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Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress

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SUMMARY

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Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress

The Navy wants to develop and procure three types of large unmanned vehicles (UVs) called Large Unmanned Surface Vehicles (LUSVs), Medium Unmanned Surface Vehicles (MUSVs), and Extra-Large Unmanned Undersea Vehicles (XLUUVs). The Navy's proposed FY2023 budget requests $549.3 million in research and development funding for these large UVs and their enabling technologies.

The Navy wants to acquire these large UVs as part of an effort to shift the Navy to a more distributed fleet architecture, meaning a mix of ships that spreads the Navy's capabilities over an increased number of platforms and avoids concentrating a large portion of the fleet's overall capability into a relatively small number of high-value ships (i.e., a mix of ships that avoids "putting too many eggs into one basket"). The Navy and the Department of Defense (DOD) have been working since 2019 to develop a new Navy force-level goal reflecting this new fleet mix. The Navy's FY2023 30-year (FY2023-FY2052) shipbuilding plan, released on April 20, 2022, includes a table summarizing the results of studies that have been conducted on the new force-level goal. These studies outline potential future fleets with 27 to 153 large USVs and 18 to 51 large UUVs.

The Navy envisions LUSVs as being 200 feet to 300 feet in length and having full load displacements of 1,000 tons to 2,000 tons, which would make them the size of a corvette. (i.e., a ship larger than a patrol craft and smaller than a frigate). The Navy wants LUSVs to be low-cost, high-endurance, reconfigurable ships with ample capacity for carrying various modular payloads—particularly anti-surface warfare (ASuW) and strike payloads, meaning principally anti-ship and land-attack missiles. Each LUSV could be equipped with a vertical launch system (VLS) with 16 to 32 missile-launching tubes. Although referred to as UVs, LUSVs might be more accurately described as optionally or lightly manned ships, because they might sometimes have a few onboard crew members, particularly in the nearer term as the Navy works out LUSV enabling technologies and operational concepts. Under the Navy's FY2023 five-year (FY2023-FY2027) shipbuilding plan, procurement of LUSVs through the Navy's shipbuilding account is programmed to begin in FY2025.

The Navy defines MUSVs as being 45 feet to 190 feet long, with displacements of roughly 500 tons, which would make them the size of a patrol craft. The Navy wants MUSVs, like LUSVs, to be low-cost, high-endurance, reconfigurable ships that can accommodate various payloads. Initial payloads for MUSVs are to be intelligence, surveillance and reconnaissance (ISR) payloads and electronic warfare (EW) systems. The Navy's FY2023 five-year (FY2023-FY2027) shipbuilding plan does not include the procurement of any MUSVs through the Navy's shipbuilding account during the period FY2023-FY2027.

XLUUVs are roughly the size of a subway car. The first five XLUUVs were funded in FY2019 and are being built by Boeing. The Navy wants to use XLUUVs to, among other things, covertly deploy the Hammerhead mine, a planned mine that would be tethered to the seabed and armed with an antisubmarine torpedo, broadly similar to the Navy's Cold War-era CAPTOR (encapsulated torpedo) mine. Under the Navy's FY2023 five-year (FY2023-FY2027) shipbuilding plan, procurement of additional XLUUVs through the Navy's shipbuilding account is scheduled to begin in FY2024.

In marking up the Navy's proposed FY2020-FY2022 budgets, the congressional defense committees expressed concerns over whether the Navy's acquisition strategies provided enough time to adequately develop concepts of operations and key technologies for these large UVs, particularly the LUSV, and included legislative provisions intended to address these concerns. In response to these markups, the Navy has restructured its acquisition strategy for the LUSV program so as to comply with these legislative provisions and provide more time for developing operational concepts and key technologies before entering into serial production of deployable units.

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Introduction

This report provides background information and potential issues for Congress for three types of large unmanned vehicles (UVs) that the Navy wants to develop and procure in FY2023 and beyond:

- Large Unmanned Surface Vehicles (LUSVs);
- Medium Unmanned Surface Vehicles (MUSVs); and
- Extra-large Unmanned Undersea Vehicles (XLUUVs).

The Navy wants to acquire these large UVs as part of an effort to shift the Navy to a more distributed fleet architecture, meaning a mix of ships that spreads the Navy's capabilities over an increased number of platforms and avoids concentrating a large portion of the fleet's overall capability into a relatively small number of high-value ships (i.e., a mix of ships that avoids "putting too many eggs into one basket"). The Navy's proposed FY2023 budget requests $549.3 million in research and development funding for these large UVs and their enabling technologies.

The issue for Congress is whether to approve, reject, or modify the Navy's acquisition strategies and funding requests for these large UVs. The Navy's proposals for developing and procuring them pose a number of oversight issues for Congress. Congress's decisions on these issues could substantially affect Navy capabilities and funding requirements and the shipbuilding and UV industrial bases.

In addition to the large UVs covered in this report, the Navy also wants to develop and procure smaller USVs and UUVs, as well as unmanned aerial vehicles (UAVs) of various sizes. Other U.S. military services are developing, procuring, and operating their own types of UVs. Separate CRS reports address some of these efforts.[1]

Background

Navy USVs and UUVs in General

UVs in the Navy

UVs are one of several new capabilities—along with directed-energy weapons, hypersonic weapons, artificial intelligence, cyber capabilities, and quantum technologies—that the Navy and other U.S. military services are pursuing to meet emerging military challenges, particularly from China.[2] UVs can be equipped with sensors, weapons, or other payloads, and can be operated remotely, semi-autonomously, or (with technological advancements) autonomously. They can be individually less expensive to procure than manned ships and aircraft because their designs do not need to incorporate spaces and support equipment for onboard human operators. UVs can be particularly suitable for long-duration missions that might tax the physical endurance of onboard

[1] See, for example, CRS Report R45519, *The Army's Optionally Manned Fighting Vehicle (OMFV) Program: Background and Issues for Congress*, by Andrew Feickert, and CRS In Focus IF11150, *Defense Primer: U.S. Policy on Lethal Autonomous Weapon Systems*, by Kelley M. Sayler.

[2] For a CRS report on advanced military technologies, see CRS In Focus IF11105, *Defense Primer: Emerging Technologies*, by Kelley M. Sayler.

human operators, or missions that pose a high risk of injury, death, or capture of onboard human operators—so-called "three D" missions, meaning missions that are dull, dirty, or dangerous.[3]

The Navy has been developing and experimenting with various types of UVs for many years, and has transitioned some of these efforts (particularly those for UAVs) into procurement programs. Even so, some observers have occasionally expressed dissatisfaction with what they view as the Navy's slow pace in transitioning UV development efforts into programs for procuring UVs in quantity and integrating them into the operational fleet.

March 2021 Campaign Framework Document for UVs

On March 16, 2021, the Department of the Navy released a "campaign framework" (i.e., overall strategy) document for developing and acquiring Navy and Marine UVs of various types and integrating them into U.S. naval operations.[4]

Smaller and Larger Navy USVs and UUVs

In addition to the large UVs covered in this report, the Navy also wants to develop and procure smaller USVs and UUVs that can be deployed from manned Navy ships and submarines to extend the operational reach of those ships and submarines. The large UVs covered in this CRS report, in contrast, are more likely to be deployed directly from pier to perform missions that might otherwise be assigned to manned ships and submarines.

Large UVs and Navy Ship Count

Because the large UVs covered in this report can be deployed directly from pier to perform missions that might otherwise be assigned to manned ships and submarines, the top-level count of the desired future number of ships in the Navy now increasingly includes two figures—one for manned ships, and another for larger USVs and UUVs.

Large UVs as Part of More Distributed Navy Fleet Architecture

The Navy wants to acquire these large UVs as part of an effort to shift the Navy to a more distributed fleet architecture, meaning a mix of ships that spreads the Navy's capabilities over an increased number of platforms and avoids concentrating a large portion of the fleet's overall capability into a relatively small number of high-value ships (i.e., a mix of ships that avoids "putting too many eggs into one basket"). The Navy and the Department of Defense (DOD) have been working since 2019 to develop a new Navy force-level goal reflecting this new fleet mix. The Navy's FY2023 30-year (FY2023-FY2052) shipbuilding plan, released on April 20, 2022, includes a table summarizing the results of studies that have been conducted on the new force-

[3] See, for example, Ann Diab, "Drones Perform the Dull, Dirty, or Dangerous Work," Tech.co, November 12, 2014; Bonnie Robinson, "Dull, Dirty, Dangerous Mission? Send in the Robot Vehicle," U.S. Army, August 20, 2015; Bernard Marr, "The 4 Ds Of Robotization: Dull, Dirty, Dangerous And Dear," *Forbes*, October 16, 2017.

[4] Department of the Navy, *Department of the Navy Unmanned Campaign Framework*, March 16, 2021, 37 pp. See also Megan Eckstein, "Navy, Marines Unveil How They Will Buy and Operate Future Pilotless Aircraft and Crewless Ships," *USNI News*, March 16, 2021; Gina Harkins, "Why You Should Trust Drone Ships and Unmanned Tech, According to the Navy," *Military.com*, March 16, 2021; Stew Magnuson, "Just In: Navy, Marine Corps Unmanned Framework Calls For 'Capabilities' Over Platforms," *National Defense*, March 16, 2021; Seapower Staff, "Navy, Marine Corps Release Unmanned Campaign Plan," *Seapower*, March 16, 2021; Jordan Wolman, "Looking to the Future of Combat and Competition, Navy Releases Much-Anticipated Campaign Plan on Unmanned Systems," *Inside Defense*, March 16, 2021.

level goal. These studies outline potential future fleets with 27 to 153 large USVs and 18 to 51 large UUVs.[5]

Acquisition Strategies and Enabling Technologies

Acquisition Strategies Restructured Following Congressional Markups

In marking up the Navy's proposed FY2020-FY2022 budgets, the congressional defense committees expressed concerns over whether the Navy's acquisition strategies provided enough time to adequately develop concepts of operations and key technologies for these large UVs, particularly the LUSV, and included legislative provisions intended to address these concerns.[6] In response to these markups, the Navy restructured its acquisition strategy for the LUSV program so as to comply with these legislative provisions and provide more time for developing operational concepts and key technologies before entering into serial production of deployable units. Land-based testing of propulsion equipment intended for the LUSV and MUSV forms a key element of the restructured acquisition strategy.

Prototypes

The LUSV and MUSV programs are building on USV prototypes and other development work done by the Department of Defense's (DOD's) Strategic Capabilities Office (SCO). SCO's effort to develop USVs is called Ghost Fleet, and its LUSV development effort within Ghost Fleet was called Overlord. A January 12, 2022, press report stated

> Project Overlord, an experimental unmanned surface vehicle program, has completed its work and has been shut down by the Strategic Capabilities Office, a secretive research and development organization within the Pentagon, a Navy official revealed today.
>
> Its conclusion is a significant milestone, marking a period of transition between the Pentagon's research and development enterprise and a complete entry into the Navy's fleet.
>
> Overlord, which produced four vessels in total that will be transferred to the Navy's developmental squadrons, ended in December with a capstone demonstration, Capt. Pete Small, program manager for unmanned maritime systems, told attendees at the Surface Navy Association's national symposium.
>
> "What did we gain out of that?" Small said referring to Project Overlord. "The first thing we gained is the platforms. We're getting those free of charge… It's something on the order of $370 million" over three years invested by the SCO into unmanned vessels.
>
> That includes not just the platforms, but the technology and capabilities held within the ships, such as the control software. With the SCO's activities complete, the Overlord vessels will be transferred to the Surface Warfare Development Squadron this month.[7]

Figure 1 shows USV prototypes that have supported or are scheduled to support the LUSV and MUSV programs. **Figure 2** shows one of those prototypes, the Sea Hunter medium displacement USV.

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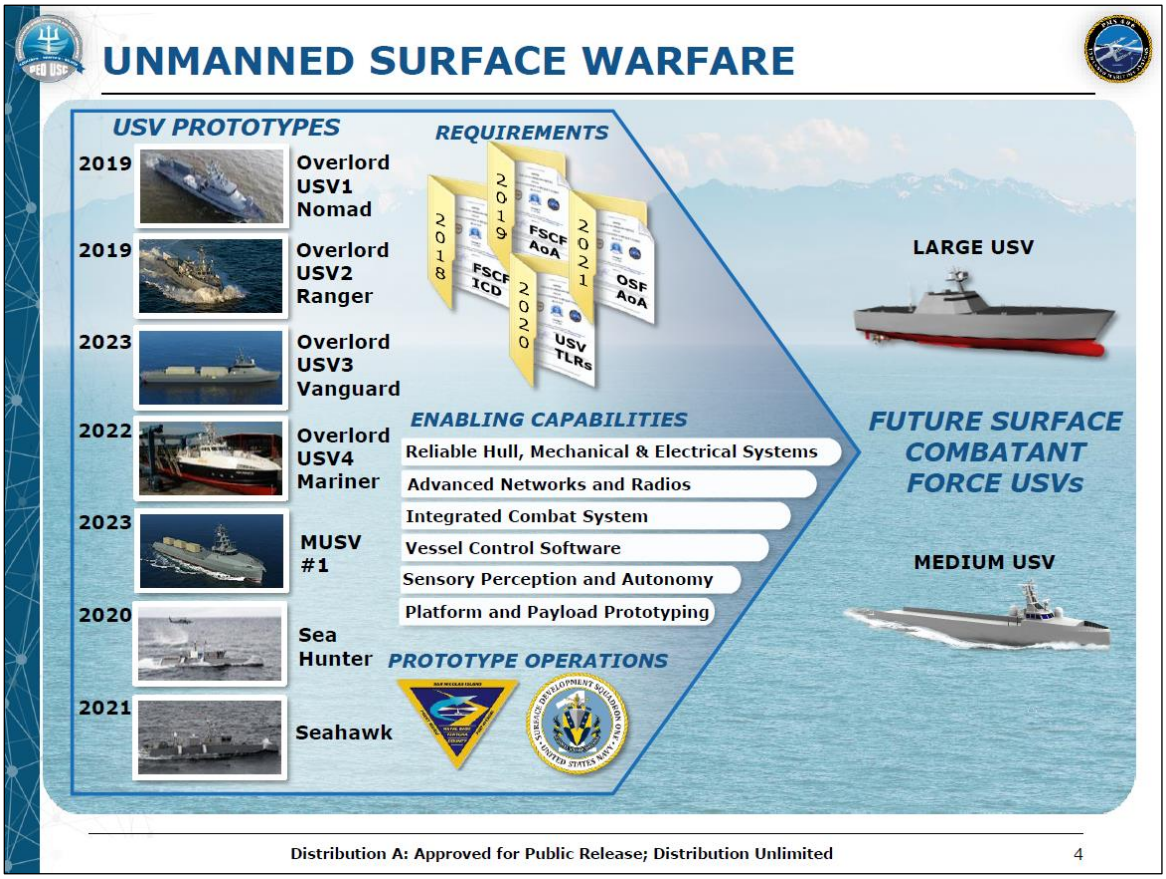
[5] For additional discussion, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by Ronald O'Rourke.

[6] In the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (H.R. 6395 /P.L. 116-283 of January 1, 2021), these provisions included Sections 122 and 227.

[7] Justin Katz, "SCO Ends Project Overlord, Shifts Unmanned Vssels to Navy," *Breaking Defense*, January 12, 2022. See also PEO Unmanned and Small Combatants (PEO USC) Public Affairs, "Strategic Capabilities Office Transfers Overlord Unmanned Surface Vessels to U.S. Navy," Naval Sea Systems Command, March 3, 2022.

Figure 1. Prototypes Supporting the LUSV and MUSV Programs



Source: Slide 4 of Navy briefing entitled "PMS 406 Maritime Unmanned Systems, CAPT Pete Small," briefing to Surface Navy Association (SNA) annual symposium, January 12, 2022.

Surface Development Squadron

In May 2019, the Navy established a surface development squadron to help develop operational concepts for LUSVs and MUSVs. The squadron was initially to consist of a Zumwalt (DDG-1000) class destroyer and one Sea Hunter prototype. A second Sea Hunter prototype was reportedly to be added around the end of FY2020, and LUSVs and MUSVs would then be added as they become available.[8]

[8] See, for example, Megan Eckstein, "Navy Stands Up Surface Development Squadron for DDG-1000, Unmanned Experimentation," *USNI News*, May 22, 2019; David B. Larter, "With Billions Planned in Funding, the US Navy Charts Its Unmanned Future," *Defense News,* May 6, 2019. See also Michael Fabey, "USN Seeks Path for Unmanned Systems Operational Concepts," *Jane's Navy International*, May 16, 2019.

Figure 2. Sea Hunter Prototype Medium Displacement USV

Source: Photograph credited to U.S. Navy accompanying John Grady, "Panel: Unmanned Surface Vessels Will be Significant Part of Future U.S. Fleet," *USNI News*, April 15, 2019.

LUSV, MUSV, and LXUUV Programs in Brief

LUSV Program

Overview

The Navy envisions LUSVs as being 200 feet to 300 feet in length and having full load displacements of 1,000 tons to 2,000 tons, which would make them the size of a corvette (i.e., a ship larger than a patrol craft and smaller than a frigate). The Navy wants LUSVs to be low-cost, high-endurance, reconfigurable ships with ample capacity for carrying various modular payloads—particularly anti-surface warfare (ASuW) and strike payloads, meaning principally anti-ship and land-attack missiles. Each LUSV could be equipped with a vertical launch system (VLS) with 16 to 32 missile-launching tubes.[9] Although referred to as UVs, LUSVs might be more accurately described as optionally or lightly manned ships, because they might sometimes have a few onboard crew members, particularly in the nearer term as the Navy works out LUSV enabling technologies and operational concepts.

Under the Navy's FY2023 five-year (FY2023-FY2027) shipbuilding plan, procurement of LUSVs through the Navy's shipbuilding account is programmed to begin in FY2025. The plan calls for the procurement of one LUSV in FY2025 at a cost of $315.0 million, two LUSVs in FY2026 at a combined cost of $522.5 million (an average of 261.3 million each), and three LUSVs in FY2027 at a combined cost of $722.7 million (an average of $240.9 million each).

[9] Source: Navy FY2022 program briefing on LUSV and MUSV programs for CRS and CBO, July 14, 2021.

LUSV Prototypes

Figure 3, **Figure 4**, and **Figure 5** show photographs LUSV prototypes.

Figure 3. USV Prototypes

Source: Photograph from briefing slide entitled "UMS [unmanned maritime systems] at Sea," slide 4 of 5 (including cover slide) of Navy briefing entitled "PMS 406 Unmanned Maritime Systems, Program Overview, August 2021, prepared for Sea-Air-Space Exposition. The briefing slide states that the photograph shows "Overlord USVs Ranger & Nomad on the West Coast."

Figure 4. LUSV Prototype

Source: Cropped version of photograph accompanying Mallory Shelbourne, "6 Companies Awarded Contracts to Start Work on Large Unmanned Surface Vehicle," *USNI News*, September 4, 2020. The caption to the photograph states in part: "A Ghost Fleet Overlord test vessel takes part in a capstone demonstration during the conclusion of Phase I of the program in September." The photo is credited to the U.S. Navy.

Figure 5. LUSV Prototype

Source: Cropped version of photograph accompanying Mallory Shelbourne, "6 Companies Awarded Contracts to Start Work on Large Unmanned Surface Vehicle," *USNI News*, September 4, 2020. The caption to the photograph states in part: "A Ghost Fleet Overlord test vessel takes part in a capstone demonstration during the conclusion of Phase I of the program in September." The photo is credited to the U.S. Navy.

Navy Description

The Navy states that

> LUSVs will provide affordable, high endurance ships able to accommodate various payloads for unmanned missions and augment the Navy's manned surface force. LUSVs will be capable of semiautonomous operation, with operators in-the-loop or on-the-loop. USV Command and Control (C2) will be maintained via an afloat element (i.e., embarked on a United States Navy (USN) combatant/other assigned afloat asset) or via an ashore element (C2 station ashore)....
>
> LUSV is a key enabler of the Navy's Distributed Maritime Operations (DMO) concept, which includes being able to forward deploy and team with individual manned combatants or augment battle groups. LUSV will complement the Navy's manned combatant force by delivering increased readiness, capability and needed capacity at lower procurement and sustainment costs and reduced risk to sailors. While unmanned surface vehicles are new additions to the fleet units, LUSV will combine robust and proven commercial vessel specifications with existing military payloads to rapidly and affordably expand the capacity and capability of the surface fleet....
>
> The Large Unmanned Surface Vessel (LUSV) development is supported by research and development prototype vessels (Overlord prototype vessels already purchased) intended to demonstrate successful integration of government furnished Command, Control, Communications, Computers and Intelligence (C4I), combat systems, and the reliability of automated hull, mechanical, and electrical (HM&E) systems. The program leverages years of investment and full scale demonstration efforts in autonomy, endurance, command and control, payloads and testing from the Defense Advanced research Projects Agency (DARPA) Anti-Submarine Warfare Continuous Trail Unmanned Vessel (ACTUV), Office of Naval Research (ONR) Medium Displacement Unmanned Surface Vehicle (MDUSV)/Sea Hunter (FY 2017 to FY 2021), and Office of the Secretary of Defense Strategic Capabilities Office (OSD- SCO) Ghost Fleet Overlord Large USV experimentation effort (FY 2018 - FY 2021). The combination of fleet-ready C2 solutions developed by the Ghost Fleet Overlord program and man-in-the-loop or man-on-the-loop control will reduce the risk of fleet integration of unmanned surface vehicles and allow

> autonomy and payload technologies to develop in parallel with fielding vehicles with standardized interfaces.[10]

The Navy states further that

> The major change between FY 2022 and FY 2023 is the delay in planned Detail Design and Construction (DD&C) for the initial production LUSV to FY 2025. The Navy instituted a comprehensive system engineering framework and supporting land and sea based prototyping plan, which will be completed prior to commencing the formal program of record and LUSV production....
>
> The supporting land and sea based prototyping plan will use the four Overlord Prototype vessels (vessels procured in FY20 will be delivered in FY22) and various land based testing facilities to mature enabling technologies and qualify representative machinery. In support of the updated developmental and prototyping plan, the Navy is aligning Detail Design and Construction for the initial production LUSVs with the risk reduction and qualification plans described in the program System Engineering Framework (Work Breakdown Structure (WBS)). In addition, the outcome of the Offensive Surface Fires Analysis of Alternatives (OSF AoA) is supporting the refinement of program requirements leading to the validation of a Capability Development Document, acquisition strategy, and timing for procurement. The Navy's new plan does not include procurement of any additional prototype vessels.
>
> The LUSV will be capable of weeks-long deployments and trans-oceanic transits and operate aggregated with Carrier Strike Groups (CSGs), Amphibious Ready Groups (ARGs), Surface Action Groups (SAGs), and individual manned combatants. The LUSV will be capable of autonomous navigation, transit planning, and COLREGS-compliant[11] maneuvering and will be designed with automated propulsion, electrical generation, and support systems. LUSV missions will be conducted with operators in-the-loop (with continuous or near-continuous observation or control) or on-the-loop (autonomous operation that prompts operator action/intervention from sensory input or autonomous behaviors). LUSVs with integrated payload capability and prototypes employing non-organic payloads will not be capable of autonomous payload engagement or execution of a complete detect-to-engage sequence. The vessel will be incapable of payload activation, deactivation, or engagement without the deliberate action of a remote, off-hull human operator in the command and control loop. The program will integrate current Navy combat systems programs of record that have been adapted to enable remote monitoring and operational control from an off-hull command and control point, and will not be equipped with components that would enable payload engagement from onboard the vessel. USV Command and Control (C2) will be maintained via an afloat element (i.e., embarked on a United States Navy (USN) combatant), or via the ashore element (C2 station ashore).
>
> The LUSV program is continuing to execute a comprehensive land and sea-based prototyping strategy to develop and deliver incremental capability increases, demonstrate key autonomy and automation enablers, and improve reliability of representative machinery....
>
> The LUSV Performance Specification that will be released under the Detail Design and Construction (DD&C) solicitation will heavily leverage the results of the prototype USV developmental effort, land based testing plan, LUSV industry design studies, and continued engagement with industry....

[10] *Department of Defense, Fiscal Year (FY) 2023 Budget Estimates, Navy Justification Book Volume 2 of 5, Research, Development, Test & Evaluation, Navy,* April 2022, pp. 11-12 (PDF pages 107-108 of 1608).

[11] This is a reference to the October 1972 multilateral convention on international regulations for preventing collisions at sea, commonly known as the collision regulations (COLREGs) or the "rules of the road" (28 UST 3459; TIAS 8587), to which the United States and more than 150 countries are parties.

> The Navy is also executing a comprehensive reliability plan with the intent to discover and implement reliability enhancements into USV machinery plants... as well as provide a means to qualify LUSV-representative machinery plants prior to award of the initial production LUSVs.... Additionally, the Navy is executing a parallel effort to qualify the main engines for the prototype MUSV (same as on 3 of 4 Overlord prototype USVs), which concludes in FY 2023. In FY 2021, the Navy worked with the American Bureau of Shipping (ABS) to develop USV machinery plant standards, which will provide potential vendors a path to prove reliability of proposed architectures and equipment for production LUSVs.
>
> As part of the long term reliability plan in FY 2022, the Navy extended the LUSV Studies Contracts to include government oversight of a robust and comprehensive industry-led main machinery and electrical distribution qualification plan to provide. The plan provides the opportunity to qualify representative machinery from multiple manufacturers through the execution of testing at vendor sites, ultimately providing increased flexibility and options for vendors in the competitive LUSV DD&C contract. In parallel, the Navy is continuing to test ancillary equipment and develop solutions for government-furnished engineering operations autonomy modules and machinery control systems at the Land Based Test Site at Naval Surface Warfare Center, Philadelphia.[12]

An August 3, 2021, press report states

> For the foreseeable future, the LUSVs will require a small crew detachment aboard to carry out tasks not conducive to machines.
>
> "We do envision accommodations for a small detachment of personnel. Those people are not intended to be driving or operating the boat directly, but we provide those accommodations as a risk manager for operations, that can't be automated or haven't been automated yet, like refueling," Capt. Pete Small, Navy Program Manager for USVs, said Monday at the Sea Air Space 2021 symposium.
>
> "They could still be aboard also for force protection or other measures that are required as we continue to refine concepts of operations."...
>
> "The current way we operate them is that we pilot the USVs into and out of port in manual mode with a small crew on board. This is consistent with the Navy's plans for medium USV and large USV," Small said last week at a virtual conference hosted by the Association for Unmanned Vehicle Systems International (AUVSI).
>
> "Once the USVs is in the open ocean, we make the transition to autonomous mode and continue with operations that include remote mission planning, command and control and supervision."
>
> In terms of how manning evolves for LUSV, "we're going to flesh that out over the next several years," Small said.[13]

Analysis of Alternatives (AOA)

The Navy is conducting an analysis of alternatives (AOA) to compare the cost-effectiveness of the LUSV to a range of alternative surface platforms, including modified naval vessel designs such as amphibious ships, expeditionary fast transport (EPF) ships, and expeditionary sea base (ESB) ships, modified commercial vessel designs such as container ships and bulk carriers, new

[12] *Department of Defense, Fiscal Year (FY) 2023 Budget Estimates, Navy Justification Book Volume 2 of 5, Research, Development, Test & Evaluation, Navy,* April 2022, pp. 13-14 (PDF pages 109-110 of 1608).

[13] Sam LaGrone, "Navy: Large USV Will Require Small Crews for the Next Several Years," *USNI News,* August 3, 2021.

naval vessel designs, and new commercial vessel designs.[14] A January 21, 2022, press report stated that "originally, the Navy was aiming to accomplish the [AOA] by October 2021. Late last year, the target slipped to early this year." The press report quoted a Navy official as saying that the AOA is now expected to be completed by the end of April 2022.[15] A March 22, 2022, press report similarly stated that the Navy expected the study to be completed by the end of April 2022.[16]

September 4, 2020, Contract Award

On September 4, 2020, DOD announced the following six contract awards for industry studies on the LUSV:

> Huntington Ingalls Inc., Pascagoula, Mississippi (N00024-20-C-6319); Lockheed Martin Corp., Baltimore, Maryland (N00024-20-C-6320); Bollinger Shipyards Lockport LLC, Lockport, Louisiana (N00024-20-C-6316); Marinette Marine Corp., Marinette, Wisconsin (N00024-20-C-6317); Gibbs & Cox Inc., Arlington, Virginia (N0002420C6318); and Austal USA LLC, Mobile, Alabama (N00024-20-C-6315), are each being awarded a firm-fixed price contract for studies of a Large Unmanned Surface Vessel with a combined value across all awards of $41,985,112.
>
> Each contract includes an option for engineering support, that if exercised, would bring the cumulative value for all awards to $59,476,146.
>
> —The contract awarded to Huntington Ingalls Inc. is $7,000,000;
>
> —the contract awarded to Lockheed Martin Corp. is $6,999,978;
>
> —the contract awarded to Bollinger Shipyards Lockport LLC, is $6,996,832;
>
> —the contract awarded to Marinette Marine Corp. is $6,999,783;
>
> —the contract awarded to Gibbs & Cox Inc. is $6,989,499; and
>
> —the contract awarded to Austal USA LLC is $6,999,020.

---

[14] The Navy stated in 2021 that

> As directed in the FY 2021 National Defense Authorization Act [Section 227(e) of H.R. 6395/P.L. 116-283 of January 1, 2021], the Navy is conducting a Distributed Offensive Surface Fires AoA [analysis of alternatives] to compare the currently planned large unmanned surface vessel (LUSV) with an integrated missile launcher payload against a broad range of alternative surface platforms and capabilities to determine the most appropriate vessel to deliver additional missile capability and capacity to the surface force.
>
> (Statement of Frederick J. Stefany, Acting Assistant Secretary of the Navy for Research, Development and Acquisition (ASN (RD&A)) and Vice Admiral James W. Kilby, Deputy Chief of Naval Operations, Warfighting Requirements and Capabilities (OPNAV N9) and Lieutenant General Eric M. Smith, Deputy Commandant, Combat Development and Integration, Commanding General, Marine Corps Combat Development Command, before the Subcommittee on Seapower of the Senate Armed Services Committee on Department of the Navy Fiscal Year 2022 Budget Request for Seapower, June 8, 2021, p. 14.)

See also Jason Sherman, "Navy Considering Alternatives to LUSV, Packing Amphibs, Commercial Designs More with Long-Range Missiles," *Inside Defense*, April 9, 2021.

[15] Jason Sherman, "Navy Now Eyeing April for LUSV Analysis of Alternatives Completion," *Inside Defense*, January 21, 2022.

[16] Megan Eckstein, "US Navy Considers Alternatives to Unmanned Boats with Missiles," *Defense News*, March 22, 2022.

> Work will be performed in various locations in the contiguous U.S. in accordance with each contract and is expected to be complete by August 2021, and if option(s) are exercised, work is expected to be complete by May 2022.
>
> Fiscal 2020 research, development, test and evaluation (Navy) funds in the amount $41,985,112 will be obligated at time of award and will not expire at the end of the current fiscal year.
>
> These contracts were competitively procured via Federal Business Opportunities (now beta.SAM.gov) with eight offers received. The Naval Sea Systems Command, Washington, D.C., is the contracting activity.[17]

A September 4, 2020, press report about the contract awards stated

> "These contracts were established in order to refine specifications and requirements for a Large Unmanned Surface Vessel and conduct reliability studies informed by industry partners with potential solutions prior to release of a Detail Design and Construction contract," Navy spokesman Capt. Danny Hernandez told USNI News in a statement.
>
> "The studies effort is designed to provide robust collaboration with government and industry to assist in maturation of platform specifications, and ensure achievable technical requirements are in place for a separate LUSV DD&C competition."…
>
> "The LUSV studies will support efforts that facilitate requirements refinement, development of an affordable and effective platform; provide opportunities to continue maturing the performance specifications and conduct analysis of alternative design approaches; facilitate reliability improvements and plans for government-furnished equipment and mechanical and electrical systems; and support development of cost reduction and other affordability initiatives," Hernandez said.[18]

MUSV Program

Overview

The Navy defines MUSVs as being 45 feet to 190 feet long, with displacements of roughly 500 tons, which would make them the size of a patrol craft. The Navy wants MUSVs, like LUSVs, to be low-cost, high-endurance, reconfigurable ships that can accommodate various payloads. Initial payloads for MUSVs are to be intelligence, surveillance and reconnaissance (ISR) payloads and electronic warfare (EW) systems. The Navy's FY2023 five-year (FY2023-FY2027) shipbuilding plan does not include the procurement of any MUSVs through the Navy's shipbuilding account during the period FY2023-FY2027.

April 2022 Reported Remarks of Chief of Naval Operations

An April 28, 2022, press report states

> The Navy is rethinking its planned portfolio of unmanned surface vehicles following testing of a variety of USVs in the Middle East, the service's top officer said on Thursday[April 28]....

[17] Department of Defense, "Contracts For Sept. 4, 2020," accessed September 8, 2020. The announcement is posted as a single, unbroken paragraph. In reprinting the text of the announcement, CRS broke the announcement into the smaller paragraphs shown here to make the announcement easier to read.

[18] Mallory Shelbourne, "6 Companies Awarded Contracts to Start Work on Large Unmanned Surface Vehicle," *USNI News*, September 4, 2020. See also Paul McLeary, "Navy Awards Study Contracts On Large Unmanned Ship—As Congress Watches Closely," *Breaking Defense*, September 4, 2020.

> On Thursday, Chief of Naval Operations Adm. Mike Gilday said the service might be rethinking buying the MUSV after a series of exercises and experiments in U.S. 5th Fleet with Combined Task Force 59, which stood up in September.
>
> "I don't know if we'll have a medium unmanned or not. The stuff that [Vice Adm. Brad] Cooper's doing right now with CTF [combined task force] 59—using small unmanned [vehicles] on the scene in the air to sense the environment … in order to yield a common operational picture for allies and partners, as well as 5th Fleet headquarters, has changed my thinking on the direction of unmanned," Gilday said during a Thursday U.S. Naval Institute-CSIS Maritime Security Dialogue.
>
> "We are learning so fast and fielding these capabilities out to the fleet, or potentially fielding them quickly inside the [Future Years Defense Plan], we may be able to close capability gaps with small expendable unmanned [vehicles] off of any platform," Gilday said, "rather than thinking that we have to build, you know, a large [USV]. There may be room for that. I'm not saying that we don't need an MUSV. I'm saying it'll cause us to consider numbers [of such platforms that may be needed]."...
>
> ... the Navy might be able to get the sensor capability it wanted from MUSV through fused data from networked commercial systems to get an accurate maritime awareness picture more affordably. The 5th fleet started experimenting late last year with a 23-foot Saildrone Explorer out of Jordan and MARTAC's Mantas T12 USV out of Bahrain. Those ongoing deployments are continuing to refine the Navy's concepts for unmanned systems.[19]

Another April 28, 2022, press report similarly stated

> Chief of Naval Operations Adm. Michael Gilday today cast doubt on whether the Medium Unmanned Surface Vessel will have a place in the service's fleet in the near future, citing work done by US 5th Fleet as having "changed my thinking on the direction of unmanned" ships.
>
> During a virtual event at the US Naval Institute and co-hosted by Center for Strategic and International Studies, Gilday was discussing what platforms and capabilities the service is developing for the 2030s and beyond.
>
> "Flight III DDGs [destroyers] will pave the way" for surface fleet capabilities, he said. "2030 is when we're looking at DDG(X)… By that time, I think we'll be in a better place with [the Large Unmanned Surface Vessel]. I don't know if we'll have a medium unmanned [surface vessel] or not."
>
> The Navy's top admiral said the work done by Vice Adm. Brad Cooper, US 5th Fleet chief, has led him to believe the service may be able to "close capability gaps with small expendable unmanned" vessels off of any platform. Cooper leads Task Force 59, a special panel inside the Navy, designed specifically to experiment with and test unmanned platforms.
>
> Gilday followed those remarks with a hedge, however, suggesting the program's fate is not predetermined.
>
> "There may be room for [larger unmanned platforms]," he added. "I'm not saying we don't need an MUSV. I'm saying that it'll cause us to consider numbers [of such platforms that may be needed] and what potential payloads they're going to have."[20]

[19] Sam LaGrone, "Navy Rethinking Medium Unmanned Surface Vehicle After Middle East Tests, Says CNO Gilday," *USNI News*, April 28, 2022.

[20] Justin Katz, "Gilday: 'I Don't Know' If Navy's Future Fleet Will Include Medium USVs," *Breaking Defense*, April 28, 2022. See also Rich Abott, "CNO Unsure If Navy Will Need MUSVs, Explains Retiring Ground-Based Growlers," *Defense Daily*, April 28, 2022.

Navy Description

The Navy states that

> The MUSV is defined as having a reconfigurable mission capability which is accomplished via modular payloads with an initial capability to support Battlespace Awareness through supporting Intelligence, Surveillance and Reconnaissance (ISR) and Information Operations (IO) mission areas....
>
> MUSVs will support the Navy's ability to produce, deploy and disburse ISR/IO capabilities in sufficient quantities and provide/improve distributed situational awareness in maritime Areas of Responsibility (AORs). MUSVs will be capable of weeks-long deployments and trans-oceanic transits, and operate aggregated with Carrier Strike Groups (CSGs) and Surface Action Groups (SAGs), as well as have the ability to deploy independently. The MUSV will be a key enabler of the Navy's Distributed Maritime Operations (DMO) concept.
>
> In FY 2020, the Navy conducted a full and open competition for a MUSV prototype, conducting source selection activities Q1-Q3 of FY20. In July 2020, the Navy announced they had awarded a Detail Design & Fabrication (DD&F) contract to L3 Harris for the delivery of the first MUSV prototype for $35M. The contract contains options for up to 8 additional MUSVs (9 total) for a total contract price of $281M. L3 Harris will be the system integrator, while also supplying the autonomy and perception systems. Subcontractors Gibbs & Cox and Incat Crowther will provide vessel design and modification services, while the vessel will be produced by Swiftships Shipyard. All work will be performed in various sites along the Louisiana Gulf Coast.[21]

Contract Award

As noted in the above-quoted passage, on July 13, 2020, the Navy announced that it had awarded "a $34,999,948 contract to L3[Harris] Technologies, Inc. for the development of a single Medium Unmanned Surface Vehicle (MUSV) prototype, with options to procure up to eight additional MUSVs. The award follows a full and open competitive procurement process. Funding is in place on this contract for the initial prototype. With all options exercised, the contract is valued at $281,435,446 if additional funding is provided in future budget years."[22] The Navy reportedly stated that there were five competitors for the contract, but did not identify the other four.[23] **Figure 6** shows a rendering of L3Harris's design concept. L3Harris states that

> will integrate the company's ASView™ autonomy technology into a purpose-built 195-foot commercially derived vehicle from a facility along the Gulf Coast of Louisiana. The MUSV will provide intelligence, surveillance and reconnaissance to the fleet while maneuvering autonomously and complying with international Collision Regulations, even in operational environments.…
>
> L3Harris will be the systems integrator and provide the mission autonomy and perception technology as the prime contractor on the program. The program team includes Gibbs &

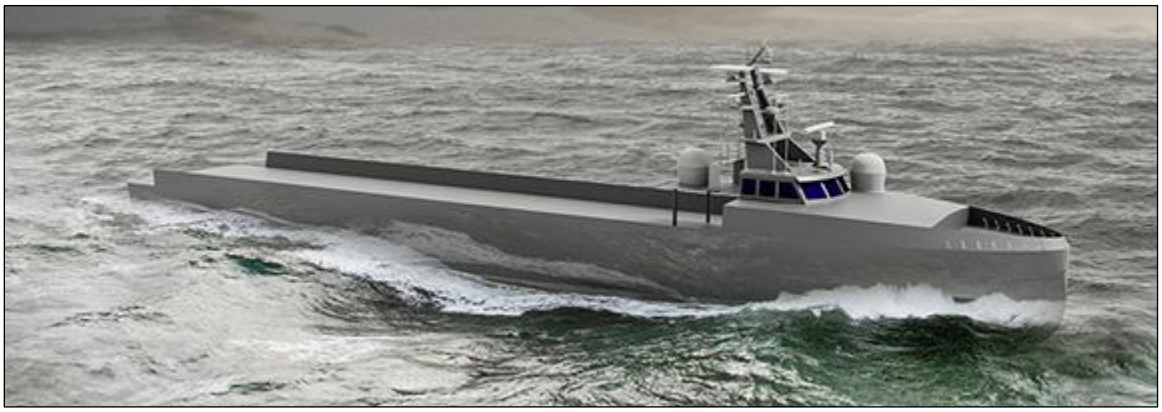
[21] *Department of Defense, Fiscal Year (FY) 2023 Budget Estimates, Navy Justification Book Volume 2 of 5, Research, Development, Test & Evaluation, Navy,* April 2022, p. 1399 (PDF page 1495 of 1608).

[22] PEO Unmanned and Small Combatants Public Affairs, "Navy Awards Contract for Medium Unmanned Surface Vehicle Prototype," Naval Sea Systems Command, July 13, 2020.

[23] Rich Abott, "L3Harris Wins $35 Million MUSV Prototype Contract," *Defense Daily*, July 13, 2020. See also Sam LaGrone, "Navy Awards Contract for First Vessel In Its Family of Unmanned Surface Vehicles," *USNI News*, July 14 (updated July 15), 2020; Paul McLeary, "Navy Inks Deal For New Unmanned Fleet," *Breaking Defense*, July 13, 2020.

Cox and Incat Crowther who will provide the ship design and Swiftships will complete the construction of the vehicle.[24]

Figure 6. Rendering of L3Harris Design Concept for MUSV



Source: L3Harris Technologies, "L3Harris Technologies Awarded Medium Unmanned Surface Vehicle Program from US Navy," August 18, 2020. See also Richard R. Burgess, "Navy's Medium USV to Be Based on Commercial Vehicle," *Seapower*, August 19, 2020.

XLUUV Program

Overview

The XLUUV program, also known as the Orca program, was established to address a Joint Emergent Operational Need (JEON). The Navy defines XLUUVs as UUVs with a diameter of more than 84 inches, meaning that XLUUVs are to be too large to be launched from a manned Navy submarine.[25] Consequently, XLUUVs instead will transported to a forward operating port and then launched from pier. The Department of the Navy's March 16, 2021, unmanned campaign framework document states that the XLUUV will be designed "to accommodate a variety of large payloads…."[26] The Navy testified on March 18, 2021, that mines will be the initial payload for XLUUVs.[27] More specifically, the Navy wants to use XLUUVs to, among other things, covertly deploy the Hammerhead mine, a planned mine that would be tethered to the seabed and armed with an antisubmarine torpedo, broadly similar to the Navy's Cold War-era CAPTOR (encapsulated torpedo) mine.[28]

The first five XLUUVs were funded in FY2019 through the Navy's research and development appropriation account. The Navy conducted a competition for the design of the XLUUV, and

[24] L3Harris Technologies, "L3Harris Technologies Awarded Medium Unmanned Surface Vehicle Program from US Navy," August 18, 2020. See also Audrey Decker, "First MUSV Platform Will Feature Broad Payload Area," *Inside Defense*, January 20, 2022.

[25] Navy submarines equipped with large-diameter vertical launch tubes can launch missiles or other payloads with diameters of up to about 83 inches.

[26] Department of the Navy, *Department of the Navy Unmanned Campaign Framework*, March 16, 2021, p. 16.

[27] Richard R. Burgess, "Navy's Orca XLUUV to Have Mine-Laying Mission, Adm. Kilby Says," *Seapower*, March 18, 2021.

[28] For a discussion of the Hammerhead mine, see, for example, David Hambling, "With Hammerhead Mine, U.S. Navy Plots New Style Of Warfare To Tip Balance In South China Sea," *Forbes*, October 22, 2020. See also Audrey Decker, "Navy's XLUUV Will Fill 'Specific Mission' in INDOPACOM," *Inside Defense*, November 22, 2021.

announced on February 13, 2019, that it had selected Boeing to fabricate, test, and deliver the first four Orca XLUUVs and associated support elements.[29] (The other bidder was a team led by Lockheed Martin.) On March 27, 2019, the Navy announced that the award to Boeing had been expanded to include the fifth Orca.[30] Boeing has partnered with the Technical Solutions division of Huntington Ingalls Industries (HII) to build Orca XLUUVs.[31] (Another division of HII—Newport News Shipbuilding (NNS) of Newport News, VA—is one of the Navy's two submarine builders.)

Under the Navy's FY2023 five-year (FY2023-FY2027) shipbuilding plan, procurement of additional XLUUVs through the Navy's shipbuilding account is scheduled to begin in FY2024. The plan calls for the procurement of one XLUUV in FY2024 at a cost of $113.6 million, one XLUUV in FY2025 at a cost of $107.6 million, two XLUUVs in FY2026 at a combined cost of $226.6 million (an average cost of $113.3 million each), and two XLUUVs in FY2027 at a combined cost of $231.1 million (an average cost of $115.6 million each).

Navy Description

The Navy states that

> The Orca XLUUV effort is established to address a Joint Emergent Operational Need (JEON). Orca XLUUV is a multi-phased accelerated acquisition effort to rapidly deliver capability to the Fleet. Phase 1 was a competitively sourced design effort. Phase 2 down selected to one of the Phase 1 vendors in FY 2019 for fabrication and testing of the vehicle and support elements. Testing and delivery of the vehicles and support elements has been delayed to FY22-23 due to contractor challenges and supplier issues. The Navy is working with Boeing to mitigate schedule delays and execute risk reduction testing through the addition of a designated test and training asset. The Navy is updating facilities at the Naval Base Ventura County site for testing, training, and work-ups, in coordination with large unmanned surface vessel testing for cost efficiencies. Fabrication awards of additional Orca XLUUV systems are planned for FY24 and out, gradually ramping up quantities in future fiscal years, depending on the progress from the first five systems. XLUUV will have a modular payload bay, with defined interfaces that current and future payloads must adhere to for employment from the vehicle. The Orca XLUUV effort will integrate the currently required payload, and potential future payloads will be developed, evaluated, and preliminarily integrated leveraging the Core Technologies Program Element 0604029N. Additional XLUUV technologies/capabilities risk reduction will occur in parallel, leveraging the competitive Industrial base.[32]

Boeing Echo Voyager

Boeing's Orca XLUUV design will be informed by (but will differ in certain respects from) the design of Boeing's Echo Voyager UUV (**Figure 7**, **Figure 8**, and **Figure 9**).[33] Echo Voyager is roughly the size of a subway car—it is 51 feet long and has a rectangular cross section of 8.5 feet

[29] Department of Defense, *Contracts for Feb. 13, 2019*.

[30] Department of Defense, *Contracts for March 27, 2019.*

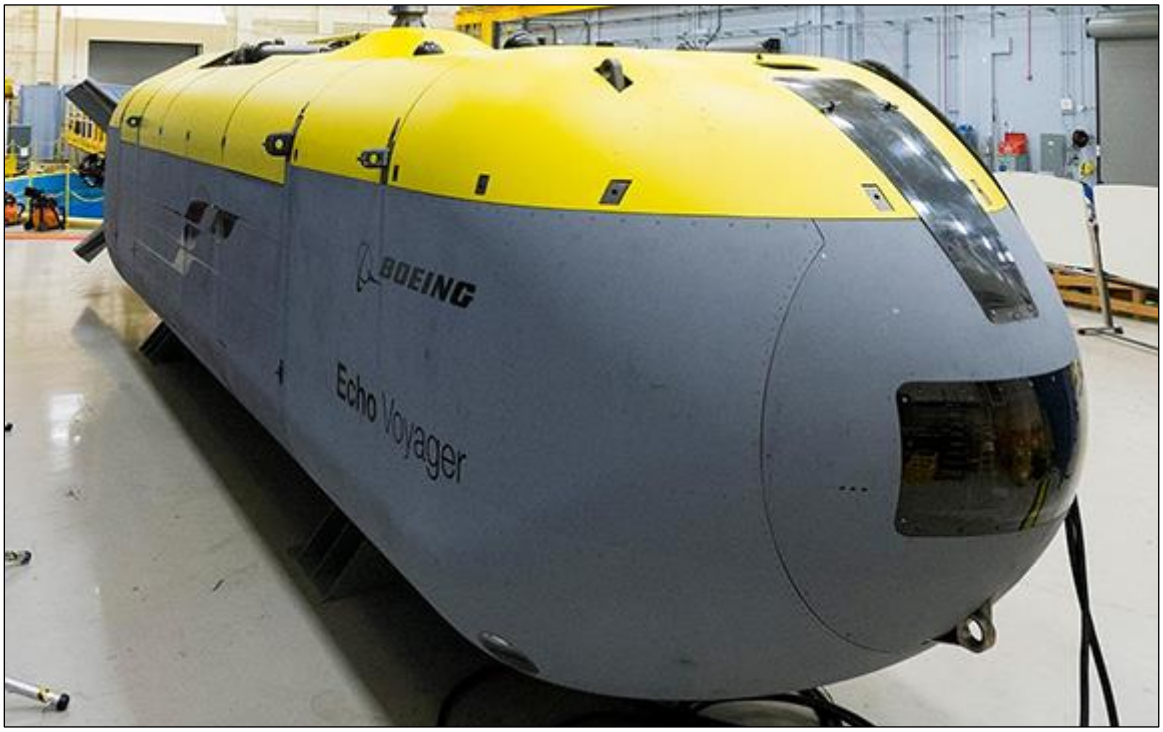
[31] See, for example, Hugh Lessig, "Shipbuilder Lends a Hand with Rise of Robot Submarines," *Defense News,* May 26, 2019.

[32] *Department of Defense, Fiscal Year (FY) 2023 Budget Estimates, Navy Justification Book Volume 2 of 5, Research, Development, Test & Evaluation, Navy,* April 2022, p. 1297 (PDF page 1393 of 1608).

[33] See, for example, Hugh Lessig, "Shipbuilder Lends a Hand with Rise of Robot Submarines," *Defense News,* May 26, 2019.

by 8.5 feet, a weight in the air of 50 tons, and a range of up to 6,500 nautical miles. It can accommodate a modular payload section up to 34 feet in length, increasing its length to as much as 85 feet. A 34-foot modular payload section provides about 2,000 cubic feet of internal payload volume; a shorter (14-foot) section provides about 900 cubic feet. Echo Voyager can also accommodate external payloads.[34]

Figure 7. Boeing Echo Voyager UUV



Source: Boeing photograph posted at https://www.boeing.com/defense/autonomous-systems/echo-voyager/index.page#/gallery.

The Navy states that the XLUUV

> is based off Boeing's Echo Voyager, but incorporates significant changes to support military mission requirements. This has resulted in challenges in establishing the manufacturing process, building up the industrial base, and aligning material purchases to produce the first group of prototype vehicles. Orca represents the leading edge of autonomous maritime vehicle technology and will have extended range and a reconfigurable, modular payload bay to support multiple payloads and a variety of missions.[35]

[34] Source: Boeing product sheet on Echo Voyager, accessed May 31, 2019, at https://www.boeing.com/resources/boeingdotcom/defense/autonomous-systems/echo-voyager/echo_voyager_product_sheet.pdf.

[35] Statement of Fredrick J. Stefany, Acting Assistant Secretary of the Navy for Research, Development and Acquisition (ASN [RD&A]) and Vice Admiral James W. Kilby, Deputy Chief of Naval Operations for Warfare Systems and Lieutenant General Eric M. Smith, Deputy Commandant Combat Development and Integration & Commanding General, Marine Corps Combat Development Command, before the House Armed Services Committee Subcommittee on Seapower and Projection Forces, on Department of the Navy Unmanned Systems, March 18, 2021, p. 12.

Figure 8. Boeing Echo Voyager UUV

Source: Boeing photograph posted at https://www.boeing.com/defense/autonomous-systems/echo-voyager/index.page#/gallery.

Figure 9. Boeing Echo Voyager UUV

Source: Navy briefing entitled "Unmanned Maritime Systems," Howard Berkof, Deputy Program Manager, Unmanned Maritime Systems, PMS 406, Distribution A: Approved for public release; distribution unlimited, October 23, 2019, slide 5.

Issues for Congress

The Navy's proposals for developing and procuring the large UVs covered in this report pose a number of oversight issues for Congress, including those discussed below.

Analytical Basis for Fleet Architecture Including Large UVs

One potential oversight issue for Congress concerns the analytical basis for the Navy's desire to shift to a more distributed fleet architecture that includes large UVs. Potential oversight questions for Congress include the following:

- What analyses led to the Navy's decision to shift toward a more distributed architecture that includes large UVs?
- What did these analyses reveal about the comparative costs, capabilities, and risks of more distributed architectures that do not include large UVs?
- How well developed and tested are the operational concepts associated with the various options for more distributed architectures that have been analyzed?

As discussed earlier, the Navy is conducting an analysis of alternatives (AOA), which Navy officials reportedly expected to complete by the end of April 2022, to compare the cost-effectiveness of the LUSV to a range of alternative surface platforms, including modified naval vessel designs such as amphibious ships, expeditionary fast transport (EPF) ships, and expeditionary sea base (ESB) ships, modified commercial vessel designs such as container ships and bulk carriers, new naval vessel designs, and new commercial vessel designs.

Concept of Operations (CONOPS)

Overview

Another potential oversight issue for Congress concerns the Navy's concept of operations (CONOPS) for these large UVs, meaning the Navy's understanding at a detailed level of how it will operate and support these UVs in conjunction with manned Navy ships in both combat operations and at other times, and consequently how, exactly, these UVs will fit into the Navy's overall force structure and operations.

December 2021 Blog Posts

Some observers have raised questions regarding the Navy's CONOPs for operating and supporting large UVs, particularly large USVs. A December 10, 2021, blog post, for example, states

> The U.S. Navy is moving forward with its plans for a more distributed fleet in which intelligent unmanned or autonomous platforms will play a significant role. Unfortunately, many of the details about these novel systems are left to the imagination—often a poor substitute for filling in the blanks. It may be that the blanks cannot be satisfactorily filled when describing the infrastructure for sustaining these unmanned systems. Rightly or wrongly, the Navy focuses most of its discussion on the direct offensive contributions of unmanned systems for combat with major powers on warfighting impact and metrics such as effects on targets, capacity, and tempo. Less discussion focuses on the indirect sustainment tasks....
>
> Our concern ... is with offboard air, surface, and subsurface unmanned vehicles that will operate with some degree of autonomy. It matters logistically whether these offboard systems are expendable or recoverable because recoverable systems must not only be launched, but also retrieved, refueled (or recharged), and maintained during the potentially long pre-combat period....
>
> ... most of the Navy's discussions are couched in terms of operations after bullets have started flying, omitting details about what happens during the days, weeks, and months

> before combat begins. Because of that, there is little discussion of the infrastructure to support those pre-combat operations—infrastructure that would seem to include "motherships" and overseas land support bases for the unmanned systems if the Navy is employing tens to hundreds of these systems. Explanations from the Navy as to how this will happen are sparse, and one might be excused for thinking there is no significant cost or preparation required at all.
>
> This leads to a fundamental tradeoff without a good solution. If the Navy wants to develop small quantities of intelligent, precision offensive unmanned systems, then those systems should be regarded as valuable and require their own (costly) defensive measures. Otherwise they become effectively expendable. Conversely, if the Navy wants to emphasize quantity over quality with inexpensive mass (such as "swarms"), it needs to recognize that there is great advantage to the side that owns the nearby land where even larger quantities of such unmanned systems can be generated. In swarm warfare, quantity trumps quality. Either way, there is an infrastructure tail that cannot be ignored....
>
> The Navy can sustain small numbers of unmanned systems today. If that is the future that the Navy envisions, with only small quantities of systems that may be superb in quality and capability, it should say so. But the illusion created by the Navy's strategy, whether intentional or not, is that the number of offboard unmanned systems in use will not be small. Furthermore, unless the offboard systems have exceedingly long range and endurance, launching and recovering them must be done with some proximity to their operational locations, presumably at risk of attack from the adversary.
>
> This begs the question: What part of the Navy force structure and budget will be used for large-scale sustainment of unmanned systems at sea? There are some possibilities, but none look particularly attractive....
>
> Unmanned or autonomous platforms have some roles to play (especially in surveillance and reconnaissance), but the quantities that are required for naval operations must be married with a sustainment plan—and maybe a shipbuilding plan—to support that level of operations both during combat and in the days, weeks, and months before combat operations ratchet up. A meaningful concept of operations must address this.[36]

A December 28, 2021, blog post states

> Two subjects are nearly inescapable in commentary about the U.S. Navy today. The first is the much-maligned, 15-year saga of the littoral combat ship (LCS), which has provided an unfortunate case study for interest group capture, misalignment of ends and means, cost overruns, and engineering failures.
>
> The second subject is more hopeful: proposals for unmanned surface vessels that will deliver cost savings and increase the size of the fleet....
>
> Very little commentary, however, explicitly connects the two subjects. This is unfortunate because, while the LCS is not unmanned, it is further on the unmanned spectrum than any other U.S. Navy vessel in operational use, making it the closest real-world test case for future surface fleet architecture....
>
> ... replacing sailors [on the LCS] with technology reduced maintenance at the operator level, but increased it at the regional maintenance center and original equipment manufacturer levels. This raised costs overall, meaning fewer platforms could be purchased. Second, minimal manning made platforms less resilient. Fewer sailors meant fewer problems spotted, and less capacity to fix them while underway. Hence, if fielded in anything approximating combat conditions, the LCS would not remain effective for long.

[36] Gregory V. Cox, "The U.S. Navy's Plans for Unmanned and Autonomous Systems Leave Too Much Unexplained," *War on the Rocks*, December 10, 2021.

We argue that these two challenges are as—if not more—likely to occur on unmanned ships as they did on minimally manned ones....

Through direct experience operating their equipment while underway, LCS sailors have developed "tribal knowledge" of their systems. They have also acquired onsite knowledge by observing contractors and regional maintenance center engineers. As sailors transition to shore tours at regional maintenance facilities and training groups, designing programs to train the next generation of LCS sailors, the Navy achieves some self-sufficiency, an experiential economy of scale that can help recoup the costs of overreliance on original equipment manufacturers and contractors.

Yet it is difficult to see how this optimistic scenario could occur with fully unmanned platforms. First, with no sailors aboard, the underway experimentation and practice that produced tribal knowledge in the LCS case can't happen. Nor will sailors be present to observe and learn from contractors who repair equipment. Without the economy of scale that began developing in the LCS case, maintenance costs will remain beholden to third-party contractors.

Second, while contractors can fly out to a manned platform that is underway, they cannot do so for an unmanned vessel. Without accommodations and life-support systems, unmanned vessels will have to return to port for repairs, or else be sustained at sea and in theater by amphibious ships, submarines, or expeditionary sea bases....

The minimal-manning construct of the LCS undermined its utility for distributed maritime operations in two ways. First, removing humans from the ship placed higher demands on contractor support. This drove up production and life-cycle costs, driving down the quantity of platforms that could be purchased. Second, the platform's minimal manning made it less resilient to routine wear and tear, and consequently, the Navy both decommissioned four LCS hulls early and had to withdraw others from routine operations repeatedly to conduct repairs. We conclude with three recommendations to help future unmanned surface vessels avoid a similar fate.

First, unmanned system development requires a different approach to project management than was used for the LCS....

... unlike with the LCS, where adding personnel to the original manning concept helped resolve failed integration points, fully unmanned platforms will lack this backstop. As a result, there is an even higher premium on ensuring that the integration points of the ship's networks and mechanical systems function properly before widespread fielding. Agile project management, a development style based on shorter timelines and multiple delivery dates, might help address the issue. The Navy's program executive office, Integrated Warfare Systems, is currently working to incorporate agile continuous delivery processes. In this approach, the product timeline is less definitive, changes to the product are frequent and expected, and the end user helps guide each iteration. The shipbuilding version of this would include the use of land-based testing sites, as it will for the Navy's new Constellation-class frigate....[37]

Second, even with perfect equipment, unmanned vessels will face attacks with a redundancy chain that is always one link shorter than it would be with sailors present.... With a distributed fleet architecture, the Navy should only use unmanned vessels for those mission areas where the ability to survive the first few salvos matters little to the extended fight.

[37] For more on the Constellation-class frigate program, see CRS Report R44972, *Navy Constellation (FFG-62) Class Frigate Program: Background and Issues for Congress*, by Ronald O'Rourke.

> Third, while purchasing and fielding a great number of vessels is necessary for distributed maritime operations, so is preventing them all from being sunk outright. Unmanned vessels should not be considered expendable if they are expected to provide quantity, so some proportion of them will have to be repaired in combat conditions.... This suggests that, if future fleet architecture depends heavily on unmanned vessels, the Navy will eventually bear the costs of more manned support vessels as well.[38]

Navy Efforts to Develop CONOPs

As mentioned earlier, in May 2019, the Navy established a surface development squadron to help develop operational concepts for LUSVs and MUSVs. The squadron was initially to consist of a Zumwalt (DDG-1000) class destroyer and one Sea Hunter prototype medium displacement USV. A second Sea Hunter prototype reportedly was to be added around the end of FY2020, and LUSVs and MUSVs would then be added as they become available.[39] A September 9, 2020, press report states

> Development squadrons working with unmanned underwater and surface vehicles are moving out quickly to develop concepts of operations and human-machine interfaces, even as they're still using prototypes ahead of the delivery of fleet USVs and UUVs, officials said this week.
>
> Capt. Hank Adams, the commodore of Surface Development Squadron One (SURFDEVRON), is planning an upcoming weeks-long experiment with sailors in an unmanned operations center (UOC) ashore commanding and controlling an Overlord USV that the Navy hasn't even taken ownership of from the Pentagon, in a bid to get a head start on figuring out what the command and control process looks like and what the supervisory control system must allow sailors to do.
>
> And Cmdr. Rob Patchin, commanding officer of Unmanned Undersea Vehicles Squadron One (UUVRON-1), is pushing the limits of his test vehicles to send the program office a list of vehicle behaviors that his operators need their UUVs to have that the commercial prototypes today don't have.
>
> The two spoke during a panel at the Association for Unmanned Vehicle Systems International (AUVSI) annual defense conference on Tuesday, and made clear that they want to have the fleet trained and ready to start using UUVs and USVs when industry is ready to deliver them.[40]

An October 30, 2020, press report stated

> The Navy is set to complete and release a concept of operations for the medium and large unmanned surface vehicles in "the next few months," a Navy spokesman told Inside Defense.
>
> Alan Baribeau, a spokesman for Naval Sea Systems Command, said the Navy extended the due date to allow for more flexibility during the COVID-19 pandemic and allow for sufficient time for review and staffing….

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[38] Jonathan Panter and Johnathan Falcone, "The Unplanned Costs of an Unmanned Fleet," *War on the Rocks*, December 28, 2021.

[39] See, for example, Megan Eckstein, "Navy Stands Up Surface Development Squadron for DDG-1000, Unmanned Experimentation," *USNI News*, May 22, 2019; David B. Larter, "With Billions Planned in Funding, the US Navy Charts Its Unmanned Future," *Defense News*, May 6, 2019. See also Michael Fabey, "USN Seeks Path for Unmanned Systems Operational Concepts," *Jane's Navy International*, May 16, 2019.

[40] Megan Eckstein, "USV, UUV Squadrons Testing Out Concepts Ahead of Delivery of Their Vehicles," *USNI News*, September 9, 2020.

> The CONOPS is currently undergoing flag-level review after completing action officer-level review as well as O6-level review, Baribeau said.[41]

A December 15, 2021, press report stated

> The Navy has announced new plans for a "purpose-built" facility at its warfare center in Port Hueneme, Calif., dedicated to testing its latest unmanned surface and subsurface vehicles.
>
> "These facilities will be the focal point of Navy learning and experimentation on the capabilities, operations and sustainment of unmanned maritime vehicle prototypes to inform future programs," Capt. Pete Small, the Navy officer leading the program office for unmanned maritime systems, said in a Dec. 14 statement.
>
> Some of the systems in Small's portfolio that are destined for Port Heuenme include the Extra Large Unmanned Undersea Vehicle (XLUUV), as well as prototypes for the Medium and Large Unmanned Surface Vehicles.[42]

Potential Oversight Questions

Potential oversight questions for Congress include the following:

- How fully has the Navy developed its CONOPS for these large UVs? What activities is the Navy undertaking to develop its CONOPS for them?
- What is the Navy's CONOPS for operating and sustaining these large UVs, including both combat operations and day-to-day, noncombat operations?
- How sensitive are the performance requirements that the Navy has established for these large UVs to potential changes in their CONOPS that may occur as the Navy continues to develop the CONOPS? How likely is it, if at all, that the Navy will have to change the performance requirements for these large UVs as a consequence of more fully developing their CONOPS? How do the Navy's acquisition strategies for these large UVs address the possibility that the UVs' performance requirements might need to evolve as the CONOPs are developed?

Acquisition Strategies and Technical, Schedule, and Cost Risk

Overview

Another potential oversight issue for Congress concerns the amount of technical, schedule, and cost risk in these programs, particularly given that these platforms potentially are to operate at sea unmanned and semi-autonomously or autonomously for extended periods of time, and the acquisition strategies that the Navy wants to use for these programs. Potential oversight questions for Congress include the following:

- How much technical, schedule, and cost risk of this kind do these programs pose, particularly given the enabling technologies that need to be developed for them?
- Are the Navy's risk-mitigation and risk-management efforts for these programs appropriate and sufficient? Are the Navy's proposed changes to the LUSV's acquisition strategy appropriate and sufficient in terms of complying with

[41] Aidan Quigley, "Navy Finishing Unmanned Surface Vehicles Concept of Operations 'in Next Few Months,'" *Inside Defense*, October 30, 2020.

[42] Justin Katz, "Navy Starts Building Hub for Surface, Subsurface Drones," *Breaking Defense*, December 15, 2021.

Congress's legislative provisions and providing enough time to develop operational concepts and key technologies before entering into serial production of deployable units?

- At what point would technical problems, schedule delays, or cost growth in these programs require a reassessment of the Navy's plan to shift from the current fleet architecture to a more distributed architecture?
- To what degree, if any, can these large UV programs contribute to new approaches for defense acquisition that are intended to respond to the new international security environment?

April 2022 GAO Report

An April 2022 Government Accountability Office (GAO) report on uncrewed maritime systems (i.e., Navy UVs) stated

> While the Navy's shipbuilding plan outlines spending more than $4 billion on uncrewed systems over the next 5 years, its plan does not account for the full costs to develop and operate these systems.
>
> Once conceived, the Navy must build these vehicles with the information technology and the artificial intelligence capabilities needed to replace crews. While the Navy has established strategic objectives for these efforts, it has not established a management approach that orients its individual uncrewed maritime efforts toward achieving these objectives. As such, the Navy is not measuring its progress, such as building the robust information technology needed to operate the vehicles. GAO has previously found that portfolio management—a disciplined process that ensures new investments are aligned with an organization's strategic needs within available resources—enables agencies to implement strategic objectives and manage investments collectively. However, if it continues with its current approach, the Navy is less likely to achieve its objectives. In addition, the Navy has yet to:
>
> • establish criteria to evaluate prototypes and
>
> • develop improved schedules for prototype efforts.
>
> With detailed planning, prototyping has the potential to further technology development and reduce acquisition risk before the Navy makes significant investments. Since uncrewed systems are key to the Navy's future, optimizing the prototyping phase of this effort is necessary to efficiently gaining information to support future decisions.[43]

Press Reports

A January 28, 2022, press report stated

> The U.S. Navy is unlikely to pursue a formal program for unmanned surface vessels in the next five years, instead focusing on the enabling technologies first, several leaders said this month.
>
> The Navy in fiscal 2020 laid out an aggressive plan to buy a handful of prototype medium and large USVs and then quickly transition into a program of record using shipbuilding funds. The service acknowledged it would adjust the program-of-record USV design over time to incorporate lessons learned as prototypes hit the water.

[43] Government Accountability Office, *Uncrewed Maritime Systems[:] Navy Should Improve Its Approach to Maximize Early Investments*, GAO-22-104567, April 2022, highlights page (PDF page 2 of 54).

> Leaders argued this strategy was necessary because the technology was key to the Navy's Distributed Maritime Operations concept, and because there was no time to waste in building and fielding the vessels.
>
> After two years of Congress pushing back against this quick move into unmanned programs, the Navy has quietly acknowledged a change in strategy.
>
> "We are focused on prototyping and maturing the fundamentals, the building blocks," Rear Adm. Casey Moton, the program executive officer for unmanned and small combatants, said earlier this month at the Surface Navy Association's [SNA's] annual conference.
>
> Though Moton said there's a lot of interest in the future large and medium USV programs—previously slated to begin as early as 2023—his team is more "focused on the system engineering pillars that we need to field any such platform."...
>
> Rear Adm. Paul Schlise, the director of surface warfare on the chief of naval operations' staff (OPNAV N96), told Defense News following his presentation at a separate SNA panel that he wouldn't move into a program of record until all those separate pillars were more mature. One key pillar is the development and maturation of hull, mechanical and electrical systems that can support unmanned vessel operations.
>
> Schlise said lawmakers were "crystal clear" in the fiscal 2021 defense authorization bill that they didn't want to invest in programs of record until it's clear hull, mechanical and electrical systems would work for weeks or months at a time without sailors around to perform routine maintenance or emergency repairs....
>
> Asked how long that would take and when the Navy will begin a program of record, Schlise said he hopes by the end of the five-year Future Years Defense Program that the service will "have gotten pretty confident in what we can and can't do. And maybe we'll learn this is going to take a little bit longer. I don't have an absolute clairvoyant picture."[44]

A February 16, 2022, press report stated

> Aircraft carriers will deploy alongside large unmanned vessels within five years, if the Navy's top officer gets his way.
>
> In 2027 or 2028—"and earlier if I can"—Adm. Mike Gilday said he wants to begin to deploy large and medium-sized unmanned vessels as part of carrier strike groups and amphibious ready groups.
>
> For the first deployments, such vessels "may not necessarily be completely unmanned; they may be minimally manned," the chief of naval operations told reporters in a Wednesday [February 16] conference call. "But I want to be in a position where we can crawl-walk-run" and "put us in a position where we can scale [i.e., increase the numbers of these UVs] in the 2030s."
>
> One key to this, Gilday said, is doing as much testing and prototyping as possible at land-based facilities and simulators....
>
> Another vital component, Gilday said, are the flexible and reliable wireless networks that will connect uncrewed vessels to the rest of a strike group.[45]

Another February 16, 2022, press report states

> "We're moving in an evolutionary instead of a revolutionary manner, in order to deliver a platform [that] is going to be reliable and that's actually going to perform as intended,"

[44] Megan Eckstein, "US Navy Adopts New Strategy Prioritizing 'the Building Blocks' of Unmanned Tech," *Defense News*, January 28, 2022.

[45] Bradley Peniston, "Navy Chief Sees Robot Ships Alongside Aircraft Carriers Within Five Years," *Defense One*, February 16, 2022.

> [Chief of Naval Operations Admiral Mike] Gilday said [February 16]. "We could actually learn greatly from our land-based engineering test sites … specifically up in Philadelphia, Pennsylvania, where we can take an engineering configuration that we want to use on a specific platform."
>
> While the Navy is proving those systems to Congress, Gilday wants to get other types of smaller vehicles into the fleet sooner....
>
> While the mechanical reliability of the platforms is a major point of concern, so are the networks that transmit the targeting data. The service plans to use its existing networks to transmit surveillance data and targeting information the same way a smartphones transitions from lower to different networks as a user moves from Wi-Fi to a cellular data network.
>
> "The software on the phone shifts you to a [cell] network automatically. You don't care, the phone doesn't care, you're just getting, you're just getting the information you want when you want it. It's that same type of idea where software would decide," Gilday said.
>
> "The system would then containerize it in a way that could ride on any one of those lightning bolts. It could move on any one of those systems to get to the endpoint system. It's leveraging the fact that every shooter doesn't necessarily have to sense the target that you're going to that it is going to fire at. That it can be set the target it can be… radio silent."
>
> The Navy has tested the software-defined system in San Diego and Gilday said there are plans to test a battle group with the concept later this year or in early 2023.
>
> The new tack from the Navy will get new unmanned systems to the fleet faster and inform the larger systems that are developing more slowly.
>
> "We thought that was important, or I thought that was important from a risk-reduction standpoint so that we could begin to mature and then hopefully scale unmanned capabilities at a faster pace," he said.[46]

A March 10, 2022, press report stated

> Public discussions between the Navy and Congress over unmanned technology in recent years have been circular: The service asks for funding to develop new technology, hesitant lawmakers balk at pouring millions into unproven tech, then the Navy re-ups its requests the next year, insistent the investment remains necessary.
>
> The routine has left Congress wary of the Navy's ideas and the service struggling to refine its pitch.
>
> But during a year filled with international exercises, with a new task force stood up by the chief of naval operations and amid significant programmatic advances, the Navy hopes to break the cycle by changing its messaging strategy around unmanned systems: More showing, less telling.
>
> It's a slow shift, but analysts told Breaking Defense there are signs that the Navy has taken cues on what it will take to sway opinions in Congress towards backing more aggressive funding of unmanned technology.
>
> "I think the new strategy by the Navy to focus on the core enabling technologies is the right strategy. [It] will bring about that comfort level from Congress that will enable the funding and allow industry to begin to scale these programs working hand in glove with the Navy,"

[46] Sam LaGrone, "CNO Gilday Taking a More 'Realistic' Approach to Unmanned Systems in the Fleet," *USNI News*, February 16 (updated February 17), 2022.

said Michael Robbins, a spokesman for the Association for Uncrewed Vehicles Systems International, a non-profit group focused on promoting unmanned systems technology.

Recently Chief of Naval Operations Adm. Michael Gilday acknowledged that the Navy took lessons from past missteps.

"I think we've learned a lot, as I said, from those other classes of ships. I think that Congress is holding our feet to the fire on those lessons, and I'm 100% in support of that," he told reporters last month.

When asked about the service's messaging to lawmakers, Gilday highlighted Congress' insistence on land-based testing, a process in which the Navy attempts to install and operate a new technology ashore before tampering with an operational warship. It's a simple concept, but the Navy has infuriated lawmakers in the past when expensive programs suffered costly setbacks after skipping this step.

The Navy has learned the importance of "moving in an evolutionary, instead of a revolutionary, manner in order to deliver a platform and it's going to be reliable and its actually going to perform as intended," he said.

In other words, small changes with proven results over time are going to instill more confidence in lawmakers than grand proposals with questionable visions....

Opinions about unmanned technology, like any issue in Washington, DC, are not uniform on Capitol Hill. But the budget cuts and restrictive language in the last handful of National Defense Authorization Acts show that lawmakers have been erring on the side of caution when pitched on the biggest projects the Navy proposes.

The most ambitious efforts have usually been predicated more so on promises from service leadership rather than proven results, lawmakers complain.

"For a long time, unmanned has been the promise of the future that will always remain in the future. And that's just where we are right now," said Chris Brose, formerly the staff director on the Senate Armed Services Committee and current chief strategy officer of the defense contractor Anduril. "The new prioritization of trying to get capability out to the fleet fast to solve problems that unmanned systems can solve now… That to me is just a welcome improvement."

For example, in just the past year, the service has established two task forces focused on unmanned technology: one at the CNO's level and one based at US 5th Fleet based in Bahrain. The Strategic Capabilities Office has transferred ownership of a flagship unmanned surface vessel program to the Navy's fleet. And the service has also publicized a variety of international exercises featuring unmanned US assets.

That is not an exhaustive list of Navy unmanned activities, but they are some of the more public events the service has flaunted in recent months to get its message across to the public and lawmakers.

"The Navy has been really focused on fielding entire systems using programs of record to move large projects forward and that's received… significant push back from Congress," said Robbins.

"What we're hearing now is a different strategy from the Navy that is focused, not so much on programs of record, but instead focusing on the various enabling technologies to build these programs. I think that is a direct result of feedback from Congress," he continued.[47]

[47] Justin Katz, "Show, Don't Tell: Navy Changes Strategy to Sell Unmanned Systems to Skeptical Congress," *Breaking Defense*, March 10, 2022. See also Megan Eckstein, "Unmanned or Minimally Manned Vessels Could Deploy Alongside Strike Groups as Soon as 2027," *Defense News*, February 17, 2022; Justin Katz, "From 7 Classified 'Spirals' to Coming Robotic Ships: Gilday on Navy's Unmanned Task Force," *Breaking Defense*, February 17, 2022.

Industrial Base Implications

Another oversight issue for Congress concerns the potential industrial base implications of these large UV programs as part of a shift to a more distributed fleet architecture, particularly since UVs like these can be built and maintained by facilities other than the shipyards that currently build the Navy's major combatant ships. Potential oversight questions for Congress include the following:

- What portion of these UVs might be built or maintained by facilities other than shipyards that currently build the Navy's major combatant ships?[48]
- To what degree, if any, might these large UV programs change the current distribution of Navy shipbuilding and maintenance work, and what implications might that have for workloads and employment levels at various production and maintenance facilities?

Potential Implications for Miscalculation or Escalation at Sea

Another oversight issue for Congress concerns the potential implications of large UVs, particularly large USVs, for the chance of miscalculation or escalation in when U.S. Navy forces are operating in waters near potential adversaries. Some observers have expressed concern about this issue. A June 28, 2019, opinion column, for example, states

> The immediate danger from militarized artificial intelligence isn't hordes of killer robots, nor the exponential pace of a new arms race.
>
> As recent events in the Strait of Hormuz indicate, the bigger risk is the fact that autonomous military craft make for temping targets—and increase the potential for miscalculation on and above the high seas.
>
> While less provocative than planes, vehicles, or ships with human crew or troops aboard, unmanned systems are also perceived as relatively expendable. Danger arises when they lower the threshold for military action.
>
> It is a development with serious implications in volatile regions far beyond the Gulf—not least the South China Sea, where the U.S. has recently confronted both China and Russia….
>
> As autonomous systems proliferate in the air and on the ocean, [opposing] military commanders may feel emboldened to strike these platforms, expecting lower repercussions by avoiding the loss of human life.
>
> Consider when Chinese naval personnel in a small boat seized an unmanned American underwater survey glider[49] in the sea approximately 100 kilometers off the Philippines in December 2016. The winged, torpedo-shaped unit was within sight of its handlers aboard the U.S. Navy oceanographic vessel Bowditch, who gaped in astonishment as it was summarily hoisted aboard a Chinese warship less than a kilometer distant. The U.S. responded with a diplomatic demarche and congressional opprobrium, and the glider was returned within the week….
>
> In coming years, the Chinese military will find increasingly plentiful opportunities to intercept American autonomous systems. The 40-meter prototype trimaran Sea Hunter, an

[48] For an opinion piece addressing this issue, see Collin Fox, "Distributed Manufacturing for Distributed Lethality," Center for International Maritime Security (CIMSEC), February 26, 2021.

[49] A glider is a type of UUV. The glider in question was a few feet in length and resembled a small torpedo with a pair of wings. For a press report about the seizure of the glider, see, for example, Sam LaGrone, "Updated: Chinese Seize U.S. Navy Unmanned Vehicle," *USNI News*, December 16, 2016.

experimental submarine-tracking vessel, recently transited between Hawaii and San Diego without human intervention. It has yet to be used operationally, but it is only a matter of time before such vessels are deployed….

China's navy may find intercepting such unmanned and unchaperoned surface vessels or mini-submarines too tantalizing to pass up, especially if Washington's meek retort to the 2016 glider incident is seen as an indication of American permissiveness or timidity.

With a captive vessel, persevering Chinese technicians could attempt to bypass anti-tamper mechanisms, and if successful, proceed to siphon off communication codes or proprietary artificial intelligence software, download navigational data or pre-programmed rules of engagement, or probe for cyber vulnerabilities that could be exploited against similar vehicles….

Nearly 100,000 ships transit the strategically vital Singapore Strait annually, where more than 75 collisions or groundings occurred last year alone. In such congested international sea lanes, declaring a foreign navy's autonomous vessel wayward or unresponsive would easily serve as convenient rationale for towing it into territorial waters for impoundment, or for boarding it straightaway….

A memorandum of understanding signed five years ago by the U.S. Department of Defense and the Chinese defense ministry, as well as the collaborative code of naval conduct created at the 2014 Western Pacific Naval Symposium, should be updated with an expanded right-of-way hierarchy and non-interference standards to clarify how manned ships and aircraft should interact with their autonomous counterparts. Without such guidance, the risk of miscalculation increases.

An incident without any immediate human presence or losses could nonetheless trigger unexpected escalation and spark the next conflict.[50]

[50] Evan Karlik, "US-China Tensions—Unmanned Military Craft Raise Risk of War," *Nikkei Asian Review*, June 28, 2019. See also David B. Larter, "The US Navy Says It's Doing Its Best to Avoid a 'Terminator' Scenario in Quest for Autonomous Weapons," *Defense News*, September 12, 2019; David Axe, "Autonomous Navies Could Make War More Likely," *National Interest*, August 17, 2020.

Legislative Activity for FY2023

Summary of Congressional Action on FY2023 Funding Request

Table 1 summarizes congressional action on the Navy's FY2023 funding request for the LUSV, MUSV, and XLUUV programs and their enabling technologies.

Table 1. Congressional Action on FY2023 Large UV Funding Request

Millions of dollars, rounded to the nearest tenth

		Authorization			Appropriation		
Research and development funding	**Request**	**HASC**	**SASC**	**Enacted**	**HAC**	**SAC**	**Enacted**
PE 0603178N, Large Unmanned Surface Vessels (LUSVs) (line 28)	146.8						
PE 0605512N Medium Unmanned Surface Vehicles (MUSVs) (line 94)	104.0						
PE 0605513N, Unmanned Surface Vehicle Enabling Capabilities (line 95)	181.6						
PE 0604536N, Advanced Undersea Prototyping (line 89)	116.9						
TOTAL	**549.3**						

Sources: Table prepared by CRS based on FY2023 Navy budget submission, committee and conference reports, and explanatory statements on the FY2023 National Defense Authorization Act and the FY2023 DOD Appropriations Act.

Notes: PE is program element (i.e., a line item in a DOD research and development account). **HASC** is House Armed Services Committee; **SASC** is Senate Armed Services Committee; **HAC** is House Appropriations Committee; **SAC** is Senate Appropriations Committee.

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