added separately by hand. This method offers excellent control and produces the highest quality, cleanest welds, making it ideal for thin materials and critical applications.

Flux-Cored Arc Welding (FCAW)

Similar to MIG welding, FCAW uses a continuously fed wire, but the electrode is tubular and filled with flux. This flux provides the gas shielding (self-shielded) or supplements an external gas (dual-shield), allowing for high deposition rates and excellent performance in outdoor or windy conditions.

Figure 1: **Current Utilization of Automated/Robotic Welding in Shipbuilding**



Source: NDIA Robotic Welding for Naval Shipbuilding Survey[7]

A combined 62% of organizations report minimal or no use of robotic welding. Only a small fraction (14%) has moved beyond niche applications to moderate or extensive use. This data provides a clear, quantitative baseline: Despite its potential, robotic welding is not a significant part of the current production model for the vast majority of the naval shipbuilding industrial base.

A 2015 National Shipbuilding Research Program (NSRP) survey serves as a quantitative baseline for the U.S. naval shipbuilding industry's historically low adoption of automation. An analysis of seven major shipyards revealed a fragmented industrial base where some yards performed nearly 100% of their welding manually, while others had automated up to 90% of certain processes. This wide disparity underscored the lack of a common, best-practice approach to robotic welding, confirming that it was not a significant part of the production model for much of the industry prior to a recent surge in investment.[8]

Global Adoption Trends

The global shipbuilding industry is increasingly adopting robotic welding to boost productivity, efficiency, and safety across shipyards.

Asian firms are leading this industrial revolution. South Korea's giants, Hyundai Heavy Industries (HHI) and Daewoo Shipbuilding & Marine Engineering (now Hanwha Ocean) are spearheading modernization with massive investments in automation. Japan is pioneering the integration of collaborative robots (cobots) and AI to maximize welding efficiency and safety. Meanwhile, China is aggressively integrating robotics across its state-owned shipyards to solidify its dominant position in the Asia-Pacific and the world.[9]

In contrast, Western nations are responding less aggressively to this new reality. Germany is driving robotic adoption in the specialized ship repair and retrofitting market, aligned with Europe's focus on sustainability and digitalization. The U.S. naval shipbuilding industry, after historically lagging in automation, is now making a strategic pivot. Intense pressure to reduce costs, improve quality, shorten schedules, and address a critical shortage of skilled welders is fueling a surge in investment and interest in these technologies.[8,9]

Ultimately, the message is clear: In the modern shipbuilding landscape, embracing robotic welding is not just an option, but a strategic necessity. With China setting a relentless pace, the failure to automate is a direct threat to national competitiveness.

Documented Benefits of Robotic Welding Across Industries

While shipbuilding lags in adopting automation, other heavy industries provide a clear and compelling blueprint of the benefits that automation can deliver. The data from these sectors, which were used to frame the potential gains for survey and interview participants, highlights transformative improvements in cost, productivity, and safety.

Cost Reduction and Return on Investment (ROI)

The financial case for robotic welding is powerful. By increasing throughput, reducing labor dependency, and minimizing material waste, automation delivers substantial cost savings.

Labor and Operational Costs

Automation allows a company to reallocate its skilled welders to more complex tasks such as installing pipes and conduits in tight spaces that are not easily automated. In a sector with a severe labor shortage, this optimization is a critical benefit. John Deere and General Motors achieved 35% and 20% reductions in labor and operational costs, respectively, by automating their welding processes. [10, 11]

Material Efficiency

Advanced welding processes enabled by robotics can lead to dramatic resource efficiencies. Italian shipbuilder Fincantieri reported a 90% reduction in welding consumables (e.g., filler wire, gas) and 60% less power consumption with a change to robotic *laser* welding for a specific application.[12] While a different welding process, it illustrates the immense resource efficiencies that can be unlocked by modern automation.

Increased Output and Quality

Robots excel at performing tasks with speed and consistency far beyond human capabilities, leading to dramatic improvements in productivity and product quality.

Efficiency and Output

A robot does not take breaks or suffer from fatigue and can operate almost continuously. This dramatically increases a facility's throughput and creates economies of scale by reducing per-unit production costs as output grows.

- MDS Manufacturing, a leading U.S. industrial equipment supplier, saw 20 to 50% efficiency improvements with the employment of a robotic welding cell[13]
- Agricultural equipment manufacturer Case IH increased its production throughput by 30% with the adoption of robotic welding[11]

Quality and Scrap Reduction

A robot executes the same weld within extremely tight tolerances during operations, eliminating human welder variability. This consistency is a cornerstone of modern quality management and contributes to weld quality improvements and scrap reduction.

- Caterpillar Inc. (a heavy machinery manufacturer) and AGCO Corporation (agricultural machinery manufacturer) reported 15% and 20% reductions in scrap rates, respectively[11]
- Kawasaki Motors Manufacturing Corp. implemented Kawasaki R series MIG welding robots to address labor shortages and inconsistent manual welding. The automated system now manages more than 80% of welding, ensuring consistent, high-quality products[14]

Enhanced Worker Safety and Workforce Optimization

Robotic welding removes human operators from hazardous environments, protecting them from toxic fumes, arc flash, and ergonomic injuries. Many interviewees independently raised this point, indicating strong interest from industry in safety and workforce optimization opportunities.

Injury Reduction

Boeing (aerospace) reported a 50% reduction in welding-related workplace injuries after adopting robotic welding systems, while Kubota (agricultural machinery) saw a 40% reduction in such injuries.[11]

Workforce Optimization

As noted by interviewees and confirmed by case studies, automation is not generally expected to be used to replace existing workers. Rather, by assigning repetitive and dangerous tasks to robots, companies can redirect their skilled human welders to higher-value work such as custom fabrication and quality oversight.[13] Companies like Tesla and John Deere have leveraged robotic welding specifically to maintain production rates amidst a shortage of skilled welders.[11]

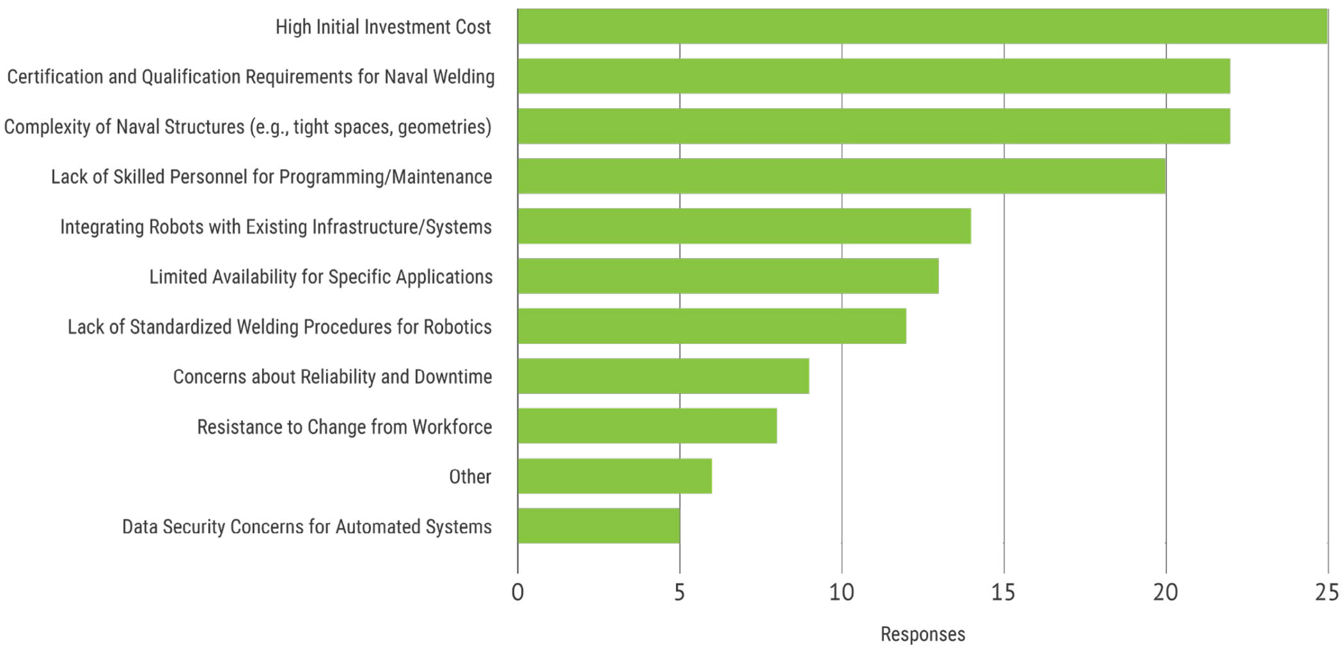
Summary

To summarize, the demonstrated cost, productivity, quality, and safety advantages of robotic welding in other heavy industries offer a compelling case for its adoption in naval shipbuilding. By leveraging automation, shipyards can mitigate labor shortages, optimize resource use, and elevate production efficiency without compromising quality or safety. These proven outcomes provide a strategic blueprint for modernizing naval shipbuilding operations and strengthening industrial resilience.

Key Barriers to Adoption in Naval Shipbuilding

Given the proven benefits, the slow adoption rates identified in the NDIA survey results point to significant barriers to such adoption. Survey results in Figure 2 and subsequent expert interviews reveal a clear consensus on the top challenges.

Figure 2: **Barriers to Robotic Welding Adoption in Shipbuilding**



Source: NDIA Robotic Welding for Naval Shipbuilding Survey, 2025 (Respondents could choose three options.)[7]

Lack of a Clear Return on Investment (ROI)

The significant capital expenditure required for a robotic welding cell is a major hurdle, especially for smaller suppliers. Building a compelling business case for investment within the low-volume, high-mix nature of shipbuilding is therefore challenging. As one interviewee from a custom automation firm noted,

> *"…a shipyard might see the technical potential, but they can't get the capital expenditure approved without a hard ROI, which is nearly impossible to generate for a unique vessel class without having already made the investment."*

An NDIA ETI study on private capital investments[15] shows that almost $100B in private capital is invested in the defense industrial base (DIB) each year. This suggests that the issue may not necessarily be a lack of capital, but instead an inability by contractors to show that there is a large enough demand signal or ROI if capital were invested in these systems.

The Challenge of Qualification and Certification

While ROI is a financial barrier, the complexity of qualification is a uniquely challenging regulatory barrier in the defense sector because of the criticality of deployed systems. The current qualification process, which is designed for manual and semi-automatic welding, is ill-suited for the digital, data-rich environment of robotics. As aptly stated by one of the interviewees, "…the qualification timeline for a single new robotic procedure can be longer than the schedule savings the robot would provide on the project and thus creates a powerful disincentive to innovate." This sentiment was echoed across multiple interviews, highlighting certification reform as a critical enabler.

Qualifying a new welding process involves welding a test coupon with specified parameters, performing a battery of destructive and non-destructive tests to verify the weld meets stringent code and quality standards, and documenting the results. The process is deemed to be slow due to the necessity of multiple, time-consuming tests to prove the new procedure's safety, repeatability, and reliability for critical applications, ensuring the structural integrity of the final product.

Technical and Integration Challenges

Interviews also shed light on technical hurdles specific to the shipyard environment. The problems of poor part fit-up and the sheer scale of ship assemblies were frequently mentioned. A standard robot programmed for a precise part will fail when faced with the real-world variations of large steel plates. Furthermore, the challenge of system integration was a key theme. An interview subject highlighted the difficulty of creating a cohesive robotic welding system from disparate original equipment manufacturer (OEM) components and software, stating the need to avoid 'vendor lock-in' by promoting common interfaces to reduce the burden of custom integration.

Some industry organizations and OEMs are actively addressing these limitations. For example, a recent National Shipbuilding Research Program (NSRP) project aims to reduce the complexity and cost of cobot welding in shipyards by creating a plug-and-play interface for existing welding equipment.[16] Similarly, Lincoln Electric's Cooper App enables a single controller to manage cobots from different manufacturers, such as FANUC and ABB.

Workforce

NDIA survey results identified the lack of specialized personnel as a key barrier, a point that was expanded upon in interviews. The industry needs a new class of "robotics technician" that blends welding knowledge with programming skills. Culturally, there is a deep-seated resistance to change with a "we've always done it this way" mentality and the workforce's fear of job replacement. The latter requires a clear strategy to upskill, not replace, existing workers.

Potential Emerging Technology Solutions

The technical challenges identified by industry experts require leveraging a suite of mature and emerging technologies that are purpose-built to make robotic welding more flexible, intelligent, and accessible. These enablers directly address the core challenges of the high-mix, low-volume nature of naval shipbuilding.

Advanced Sensor Systems and AI-Driven Control

To solve the problem of imprecise part fit-up, modern robotic systems can be equipped with sophisticated sensors.

Vision Systems and Laser Scanners

Advanced vision systems and laser scanners generate a high-resolution 3D map of the weld joint immediately ahead of the torch, enabling the robot to adapt its path and parameters in real-time. This capability[17] is critical for automating work on large or imprecise assemblies, as it compensates for imperfect fixturing. However, a key consideration is that system performance can be sensitive to the surface condition of the base material.

AI-Powered Quality Assurance

Integrating advanced sensors, artificial intelligence (AI), and machine learning enables real-time defect detection and quality monitoring during welding.[18] This adaptive AI solution gives robots the ability to perceive and respond to real-time scenarios, unlike existing methods that rely on pre-welding scans or laser readings.[19] This directly addresses one trend in NDIA survey responses, where "real-time data collection for quality assurance" was identified as a highly desired feature. The resulting physics-informed, data-driven framework could dramatically reduce post-weld inspection and rework.[20] These technologies, while at various levels of maturity, hold great promise and can complement final nondestructive testing after production.

Offline Programming (OLP) and Digital Twins

Offline Programming (OLP) software is a critical enabler for the high-mix environment of shipbuilding. It allows programmers to create and simulate complex robot paths on a computer using the ship's 3D CAD models, maximizing the robot's productive uptime.[21, 22] This approach directly addresses the concern that a robot would spend too much time being programmed on the shop floor. This concept extends to the digital twin, a virtual replica of the entire production environment. By using offline programming software to identify the optimal path, planners can integrate the design, welding, and quality assurance phases into a single digital thread.[23] Newer cobot controllers with intuitive touchscreen interfaces allow operators to import a 3D part scan and simply tap the screen to define weld start and stop points.

Collaborative and Mobile Robotics

For tasks in confined spaces or alongside human workers, new types of robots are emerging.

Collaborative Robots (Cobots)

Cobots offer a low-cost, flexible automation solution designed to safely assist humans with demanding welding tasks. Developed by leading firms like Path Robotics, Universal Robots, ABB, and FANUC Corporation, they are already transforming industries from automotive to healthcare—and are beginning to make inroads into shipbuilding.[24, 25] A recent National Shipbuilding Research Program cobot pilot showed that welding efficiency and first-time production quality increased by more than 45% and that cobots reduced training time for would-be welders or pipefitters from the street to the shipyards.[26]

Mobile Robots

The long-term vision for robotic welding, discussed in expert interviews, involves autonomous mobile platforms. Specialized quadruped robots are already being used for inspection,[27] and companies like Hyundai are testing humanoid robots for shipyard tasks.[28] Equipping such platforms with welding capabilities would represent a paradigm shift in shipyard automation.

Recommendations

Based on the synthesis of survey data, expert interviews, and a review of existing literature, the following recommendations are proposed to create a cohesive strategy for accelerating the adoption of robotic welding in naval shipbuilding. The recommendations are designed to directly address the primary barriers identified by the industrial base.

Department of the Navy

The Navy must lead by creating an environment that de-risks and encourages innovation.

1. Establish a Robotic Welding Pilot Program (RWPP)

NDIA survey respondents identified the lack of a clear ROI as the number one barrier to implementation. To accelerate the adoption of robotic welding, the Navy should establish a dedicated funding mechanism, such as grants or cost-sharing agreements, for shipyard pilot projects. This program would de-risk the initial investment and generate the tangible performance data organizations need to build a strong internal business case. To support this effort, the initiative could leverage the expertise of the ARM Institute's Robotics Manufacturing Hub, which guides companies through customized automation assessments, complete with ROI analysis and risk mitigation. Furthermore, these activities could attract investment from other DoW-wide programs, including the Manufacturing Technology Program (ManTech), the Navy's Maritime Industrial Base (MIB), the Office of Strategic Capital, the Defense Innovation Unit, and the Industrial Base Analysis and Sustainment (IBAS) Program.

2. Modernize and Streamline Welding Qualification Processes

According to survey respondents, the second most prohibitive barrier is the complexity of certification. To accelerate the adoption of automation, the Navy and regulatory partners like the American Bureau of Shipping (ABS) should establish a dedicated, fast-track approval process for robotic welding procedures. This could involve leveraging simulation data, establishing pre-approved parameter sets for common applications, and accepting in-process monitoring data from the robot as part of the official quality record.

3. Fund Regional Training and Demonstration Centers

In direct response to industry requests for "access to demonstration facilities" and "specialized training programs," the Navy should partner with academic institutions and non-profits to establish regional "Automation Centers of Excellence." Demonstration Centers, such as the NSRP's Shipbuilding CoBot Alliance, would offer a low-risk environment for companies to test technologies and provide the training needed to upskill their workforce.[29]

4. Provide Government Incentives and Update Contract Mechanisms

In addition to direct funding, the government could offer grants and tax credits for automation investment. Furthermore, contracts could be structured to reward manufacturing innovation by allowing for higher initial target costs that reflect capital investment but also including aggressive incentives for achieving cost and schedule improvements through said automation.

Shipbuilding Industry Stakeholders

To accelerate adoption, the shipbuilding industry must integrate robotic fabrication concurrently into ship design and infrastructure planning, rather than treating it as an afterthought. This requires a holistic approach, combining sustained investment in flexible, open technologies like automated programming and AI-driven quality control with a deliberate campaign to educate the workforce at all levels.

5. Increase Use of Pre-Engineered Cells

As a key lesson from other industries suggests, organizations do not need to automate everything at once.[30] Shipyards should begin with lower-cost, pre-engineered robotic welding cells for simple, repetitive sub-assemblies. This approach builds institutional knowledge, creates initial successful projects at a small scale, and fosters the confidence needed for larger projects.

6. Develop a Holistic Business Case for ROI

When evaluating ROI, industry leaders must look beyond direct labor savings. The business case should quantify the significant benefits of reduced rework and scrap with documented reductions of 15 to 60%, increased throughput, lower consumable costs, and improved worker safety, which leads to reduced insurance premiums and helps alleviate critical labor shortages.

7. Prioritize Standardization and Interoperability

To address the "custom integration" challenge highlighted in expert interviews, industry should work through consortia such as the CoBot Alliance (nsrp.org) and ARM Institute (manufacturingusa.com) to develop common interfaces and data formats for robotic systems. This will prevent vendor lock-in, reduce integration costs, and create a more competitive and innovative supplier marketplace.

8. Foster a Culture of Continuous Improvement

Leadership must engage welders and engineers in the process of identifying tasks for automation and invest in upskilling them to manage, program, and maintain systems, transforming them into high-value robotics technicians.

Strategic Roadmap

This roadmap outlines a structured, multi-year approach to systematically integrate robotic welding into naval shipbuilding, moving from foundational capabilities to a fully autonomous production environment.

Short-Term (1 – 3 years)

Goal: Demonstrate feasibility, generate initial ROI, and build foundational skills.

Actions:

- Launch pilot programs funded by the proposed RWPP, with a focus on high-criticality parts that allow current in-place nondestructive testing (NDT) quality measures to be leveraged for data on repeatability, reliability, and validation. This will improve training, certification, and quality assurance for a more streamlined adoption
- Deploy cobots in confined or hazardous spaces for repetitive tasks, providing immediate safety benefits
- Begin integrating vision systems and AI-driven quality assurance (QA) in pilot projects to collect baseline performance data

Medium-Term (3 – 7 years)

Goal: Scale proven solutions, standardize processes, and integrate more advanced technologies.

Actions:

- Scale robotic welding to hull assembly and structural components, moving to more complex 3D structures
- Standardize robotic welding procedures across shipyards based on data from successful pilots
- Introduce hybrid welding processes (e.g., Hybrid Laser Arc Welding) in robotic applications for thick-plate welding
- Establish mature workforce training pipelines in partnership with trade schools and the new Automation Centers of Excellence

Long-Term (7 – 15 years)

Goal: Achieve a state of hyper-automation with fully integrated, autonomous systems.

Actions:

- Deploy autonomous mobile robots capable of navigating entire ship sections to perform welding tasks
- Fully integrate digital twins across design, welding, and QA, making it the central hub for all production activities
- Apply robotic welding at scale for sustainment and fleet maintenance in naval shipyards
- Achieve certification of robotic welds across all naval platforms, making automation the default standard

This strategic roadmap, by directly addressing the barriers identified by the industrial base, will support efforts to systematically transform the U.S. shipbuilding sector into a more efficient, globally competitive, resilient, and technologically advanced enterprise.

Conclusion

The U.S. naval shipbuilding industrial base is at an inflection point. The evidence gathered from a literature review, in-depth expert interviews, and a national industry survey indicates that the current reliance on manual welding is a critical vulnerability, and the adoption of robotic automation is perilously slow. The industrial base itself has clearly articulated the primary obstacles: a challenging business case, cumbersome certification processes, and a shortage of specialized skills.

These barriers, while formidable, are not insurmountable. The path forward requires a concerted, collaborative effort. The Navy should act as a catalyst for innovation by de-risking early investments through targeted pilot programs and modernizing regulatory frameworks that hinder progress. These pilots should test proposed regulatory updates, push existing boundaries, and generate the data needed to revise qualification standards and establish open benchmarks for training, equipment, and processes. The shipbuilding industry, in turn, must embrace an incremental but deliberate strategy of adoption by starting small, proving value, and scaling intelligently.

The technologies to enable this transformation are mostly ready. The roadmap to implement them is clear. By listening to the needs of the industrial base and implementing the targeted recommendations outlined in this report, the United States can bridge the gap between technological potential and practical application. The strategic pivot to automation is not merely an opportunity for process improvement, but also a national security imperative, essential for revitalizing the industrial base and building the naval fleet required to ensure maritime superiority for decades to come.

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