NPS-AM-26-269

ACQUISITION RESEARCH PROGRAM
SPONSORED REPORT SERIES

Preparing the U.S. Industrial Base for Large-Scale Manufacturing of Small-To Medium-Sized Unmanned Surface Vessels

December 2025

GySgt Steven P. Gillham, USMC
Capt Christopher R. Fuchs, USMC
SSgt Kailee A. Bird In Ground, USMC

Thesis Advisors: Lt Col Jamie Porchia, Assistant Professor
Harrison C. Schramm, Senior Lecturer

Department of Acquisition, Finance and Manpower

Naval Postgraduate School

The research presented in this report was supported by the Acquisition Research Program of the Department of Acquisition, Finance and Manpower Naval Postgraduate School.

To request defense acquisition research, to become a research sponsor, or to print additional copies of reports, please contact the Acquisition Research Program (ARP) via email, arp@nps.edu or at 831-656-3793.

ABSTRACT

The U.S. Navy's Hybrid Fleet concept and the DoD's demand for attritable unmanned systems require a domestic industrial base capable of rapidly producing small- to medium-sized unmanned surface vessels (USVs). This thesis hypothesizes that current U.S. manufacturing capacity, shaped by foreign component dependence, workforce shortages, and fragmented production infrastructure, is insufficient to scale USV output to operational requirements. The study uses a mixed-methods approach, including a historical review of industrial mobilization, Bill of Materials (BOM) risk scoring, North American Industry Classification System (NAICS) labor force analysis, and industry engagement. Results indicate significant constraints in electronics and energy components, limited surge capacity among U.S. manufacturers, and acquisition timelines that do not incentivize scalable production. The thesis concludes that the U.S. has several challenges that it must address now to ensure that future USV demands are met. Key recommendations include domestic investment in high-risk components, expanding the workforce pipeline, implementing modular production lines, improving supply chain visibility, and synchronizing government furnished payload to vessel acquisition timelines.

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

The authors wish to express their sincere gratitude to the faculty of the Department of Defense Management at the Naval Postgraduate School. Your daily dedication to maintaining an extremely high standard of education has truly made a difference, and we are grateful to have had the opportunity to learn from such a faculty. We are especially grateful to Senior Lecturer Harrison Schramm and Lieutenant Colonel Jamie Porchia for their constant support and mentorship throughout the thesis process. We would also like to especially thank our families for their patience, support, and sacrifices. To the women in our lives, Veronica Gillham, Mariah Fuchs, and Elfreida Bizaholoni thank you for your constant encouragement, understanding and space you have given us to focus and succeed. Lastly, to Mr. Gimli-San your companionship and loyalty made the long days a little easier.

THIS PAGE INTENTIONALLY LEFT BLANK

NPS-AM-26-269

ACQUISITION RESEARCH PROGRAM SPONSORED REPORT SERIES

Preparing the U.S. Industrial Base for Large-Scale Manufacturing of Small-To Medium-Sized Unmanned Surface Vessels

December 2025

GySgt Steven P. Gillham, USMC
Capt Christopher R. Fuchs, USMC
SSgt Kailee A. Bird In Ground, USMC

Thesis Advisors: Lt Col Jamie Porchia, Assistant Professor
Harrison C. Schramm, Senior Lecturer

Department of Acquisition, Finance and Manpower

Naval Postgraduate School

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

A2/AD	anti-access/area aenial
AI	Artificial Intelligence
ASW	anti-submarine warfare
BOM	bill of materials
CNAS	Center for a New American Security
COLREGs	International Regulations for Preventing Collisions at Sea
COTS	commercial off-the-shelf
CRS	Congressional Research Service
CSIS	Center for Strategic and International Studies
DARPA	Defense Advanced Research Projects Agency
DDG	guided-missile destroyer
DIU	Defense Innovation Unit
DMO	Distributed Maritime Operations
DoD	Department of Defense
DoE	Department of Energy
DON	Department of the Navy
DPA	Defense Production Act
EABO	Expeditionary Advanced Base Operations
ETI	Emerging Technologies Institute
EW	electronic warfare
FAStBat	Family of Advanced Standard Batteries
FY	fiscal year
GIUK	Greenland-Iceland-United Kingdom
GFE	government furnished equipment
HF/DF	high frequency/direction finding
INDOPACOM	Indo-Pacific Command
ISR	intelligence, surveillance, and reconnaissance
IUSS	Integrated Undersea Surveillance System
LCS	Littoral Combat Ship
LRIP	low-rate initial production

NAICS	North American Industry Classification System
NATO	North Atlantic Treaty Organization
NDIA	National Defense Industrial Association
OPNAV	Office of the Chief of Naval Operations
PCBA	Printed-Circuit Board Assembly
R&D	research and development
SOSUS	Sound Surveillance System
SSN	Nuclear Powered Attack Submarine
UMS	unmanned maritime systems
USV	unmanned surface vehicle
USSR	Union of Soviet Socialist Republics
USX	united states experimental
UUV	unmanned underwater vehicle

I. INTRODUCTION

The U.S. is under increasing pressure to scale up the development, production, and operation of Unmanned Maritime Systems (UMS). What was once a niche capability with complementary utility is increasingly poised to form the center of gravity in maritime strategy as autonomy, communications, and sensing technologies continue to accelerate at rates that are rapidly redefining what is possible (Department of Defense [DoD], 2022b). At the same time, great power competitors are fielding new unmanned systems with great regularity. China has made unmanned platforms a key part of its naval modernization strategy, and Russia is already experimenting with a variety of roles, from reconnaissance to strike, with systems in service (Pettyjohn et al., 2024). As a result, industrial-scale production and sustainment of UMS may well be where the competition is won or lost.

As described by the Force Design 2045 and the CNO's Navigation Plan, the U.S. Navy's future force will be a hybrid fleet that is part traditional, crewed warships and part a new class of uncrewed vessels operating in combination as a system (Gilday, 2022; OPNAV, 2024). This is a common way to describe the future fleet, both in terms of force composition and long-term vision for distributed maritime operations. In practical terms, the two ideas are very much intertwined: the hybrid fleet is the intermediate phase of experimentation and a realistic "operating testbed" for the future fleet's technologies, tactics, and organization (Gilday, 2022; OPNAV, 2024). For this reason, this thesis uses the terms interchangeably.

Operational employment of the future, hybrid fleet will take the form of Distributed Maritime Operations (DMO) and Expeditionary Advanced Base Operations (EABO), which are both complementary naval concepts to the hybrid fleet that seek to reshape the nature of U.S. maritime U.S. in contested areas. DMO seeks to shift naval forces across space to increase temporal and spatial complexity for the adversary in detection and targeting, blending people, platforms, munitions, and data across time, spectrum, and space to enable distributed warfare and mission command (O'Rourke, 2025a). EABO, in turn, emphasizes mobile, low-signature, mission-critical force packages that are capable of operating from austere or temporary locations ashore or inshore within contested maritime domains (United States Marine Corps, 2023). These expeditionary formations are tailored for easier sustainment and rapid distribution to support operations and effects related to objectives such as sea denial, sea control, and fleet sustainment. Both DMO and EABO signal a move towards more decentralized, resilient, and adaptive operations that prioritize survivability and operational reach in peer-conflict scenarios.

For the U.S., UMS is of special value in a contested environment because it can extend the range of operational effects, reduce human risk, and enable new warfighting concepts such as distributed lethality and persistent surveillance (DoD, 2018). In particular, attritable platforms, those intended for mass production and with cost-of-use profiles that allow them to accept combat losses, present a way to increase combat potency by adding a mass of relatively cheap expendables that can be used to complicate adversary decision-making and sustain combat over time (Sayler, 2025).

We find that the U.S. industrial base is not currently primed to meet this demand. In particular, current production remains fragmented, dependent on niche manufacturers, and at risk from concentrated foreign suppliers (DoD, 2023; National Defense Industrial Association [NDIA], 2025a). Moreover, existing workforce constraints in shipyards and other supplier firms further limit the overall industrial base's capabilities, which directly impacts the shipbuilding industry's capacity to expand (O'Rourke, 2025b). The source of these problems can be traced back decades of consolidation and budget-driven efficiencies that emphasized reductions in acquisition and operational costs, at the expense of strategic resilience and industrial diversity, leaving the U.S. maritime industrial base fragile and vulnerable to stress (Center for Strategic and Budgetary Assessments [CSBA], 2020). While this is something that can be weathered in peacetime, it could be fatal in wartime. In a major conflict with a peer competitor, it is not difficult to imagine a combat pace and demand for replacements that far outstrip the limits of the current industrial base (DoD, 2022a). As a result, it is the policy of the U.S. to rebuild the domestic maritime industries and workforce for the sake of national security and economic prosperity (Executive Order No. 14629, 2025). "Restoring America's Maritime Dominance" is intended to reinvigorate US Domestic shipbuilding and meet the demands of a hybrid fleet.

Addressing these issues will require prioritizing UMS as an integral part of the fleet with mature supply chains, predictable manufacturing throughput, and ready access to necessary skills (NDIA, 2025b). Autonomy, robotics, and artificial intelligence are maturing rapidly in commercial sectors, but their adoption in defense manufacturing has been piecemeal (Hamilton et al., 2023), due to a combination of regulatory and business practices. As a result, this thesis seeks to explore the key challenges in meeting the large-scale production of UMS in the era of great power competition, with an emphasis on actionable levers to improve industrial resiliency, domestic sources, and surge capacity (Rehberg, 2020). In particular, it aims to connect lessons from the past with the requirements of the future by looking at unmanned systems through a "maritime industrial readiness" lens, with a view towards informing policymakers, industry leaders, and operational planners on how to ensure the U.S. industrial base can sustain a scalable and hybrid fleet.

A. PRIMARY RESEARCH QUESTION

What are the principal materiel and workforce challenges involved in expanding the U.S. industrial base for the large-scale manufacturing of attritable unmanned surface vessels (USV)?

B. SECONDARY RESEARCH QUESTIONS

- What is the current state of the U.S. USV manufacturing, and where are the most significant constraints and bottlenecks?
- How can the existing U.S. industrial base be leveraged to improve the throughput of USV production?

C. RESEARCH OBJECTIVES

The study has two primary objectives:

- Assess the status of infrastructure readiness, workforce availability, and supply chain resilience.

- Identify strategies to enhance the scalability, efficiency, and resilience of domestic USV production, enabling quick deployment of an integrated future fleet.

D. SCOPE

This research analyzes the U.S. infrastructure readiness to meet the need to the manufacturing and sustainment of small to medium-sized USVs. It emphasizes the risks to resilience at the component and manufacturer level, as well as implications for scalability at near- and long-term horizons, by drawing on industry and trade data, defense reports, and secondary literature on industrial capacity and supply chain and technology development for surface systems.

The UMS portfolio, which includes USV, Unmanned Undersea Vehicles (UUV), and hybrids, is already a significant part of the naval competition for great power competition. However, this thesis focuses on small- to medium-sized USVs, which present the most immediate and obvious route to scalable production and experimentation, as well as integration with the future fleet's operations. Focusing on USVs allows a more concrete evaluation of both the domestic industrial capacity and supply chain dynamics while remaining broadly relevant to the full UMS portfolio.

E. THESIS OVERVIEW

This thesis examined the state of the U.S. USV manufacturing base in the current moment. It describes both the opportunities and the challenges, with a particular focus on strategies that can be used to improve production and sustainment of small- to medium-sized USVs at scale and enable a shift to a more attritable, hybrid fleet. Chapter II summarizes the historical record on maritime strategic challenges, technological development and global tactics, and the industrial impacts and hard-learned lessons for the U.S.; Chapter III reviews the current USV landscape, from manufacturers and demand to supply chain and relevant infrastructure, production practices, and emerging technologies, along with concepts of attritability and the hybrid fleet; Chapter IV presents the engagement-driven methodology and data collection process, while Chapter V presents the findings, both qualitative and quantitative. It focuses on three primary themes: industrial base resiliency, technological innovation, and supply-chain security and combines the quantitative results across categories into a set of risk scores that identify bottlenecks and practical levers. Finally, Chapter VI recaps the study's key challenges, provides responses to the research questions and actionable recommendations, and offer research gaps and future work for those who wish to pursue the topic further, to enable domestic production of USVs at scale.

THIS PAGE INTENTIONALLY LEFT BLANK

II. BACKGROUND

This chapter examines the mutual evolution of strategy, technology, and industry which resulted in today's U.S. USV industrial base. It starts with the interwar period, which is characterized by treaty restrictions, austerity, and rapid innovation, when strategy was the main driver of production. It then describes the succeeding historical eras of World War II, the Cold War, the post–Cold War period, and modern great-power competition. Each period is considered globally through three primary lenses: the strategic challenges of the day, the nascent technologies and tactics, and the resulting impacts to U.S. industrial base.

A. INTERWAR PERIOD (1920S–1930S): FOUNDATIONS OF MODERN SEA DENIAL

Strategic Challenges. In 1922, the U.S. and its future adversaries of the United Kingdom, Japan, France and Italy, signed the Washington Naval Treaty, which limited the total number and tonnage of ships allowed in each nation's fleet (Dingman, 1976). Although these agreements slowed the naval arms race, they also incentivized innovation with nascent technologies, from aircraft carriers to submarines and primitive sonar (Goldman, 1994). Figure 1 lists the treaty limits by signatory and illustrates the resulting capacity constraints and remaining industrial headroom.

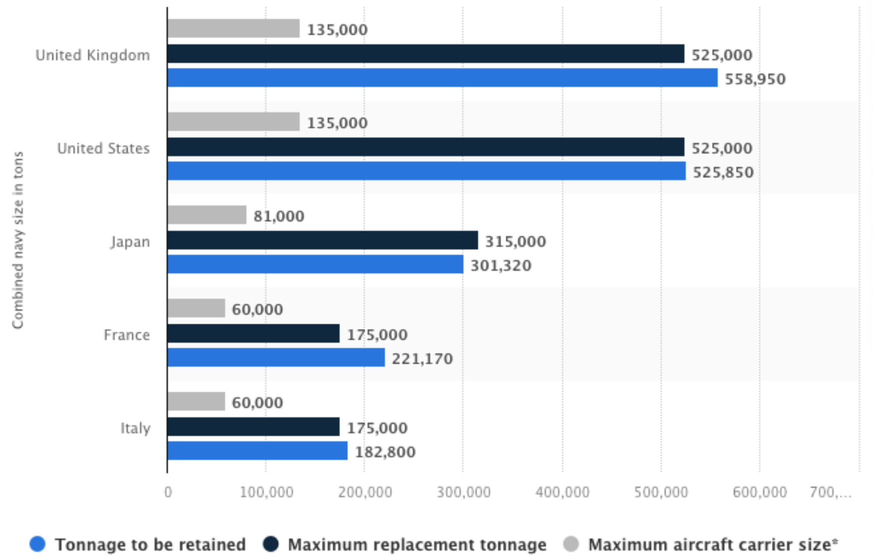


Figure 1. Naval restrictions of the Washington Treaty 1922.
Source: O'Neill (2024).

Global Technologies and Tactics. Three examples show the typical responses under limitation: Germany, prohibited from having submarines by the Treaty of Versailles, secretly acquired design and construction partnerships abroad and made incremental advances in diesel-electric propulsion efficiency and torpedo effectiveness (Herwig, 1987); other small naval powers, especially in Scandinavia and Southeast Asia, relied more on coastal defense with minefields, torpedo boats, and shore-based guns (Till, 2009); and the Soviet Union adopted a maritime depth defense concept against naval forces in the Baltic and Black Seas, with an integrated mix of submarines, minefields and coastal artillery (Åselius, 2005).

U.S. Industrial Impact. Despite the large technological leaps, American industrial capacity for building new naval ships was unevenly distributed during the 1920s and 1930s. As the consequence of postwar disarmament, treaty limitations, and the Great Depression, a significant number of shipyards were compelled to scale down or halt operations as Congressional and budgetary support for new construction fell sharply (Baer, 1994).

B. WORLD WAR II (1939–1945): WARTIME SCALING AND COUNTERMEASURE RACES

Strategic Challenges. Industrial mobilization is the so-called ‘x-factor’, by which we mean an individual lever that can have the greatest impact on outcomes, in the maritime competition (Blair, 1996). German U-boat wolfpack tactics inflicted unsustainable losses on Allied merchant shipping, isolating Britain and bringing about its potential extinction as a nation (Till, 2009). Air and surface anti-submarine warfare (ASW), utilizing convoys, radar, HF/DF, and improved escort doctrine (Blair, 1996), developed over time in concert with aerial patrol and intelligence methods to reverse the trend by mid-1943 (Milner, 1990), while growing fleet construction in all nations focused on destroyers and destroyer escorts.

Global Technologies and Tactics. In an escalating measure–countermeasure cycle: U-boat group hunting, acoustic/pressure-fused torpedoes, and snorkels were met by Allied air coverage, centimetric radar, and codebreaking (Blair, 1996). Improved ASW methods applied greater numbers of forces and new techniques which built upon existing competencies and slowly turned the tide, allowing the Allies to control critical sea lines (Milner, 1990).

U.S. Industrial Impact. Allied yards not only strove to replace losses but build to expand production capacity; in the U.S., Liberty and Victory ships were icons of mass production via standardization of design, prefabrication/modular construction, and simplified labor specialization (Herman, 2013). Figure 2 illustrates the extent of 1,294 Liberty ships in 1943 and 3,243 cumulative by 1945, and Victory ships sustaining the production rate, resulting in overall U.S. production surmounting attrition rates, delivering the Atlantic lifeline, and enabling two-ocean offensive operations (Math Encounters Blog, 2018).

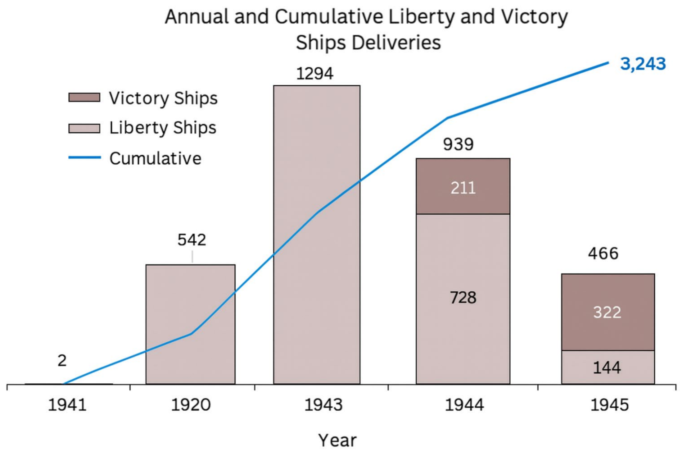


Figure 2. Liberty ship production data. Source: Math Encounters Blog (2018).

C. EARLY COLD WAR (1945–1970S): SOVIET ASCENDANCY AND NATO RESPONSE

Strategic Challenges. The onset of the Cold War marked the start of a new chapter in the maritime competition, as the Soviets pursued asymmetric responses to Western naval supremacy by developing layered sea-denial strategies, spearheaded by the leadership of Admiral Sergei Gorshkov. The Soviet Navy emphasized submarines, coastal defenses, and anti-ship missiles as force multipliers to counter the sea-based advantages of NATO at critical maritime chokepoints and bastions (Polmar & Moore, 2004). By the mid-1950s, the Soviet Union had one of the largest submarine fleets in the world, which, combined with their diesel-electric and early nuclear boats in the Baltic, Black, and Arctic seas, posed a credible undersea threat to NATO surface ships (Hattendorf, 2007).

Global Technologies and Tactics. The development and deployment of the P-15 anti-ship cruise missile, also known by its NATO reporting name "STYX", in the 1960s, enabled small, fast-attack craft to threaten large surface combatants at long ranges, turning Osa-class missile boats into a low-cost asymmetric counter to surface fleets (Polmar & Moore, 2004). Figure 3 depicts this missile-boat paradigm and its associated littoral operating concept, which NATO countered with a multi-tiered ASW kill chain. The advent of nuclear attack submarines, maritime patrol aircraft, and towed-array sonar again tilted the playing field toward open-ocean dominance despite Soviet numerical advantage (Friedman, 1994; Till, 2009).

Figure 3. STYX P-15 missile. Source: Prakash (2020).

U.S. Industrial Impact. Industrial decisions reflected strategic direction: NATO shipyards produced fewer but more capable hulls with higher unit costs and longer lead times, but with a qualitative advantage over the Soviet standardized types (Hattendorf, 2000). In contrast, the Soviet volume-based approach struggled to keep pace with the maintenance burden, shipyard capacity constraints, and skilled-labor shortages that depressed operational readiness (Polmar & Moore, 2004; Friedman, 2004). The end result was a never-ending capability–countermeasure cycle, driving the need for persistent research and development, rapid technological adoption, and resilient industrial base on both sides (Till, 2009).

D. COLD WAR (1980–1991): FORWARD DEPLOYMENT AND CHOKEPOINT CONTROL

Strategic Challenges. U.S. naval strategy focused on containing Soviet breakout from the GIUK (Greenland–Iceland–United Kingdom) Gap and adjacent chokepoints into the open Atlantic with forward-deployed carrier strike groups, nuclear attack submarines (SSNs), and P-3 Orion maritime patrol aircraft (MPA) (Hattendorf & Swartz, 2008). Figure

4 shows the GIUK Gap, an enduring chokepoint between Greenland, Iceland, and the UK, where NATO's renewed anti-submarine focus highlights its role as a defensive barrier and force multiplier (U.S. Naval Institute, 2016). Forward-deployed carrier task groups, patrol aircraft, and SSNs in turn operated from intelligence provided by SOSUS and its successor, the Integrated Undersea Surveillance System (IUSS), in a system that provided both cueing and attack options to those ships and patrol aircraft (Polmar & Moore, 2004).

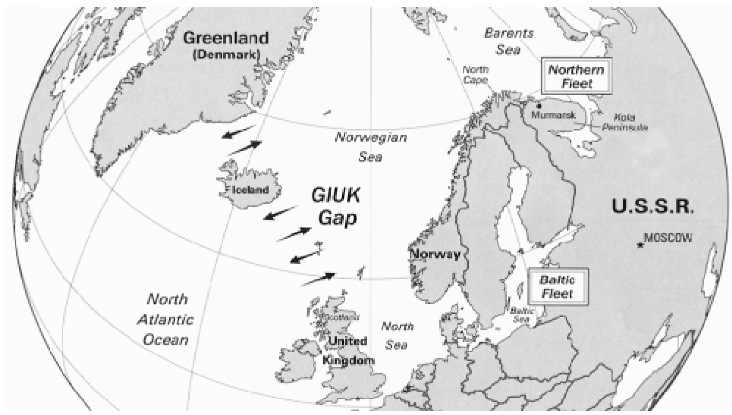


Figure 4. Russian subs are reheating a Cold War chokepoint: The GIUK Gap. Source: CDRSalamander (2016).

Global Technologies and Tactics. The resulting "barrier concept" integrated the undersea acoustic system (SOSUS/IUSS), satellite reconnaissance, and defensive minefields in a multilayered screen of sensors that provided cueing to patrol aircraft and attack submarines directed against transiting Soviet submarines and surface ships" (Polmar & Moore, 2004, pp. 72-73). The barrier was effectively a chokepoint whose construction had the effect of increasing detection and attrition risk even as the Soviet Union deployed larger numbers of submarines in its fleet (Hattendorf & Swartz, 2008).

U.S. Industrial Impact. Shipbuilding and associated ship types during the last ten years of the Cold War reached a postwar peak in both raw volume and high-end capabilities, including nuclear propulsion and complex Aegis combat systems with associated advanced ASW electronics, that enabled a combination of forward deployed task groups, presence and maritime control during this period (Baer, 1994). The same period also demonstrated the fact that the United States had maintained advantage in the second postwar period less through raw volume of output than in the tight alignment of industrial capacity with technological modernization and long-haul logistics that had shaped naval success during the previous period (Hattendorf, 2004).

E. POST–COLD WAR (1991–2000): GLOBAL RIVALRY TO LITTORAL DOMINANCE

Strategic Challenges. Naval strategy responded to the Soviet Union's disintegration by refocusing on competition and U.S. maritime dominance in contested littoral regions, prioritizing presence, access, and power projection around the globe's key coastlines (Hattendorf, 2006). The 1991 Gulf War underscored this shift, showcasing how integrated operations, precision strike capabilities, carrier aviation, and submarine warfare could rapidly defeat regional adversaries and control maritime space in a limited sea (Work, 2004). In the late 1990s, the Navy shifted strategic emphasis further from blue-water peer competition to domination of shallow, high-threat littoral areas, where potential regional powers might threaten U.S. access and maneuver (Till, 2009).

Global Technologies and Tactics. Technological developments emphasized long-range precision strike from the sea, especially via Tomahawk cruise missiles launched from submarines and surface combatants. These assets represented evolving naval concepts toward joint, more flexible, expeditionary operations able to project power ashore without necessarily relying on Cold-War–era blue-water and power-projection-ship dominance (Krepinevich, 1999).

U.S. Industrial Impact. Deep defense budget cuts had a direct and immediate effect on the U.S. Navy's industrial base, as Congressional Research Service (CRS) data show declining shipbuilding budgets producing slower build rates, fewer new orders, and reduced industrial surge capacity, despite qualitative and technological advantages (O'Rourke, 2025b). The industrial base itself shrank, with a smaller share of the total number of shipyards operating at capacity in 2000 than in 1990 and with the available skilled workforce spread thinner across fewer shipyards, limiting the production expansion options during surge (O'Rourke, 2025b). These trends have played out in a steady decline in the U.S. Navy's battle force size from nearly 600 ships at the end of the Cold War to fewer than 320 in 2000, reflecting the drawdown's structural effects on the force (U.S. Naval History and Heritage Command, n.d.). Downsizing matched the strategic reality of reduced competition and maintained U.S. overmatch after the Cold War, but it also sowed the seeds of long-term vulnerabilities that have complicated later efforts to integrate and scale unmanned systems across the Navy (O'Rourke, 2025b).

F. PREPARING FOR PEER CHALLENGES (2000–2010): BALANCING TECHNOLOGY AND SCALING

Strategic Challenges. Anti-access/area-denial (A2/AD) strategies proliferated, particularly in China and Iran, with submarines, long-range anti-ship missiles, mines, and swarm attacks to deter or prevent U.S. access to key waters (Cole & Erickson, 2014). Naval concept development focused more on distributed maritime operations, spreading out force elements and operating on networking in order to survive under precision strike (Krepinevich et. al., 2003).

Global Technologies and Tactics. Responses emphasized high-end platforms and networks: Virginia-class SSNs, Aegis surface combatants with ballistic missile defense capabilities, and efforts to expand integrated Intelligence, Surveillance, Reconnaissance (ISR) networks to detect and cue against A2/AD systems (Krepinevich et. al., 2003). New designs and concepts were also experimented with, such as Littoral Combat Ship (LCS) modularity or DDG-1000 survivability/stealth experimentation, to try to improve agility against mines, small-boat swarms, or coastal missiles even as the rest of the fleet re-tooled tactics for long-range precision strike environments (O'Rourke, 2025b).

U.S. Industrial Impact. Procurement policy during this period generally placed emphasis on increasing sophistication at the cost of overall numbers: ship programs concentrated resources into fewer, more capable ships, while overall numbers fell significantly leading to strains on sustainment and vendor bases (Gilmore & Labs, 2006).

G. IRAQ, AFGHANISTAN, AND CRIMEA (2010–2018): RISE OF UMS

Strategic Challenges. In the long grind of land wars in Iraq and Afghanistan, US modernization efforts began refocusing on great-power maritime competition.

Simultaneously, China and Russia commenced field trials of UMS capable of autonomous navigation, persistent surveillance, and strike (Office of Naval Research, 2021). Initial US UMS initiatives prioritized distributed operations and persistent ISR to mitigate adversary numerical superiority and serve as force multipliers in contested maritime environments (DoD, 2022b).

Global Technologies and Tactics. In the Indo-Pacific, China accelerated testing of unmanned surface and underwater vehicles, integrating them with long-range missiles and surveillance networks to project power and expand its A2/AD reach (Cole & Erickson, 2014). These developments underscored the recognition that unmanned systems would play a pivotal role in future maritime competition.

U.S. Industrial Impact. Industrial infrastructure to support the UMS race lagged far behind strategic aims. Manufacturing capacity was constrained, dedicated production lines for serial UMS production were few, and skilled labor pipelines were underdeveloped to support both large-scale production and sustainment (Hamilton et al., 2023). Supply chains for critical components such as sensors, batteries, and communications modules were often foreign dependent, introducing vulnerabilities to potential disruptions. The resulting mismatch between strategic demand and production capacity exposed broader acquisition process weaknesses and highlighted the need for modular and scalable production lines capable of rapid response to emerging strategic imperatives (DoD, 2023).

H. SOUTH CHINA SEA AND UKRAINE (2018–PRESENT): SCALING FOR GREAT POWER COMPETITION

Strategic Challenges. The 2018 NDS relabeled China and Russia as top competitors in an era of resumed great-power rivalry (DoD, 2018). In the South China Sea, Beijing's artificial-island militarization and assertive patrols of rivals' exclusive economic zones demonstrated an imperative for distributed and resilient U.S. maritime networks (O'Rourke, 2023). In Ukraine, Russia's 2022 invasion revealed how unmanned and attritable systems can create asymmetric costs and losses for conventional militaries (Galushko, 2023).

Global Technologies and Tactics. In the Black Sea, relatively inexpensive USVs such as the Magura V5 boat made from converted jet skis, served as force multipliers for strikes that sank or damaged multiple Russian warships, achieving denial of sea terrain and rapid adaptations and countermeasures. (Center for Strategic and International Studies, 2025). Figure 5 is one example of an attritable Ukrainian explosive USV with commercial and off-the-shelf components, modular payloads, demonstrating that scalability and expendability can outvalue exquisite sophistication (Galushko, 2023). In the South China Sea, China increased testing of unmanned surface and undersea vehicles with A2/AD missiles and sensors for integrated maritime surveillance and denial capabilities (O'Rourke, 2023).

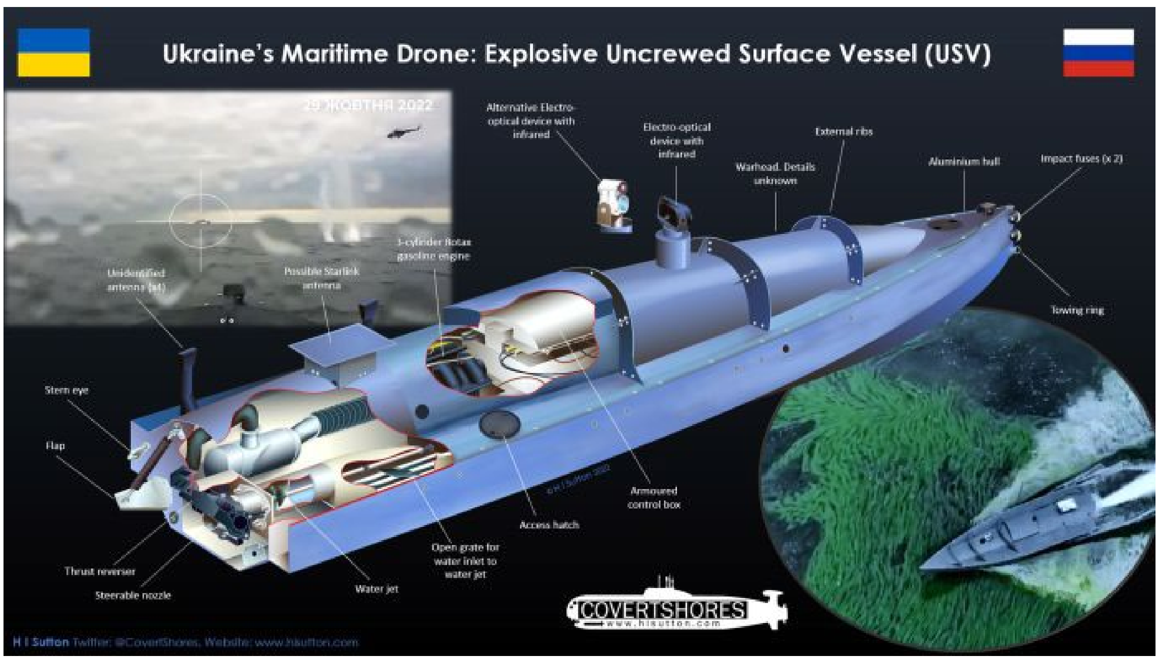


Figure 5. Ukraine's maritime drone, 2022. Source: Galushko (2023).

U.S. Industrial Impact. The South China Sea and Ukraine insights revealed a new level of tactical application for USVs and UUVs, which led experts to identify a set of U.S. vulnerabilities, including overseas concentration of semiconductors, batteries, and rare-earth materials, as well as skilled-labor shortages and aging yard infrastructure

(Government Accountability Office, 2016). Reforms such as the Adaptive Acquisition Framework and civil–military collaborations sought to shorten timelines for fielding new systems, but a decisive edge now depends on serial production of proven, attritable unmanned systems, scaling beyond prototypes to include resilient supply chains, automation, and workforce regeneration (Defense Acquisition University, 2025; Sayler, 2024).

I. CONCLUSION

The findings demonstrate how understanding strategic challenges, global technologies and tactics, and the U.S. industrial impact provides insights into the industrial capacity, technological advancements, and supply network challenges that shape maritime power. Each era reveals the constraints and opportunities generated by these elements, whether through treaty restrictions, wartime mobilization, Cold War arms races, or post–Cold War contractions. Collectively, these experiences underscore the enduring role of industrial foundations in shaping naval strategy. This historical framework provides essential context for understanding the contemporary challenges of scaling and sustaining unmanned maritime systems.

THIS PAGE INTENTIONALLY LEFT BLANK

III. LITERATURE REVIEW

The rise of USVs in U.S. defense planning has become more urgent than ever, especially with a strategic focus on the Pacific. Notably, Indo-Pacific Command (INDOPACOM) Commander, Adm. Samuel Paparo's proposed "Hellscape" concept, which "pictures floods of inexpensive, attritable UMSs making contested seas a no-go zone to help buy time for allies to respond" (Rogin, 2024). This concept aligns with the Department of the Navy's (DON) future fleet vision, in which manned and unmanned systems work together for adaptable, distributed operations that rely on reliable, large-scale production of attritable unmanned systems (OPNAV, 2024). Achieving this strategic vision depends on overcoming real-world obstacles, especially a fragile U.S. manufacturing base, vulnerable supply lines, and a heavy dependence on overseas components, which consistently hinder progress and make it difficult to turn these ideas into reality (U.S.–China Economic and Security Review Commission, 2022).

The U.S. government is adopting a new strategy to address long-standing challenges in its maritime industrial base. In April 2025, the Executive Order on *Restoring America's Maritime Dominance* established the foundation for a comprehensive naval action plan to revitalize the nation's shipbuilding industry, which has suffered from *decades of neglect* (Executive Order No. 14629, 2025). Today, the U.S. accounts for less than 1% of global commercial vessel production, compared to China's over 50% (Executive Order No. 14629, 2025).

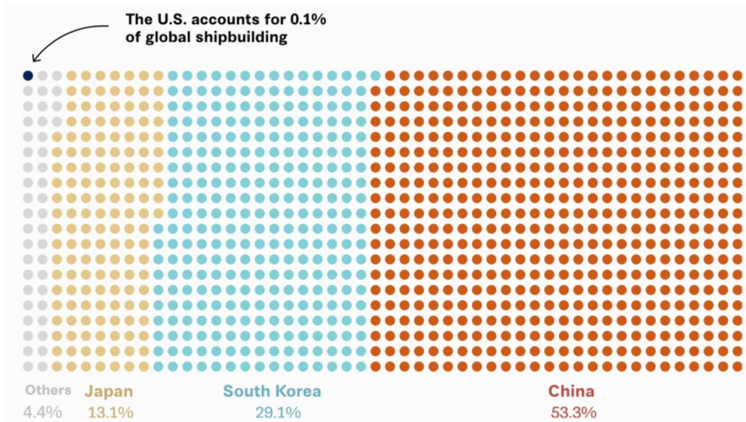


Figure 6. Global shipbuilding market share by country.
Source: Funaiole, Hart, & Powers-Riggs (2025).

While not stated explicitly, the Executive Order also reflects interest in UMSs in its focus on rebuilding America's maritime manufacturing base and maritime workforce by investing in infrastructure, workforce development, and revitalization of the industrial base and by modernizing industrial capabilities. Infrastructure, workforce, and modernization of industrial capabilities are all drivers of longer-term technologies, supply chains, and production processes required to produce the platforms needed to field hybrid fleets of manned and unmanned ships and boats capable of defeating emerging threats. Building on this positive step, another recent report released by the Center for a New American Security (CNAS), Swarms Over the Strait, makes the case for designing and building good enough UMSs, with an emphasis on explosive surface drones modeled on Ukraine's powerful drone campaign that has wreaked havoc on Russia's Black Sea fleet (Pettyjohn et al., 2024). The NDIA has also echoed this point. Its Vital Signs 2025 report concluded that the U.S. defense industrial base is hamstrung by production bottlenecks, lacks surge capacity, and faces ongoing workforce shortages that limit its ability to achieve defense goals, noting in the same report that data is classified or incomplete regarding UMS-related production issues (NDIA, 2025b). Taken together, these views put forth the essential challenge of matching the U.S. maritime strategy to the new normal of a hobbled industrial base and how to ensure unmanned systems can be produced in adequate numbers to compete with great-power adversaries.

A. ANATOMY AND DEFENSE CLASSIFICATION OF USVS

USVs are a diverse platform family. They vary widely in size, mission and technology complexity. However, all share a common set of fundamental platform subsystems that enable a USV to operate autonomously or remotely in maritime environments. These subsystems include autonomy software, communications and navigation links, propulsion and power systems, and modular payloads integrated into a mission-optimized hull form. Together, these form a harmonious architecture that provides the endurance, controllability, and flexibility to operate across missions and in different OEs (O'Rourke, 2025b). Figure 7 provides an integrated view of these classifications and corresponding mission sets that shows a practically executable efficient pathway of capability across common hull form and autonomy levels (O'Rourke, 2025b).

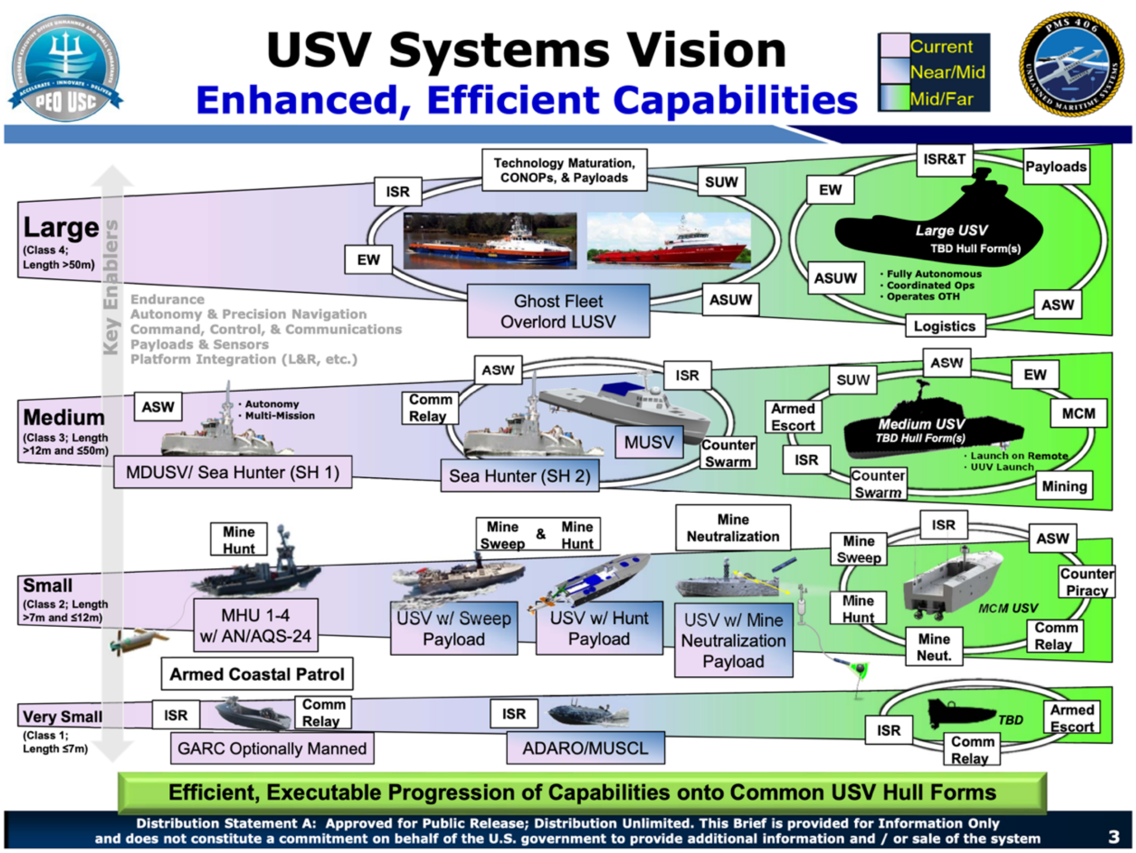


Figure 7. U.S. Navy classification of unmanned surface vessels. Adapted from Small (2019).

The U.S. Navy classifies USVs into four size-based categories that determine both their mission profiles and their industrial requirements:

- Large USVs (> 164 ft): High-endurance, optionally or fully autonomous vessels derived from commercial hulls. They are envisioned as weaponized or logistics platforms capable of carrying strike or anti-surface payloads.
- Medium USVs (39 – 164 ft): Primarily for ISR, Electronic Warfare (EW), and anti-submarine warfare.
- Small USVs (23 – 39 ft): Primarily support mine countermeasures, harbor security, and armed coastal patrol missions.
- Very Small USVs (≤ 23 ft): Lightweight, rapidly deployable systems optimized for ISR, communications relay, or mine neutralization.

Taken together, these classes demonstrate that USVs represent a continuum of scalable platforms rather than a single vessel type. Each class introduces unique industrial implications: large USVs draw on naval shipyard expertise and complex integration, while small and very small craft align more closely with commercial manufacturing and rapid-iteration production. Building this range of capabilities will require the U.S. to align industrial policy with emerging operational concepts such as DMO and the Navy's hybrid manned-unmanned fleet vision (O'Rourke, 2025b).

B. CURRENT STATE OF THE USV INDUSTRY

The US Navy has declared USVs as essential elements of its future force configuration in support of DMO operations. By enabling operations to go farther, be more lethal and operate at reduced risk to manned platforms, USV's fit well into the Navy's efforts (O'Rourke, 2025c; O'Rourke, 2025a). However, the industrial base does not come without longstanding issues, limited production capacity, a lack of skilled workforce, and supply-chain dependencies that will limit the scaling of prototype USVs to fleet-rate production (O'Rourke, 2025c). However, there has been development on increased vessel autonomy, modular payloads, and future energy systems as desired capabilities in unmanned systems, whereas recent national-level industrial policies on batteries, semiconductors, and shipbuilding may also begin to meet present-day alignment (Executive Order No. 14629, 2025). In summary, the USV industry is at an inflection point where the potential for industrial innovation and domestic policy will set the tone for whether the U.S. has the potential to create a mass, resilient, and attritable unmanned force.

Commercial maritime companies such as Saildrone, Ocean Infinity, and Sea Machines Robotics have capitalized on bridging the civil and defense markets by offering unmanned surface platforms across a variety of potential applications. The U.S. Navy formalized this area of industry development by issuing the USV Family of Systems program for the fiscal year (FY) 2024-2025 timeframe. DoD awarded a multiple-award Indefinite Delivery/Indefinite Quantity contract to 49 U.S. companies, including several of the top tier domestic shipbuilders, system integrators, and smaller autonomy startups in June of 2024 (DoD, 2024). A subsequent action expanded the vendor pool to 88 companies, in an effort to diversify the manufacturing, design, and sustainment work base (Wilkers, 2024). The following sections outline the current state of the U.S. unmanned maritime industry, examining its principal manufacturers, emerging demand signals, supporting infrastructure, supply-chain composition, and workforce dynamics.

Figure 8. Saildrone Surveyor-class USV. Source: Saildrone (2024).

1. Manufacturers

The U.S. USV industry for small- to medium-sized platforms is led by both commercial innovators and military-focused manufacturers. On the commercial side, companies like Saildrone produce small USVs, such as the Explorer and Surveyor classes, that operate globally for climate research, fisheries monitoring, and, increasingly, defense ISR missions (Saildrone, Inc., 2024). Sea Machines Robotics specializes in autonomy kits, which convert existing small vessels into unmanned maritime vehicles and are proven to comply with the 1972 International Regulations for Preventing Collisions at Sea (COLREGs). On the defense side, Saronic Technologies is developing small and medium-sized vessels (Spyglass, Cutlass, Corsair) with modular payloads optimized for distributed maritime operations (Vincent, 2025). Leidos continues to evolve its Sea Hunter lineage into medium USV programs, supporting the Navy's Medium USV efforts (Leidos, 2023). Anduril Industries is investing in maritime autonomy, extending into USV platforms integrated with larger distributed fleet concepts (Cha, 2025). With these manufacturers, production is slowly switching from one-off prototypes to modular builds to meet growing demand. The Navy's USV programs emphasize standardized hulls with modular payload bays, allowing parallel construction across different yards. For example, Defense Advanced Research Projects Agency (DARPA)'s USX-1 Defiant is constructed with an open deck system to easily load and offload modular payloads including the vessel's powertrain (Starr, 2025).

2. Demand

Defense: Admiral Samuel Paparo, Commander, U.S. Indo-Pacific Command, has said it takes years to build capital ships. If we want to change the calculus, we should focus on systems we can develop and integrate quickly, with a particular emphasis on unmanned systems, to "increase warfighting capability in the near term" (Rowley, 2025). The U.S. Navy's focus on medium- and small-sized USVs would seem to fit that bill, as their rapid, scalable production enables maturation to operational requirements faster and facilitates swarm tactics, creating demand for commercially available, affordable, and flexible solutions (Pettyjohn et al., 2024). Recent budget documents have highlighted that medium USVs would receive $100 million per year and that small USVs were finally funded in FY24 at $232 million (Rowley, 2025).

Commercial: Market research reports have stated that the "environmental monitoring, offshore energy, and scientific research commercial industry segments represent a sizeable growth segment for USV adoption because of their ability to gather real-time information at a lower cost and with a reduced risk than crewed vessels" (Fortune Business Insights, 2024). In a similar vein, a survey of USV applications has found that industry, academia, and government "interests are increasingly converging on environmental use cases as the field's most active, with sustainability and pollution response mentioned as key motivators to action and investment" (Patterson et al., 2022). A market analysis by Mordor Intelligence (2025) also predicted the commercial segment to be the one with the fastest growth. In one forecast, they predicted that while the defense segment accounted for 52.2% of the market in 2024, the commercial industry will have a CAGR of 14.8% until 2030.

3. Infrastructure

Infrastructure for small- and medium-sized USVs is shifting towards modular fabrication facilities, commercial boatyards, and waterfront test ranges, reducing dependence on traditional large shipyards (Dougherty & Diehl, 2025). In contrast to automotive startups that can leverage existing supply chains and contract manufacturers, many USV companies must establish their own infrastructure, leading to increased expenses (Dougherty & Diehl, 2025).

In February 2025, Saronic Technologies unveiled Port Alpha, an upcoming autonomous shipyard dedicated to the construction of USVs, to be deployed for use by the U.S. Navy (Valle, 2025). The shipyard is stated to resolve challenges associated with traditional shipbuilding practices, such as supply chain bottlenecks and manual labor constraints. These issues are to be addressed through complete automation and the implementation of new techniques and systems throughout the production process, facilitating greater scalability in the development of USVs. The shipyard is expected to be completed within the next 5 years (Valle, 2025).

4. Supply Chains

Supply chains for small- to medium-sized USVs are anchored by commercial off-the-shelf (COTS) components, autonomy software, sensors, and lithium-based power systems. In contrast to mature sectors like the automotive industry or conventional shipbuilding, which enjoy the benefits of large-scale, high-volume supply networks, the manufacture of USVs is driven by a fragmented ecosystem of specialized maritime hardware, propulsion, software, and sensor suppliers (Anonymous UMS Manufacturer, personal communication, July 10, 2025). This diversity elevates integration risk and poses significant supply-chain management challenges for companies that look to combine commercial off-the-shelf technologies with defense-level resilience (Dougherty & Diehl, 2025).

The DoD’s Lithium Battery Strategy (2023–2030), published in April 2024 for limited distribution to U.S. Government personnel and contractors, bears directly on these platforms, whose endurance is enabled by high-density energy storage systems (DoD, 2023). Dependence on imported cathodes, rare-earth magnets for electric motors, and electronics for battery management systems expose the supply chain for these advanced batteries to international events like geopolitical conflict or trade embargoes (U.S. Department of Energy [DoE], 2024). Vulnerabilities are derived from overreliance on foreign processing of critical minerals and materials and the existence of gaps in the supply of critical technologies. China's stranglehold on midstream lithium-ion battery production places it at the top of the global leaderboard, which could present risks for national defense supply chains related to unmanned systems, precision-guided munitions, EW, and other advanced military applications (DoE, 2024). The report's solutions include strengthening domestic manufacturing and building more robust international partnerships to ensure stable supply chains for these critical sectors (DoE, 2024). Mitigation measures include multi-sourcing autonomy hardware and cultivating domestic battery supply chains (Executive Order No. 14629, 2025).

5. Workforce

Decades of underinvestment in vocational education, an aging workforce, and competition from the private technology sector have hollowed out the defense industrial workforce, including key production skills across the defense industrial base, according to a report on the NDIA Vital Signs 2025 study. This hollowing out has degraded production capacity, innovation and the defense industrial base's surge readiness in a protracted conflict environment (NDIA, 2025b). Sectors like shipbuilding, precision machining, electronics, and composites are experiencing acute shortages that could further limit near-term industrial production capabilities as these labor forces are aging and prolonged security clearance vetting limits labor flexibility to fill roles in these industrial sectors (NDIA, 2025b). Competition from the private technology sector has also added additional headwinds for defense companies to compete for skilled labor, which has the advantage of higher pay and better work conditions. The workforce challenges facing the defense industrial base from a labor and skills perspective identified in the NDIA Vital Signs 2025 report were particularly damaging to the industry's production capacity, innovation, and its ability to maintain surge readiness in the long-term (NDIA, 2025b).

Linking workforce and supply-chain trends across NAICS sectors was accomplished through broad identifiers like shipbuilding (336611), electronics (334511), and composite materials (326199). Employment trends in these NAICS sectors are stagnant or declining while competition for talent is on the rise in each sector (Bureau of Labor Statistics, 2024). These labor forces are relevant to the USV manufacturing industry but are otherwise difficult to disaggregate because much of their skill sets (advanced composites lay-up, precision electronics assembly, systems integration) are being shared with adjacent industries that are also experiencing workforce shortages themselves. The USV workforce thus depends on cross-sector labor mobility or training pipelines that are currently immature compared to legacy shipbuilding or aerospace programs (Dougherty & Diehl, 2025).

C. ATTRITABILITY

Attritability is a defining concept for the design and employment of UMS. In defense planning, attritable platforms are those that combine low unit cost with sufficient capability to justify deployment in high-risk environments where losses are expected (Sayler, 2025). Compared to exquisite, high-value platforms like nuclear-powered submarines or Aegis destroyers, attritable vessels can be produced on a larger scale, employed in great numbers, and replaced rapidly, meaning that force structures can take losses during combat without incurring high strategic costs.

Recent conflicts demonstrate the relevance of attritability. Ukrainian low-cost explosive USV made from commercial off-the-shelf components provided a strategic effect against Russia's Black Sea Fleet by imposing costs on its operations despite potential countermeasures, such as jamming, and relatively limited endurance (Pettyjohn et al., 2024). These events demonstrated the scalability of this type of attritable USV in influencing naval warfare, aligning with U.S. Navy concepts for the future fleet that aim to utilize rapid production of modular systems to generate mass as part of future strategies to counter adversary capabilities in contested maritime environments (Kline, 2025; Pettyjohn et al., 2024).

D. HYBRID AND FUTURE FLEET

The U.S. Navy is in the process of a paradigm shift in its naval force design with the development of the hybrid fleet. The hybrid fleet will comprise unmanned maritime systems that will be an integral part of the naval warfighting in the distant future as well as the Navy's immediate near-term plans for littoral warfare (Kline, 2025). The hybrid force will have a world-class, decisive warfighting capacity; distributed sea control; and a capacity to integrate into and interoperate with joint and allied forces (Vandenengel & Kline, 2025). It will be a force designed within the limitations of resources and force design considerations (Rowley, 2025). Figure 9 illustrates the Navy's shortfall in meeting shipbuilding targets; consequently, attention has shifted toward UMS undertaking high-risk missions to facilitate entry for larger platforms into vital maritime routes (Kline, 2025). In so doing, it not only fundamentally reframes ship numbers as a ratio between attritable and high-value capital ships but also weaponizes this relationship by favoring offense over defense through missile- and drone-centric armament designed to help U.S. forces control the seas and deny them to rivals (Vandenengel & Kline, 2025). The future fleet addresses global commitments and allied mission-sharing for less-critical operations through a streamlined, robust fighting force designed for intense naval conflicts.

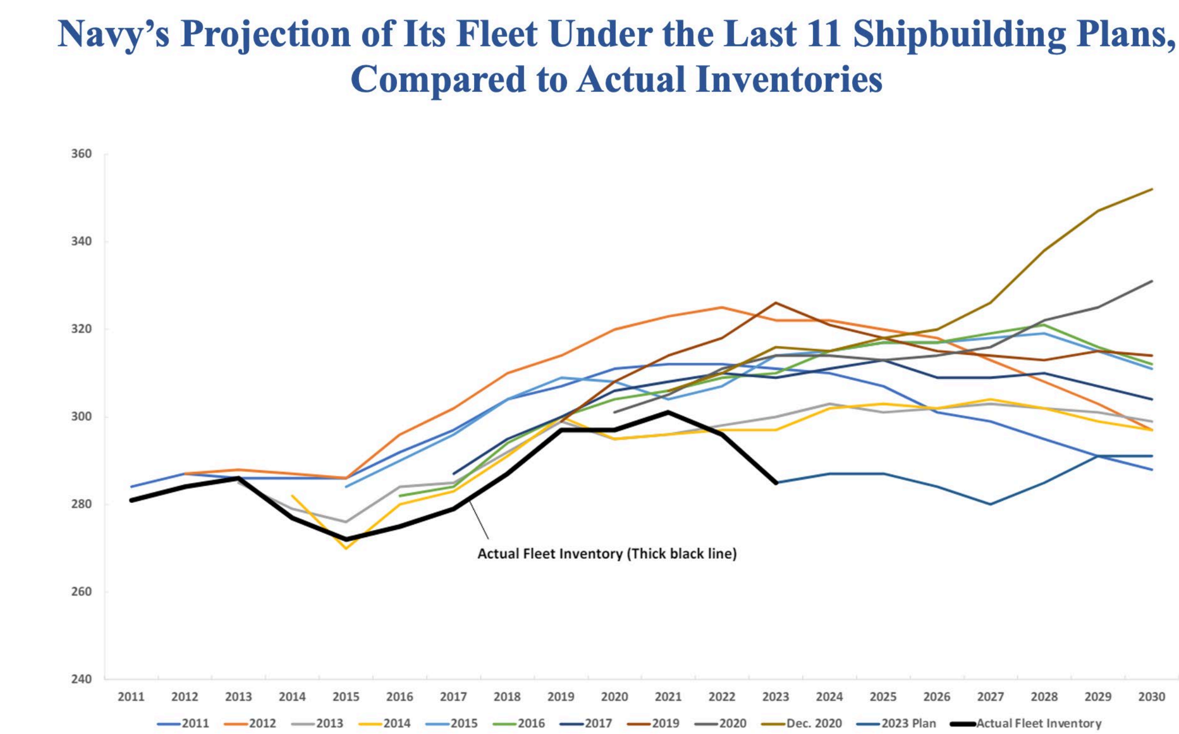


Figure 9. The 2023 outlook for Navy shipbuilding. Source: Labs (2023).

UMS serves as both a critical component and a primary facilitator for hybrid fleet strategy, functioning as a key mechanism enabling risk transfer and operational expansion while maximizing scalability and logistical power in disputed maritime regions. USVs and UUVs support A2/AD operations through standoff missile launches and ISR across distributed lethal strike networks, enabling the protected deployment of manned fleets to sea lanes (Kline, 2025). As outlined in INDOPACOM's recent posture statement, USVs are key enablers for providing significant and affordable asymmetric advantages, including persistent surveillance and reconnaissance in contested waters, with expanded acquisition of such systems critical for full deployment in the region (Paparo, 2025). The use of UMS to target specific naval platforms in Ukraine's Black Sea fleet operations emerged as a critical learning element for achieving disproportionate naval advantages against potent adversaries, which indicates possible strategic benefits for attritable mass systems to counter advanced A2/AD threats encountered by the U.S. Navy (Pettyjohn et al., 2024). This, in turn, allows the fleet to spread its risk across a fleet of attrittable yet capable platforms, keeping manned ships off the most threatening missions where possible.

IV. METHODOLOGY

This study uses a qualitative research design to assess the findings presented in the literature review on scaling the U.S. industrial base for small- to medium-sized USVs. In combining secondary data from government and industry reports with primary data through semi-structured interviews and manufacturers' input, this study will uncover industrial bottlenecks and capabilities as well as draw actionable conclusions for recommendations in industrial resilience.

The purpose of this chapter is three-fold: First, the "industry engagement" section highlights the authors' use of stakeholder interviews in this study to account for industry perspectives on both current production constraints and manufacturing opportunities. Second, the "Data collection summary" section will report on a bill of materials (BOM) dataset used in this study, detailing how the information on material composition and sourcing for a USV platform will inform scalability considerations.

A. INDUSTRY ENGAGEMENT

Industry engagement has provided an important primary source of evidence in this case study. Semi-structured interviews with two anonymous USV manufacturers were conducted and included complementary information from meetings and discussions with defense officials and industry representatives. Structured around a set of open-ended questions, the interviews have been directed at eliciting responses about both the potential of and constraints manufacturers see when it comes to expanding production of attritable platforms.

B. DATA COLLECTION

The second source of primary data in this study was a BOM provided by one of the interviewed manufacturers. The dataset was a list of components assembled for a particular project by the manufacturer, including supplier part number, detailed description, quantity used, and a unit of measure. The use of a BOM as an open reference for a platform's material requirements and procurement sources allowed for a high degree of transparency and reproducibility (due to the dataset's structured form), thus making it possible to reliably trace and cross-reference parts and materials used in USV construction.

Combining information provided by the manufacturer BOM with other industry reports from DoD, CRS, and NDIA, this study was able to analyze both the micro-level detail of UMS component requirements, and the macro-level industry dynamics that shape the defense industrial base. This multi-perspective approach to data collection should, in theory, ensure that the reliability of the study's conclusions is high and its recommendations are both operationally sound and strategically informed.

V. ANALYSIS AND FINDINGS

This chapter draws on industry engagement, a Bill of Materials (henceforth, BOM), and an assessment of relevant policy frameworks to evaluate the U.S. defense industrial base's ability to scale up USV production. It combines quantitative and qualitative methods to connect empirical data from manufacturers with the broader knowledge base of defense industrial resilience.

Key vulnerabilities are found to be consistent across scalability, data transparency, and dependence on foreign technologies and suppliers. Analyses from Center for a New American Security (CNAS) offer concrete actions to address the gaps and shore-up U.S. maritime strength to power future fleets (Pettyjohn et al., 2024). Secondary research from the National Defense Industry Association (NDIA) and Congressional Research Service (CRS) underlines the need for measurable improvements in supplier diversity, modularity, and access to capital (NDIA, 2025a; Sayler, 2025). These diverse voices synthesize the following themes: At the center of scaling decisions is the ability of the U.S. defense industrial base to keep up with the anticipated demand for attritable systems (Executive Order No. 14629, 2025). The Replicator effort and the effort to scale up the maritime industrial base more broadly have made clear that technological breakthroughs and investment alone will not be enough.

Industry engagement was an important part of the research process and the internal validity of this study. To respect the trade secrets of our industry partners, we henceforth identify them as Manufacturer 1 and Manufacturer 2. Both indicated that the challenges they described are not idiosyncratic technical failures but characteristics endemic to a fragmented, siloed, and poorly connected maritime industrial base, which we illustrate below.

A. CHALLENGES IN USV INDUSTRIAL BASE

The U.S. is, in the opinion of both manufacturers, a leading user and developer of USVs and maintains a highly developed research infrastructure. However, the U.S. industrial USV base remains relatively small. Feedback from interviews and site visits revealed several common themes regarding weaknesses in the industrial base that have affected the U.S. response to date and that need to be addressed if the U.S. is to industrialize the production of USVs going forward.

These weaknesses, based on industry perspectives and presented in no particular order, include:

(1) a fragile and thin supply-chain

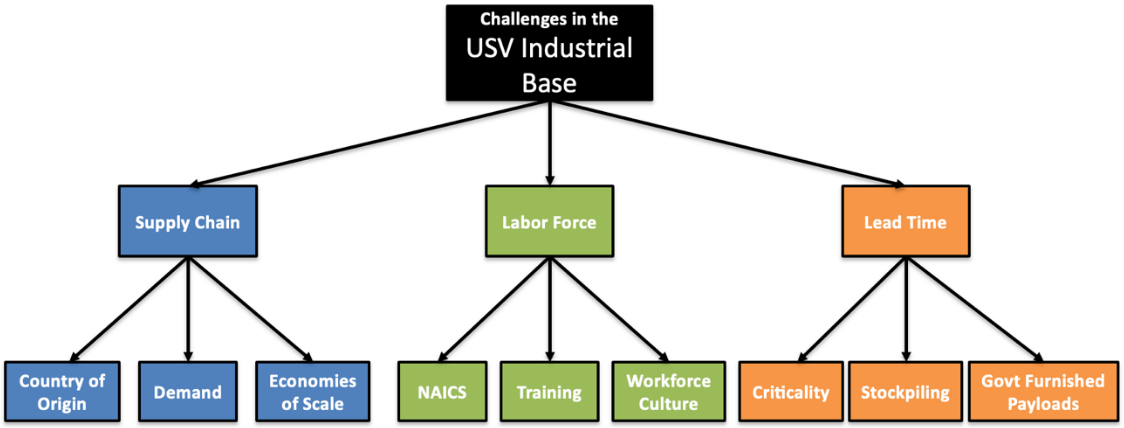
(2) Gaps in a competitive and specialized labor force, and

(3) long lead times and other hurdles that limit rapid scale-up from prototype to production.

The current regulatory and business environment creates excessive - from the manufacturer's point of view - hurdles to market participation. This especially hurts smaller manufacturers because of limited access to information about federal investment programs, as well as hurdles to the ability to contract with the government, which also limit their ability to be responsive and agile in a rapidly changing environment.

The U.S. shipbuilding infrastructure specializes in producing warships but lacks the flexibility needed to produce modular unmanned systems that require rapid reconfiguration. The U.S. industrial base is incentivized to function under traditional production cycles – such as the '30-year shipbuilding plan' instead of the responsive, flexible systems needed for rapid scaling of USVs.

Figure 10 summarizes the systemic challenges the industry is facing. As shown, supply chain, labor force and lead-time dynamics interact to frame the resilience and scalability of the U.S. USV industrial base.



This figure points to three major issues which we examine below; supply chain, labor force, and lead time, which in many ways is the synthesis of the first two.

Figure 10. Mapping the Challenges, 2025.

2. Supply Chain

The supply chain is the foundation of the U.S. USV industrial base and represents the most immediate limiting factor to increased production. Despite having the innovative capacity at the firm-level, the supply chain has numerous bottlenecks when it comes to the supply of the necessary materials and components, as well as overall production capacity.

For purposes of analysis, we have divided this into three parts. First, the origin of the nation from which a component is sourced from is a factor for many manufacturers due to the associated geopolitical and supply-security risks and how they impact decisions to source materials and comply with DoD defense acquisition policy. Second, demand signals received by these suppliers are hampered by uncertain procurement quantities and ambiguous timelines of Navy programs, which creates inefficiencies in supplier planning and investment into the supply base for longer-term production. Third, most production is what traditional procurement refers to as "LRIP" – Low Rate Initial Production. However, because of the innovation cycles of USVs in the current market, most systems are obsolete before they could ever reach a traditional production profile. Thus, lacking the benefit of economies of scale to reduce costs through industry learning, and it has not transitioned from prototype-rate production to serial production. This is, in our analysis, the main reason why increased U.S. industry production for assembly (an integration task) will not unilaterally solve the production problem, as it does not address the problem from the supply perspective. Without stable demand profiles, the ability to source needed parts to continue production is not guaranteed, despite increased domestic capacity. We now address these risk factors in turn:

a. Country of Origin

Reliance on foreign technologies and suppliers is one of the most significant constraints on expanding the U.S. USV industrial base. The literature supports this finding and also validates the primary research question. The CNAS report notes that attritable USVs are currently held back by “fragmented infrastructure, vulnerable supply chains, and foreign-sourced components,” the very gaps that the survey is designed to uncover (Pettyjohn et al., 2024). NDIA likewise identified “supply-chain choke points continue to constrain production speed and resilience within the U.S. maritime industrial base” (NDIA, 2025b). At the national level, the National Security Commission on Artificial Intelligence (NSCAI) went further in its warning, stating that the U.S. is dependent on foreign, especially Chinese, sources of microelectronics, lithium batteries and other AI-enabling components, and that the current situation represents a foundational national-security risk (NSCAI, 2021). These three sources together show that the problem of foreign dependency is not only a maritime autonomy problem, but a systemic one for the larger U.S. defense technology base.

CNAS reports that one of the places where the United States falls behind China is in drone production, specifically in ruggedized systems capable of enduring trans-Pacific distances (Pettyjohn et al., 2024). Manufacturer 1 (interview with author, October 16, 2025) and Manufacturer 2 (email to author, October 6, 2025) confirmed this challenge in field data, citing consistent needs for Asia-based suppliers for high-value subsystems (battery technology, semiconductors, propulsion assemblies) (Manufacturer 2, email to author, October 6, 2025). Some companies even note that they emphasize U.S. final assembly (Manufacturer 2, email to author, October 6, 2025), yet the subcomponent landscape remains globalized and affected by “external supply-chain choke points” (NDIA, 2025b), giving the appearance of ‘Made in America’ but actually with critical overseas dependencies. Dependence on multinational suppliers leaves these production timelines vulnerable to single-point failures and geopolitical risk. This pattern mirrors NSCAI’s assessment that U.S. defense platforms often rely on domestically assembled systems built around foreign-made technological cores.

Manufacturer 2 (email to author, October 6, 2025) also reported that some propulsion and sensor subsystems within their UMS products still use imported components. This data point corroborates the overall conclusion that foreign-sourced parts remain a key bottleneck to scaling domestic USV production. Manufacturer 1 (interview with author, October 16, 2025) also underscored the challenge by stating that “designing for defense also means designing domestically,” the primary way in which U.S. scalability is distinguished from other centers of production. It is true that firms such as Volvo Penta have U.S. production facilities and partner with U.S. prime contractors, but the existence of foreign parent companies and tiered supplier networks muddy the definition of “domestic production,” making DPA and industrial-base expansion funds less clear-cut (Manufacturer 1, interview with author, October 16, 2025).

The combined effect of these conditions is both a resilience factor and a driver of short-term COTS technology use over wholly bespoke production. Manufacturer 1 also emphasized that the U.S. still has limited capacity for aluminum hull fabrication and few high-volume suppliers for other lightweight marine structures, adding that, “If we’re really going to get into designing domestically, we need to have a supply chain for a lot of these components within the country as well, otherwise they still require foreign suppliers.” (interview with author, October 16, 2025). ”. Manufacturer 2 (email to author, October 6, 2025) also returned to the point that, while a U.S. final assembly would be possible, imported microcontrollers and lithium modules remain a requirement to deliver on power and performance specifications.

To be successful in the mid- to long- term, the United States needs to decrease its dependence on foreign countries for major components in USVs to prevent critical production delays during a crisis. CNAS points to the need for expanding and incentivizing domestic alternatives in the current landscape, which features high dependencies, particularly on Chinese parts and manufacturers (Pettyjohn et al., 2024). The vulnerability is further detailed by Rogin (2024), who discusses U.S. hypersonic-defense and satellite program shortfalls due to People's Republic of China vendors. Manufacturer 1 (interview with author, October 16, 2025) added that capital-backflow requirements and contracting requirement was cancelled or delayed, have also hindered onshoring of long-lead items and pushed firms into the arms of foreign vendors that offer financing and bulk-pricing options. These incentives function as a kind of structural market failure rather than a purely technological barrier, preventing the industrial base from true self-sustainment. As NSCAI notes, such foreign cost advantages distort market behavior and create long-term dependencies that erode U.S. technological competitiveness.

Government programs and investments in domestic alternatives are taking place, however. The DoD Lithium Battery Strategy (2023–2030) allocates $43 million to onshoring battery manufacturing (DoD, 2023), and the Defense Innovation Unit (DIU) Family of Advanced Standard Batteries (FAStBat) initiative is designed to fund new interchangeable energy modules (DIU, 2023). These may smooth the transition even if the cost of early production runs increases by 20 to 50 percent. Both Manufacturer 1 and Manufacturer 2 concurred that these types of programs were helpful but again noted that the long procurement timelines must be shortened to match commercial production cycles (Manufacturer 1, interview with author, April 29, 2025, and October 16, 2025; Manufacturer 2, email to author, October 6, 2025).

Sourcing vulnerabilities also affect manufacturer response to and interpretation of demand signals. Both Manufacturer 1 and Manufacturer 2 stated that uncertainties in component availability and sourcing risk create disincentives for long-term contracting and investment into expanded capacity. For smaller companies, volatile procurement timelines make it difficult to plan production windows or to justify the costs of scaling. This instability compounds supply-chain fragility and limits the current U.S. USV industrial base's ability to respond to future demand (Manufacturer 1, interview with author, April 29, 2025 and October 16, 2025; Manufacturer 2, email to author, October 6, 2025).

b. Demand

In order to increase the resilience of the supply-chain, as well as to support a developing USV industrial base, demand must be both stable and predictable. In this sense, past policy levers in the form of executive actions to boost shipbuilding could also be employed in developing demand for smaller unmanned vessels and expediting decision-making timelines. Moreover, in order to move the USV sector from boutique prototyping to scale production, demand signals must be sustained and predictable over a long horizon. This concept has a direct line of sight to industrial base health, as firms cannot commit capital to tooling, workforce expansion, or material purchases in the absence of continuity of orders.

Interviews with Manufacturer 1 (interview with author, April 29, 2025 and October 16, 2025) and Manufacturer 2 (email to author, October 6, 2025) found that the single greatest inhibitor to long-term industrial commitment is the perceived procurement horizon. As one manufacturer noted, their demand signal from the government is "episodic" or "project-based," leading to incentives for minimal inventory and short-duration contracts rather than scalable, long-term production capacity (Manufacturer 1, interview with author, October 16, 2025).

The DoD has assigned the Replicator program with an important role in closing this industrial base gap. Its stated goal is to "produce unmanned fleets, including maritime platforms, at an accelerated pace with Ukrainian-like adaptability of innovation and field-driven integration" (Pettyjohn et al., 2024). In this regard, it will be the first Pentagon effort to tie tactical innovation to industrial responsiveness, with the idea that demand will be created through demonstration, with combat utility driving production momentum (Manufacturer 1, interview with author, October 16, 2025).

In August 2025, the CRS published an updated Replicator report, which noted that the program had yet to meet its initial objective of fielding thousands of systems, but also that the program was making progress in selecting the second tranche of Replicator 1 awards and narrowing its focus under Replicator 2 to prioritizing counter-small uncrewed aerial systems operations. The report noted similar challenges to those of the Manufacturer

1, such as limited transparency, acquisition barriers, and operational security restrictions (Sayler, 2025).

Executive Order No. 14629 (2025) takes these factors into account. In addition to implementing other policy measures discussed above, such as the "Buy American" preferences and Section 3203 reform, Executive Order No. 14629 takes a significant interest in expanding the maritime industrial base and the necessary material and manufacturing capacity. Among several initiatives, it orders studies on how to leverage DPA Title III investments, as well as private capital, to build out industrial shipyards and supply chains. The Executive Order also tasks DoD with recommending two management tools for this transformation: the Maritime Security Trust Fund and the Shipbuilding Financial Incentives Program, both of which would create reliable funding streams or offer grants and loans adaptable to USV-oriented facilities. These efforts, working in conjunction with policy measures outlined above, represent a DoD-wide shift from reactive procurement to proactive industrial stewardship, reflecting recommendations from organizations such as NDIA on sustained and long-horizon government demand signals to maintain production-line readiness (NDIA, 2025b).

CRS similarly puts Replicator in broader context by noting that the characteristics of attritable systems, including AeroVironment's Switchblade-600, could enable new tactics such as swarming, or the independent or semi-independent operation of autonomous platforms in coordinated and distributed formations (Sayler, 2025). This platform-agnostic approach to procurement and production is consistent with the Navy's evolving operational concepts of note, particularly DMO and EABO, where demand generation is directly related to distributed lethality and the employment of attritable mass (Manufacturer 1, interview with author, October 16, 2025).

Policy levers noted in Executive Order No. 14629 (2025) "Restoring America's Maritime Dominance" also target supply-chain competition, by mandating tariffs on Chinese equipment, close coordination on trade policy with allied partners, and financial incentives for private investment in domestic production facilities. The CRS report on Replicator similarly puts Replicator in the context of the need to build up the U.S. drone industrial base and become less dependent on foreign sources, and cautions that transparency gaps and funding trade-offs could undermine the program's long-term independence (Sayler, 2025). In conversations with the two interviewed manufacturers, both Manufacturer 1 and Manufacturer 2 expressed skepticism that the declaration of policy intent in itself would result in industrial throughput if not directly accompanied by committed contract volumes and rapid funding execution (Manufacturer 1, interview with author, April 29, 2025 and October 16, 2025; Manufacturer 2, email to author, October 6, 2025).

c. Economies of Scale

Transitioning the U.S. USV industry beyond prototype development and toward persistent manufacturing also depends on achieving economies of scale. Expanding USV production in volume drives down unit costs, stabilizes the supply chain, and hastens industrial learning necessary to field affordable, attritable fleets at speed. In this context, the most credible means of delivering scalable USV industrial capacity revolve around three interrelated policy levers: modularity in design and acquisition, standardization of components and interfaces, and adaptive acquisition frameworks (Pettyjohn et al., 2024; Executive Order No. 14629, 2025). In combination, these levers enable streamlined interfaces and interoperability across sub-systems, facilitate modular production lines for defense and commercial manufacturers, and support manufacturing scalability and flexibility.

The Government Accountability Office's (GAO's) program report on the Replicator program concluded that funding shortfalls and acquisition hurdles had impeded the fielding of thousands of attritable systems by August 2025 (Sayler, 2025). In its 2025 Vital Signs report, the NDIA (2025b) also found that the U.S. defense industrial base continued to face segmented, incompatible infrastructure and regulatory impediments that hamper the scalability of systems, including USVs. The report called on the government and industry to share risk equitably and build resilience, and, in related efforts, NDIA's Emerging Technologies Institute (ETI) has focused on accelerating prototype programs in ways that build on existing facilities and capacity (NDIA, 2025a). Industry interviews reflect similar and related findings in Manufacturer 1's and Manufacturer 2's responses that U.S. manufacturers are able to innovate at the prototype level and are quickly able to iterate on new designs with commercial customers but have not received commensurate levels of demand from the U.S. government to justify making investments into tooling, modular-line expansions, or other quality-assurance certification (Manufacturer 1, interview with author, April 29, 2025 and October 16, 2025; Manufacturer 2, email to author, October 6, 2025).

In an interview (April 29, 2025), Manufacturer 1 highlighted their company's internal capabilities and external support in manufacturing, which includes an emphasis on innovation, a focus on quality-assurance processes, a commitment to modularity and sustainability in production, and continued internal investment. Nevertheless, the company expressed the same concern that fielding serial production USVs could come at the expense of reliability without modular components and standardized interfaces or orders in consistent volumes. Manufacturer 2 (October 6, 2025) noted modular integration across propulsion, sensor, and communications as a major bottleneck caused by the evolving nature of government requirements and shifting acquisition timelines. Industry interview feedback thus far suggests that intractable barriers to modular integration among USV sub-systems may continue to prove difficult to surmount.

Executive Order No. 14629 (2025) has responded to some of these industrial infrastructure disparities with the Maritime Prosperity Zones intended to incentivize private investment in emerging areas of capability and counterbalance industrial bottlenecks. Both Manufacturer 1 and Manufacturer 2 have seen the Maritime Prosperity Zones as potentially catalytic if implemented alongside specific investment incentives in dual-use infrastructure that can handle both commercial and defense unmanned-platform production (Manufacturer 1, interview with author, April 29, 2025 and October 16, 2025; Manufacturer 2, email to author, October 6, 2025). In sum, the emerging set of policies across both government and industry indicates a clear understanding and pathway of making better use of extant facilities through adaptable, modular factories that can scale based on current demand.

A final frontier for scalability resides in emerging domains of digital engineering and manufacturing. Academic and industry research has confirmed the importance of digital-twin modeling, additive manufacturing, and open-architecture autonomy frameworks that support component reuse across a range of hull-forms (Manufacturer 1, interview with author, April 29, 2025 and October 16, 2025; NDIA, 2025b). This burgeoning industrial ecosystem is contributing to USV innovation at speed through a combination of 3-D printing custom components and artificial-intelligence-enabled decision tools that can help accelerate design iteration and certification. Thornberry (2025) notes that NDIA's ETI is seeking to bridge this capability in part with research into AI-assisted prototyping and acquisition to harmonize development across unmanned domains. In other words, economies of scale ultimately depend on modular production methods and rapid innovation in engineering and manufacturing capabilities but also on the human capital available to support and sustain them. As scalable production capacity expands, how well U.S. institutions cultivate and attract the talent required to work in advanced manufacturing, systems integration, and quality assurance (QA) will go a long way toward determining the country's ability to rapidly increase USV output.

3. Labor Force

Modularity and acquisition reform may set the conditions for production to grow, but the industrial workforce will ultimately determine if the U.S. can keep pace over the long term. Scaling industrial capacity demands a skilled and flexible workforce to close the gap between prototype development and serial production. However, as is evident from existing data, the labor bottleneck has emerged in many ways to mirror material and financial shortages in becoming a constraint on USV expansion. This industrial workforce lens is broken into three complementary domains: (1) NAICS-based workforce profile, which measures the overall size and skillset allocation in each key segment of manufacturing employment; (2) training gap, which evaluates the impact of the current institutional supply chain on preparedness and capacity; and (3) industrial workforce culture, which analyzes the behavioral and structural changes necessary to incentivize and align skilled trades, leadership, and acquisition communities with the workforce demands of autonomous shipbuilding. Cumulatively, these three areas frame the importance of renewing the human aspect of production as a key to unlocking the scale and robustness necessary to reach the Navy's hybrid-fleet vision.

a. *North American Industry Classification System*

NAICS data are an objective way of understanding where labor shortages and constraints most stress the U.S. industrial base. By creating a top-level, picture of the industrial base by industrial activity, NAICS codes identify the industries involved in producing USVs; by mapping components to these sectors and then applying additional data, such as workforce availability, specialization needs, or existing production load, it becomes possible to assess which portions of the manufacturing base are most stressed when scaling from prototypes to serial production.

NDIA's Vital Signs 2025 report finds persistent labor shortages to be a defining constraint on the defense manufacturing base and indicates that these gaps are most acute at the three-digit NAICS subsector levels 325 (Chemical Manufacturing), 326 (Plastics and Rubber Products Manufacturing), and 334 (Computer and Electronic Product Manufacturing), all of which have a foundation in propulsion and composite manufacturing as well as sensor integration for USV platforms (NDIA, 2025b). Furthermore, the report notes that absent new training pipelines and an explicit effort at cross-sector collaboration to share skilled labor, these skills gaps will continue to bottleneck manufacturing throughput even where there is sufficient material and capital exist to produce at scale.

Manufacturer 1 and Manufacturer 2 both noted that significant gaps in composite manufacturing, precision electronics, and systems integration have been, and continue to be, a production bottleneck for both firms, and both attribute these gaps to workforce attrition, an aging skilled workforce, and a lack of vocational training pipelines (Manufacturer 1, interview April 29 and October 16, 2025; Manufacturer 2, email October 6, 2025). Both manufacturers reported success in recruiting software and AI engineers, but persistent challenges in recruiting and retaining composite technicians, systems integrators, and marine electricians, all of which are core to scaling physical output.

This digital-first skills gap has created an unbalanced labor market, where hands-on manufacturing capacity (vs. software-centric design and integration) is the scarce resource. NAICS-based output for industry subsets such as NAICS 334418 (Printed Circuit Assembly Manufacturing) and NAICS 326130 (Laminated Plastics Plate, Sheet, and Shape

Manufacturing) report some of the lowest unemployment rates across the nation (US Bureau of Labor Statistics, 2025c). Therefore, narrow labor markets in these production areas have the effect of exacerbating lead-time and capacity risks throughout the USV supply chain. Production schedules become dependent on a small pool of qualified specialists, such that localized skill shortages can easily ripple outward and create nationwide shortages.

The interview participants also noted a lack of standard apprenticeship programs and defense industry-recognized credentials, which they saw as a direct contributor to lack of cross-sector workforce mobility between commercial and naval subsectors (Manufacturer 1, interview April 29, 2025). This directly aligns with NDIA's (2025b) call for public-private "dual-use" certification programs to allow skilled labor to move from defense to commercial sector (and vice versa) without onerous requalification or security clearance time delays.

These results suggest that resilient workforce development is foundational to the industrial base's adaptive capacity. Ensuring the health of the U.S. manufacturing base with regard to UMS production thus requires both top-level, quantitative labor force forecasting anchored in NAICS sector output and bottom-up, qualitative investment in skilled labor education, training, and retention pipelines to ensure that labor market bottlenecks do not upend strategic readiness (Manufacturer 1, interview October 16, 2025).

b. Training Requirements

The maritime-autonomy industrial base is another example of a sector still in its adolescence when compared to mature aerospace or automotive industries. There are no standard training, certification, or credentialing pathways for personnel in USVs. The maritime-autonomy workforce has evolved through ad hoc training, on-the-job instruction, and informal knowledge transfer. As a result, each firm has its own learning curve, with serious implications for safety and quality management.

According to Manufacturer 1, "The new techs coming in have mechanical skills, but they require a couple of months of cross-training to produce the composite lay-ups, do the sensor wiring and connections, and the closed-hull integration that makes UMS what it is.” (interview with author, April 29, 2025 and October 16, 2025). Manufacturer 2 concurs: “While we can attract very capable engineers, we do not have a reliable feeder system to provide us with certified and qualified composite technicians and marine-systems technicians who will be able to hit the ground running to support a continuous serial build.” (email to author, October 6, 2025). The NDIA Vital Signs 2025 report concluded that new, emerging defense sectors that lack training standards have workforce readiness and productivity bottlenecks, as reflected in industry interviews (NDIA, 2025b). Interviews with Manufacturer 1 and 2 confirmed the NDIA observation and noted that, to date, there are no maritime equivalents of commercial programs, like the Federal Aviation Administration’s (FAA) Airframe and Powerplant license or Department of Labor’s Registered Apprenticeship Program, that could cover robotics, autonomy, and naval-systems integration.

The result is that each company is left with significant training costs and schedule risk because onboarding and training are part of the production schedule. Both NDIA’s research and the manufacturer interviews found common ground in suggesting the creation of dual-use apprenticeship pipelines in cooperation with technical schools and regional shipyards that focus on developing transferable skills in composites, electronics, and autonomy integration (NDIA, 2025b; Manufacturer 1, interview with author, October 16, 2025).

Until the maritime-autonomy sector formalizes training and certification standards, the U.S. is likely to continue to struggle with uneven capacity and quality control, further delaying the expansion of attritable-fleet production to the rate required by demand. But standard training pipelines are only part of the solution. A longer-term requirement is a cultural transformation of how the skilled trades, industry leaders, and government stakeholders view their roles in an autonomous maritime enterprise.

c. Workforce Culture

Workforce culture change will be just as important as technology development in scaling UMS production. In the Navy, it will also likely signal a change in the way sailors, civilians, and industrial teammates view their relationships with autonomous platforms and their roles in the future hybrid fleet.

Crewing the hybrid-fleet design by emphasizing UMS allows the Navy to simultaneously meet many of the broad operational goals it has articulated, by reducing manning levels and risk exposure, and enabling service members to focus on higher-value analytical and maintenance tasks (Kline, 2025). Manufacturer 1 (interviews with author, April 29 and October 16, 2025) commented that many qualified workers, even in the skilled trades, view shipbuilding as being synonymous with legacy manned platform construction and manning, and it can be difficult to draw them into UMS programs. Culture change will be required through clearly defined career paths, re-skilling and certification for automation-specific skills, and acceptance of "uncrewed" production work as a career.

Manufacturer 2 (email to author, October 6, 2025) noted that government-side changes are also needed; program managers and contracting officers are often focused on the large-deck, 30-year service life acquisition pace and risk-averse culture, but UMS workforce sustainment will require rapid-iteration manufacturing practices comparable to those in the commercial robotics and aerospace industries. Inculcating modularity in not just technical design but in organizational processes and training will help address workforce shortages while providing flexibility across the UMS industrial base, with a modular workforce that spans mechanical, electrical, and software disciplines being necessary in the hybrid-fleet environment.

Changes in UMS work-culture acceptance are as much about naval leadership, the industry supply chain, and the skilled trades redefining "shipbuilding" as about the technologies needed to field a hybrid fleet. Digital, data-analytics, cross-domain tradecraft, and high adaptability are all qualities that will be valued in an industrial workforce that can realize, field, and sustain UMS as the new normal of American maritime power.

4. Lead Time

Lead time, or the period from production start to the delivery of fielded capability, represents an important metric of the U.S. ability to translate industrial base capacity into fielded readiness. Although supply-chain robustness and access to a trained workforce are important enablers of manufacturing capacity, the pace of production governs if and how that capacity keeps up with the cadence of current conflict. A fast production pace for unmanned platforms to achieve fielded levels of readiness is as important in the Navy's hybrid fleet as their initial procurement. This subsection looks at lead time with three main focus areas: (1) criticality, or the importance of rapid production to the maintenance of maritime operations; (2) stockpiling of materials as a buffer against procurement delays; and (3) government-furnished payloads, whose production timeline affects the delivery timeline for the final payload-integrated system.

a. Criticality

In the USV supply chain, criticality is a measure of the extent to which the completion of a build is depends on one or more components and subsystems. Critical components, like propulsion modules, energy-storage systems, control processors, and sensor payloads, have no substitution and are thus the chokepoints of the build process. Build stops if critical components are unavailable, even if other aspects of the platform are ready or in process. In interviews, both manufacturers singled out component criticality as the primary driver of schedule risk and the main contributor to lead time.

Manufacturer 1 (personal communication to author, April 29 and October 16, 2025) observed that critical propulsion and control systems have "zero workarounds". Alternate parts, suppliers, and designs cannot be integrated once an assembly line has been started; any disruption in the supply of these components immediately stalls all build activities, regardless of the status of the hull, composites, or hardware build. Manufacturer 2 (personal communication to author, October 6, 2025) concurred, and reported that for several propulsion and sensor subsystems, imported components are still required, and a single late shipment can "idle an entire line for weeks."

These statements are consistent with NDIA's (2025b) finding that supply chain concentration in a very small number of highly specialized component vendors wields outsized power over defense production capacity, and that these chokepoints are largely found in the propulsion, battery, and microelectronics industries. These bottlenecks ensure that a small subset of components typically contribute more than their share to the total build time of a single platform.

The criticality of individual parts is also visible in field data from the BOMs. Structural and composite components are either all domestic or otherwise available from multiple vendors, but advanced electronics, lithium modules, and many sensor assemblies are imported. PCBAs, servo actuators, and navigation processors are recurrent single-source dependencies, among other parts. Component-level criticality is in many cases a stronger lead-time driver than facility or workforce capacity.

Both manufacturers suggested that greater modularity and interchangeability of USV components could lessen this dependency. By standardizing interfaces and offering multiple redundant options for subsystems, partial builds could be completed even when specific components fall behind schedule. As Manufacturer 1 put it, "We can build three boats' worth of hulls, but if the propulsion and control package doesn't arrive, none of them can sail" (personal communication to author, April 29, 2025).

In this sense, criticality acts as a bottleneck for maximum achievable throughput. To expand UMS production capacity, any program designed to address lead time must focus on diversification and modular substitution for the most time-critical and technically constrained components. Through a combination of domestic sourcing, alternative vendor qualification, and forward stocking of material, component criticality is the first lead time driver to be addressed.

As discussed above, the identification of high-criticality components signals the need for pre-positioned component stockpiling to hedge against supply risk. In a supply chain where propulsion systems, batteries, or sensor modules can be a single point of failure, short-duration procurement disruptions can result in idle production lines and lost surge capacity. To anticipate these effects requires not only supplier diversification, but also component stockpiles and material reserves tailored to and sufficient for a component's assessed criticality.

b. Stockpiling

In parallel with operational readiness, strategic stockpiling is the industrial-base analogue for the USV portfolio. Manufacturers keep critical components in inventory against production ramp-ups or international supply chain interruptions. Forwarding the supply chain for risky or long-lead materials and subcomponents can compensate for lead times inflated by the acquisition process, particularly in propulsion, energy storage, and electronics assembly. The problem, of course, is that today's USV industrial base simply does not have the liquidity, storage capacity or reliable demand signal to facilitate stockpiling at scale, resulting in the practice being far more aspirational than it is regular and production schedules remaining vulnerable to long-lead imports and foreign sourcing risks.

Manufacturer 1 (interviews with author, April 29 and October 16, 2025) cited stockpiling of long-lead items as critical in the face of currently observed six-month import delays, especially for lithium-ion batteries, PCBAs, and composite laminates, which are still sourced from Asia. Manufacturer 2 (email to author, October 6, 2025) also highlighted that simple stockpiles of propulsion modules and sensors, even at minimal buffer levels, allow for significant reductions in downtime and stoppages during assembly when domestic on-hand reserves are available and purchases from Asia-Pacific sources are still being fulfilled.

The DoD (2023) and NDIA (2025a) both underscore that component stockpiling is relevant to DPA Title III’s intent of aligning investment decisions with U.S. defense industrial capacity; component reserves of critical materials directly support production continuity in times of market instability, trade disruption, or geopolitical risk. The DoD’s Lithium Battery Strategy (2023–2030) references this, as do attempts to jumpstart the Domestic Manufacturing Incentive Act (DMAIA, 2024) such as the DIU’s Family of Advanced Standard Batteries (FAStBat) initiative, in which temporary stockpiles of rare materials are being used to directly subsidize and support prototype manufacturing while domestic producers build their own production capacity.

Executive Order No. 14629 (2025) even codifies this model into the Maritime Security Trust Fund, authorizing multiyear, future-directed investment is authorized for industrial-base sustainment and supply-chain buffering, on an incentivized basis, across shipbuilding and autonomy. Combined with NDIA's (2025b) "advocacy for dual sourcing and forward warehousing as part of a hybrid manufacturing strategy," (para. 7), this allows manufacturers the flexibility to unbundle production tempo from the uncertainty of just-in-time logistics.

Manufacturer 1 felt strongly that a push for over-capacity in stored inventory risks negative consequences for the private sector by depleting smaller companies' liquidity (personal communication to author, April 29, 2025). Manufacturer 2 identified a range of factors to consider in prioritizing items to stockpile, including part specificity (no easily-sourced alternative), export-control risk, and the likelihood of causing a production delay multiplier if unavailable (email to author, October 6, 2025). NDIA similarly advocates for a three-tiered approach, stratifying critical stockpiles as either strategic (national-level materials), operational (regional depots), or tactical (on-site subcomponent storage) (NDIA, 2025a).

Stockpiling therefore reduces lead times not only by keeping parts on hand but by directly incentivizing and enabling production confidence. Firms can confidently commit to serial production knowing the critical elements within their parts bills are hedged against shipping delays and/or sanctions risk, creating a predictable and therefore investable situation, a central theme in both the Replicator proposal and the larger USN maritime industrial-base expansion. The problem is that USV manufacturers today do not have the capital, storage facilities or demand certainty to make stockpiling work at scale. In the real world, the lack of such buffers means that lead-time reductions have so far been mostly notional and that production schedules are still dependent on long-lead imports and imported subcomponents.

Stockpiling in this way can thus be seen as one aspect of a larger transition from the historical practice of just-in-time, need-based, reactive procurement toward a more intentional, holistic industrial investment strategy. Combined with the modular design and domestic dual-sourcing measures recommended earlier, it can make material readiness a competitive differentiator, and help position the United States to meet the tempo of attritable USV production expected for future conflict.

c. Government-Furnished Payloads

Government-Furnished Equipment (GFE) and the associated policies regarding payload integration are significant factors in the production rate and cost of USVs. While the concept behind GFE should ensure the standardization of sensitive subsystems as well as operability across different platforms, the current GFE implementation and process have the opposite effect, introducing backlogs to the modular production and fast-turnaround cycle of development.

According to Manufacturer 1(interviews with author, April 29 and October 16, 2025), propulsion and sensor payloads are currently the most significant GFE contributors to redundancy. The same equipment procured through a different channel, then provided by the government, requires repeated certification and interface validation procedures, often elongating the production schedule by months. Manufacturer 2 (email to author, October 6, 2025) further stated that GFE hardware is often not shipped with consistent digital documentation or digital baseline configurations. Manufacturers must often "reverse-engineer compatibility" before installation is even possible.

These GFE redundancies exemplify the ways in which legacy acquisition policies, modeled for costly manned capital ships and kept in place for decades, are detrimental to the ethos of attritable, fast-iterated manufacturing. Manufacturer 1 stated, "A six-week hold-up in payload certification can ground a production line that would otherwise have turned out three ships," exposing how small barriers to production on the acquisition end are magnified to critical lags on the output end (personal communication to author, April 29, 2025). Executive Order No. 14629 (2025) is a step in the right direction in this regard, calling on the DoD to reform its commercial integration standards, modular certification protocols, and contracting options for smaller-quantity purchases.

Executive Order No. 14629's emphasis on a "certify-once, deploy-many" approach is similar to the commercial aviation industry's Supplemental Type Certificate process, which allows pre-certified payloads to be installed on multiple USV hulls by different vendors without duplicative testing procedures. Taken together with the manufacturers' firsthand accounts of the industry's challenges, it becomes clear that payload is not just a technical question, but a structural one. Limiting government redundancy in certification, digitizing GFE technical documentation, and pre-certifying payloads on a modular basis would speed up delivery schedules, increase industrial response rates, and allow for more rapid fielding of unmanned platforms. By doing so, the DoD would restructure its USV procurement in a way that could keep up with its fleet's operational tempo, no longer considering ships as episodic purchases, but as continuous capabilities.

The material, workforce, and latency factors described above are not distinct in practice, but rather facets of the systemic, layered complexity of the U.S. USV industrial base. Supply-chain fragility, partially caused by both foreign reliance and lack of production volume, converges with consistent workforce issues and sub-procedural roadblocks, which slow the tempo of production even further. These issues have both direct and indirect effects and are compounded when examined as an ecosystem of constraints on the material, human, and institutional resources needed for high-throughput production of resilient, industrial-scale platforms. A solution to address the previously mentioned challenges should include supplier diversification, attritable-skilled workforce education and employment, and acquisition modernization if the U.S. maritime strategy is to reach a point of sustainable capability for an attritable fleet of unmanned vessels.

B. BILL OF MATERIAL (BOM) RISK ASSESSMENT

Mirroring the qualitative risk framework outlined in Section A, Section B maps USV manufacturers' supply-chain, labor-force, and lead-time risk factors to three quantifiable proxies. Using BOM data submitted by a U.S. USV producer, this section demonstrates how the industry can operationalize the risk framework to highlight and address specific production pinch points. The analysis tests three proximity metrics: Country of Origin, NAICS sector classification, and Lead Time, identified in manufacturer interviews as key proxies of production risk, and relates these dimensions to manufacturers' assessed capacity to surge capacity.

- Country of Origin: an indicator of dependence on foreign supply chains, as well as the associated geopolitical risk.
- NAICS sector classification: a metric for the availability and concentration of labor forces in specific production sectors.
- Lead Time: a temporal dimension of the supply chain, which gauges the distance between procurement time and surge response.

Summarizing the location, type, and temporal aspect of supply bottlenecks, each metric and their respective measures provide a quantitative understanding of the nature and location of risk in the production network. By tracing the country of origin, labor class, and procurement time of each component, the production framework scores and visually represents where the most prominent vulnerabilities lie in the supply network. This process operationalizes the qualitative data of manufacturer interviews and distills it into a quantitative visualization of the interplay between geopolitical exposure, labor-force specialization, and production cadence in scaling the U.S. USV industrial base.

1. Country of Origin

Country of origin was one of the more unambiguous measures of supply-chain risk for the USV industrial base. Manufacturer interviews flagged foreign dependence for critical subsystems as one of the primary chokepoints to expanding domestic production. While domestic capacity exists for final assembly and low-complexity fabrication steps, key imported subcomponents remain foreign-sourced. This distribution affirms a consistent theme across policy and industry data: U.S. integration and assembly capacity is high, but upstream command over component manufacturing is limited. Batteries, PCBAs, and microelectronics are the most critical chokepoints where, even for firms assembling in the United States, foreign suppliers are necessary for crucial performance elements. This is not dissimilar to the DoD’s warnings on critical-material shortfalls (DoD, 2023) or NDIA’s advocacy to broaden domestic semiconductor and microelectronics production to reduce foreign reliance (NDIA, 2025a).

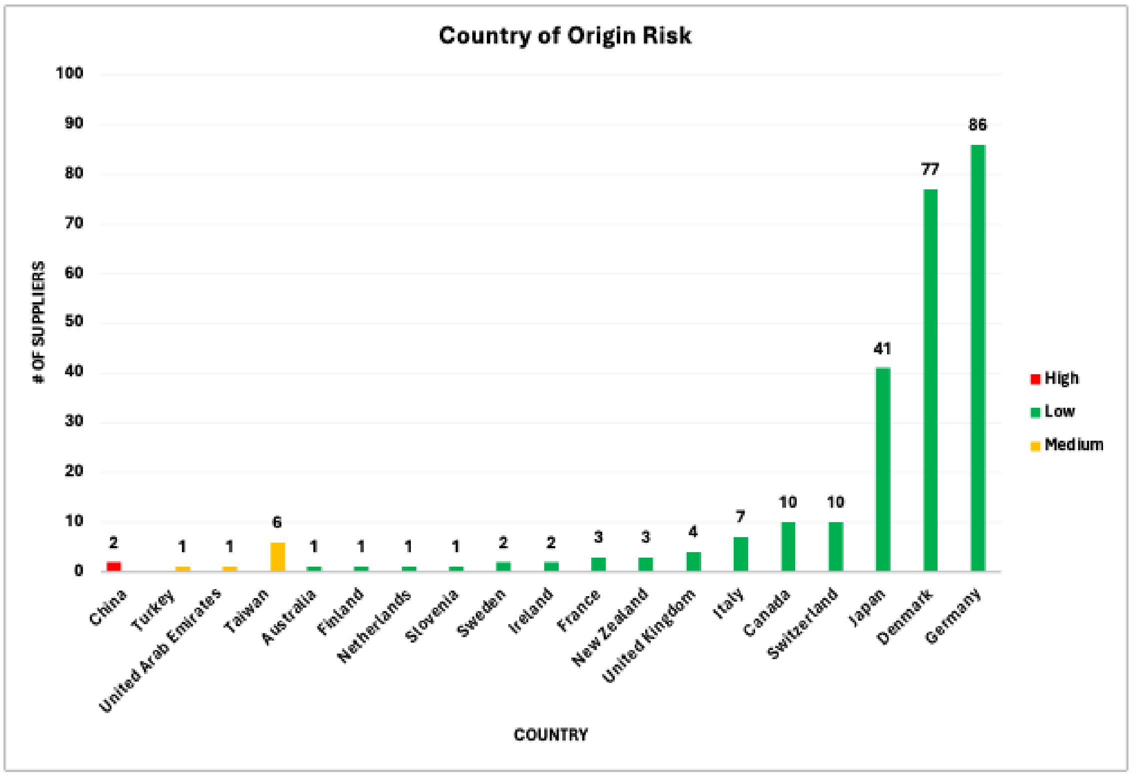
Table 1 applies a geopolitical risk framework to each component of the BOM for one low USV. Each component is given an Origin Category and Origin Risk score on a Low (Five Eyes or NATO) to High (non-ally or strategic competitor) scale. This risk rubric allows for analysis at the component level, instead of across broad supplier categories, in order to surface specific dependencies that could limit or slow production in a crisis situation.

Table 1. Geopolitical Risk Framework.

Country Origin Risk			
Country	**Origin Category**	**Origin Risk**	**Country Risk Alignment**
China	Non-ally / Strategic competitor	High	Tariffs, controls, supply-chain & IP risk
Taiwan	Ally (elevated)	Medium	Geopolitical exposure / strait risk
Turkey	Partner / Volatile	Medium	NATO member with policy volatility/sanctions risk
United Arab Emirates	Partner / Volatile	Medium	Close partner; export-control sensitivity
Australia	Ally	Low	Five Eyes
Canada	Ally	Low	Five Eyes
Denmark	Ally	Low	NATO/EU
Finland	Ally	Low	NATO/EU
France	Ally	Low	NATO/EU
Germany	Ally	Low	NATO/EU
Ireland	Ally	Low	EU
Italy	Ally	Low	NATO/EU
Japan	Ally	Low	US security ally
Netherlands	Ally	Low	NATO/EU
New Zealand	Ally	Low	Five Eyes
Slovenia	Ally	Low	NATO/EU
South Korea	Ally	Low	US security ally
Sweden	Ally	Low	NATO/EU
Switzerland	Ally	Low	Close alignment/export-control cooperation
United Kingdom	Ally	Low	Five Eyes
United States	US	Low	Domestic jurisdiction, export-control alignment

Adapted from Anonymous USV Manufacturer, personal communication [proprietary data], July 10, 2025.

Figure 11 aggregates these results by country of origin and risk tier. The U.S. has more than 150 domestic suppliers and is purposefully left out of the figure to prevent skewing the distribution. Figure 11 isolates non-domestic suppliers and breaks them out by country to identify the relative share of foreign-sourced components by system. The majority of suppliers are in allied nations, though system-critical components are more highly concentrated in East Asia. While Chinese vendors only make up only a small share of total suppliers, they have a higher risk weighting given their focus on batteries and electronic subsystems. Medium-risk dependencies also exist for Taiwan, Turkey, and the United Arab Emirates, nations with high exposure to regional instability or sanctions volatility.



Adapted: Anonymous USV Manufacturer, personal communication [proprietary data], July 10, 2025. While the nations with the most suppliers all tend to be high risk, China, Taiwan, Turkey and UAE are small suppliers with significant risk. Supplier Risk by Country.

Figure 11. Country of Origin and Risk Tier.

These findings validate both manufacturers' point that domestic assembly does not equal domestic independence. Scaling production of unmanned vessels depends as much on securing upstream component sources as it does on scaling final assembly lines. To reduce these dependencies, the U.S. will need dual-sourcing strategies, closer alignment with allied industrial bases, and domestic investment in batteries and microelectronics manufacturing, identified as critical chokepoints in both BOM data and industry interviews.

2. NAICS

The labor-force component of BOM risk is translated through the NAICS industrial system. The North American Industry Classification System is a standard federal taxonomy used to classify all U.S. industries according to their primary economic activity. DoD analysts use NAICS codes to connect specific components to the industrial sector that produces the component. Each BOM item is matched to its associated six-digit NAICS industry designation so labor-market conditions can be indexed with values for country-of-origin and lead-time. Table 2 provides thresholds for workforce tightness, which are based on broader labor-market characterizations that have generally defined unemployment of 3–5 percent as indicative of a stable or "healthy" labor market (Melhorn & Hoover, 2023). Using this range as a benchmark, unemployment below 3 percent is considered tight (high-risk), 3–4 percent is considered moderate, and above 4 percent is considered loose, allowing for standardized comparison of labor-market tightness across NAICS-coded industries. The classification tiers allow for consistent measurement of labor availability on the throughput margin.

Table 2. Labor-Force Risk Thresholds.

Unemployment Rate → Labor Market	
Tight	≤ 3%
Moderate	3–4%
Loose	> 4%

These compared to an overall US unemployment rate of 4.3% (U.S. Bureau of Labor Statistics, n.d.) Adapted: Anonymous USV Manufacturer, personal communication [proprietary data], July 10, 2025.

Table 3 shows the results of applying the proximity measure to 192 critical components of the BOM, yielding 19 six-digit NAICS codes. Notice how risk is denser in the production subsectors of NAICS 331–334. Keel casting, hydraulics, metalworking, and electronics integration rely on narrow technical skills, and the mean unemployment rate is between 2.2% and 2.6%. All of these classifications reflect a tight labor market that has been persistent. The workforce gaps that were named by manufacturers for the most difficult-to-fill production processes lined up with those NAICS categories and skills: composite layup technicians, electronics integrators, and systems engineers were all listed by producers in interviews and correspondence as continuing sources of labor shortage (Manufacturer 1, interviews with author, April 29 and October 16, 2025; Manufacturer 2, email to author, October 6, 2025).

Table 3. Labor-Force Risk.

Labor Force Risk							
NAICS Subsector (3-digit)	2024 Avg Employment	2024 Avg Unemployment	NAICS (6-Digit)	Industry	2024 Avg Unemployment Rate (%)	Unemployment Market	Risk
335- Electrical Equipment, Appliance, and Component Manufacturing	413,700	15,305	335911	Battery & Energy Storage Manufacturing	3.7	Moderate	High
331- Primary Metal Manufacturing	373,100	9,701	331529	Non-Ferrous Metal Foundries (Lead / Metal Keel Casting)	2.6	Tight	High
332- Fabricated Metal Product Manufacturing	1,441,800	no data	332312	Structural/Welded Plate Fabrication	no data	Tight	High
332- Fabricated Metal Product Manufacturing	1,441,800	no data	332322	Sheet Metal Fabrication (enclosures, brackets)	no data	Tight	High
332- Fabricated Metal Product Manufacturing	1,441,800	no data	332710	Machine Shops / Metal Fabrication & Machining	no data	Tight	High
332- Fabricated Metal Product Manufacturing	1,441,800	no data	332912	Hydraulic Components (Fittings/Quick-connects)	no data	Tight	High
332- Fabricated Metal Product Manufacturing	1,441,800	no data	332991	Bearing Manufacturing	no data	Tight	High
332- Fabricated Metal Product Manufacturing	1,441,800	no data	332999	Misc. Metal Products (die-cast enclosures, guards)	no data	Tight	High
334 - Computer and Electronic Product Manufacturing	1,027,800	22,613	334220	Radio & Wireless Communications Equipment	2.2	Tight	High
334 - Computer and Electronic Product Manufacturing	1,027,800	22,613	334413	Semiconductors & Related Device Mfg	2.2	Tight	High
334 - Computer and Electronic Product Manufacturing	1,027,800	22,613	334519	Sensors / Instrumentation / Measurement Devices	2.2	Tight	High
326- Plastics and Rubber Products Manufacturing	725,400	23,938	326130	Composites & Advanced Materials (Carbon fiber structures)	3.3	Moderate	Medium
326- Plastics and Rubber Products Manufacturing	725,400	23,938	326199	Plastics & Polymer Manufacturing (Molding / Extrusion)	3.3	Moderate	Medium
326- Plastics and Rubber Products Manufacturing	725,400	23,938	326220	Hoses, Belting & Flexible Ducting	3.3	Moderate	Medium
335- Electrical Equipment, Appliance, and Component Manufacturing	413,700	15,305	335129	Marine/Vehicle Lighting	3.7	Moderate	Medium
335- Electrical Equipment, Appliance, and Component Manufacturing	413,700	15,305	335929	Communication & Energy Wire / Harness Mfg	3.7	Moderate	Medium
423- Merchant Wholesalers, Durable Goods	3,439,300	no data	423690	Electronic Parts & Equipment Wholesalers (Distribution)	no data	Loose	Low
441- Motor Vehicle and Parts Dealers	2,051,000	no data	441310	Retail – Auto Parts	no data	Loose	Low
454- Nonstore Retailers	no data	no data	454110	E-commerce Retail	no data	Loose	Low

Adapted from Anonymous USV Manufacturer, personal communication [proprietary data], July 10, 2025.

Downstream distribution and after-market service sectors (423–454) operate in looser markets and face less risk. This is the logical result of activities that are ancillary to USV fabrication. Together, the findings strongly indicate that labor shortage is highly concentrated in high-skill and defense-adjacent trades, not across the manufacturing sector as a whole. The gradient in labor risk again illustrates how finite labor inputs in specialized trades bind the capacity to meet demand. Production growth to meet improved supply or material access can only proceed so far. The following subsection will examine the third proximity driver, lead time, and determine how production cycles align with other workforce and sourcing inputs in the compounded risk assessment.

3. Lead Time

Lead time, as a metric in the BOM risk analysis, is the time between ordering a component and its physical availability and integration into a finished platform. Table 4 shows the risk thresholds for this metric, which were informed through industry engagement: 1–4 weeks is low risk, 5–11 weeks is medium risk, and 12 weeks or more is high risk.

Table 4. Lead-Time Risk Thresholds

RISK	WEEKS
HIGH	12+
MEDIUM	5-11
LOW	1-4

Adapted from Anonymous USV Manufacturer, personal communication [proprietary data], July 10, 2025.

Both manufacturers stated that even short delays in receiving electronic components have significant impacts on final integration. Manufacturer 1 noted that “if one board is late, it can shut down the line,” (personal communication to author, April 29, 2025). While Manufacturer 2 pointed out that small-lot defense orders typically face conservative delivery time estimates, magnifying schedule uncertainties (email to author, October 6, 2025). Table 5 shows the estimated distribution of lead-time risk for several printed circuit board assemblies manufactured by a sole supplier. While the majority of items are in the low-risk range, a few mission-critical assemblies are in the medium category, demonstrating that even domestically, schedule uncertainty exists.

Table 5. Lead-Time Risk Distribution (Estimated

Part Name	Lead Time (Weeks)	Lead Time Risk
GEN7.5-iMX8-BASEBOARD PCB ASSEMBLY	6	Medium
PCBA, IRIDIUM SBD CARRIER, GEN8	5	Medium
PCBA, MPPT, GEN7, 60V RATED	5	Medium
PCBA, QUAD-SERIAL, GEN7, SDE01132:D	5	Medium
BME 280 SENSOR, POWERBRICK, SDE01301, REV A	2	Low
DOODLE-EMBEDDED-POE-SPLITTER PCB ASSEMBLY	3	Low
PCBA, RS422 ABSOLUTE ENCODER	4	Low
PCBA, SUBCONN BREAKOUT, NAV TUBE	4	Low
PCBA, VN300 INS CARRIER, GEN8	4	Low
POWERBRICK-12V PCBA, REV B, SDE01285	3	Low
POWERBRICK-24V PCBA, REV B, SDE01281	2	Low
POWERBRICK-48V, PCBA, REV B, SDE01287	2	Low

Adapted from Anonymous USV Manufacturer, personal communication [proprietary data], July 10, 2025.

Lead time variability is a practical indicator of how disruptions and shortages affect production rates. Components with long procurement times and limited responsive capacity exert an outsize impact on production timing and operational tempo. Lead-time uncertainty is the temporal analogue to the geographic and workforce-related constraints. The longer it takes to secure components, the more exposure production operations have to interruption and delay. Time is thus another strategic dimension of resilience that must be considered and ameliorated through modularity, dual-sourcing, and improved supplier collaboration and capacity.

C. BOM RESULTS

The final step is to combine the three proximity measures to create a composite framework for measuring the overall production vulnerability across the U.S. USV industrial base. This is achieved by attributing each component with a categorical value for the three previously mentioned dimensions (Country of Origin, NAICS Labor Force Risk, and Lead Time), with each dimension weighted equally in the composite risk calculation. This captures their combined geopolitical exposure, labor specialization, and temporal risk respectively.

A look at the complete picture highlights where multiple problems overlap in the system. Components that rank high in all three areas are areas where production bottlenecks could occur even if there is money or capacity to produce more. Items that have a short lead-time and are produced domestically by a flexible labor pool are likely to be more scalable.

The categorical ratings were assigned a numeric value (Low = 1, Medium = 2, High = 3) to determine an overall composite risk score for each BOM part. These numeric risk ratings were based on an aggregated scale of 3-9 in order to obtain a normalized scoring baseline for total part-level exposure. A summary of the individual risk categories and their respective assessment is provided in Table 6 for the determination of the composite risk level for the USV production set.

Table 6. Composite Risk Index, 2025.

Risk Category	**Numerical Range**	**Interpretation**
Low Composite Risk	3–4	Component is domestically sourced, supported by flexible labor markets, and readily available within short procurement cycles.
Medium Composite Risk	5–7	Component exhibits one or more moderate constraints (e.g., specialized labor or foreign sourcing) but remains manageable under steady-state conditions.
High Composite Risk	8–9	Component depends on foreign suppliers, constrained labor categories, and long-lead inputs—posing a significant bottleneck during surge or attrition scenarios.

The composite model, when applied to the dataset, reveals that the twelve components that we analyzed for the representative supplier are all in the medium-risk category (scores of 5 or 6). In every case, this is due to consistent vulnerabilities. The average composite score is 5.3 out of 9, suggesting that, for each component, there is at least one constraint (in most cases, workforce specialization), even though they are all domestic with fairly short lead times.

Instead of an even spread across low-, medium-, and high-risk categories, the numbers have shown a clustering effect (all in the range of 5 to 6) which indicates that risk is not itemized but systemic. Table 7, which shows composite risk for a typical supplier, reflects this finding and demonstrates that even U.S.-based companies accrue medium composite risk when the labor-intensive nature of the assembly process and the specialization required for electronic integration are factored in.

Table 7. Composite-risk distribution of a supplier.

Part Name	Country of Origin	Country Risk	NAICS (6-digit)	Labor Risk	Lead Time (Weeks)	Lead Time Risk	Final Risk Level
BME 280 SENSOR, POWERBRICK, SDE01301, REV A	United States	Low (1)	334519	High (3)	2	Low (1)	Medium (5)
DOODLE-EMBEDDED-POE-SPLITTER PCB ASSEMBLY	United States	Low (1)	334519	High (3)	3	Low (1)	Medium (5)
GEN7.5-iMX8-BASEBOARD PCB ASSEMBLY	United States	Low (1)	334519	High (3)	6	Medium (2)	Medium (6)
PCBA, IRIDIUM SBD CARRIER, GEN8	United States	Low (1)	334519	High (3)	5	Medium (2)	Medium (6)
PCBA, MPPT, GEN7, 60V RATED	United States	Low (1)	334519	High (3)	5	Medium (2)	Medium (6)
PCBA, QUAD-SERIAL, GEN7, SDE01132:D	United States	Low (1)	334519	High (3)	5	Medium (2)	Medium (6)
PCBA, RS422 ABSOLUTE ENCODER	United States	Low (1)	334519	High (3)	4	Low (1)	Medium (5)
PCBA, SUBCONN BREAKOUT, NAV TUBE	United States	Low (1)	334519	High (3)	4	Low (1)	Medium (5)
PCBA, VN300 INS CARRIER, GEN8	United States	Low (1)	334519	High (3)	4	Low (1)	Medium (5)
POWERBRICK-12V PCBA, REV B, SDE01285	United States	Low (1)	334519	High (3)	3	Low (1)	Medium (5)
POWERBRICK-24V PCBA, REV B, SDE01281	United States	Low (1)	334519	High (3)	2	Low (1)	Medium (5)
POWERBRICK-48V, PCBA, REV B, SDE01287	United States	Low (1)	334519	High (3)	2	Low (1)	Medium (5)

Adapted from Anonymous USV Manufacturer, personal communication [proprietary data], July 10, 2025.

The basic comparison of these outcomes reveals that current USV scalability constraints are primarily due to labor specialization instead of foreign sourcing limitations. The assessed components may not represent a high-risk environment, but the lack of low-risk items is also telling and implies that few components within the U.S. supply chain are considered fully free of any foreseeable production vulnerabilities. Depending on the nature of the threat, such medium-level stresses might be tolerable for stable-state demand but could potentially be magnified quickly in surge or attrition-level demand.

In sum, the composite index provides an objective measure to help prioritize where additional investment into supplier diversification, technical workforce development, and on-shore stockpiling will do the most to mitigate industrial risk.

VI. CONCLUSION

This thesis sought to identify the primary material resources and workforce challenges that restrict the United States from expanding production and distribution of attritable USVs. U.S. technical expertise and industrial experience provide strong foundations for expanding the production and distribution of attritable USVs. However, current capacity is limited by three interrelated factors of foreign supply chain dependencies, labor shortages, and current acquisition processes. All three directly impact USV's industrial readiness and, by extension, the country's capability to operate distributed fleets at scale.

Interviews with manufacturers and available BOM data found that foreign supply chain dependencies for propulsion, energy storage, and electronics still exist in Asia, leading to longer lead times, higher prices, and a larger footprint of geopolitical risk. Batteries, semiconductors, and PCBAs were specifically noted by both manufacturers for their risk to production timelines. Labor-force and manpower data were then validated through additional manufacturer interviews and comparison to NAICS Industry codes, which found similar shortages in composites fabrication, marine electrical work, and systems integration. The research then found that U.S. supplier and labor shortages were exacerbated by slow, inflexible acquisition processes that often repeat certification cycles for certain GFE. In terms of additional consideration for attritability, one critical finding of this research is that growth of USV production can be achieved through adaptation and adoption of the existing U.S. industrial base as opposed to full-fledged re-builds.

Smaller shipyards, composites fabricators, and electronics assemblers can be retooled into more modular, dual-use facilities to support both defense and commercial USV production in larger numbers. The Maritime Prosperity Zones, Shipbuilding Financial Incentives Program, and broadening of DPA Title III funds allow for pre-existing public-private partnership capabilities to be leveraged to better align with available industrial base. On the materiel side, stockpiling of certain minerals and critical materials, dual-sourcing of key components, and adoption of pre-certified modular payloads can mitigate the risk of supply and labor shocks as well as help speed up production time.

Strategically, however, the culture of attritability will require a departure from the traditional boom-bust cycle and towards sustained capability delivery. Continuous recapitalization of the U.S. Navy's hybrid-fleet will require more demand predictability, acquisition timeline synchronization, and investment into the skilled trades required for high-end manufacturing. As a result, this is not just a materiel problem of technical maturity, but a larger problem of national-level alignment. By strengthening the labor base, expanding supply chain capabilities, and improving current acquisition process, the U.S. has the opportunity to turn untapped industrial potential into sustainable production capability.

A. RECOMMENDATIONS

The assessments and observations from the previous sections suggest strategic actions to enhance the U.S. industrial base for UMS and enable scalable attritable USV production. As a whole, these recommendations seek to connect policy objectives with specific and measurable industrial outcomes in the domains of supply-chain resilience, labor-force development, acquisition reform, and technology modernization.

1. Use Existing Shipyards and Modular Factories.

Instead of building new shipyards and advanced-manufacturing facilities, the DoD and manufacturers should retrofit idle regional shipyards, such as manufacturer 1's acquisition of a shipyard on the Gulf coast. (Manufacturer 1, interview with author, October 16, 2025). These allow utilization as flexible-use dual-use modular factories that can produce both commercial and defense unmanned platforms. Tax incentives and DPA Title III grants should be offered for Maritime Prosperity Zones with thresholds for eligibility linked to quantifiable throughput metrics and domestic content standards (Executive Order No. 14629, 2025). This would allow the U.S. to accelerate the selection of a standard model for USVs that appropriately fits its required mission set while also solving the fragmentation that is currently stifling scalability.

2. Localize Production of Critical Subcomponents

The DoD and NDIA should facilitate the localization of supply sources, in an effort to lessen reliance on foreign supply chains, for battery and energy storage systems, semiconductors, and propulsion assemblies via expanded utilization of specific DPA Title III investment and cost-share initiatives. This approach should include the formation of public-private consortia focused on the production of lithium-ion batteries, PCBA, and marine-rated propulsion systems, all of which should be grounded in a standardization of interface designs to ensure multi-hull class interoperability (NDIA, 2025a; Pettyjohn et al., 2024).

3. Accelerate Workforce Credentialing Pipelines

The Department of Labor, DoD, and NDIA should establish dual-use apprenticeship models for composite technicians, marine electricians, and systems integrators, using NAICS-aligned data to focus on high-risk categories (325, 326, 334). Defense-accepted credentials that allow for lateral entry and exit between commercial and naval production should be used to overcome micro labor shortages. "UMS Centers of Excellence" housed at universities and community colleges close to regional maritime centers should connect academic R&D to industrial production training (Manufacturer 1, interview with author, April 29, 2025 & October 16, 2025).

4. Commit to Programs of Record and Service Doctrine Updates

Effective change requires hard commitments to implement true programs of record to develop an industrial base for USV manufacturing because aspirational goals for hybrid and future fleets need genuine buy-in. The Marine Corps could be used to deploy small- to medium-sized USVs which should guide Navy integration through this advantage while accelerating demand for scalable USV production.

5. Build Strategic Reserves of Long-Lead Materials

In line with the NDIA recommendations, the DoD should establish multi-tiered strategic reserves of long-lead USV components to include energy storage systems, navigation electronics, and hull composites. These reserves should be regionally distributed within the Maritime Prosperity Zones to reduce logistical response time and increase surge capacity.

6. Expand Allied Integration and Co-Production

Formalize industrial co-production agreements with allied nations already in-service of US-built USV. These agreements should align production cadence, component standardization and joint-buy arrangements (Rowley, 2025). Tooling standardization and open-architecture autonomy software would broaden total-market demand and higher-scale efficiencies in the allied naval-industrial base.

7. Codify Maritime Autonomy Policy and Oversight

Congress and the Office of the Secretary of Defense should also establish a permanent Maritime Autonomy Policy Office to coordinate inter-service requirements, acquisition pathways, and industrial incentives. The Maritime Autonomy Policy Office should annually report on domestic content requirements, production throughput and workforce readiness, to provide sustained policy coherence across the hybrid-fleet enterprise.

Taken together, these recommendations give form and substance to the central insight of this study: that the United States can only mass-produce attritable USVs if and when predictable demand, a modular approach to industrial base development, and skilled-labor investment are brought into alignment within a common maritime autonomy architecture. Through implementation of these recommendations industrial potential will evolve into enduring capability which would bridge the existing fragmented foundation to tomorrow's hybrid fleet.

B. LIMITATIONS

Although this research uses qualitative interviews and secondary research along with industrial datasets to validate findings there are limitations that readers should consider when interpreting results. Primary data was only received in detail from two manufacturers, which we have anonymized and refer to as Manufacturer 1 and Manufacturer 2, and while their perspectives were highly representative, they may not represent all U.S. USV producers. Despite multiple attempts at reaching out to manufacturers for bills of materials, we received only a single response from one manufacturer who agreed to do so anonymously. The underlying cost, production, and performance data are classified or proprietary to a large extent, which limits quantitative precision. This is especially true given the fast pace of change in autonomy, artificial intelligence, and advanced manufacturing technologies, which likely means that these findings will need to be periodically updated as new systems and production methods are introduced. Finally, the current analysis focused on small- and medium-sized UMS, especially USVs, and we make only passing reference to larger unmanned and undersea platforms.

Though this research has limitations its results provide a strong data-backed framework to assess industrial resilience capabilities and implement scalable industrial strategies. The bottom line is that the U.S. can scale manufacturing of attritable USV if it coherently and purposefully aligns workforce development, modular design, and demand predictability within the framework of a maritime-autonomy policy. A realigned platform would change industrial preparation into an active force capable of driving the future fleet's hybrid capabilities and resilience.

C. FUTURE RESEARCH

The framework developed in this study—integrating BOM analysis, NAICS labor profiling, and composite risk indexing—provides a repeatable analysis tool for examining industrial readiness throughout the USV portfolio. This work is limited to small- to medium-sized USVs; however, given the dynamic nature of the unmanned systems landscape, evolving geopolitical risk factors, and continuing policy evolution, there are many opportunities for future research.

1. Expand the Sample Size of BOMs and Manufacturers

Future work should involve more UMS manufacturers in supplying multiple BOM datasets under the developed risk framework (Country of Origin, NAICS, Lead Time). Pooling data across multiple firms would allow for statistical validation of aggregate risk trends, identification of sector-specific chokepoints, and construction of an industrial resilience dashboard at the national scale.

2. Apply the Framework to Larger USVs and UUVs

Extend the methodology to large USVs (>164 ft) and UUVs to compare industrial requirements across platform classes. This would test whether scalability challenges are uniform or vary by size, endurance, and mission complexity, informing differentiated investment strategies.

3. Track Implementation of Executive Order No. 14629

Perform longitudinal case studies of Maritime Prosperity Zones, DPA Title III awards, and the Maritime Security Trust Fund to track their effectiveness on increasing domestic content, production throughput, and workforce development. A quantitative before-and-after study would measure the impact of the policy changes on reducing foreign dependence and lead times.

4. Study Marine Corps USV Integration and Doctrine

Because the Marine Corps leads EABO positioning compared to other services, it stands ready to investigate the operational application of small- to medium-sized USVs within expeditionary settings. Field experiments and wargaming may generate tactical demand signals to help update Navy-wide doctrine and plan for industrial base needs.

LIST OF REFERENCES

Åselius, G. (2005). *The rise and fall of the Soviet Navy in the Baltic, 1921–1941*. London, UK: Routledge. https://api.pageplace.de/preview/DT0400.9781135769604_A24928989/preview-9781135769604_A24928989.pdf

Baer, G. W. (1994). *One hundred years of sea power: The U.S. Navy, 1890–1990.* Stanford, CA: Stanford University Press. https://archive.org/details/onehundredyearso0000baer/page/n7/mode/2up

Blair, C. (1996). *Hitler's U-boat war*. Random House.

Bureau of Labor Statistics. (2024). *Occupational Outlook for Production and Manufacturing Occupations*. U.S. Department of Labor. https://www.bls.gov/ooh/production/home.htm

CDRSalamander. (2016, April 20). *Once more unto the gap.* U.S. Naval Institute Blog. https://blog.usni.org/posts/2016/04/20/once-more-unto-the-gap

Center for Strategic and Budgetary Assessments. (2020). *Strengthening the U.S. Defense Maritime Industrial Base.* https://csbaonline.org/uploads/documents/CSBA8199_Maritime_Industrial_FINAL.pdf

Cha, E. (2025). *HD HHI partners with Anduril to develop unmanned surface vessel*. Naval News. https://www.navalnews.com/naval-news/2025/04/hd-hyundai-partners-with-anduril-to-develop-unmanned-surface-vessel/

Cole B. & Erickson A. (2014). *Chinese Anti-Ship Ballistic Missile Development: Drivers, trajectories, and strategic implications*. Naval War College Review, 67(2), 134.

Defense Acquisition University. (2025). *Adaptive Acquisition Framework: A guide to implementation*. https://aaf.dau.edu

Department of Defense. (2018). *Summary of the National Defense Strategy of the United States of America*. https://media.defense.gov/2020/May/18/2002302061/-1/-1/1/2018-NATIONAL-DEFENSE-STRATEGY-SUMMARY.PDF

Department of Defense. (2022a). *National defense strategy of the United States of America*. https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.pdf

Department of Defense. (2022b). *Unmanned systems integrated roadmap 2017–2042*. https://apps.dtic.mil/sti/pdfs/AD1059546.pdf

Department of Defense. (2023). *2023-2030 DoD Lithium battery strategy.* *https://www.businessdefense.gov/ibr/pat/battery-strategy.html*

Department of Defense. (2024). *Contracts for June 14, 2024.* https://www.war.gov/News/Contracts/Contract/Article/3808062

Dingman, R. (1976). *Power in the Pacific: The origins of naval arms limitation, 1914-1922.* University of Chicago Press.

Dougherty, J., & Diehl, M. (2025). *Janus review: 2025*. Janus Marine and Defense. [Unpublished Report].

Exec. Order No. 14629, 3 C.F.R. (2025). *Restoring America's maritime dominance*. https://www.whitehouse.gov/presidential-actions/2025/04/restoring-americas-maritime-dominance/

Fortune Business Insights (2024). Unmanned surface vehicle market size, 2024-2032. https://www.fortunebusinessinsights.com/unmanned-surface-vehicle-usv-s-market-102526

Friedman, N. (1994). *U.S. submarines since 1945: an illustrated design history.* Naval Institute Press.

Friedman, N. (2004). *U.S. destroyers: an illustrated design history* (Rev. ed.). Naval Institute Press.

Funaiole, M. P., Hart, B., & Powers-Riggs, A. (2025). *China Dominates the Shipbuilding Industry*. Center For Strategic & International Studies. https://www.csis.org/analysis/china-dominates-shipbuilding-industry

Galushko, A. (2023). *Ukraine sea drones show the way.* The Australian Naval Institute. https://www.blackseanews.net/en/read/200783

Gilday, M. (2022). CNO hosts media conference call to discuss Navigation Plan 2022 [Press briefing transcript]. U.S. Navy. https://www.navy.mil/Press-Office/Press-Briefings/display-pressbriefing/Article/3119029/cno-hosts-media-conference-call-to-discuss-navigation-plan-2022/

Gilmore, J. M., & Labs, E. J. (2006, March 30). *Potential costs of the Navy's 2006 shipbuilding plan* [Testimony before the Subcommittee on Projection Forces, Committee on Armed Services, U.S. House of Representatives]. Congressional Budget Office. https://www.cbo.gov/publication/17679

Goldman, E. O. (1994). *Sunken treaties : naval arms control between the wars.* Pennsylvania State University Press.

Government Accountability Office. (2016). *Defense acquisitions: Assessments of selected weapon programs*. (GAO-16-329SP). Government Accountability Office. https://www.gao.gov/assets/gao-16-329sp.pdf.

Hamilton, T., Blickstein, I., Osoba, O., McInnis, B., & Kendall, L. (2023). *Characterizing the uncrewed systems industrial base* (Report No. RR-A1474-1). RAND Corporation. https://www.rand.org/pubs/research_reports/RRA1474-1.html

Hattendorf, J. B. (2000). *Naval history and maritime strategy: collected essays.* Krieger Publishing.

Hattendorf, J. B. (2004). *The Evolution of the U.S. Navy's Maritime Strategy, 1977-1986.* Newport Papers #19. Naval War College Press. https://digital-commons.usnwc.edu/newport-papers/35

Hattendorf, J. B. (2006). *U.S. naval strategy in the 1990s.* Newport Papers #27. Naval War College Press. https://digital-commons.usnwc.edu/usnwc-newport-papers/27

Hattendorf, J. B. (2007). *The Oxford encyclopedia of maritime history*. Oxford University Press.

Hattendorf, J. B., & Swartz, P. M. (2008). *U.S. naval strategy in the 1980s* (The Newport Papers, No. 33). Naval War College Press. https://digital-commons.usnwc.edu/newport-papers/21

Herman, A. (2013). *Freedom's forge: how American business produced victory in World War II* (2013 Random House Trade paperback edition.). Random House Trade Paperbacks.

Herwig, H. H. (1987). *Luxury fleet: the Imperial German Navy, 1888-1918* (Rev. ed.). Ashfield Press.

Kline, J. (2025). *The Navy's 2045 Hybrid Fleet: A missile-centric and drone-centric force* [Brief]. Naval Postgraduate School.

Krepinevich, A. F. Jr. (1999). *The stealth battleship. Issues in Science and Technology, 15*(3), 72–79. https://issues.org/p_krepinevich/

Krepinevich, A., Watts, B., & Work, R. (2003, May 20). *Meeting the anti-access and area-denial challenge*. Center for Strategic and Budgetary Assessments. https://csbaonline.org/uploads/documents/2003.05.20-Anti-Access-Area-Denial-A2-AD.pdf

Labs, E. J. (2023). *The 2023 outlook for Navy shipbuilding: Finding a course to a more distributed fleet* [Presentation]. Congressional Budget Office. https://www.cbo.gov/publication/58447

Lambert, A. (2004). *Review of Russian and Soviet battleships by S. McLaughlin*. International Journal of Maritime History, 16(1), 314. https://journals-sagepub-com.nps.idm.oclc.org/doi/epdf/10.1177/084387140401600187

Leidos. (2023). *Leidos selected by U.S. Navy to operate and sustain medium unmanned vessels*. https://www.leidos.com/insights/leidos-selected-us-navy-operate-and-sustain-medium-unmanned-vessels

Math Encounters Blog. (2018, May 22). *Liberty ship production data*. https://www.mathscinotes.com/2018/05/liberty-ship-production-data/

Melhorn, S. F., & Hoover, M. (2023). Understanding America's labor shortage: The most impacted industries. U.S. Chamber of Commerce. https://www.uschamber.com/workforce/understanding-americas-labor-shortage-the-most-impacted-industries

Milner, M. (1990). *The Battle of the Atlantic*. Journal of Strategic Studies, 13(1), 45–66. https://doi.org/10.1080/01402399008437400

Mordor Intelligence. (2025). *Unmanned surface vehicle market (2025-2030).* https://www.mordorintelligence.com/industry-reports/unmanned-surface-vehicle-market

National Defense Industrial Association. (2025b). *Vital signs 2025: The health and readiness of the defense industrial base*. https://www.ndia.org/-/media/sites/ndia/policy/vital-signs/2025/vitalsign_2025_final.pdf?download=1

National Security Commission on Artificial Intelligence. (2021). *Final report*. https://www.nscai.gov/2021-final-report

Naval History and Heritage Command. (n.d.). *U.S. ship force levels: 1886–present.* https://www.history.navy.mil/research/histories/ship-histories/us-ship-force-levels.html

Office of the Chief of Naval Operations. (2024). *Chief of Naval Operations Navigation Plan for America's Warfighting Navy 2024.* Department of the Navy. https://www.navy.mil/Portals/1/CNO/NAVPLAN2024/Files/CNO-NAVPLAN-2024-high-res-v2.pdf

Office of Naval Research. (2021). *Unmanned campaign.* Department of the Navy. https://www.navy.mil/Portals/1/Strategic/20210315%20Unmanned%20Campaign_Final_LowRes.pdf

O'Neill, A. (2024). *Naval restrictions of the Washington Treaty 1922*. Statista. https://www.statista.com/statistics/1328434/naval-restrictions-washington-treaty-1922/

O'Rourke, R. (2023). *China naval modernization: Implications for U.S. Navy capabilities.* (CRS Report No. RL33153). Congressional Research Service. https://www.congress.gov/crs-product/RL33153

O'Rourke, R. (2025a). *Defense primer: Navy distributed maritime operations concept* (CRS Report No. IF12599). Congressional Research Service. https://www.congress.gov/crs-product/IF12599?q=%7B%22search%22%3A%22Defense+primer%3A+Navy+distributed+maritime+operations%22%7D&s=1&r=1

O'Rourke, R. (2025b). *Navy force structure and shipbuilding plans: Background and issues for Congress.* (CRS Report No. RL32665). Congressional Research Service. https://www.congress.gov/crs-product/RL32665

O'Rourke, R. (2025c). *Navy large unmanned surface and undersea vehicles: Background and issues for Congress* (CRS Report No. R45757). Congressional Research Service. https://crsreports.congress.gov/product/pdf/R/R45757

Page, S. (2024, June 21). *3d MDTF demonstrates ability to operate in the Indo-Pacific*. United States Army. https://www.army.mil/article/277487/3d_mdtf_demonstrates_ability_to_operate_in_the_indo_pacific

Paparo, S. J. (2025). *Statement of Admiral Samuel J. Paparo Commander, U.S. Indo-Pacific Command U.S. Indo-Pacific Command Posture April 2025* [Unclassified posture statement]. U.S. House Committee on Armed Services. https://armedservices.house.gov/uploadedfiles/indopacom_posture_statement_2025.pdf

Patterson, R. G., Lawson, E., Udyawer, V., Brassington, G. B., Groom, R. A., & Campbell, H. A. (2022). *Uncrewed surface vessel technological diffusion depends on cross-sectoral investment in open-ocean archetypes: A systematic review of USV applications and drivers. Frontiers in Marine Science, 8*, 736984. https://doi.org/10.3389/fmars.2021.736984

Pettyjohn, S. L., Dennis, H., & Campbell, M. (2024). *Swarms over the Strait: Drone warfare in a future fight to defend Taiwan*. https://www.cnas.org/publications/reports/swarms-over-the-strait

Polmar, N., & Moore, K. J. (2004). *Cold War submarines : the design and construction of U.S. and Soviet submarines.* Brassey's.

Polmar, N. (2013). *The Naval Institute guide to the ships and aircraft of the U.S. fleet* (19th ed.). Naval Institute Press.

Prakash, B.R. (2020). *Reminiscing the P 15 missile*. Defense Research and Studies. https://dras.in/reminiscing-the-p-15-missile/

Rehberg, J. E. (2020). *Building resilience: Mobilizing the defense industrial base in an era of great-power competition.* The Heritage Foundation. https://www.heritage.org/military-strength-topical-essays/2021-essays/building-resilience-mobilizing-the-defense-industrial

Rogin, J. (2024). *The U.S. military plans a 'Hellscape' to deter China from attacking Taiwan*. The Washington Post. https://www.washingtonpost.com/opinions/2024/06/10/taiwan-china-hellscape-military-plan/

Rowley, J. (2025). *Building the Navy's hybrid fleet*. Proceedings, 151(7), Article 1469. https://www.usni.org/magazines/proceedings/2025/july/building-navys-hybrid-fleet

Saildrone Inc. (2024, March 7). *Saildrone unveils new Surveyor-class USV*. [Press Release] https://www.saildrone.com/news/new-saildrone-surveyor-usv

Sayler, K. M. (2025). *DOD Replicator Initiative: Background and issues for Congress*. (CRS Report No. IF12611). Congressional Research Service. https://www.congress.gov/crs-product/IF12611

Sea Machines. (2023). *SM300 autonomy system certified for COLREGs compliance.* Sea Machines Robotics. https://sea-machines.com/the-future-of-marine-autonomy-and-colregs/

Small, P. (2019). *Unmanned maritime systems update* [PowerPoint slides]. Program Executive Office Unmanned and Small Combatants (PMS 406), U.S. Navy. https://www.navsea.navy.mil/Portals/103/Documents/Exhibits/SNA2022/SNA2022-CAPTPeteSmall-PMS406-LPD-UnmannedMaritimeSys.pdf

Starr, T. (2025). *Our best look at DARPA's Defiant uncrewed surface ship.* The War Zone. https://www.twz.com/sea/our-best-look-at-darpas-defiant-uncrewed-surface-ship

Thornberry, W. M. (2025). *Work remains when it comes to acquisition reform.* National Defense Magazine. https://www.nationaldefensemagazine.org/articles/2025/8/4/ndia-perspective-work-remains-when-it-comes-to-acquisition-reform

Till, G. (2009). *Seapower: A guide for the twenty-first century* (2nd ed.). Routledge.

U.S. Bureau of Labor Statistics. (n.d.). *Civilian unemployment rate* [Chart]. Employment Situation Summary. https://www.bls.gov/charts/employment-situation/civilian-unemployment-rate.htm

U.S. China Economic and Security Review Commission. (2022). *U.S. supply chain vulnerabilities and resilience (*Section 4*).* https://www.uscc.gov/sites/default/files/2022-11/Chapter_2_Section_4--U.S._Supply_Chain_Vulnerabilities_and_Resilience.pdf

U.S. Department of Energy, Office of Manufacturing and Energy Supply Chains. (2024). *2021–2024 four-year review of supply chains for the advanced batteries sector*. https://energy.gov/sites/default/files/2024-12/20212024-Four%20Year%20Review%20of%20Supply%20Chains%20for%20the%20Advanced%20Batteries%20Sector.pdf

United States Marine Corps. (2023). *Tentative manual for expeditionary advanced base operations (2nd ed.)*. Department of the Navy, Headquarters, United States Marine Corps. https://www.marines.mil/Portals/1/Docs/230509-Tentative-Manual-For-Expeditionary-Advanced-Base-Operations-2nd-Edition.pdf?ver=05KvG8wWlhI7uE0amD5uYg%3D%3D

Valle, G. (2025). *Saronic unveils plans for autonomous shipyard*. Defense News. https://www.defensenews.com/naval/2025/02/18/saronic-unveils-plans-for-autonomous-shipyard/

Vandenengel, J., & Kline, J. (2025). *Hybrid Fleet Design* (Version 2.81). [Unpublished].

Vincent, B. (2025, August 22). *Navy moves to buy autonomous maritime drones from Saronic via $392M OTA*. DefenseScoop. https://defensescoop.com/2025/08/22/navy-buy-saronic-autonomous-maritime-drones-usv-asv-ota/

Wilkers, R. (2024, June 25). *Navy adds 49 more to $982 M unmanned surface vehicle program*. Washington Technology. https://www.washingtontechnology.com/contracts/2024/06/navy-adds-49-more-982m-unmanned-surface-vehicle-program/397627

Work, R. O. (2004). *Naval transformation and the Littoral Combat Ship*. Center for Strategic and Budgetary Assessments. https://csbaonline.org/uploads/documents/2004.02.18-Littoral-Combat-Ship.pdf

Acquisition Research Program
Naval Postgraduate School
555 Dyer Road, Ingersoll Hall
Monterey, CA 93943

www.acquisitionresearch.net