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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 in FY2021 and beyond wants to develop and procure three types of large unmanned vehicles (UVs). These large UVs are called Large Unmanned Surface Vehicles (LUSVs), Medium Unmanned Surface Vehicles (MUSVs), and Extra-Large Unmanned Undersea Vehicles (XLUUVs). The Navy is requesting $579.9 million in FY2021 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. Compared to the current fleet architecture, this more distributed architecture is to include proportionately fewer large surface combatants (i.e., cruisers and destroyers), proportionately more small surface combatants (i.e., frigates and Littoral Combat Ships), and the addition of significant numbers of large UVs.

The Navy wants to employ accelerated acquisition strategies for procuring these large UVs, so as to get them into service more quickly. The Navy's desire to employ these accelerated acquisition strategies can be viewed as an expression of the urgency that the Navy attaches to fielding large UVs for meeting future military challenges from countries such as China.

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. The Navy wants LUSVs to be low-cost, high-endurance, reconfigurable ships based on commercial ship designs, with ample capacity for carrying various modular payloads—particularly anti-surface warfare (ASuW) and strike payloads, meaning principally anti-ship and land-attack missiles. 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. In marking up the Navy's proposed FY2020 budget, some of the congressional defense committees expressed concerns over whether the Navy's accelerated acquisition strategies provided enough time to adequately develop concepts of operations and key technologies for these large UVs, particularly the LUSV. In response, the Navy's FY2021 budget submission proposes to modify the acquisition strategy for the LUSV program so as to provide more time for developing operational concepts and key technologies before entering into serial production of deployable units. Under the Navy's proposed modified LUSV acquisition strategy, the Navy is proposing to use research and development funding to acquire two additional prototypes in FY2021 and one more additional prototype in FY2022 before shifting in FY2023 to the use of procurement funding for the procurement of deployable LUSVs at annual procurement rates in FY2023-FY2025 of 2-2-3.

The Navy defines MUSVs as being 45 feet to 190 feet long, with displacements of roughly 500 tons. 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 is pursuing the MUSV program as a rapid prototyping effort under what is known as Section 804 acquisition authority. The first MUSV prototype was funded in FY2019 and the Navy wants fund the second prototype in FY2023. On July 13, 2020, the Navy announced that it had awarded "a $34,999,948 contract to L3 Technologies, Inc. for the development of a single Medium Unmanned Surface Vehicle (MUSV) prototype, with options to procure up to eight additional MUSVs."

The first five XLUUVs were funded in FY2019; they are being built by Boeing. The Navy wants procure additional XLUUVs at a rate of two per year starting in FY2023. The Navy's FY2021 budget submission does not include funding for the procurement of additional XLUUVs in FY2021 or FY2022.

The Navy's large UV programs pose a number of oversight issues for Congress, including issues relating to the analytical basis for the more distributed fleet architecture; the Navy's accelerated acquisition strategies for these programs; technical, schedule, and cost risk in the programs; the proposed annual procurement rates for the programs; the industrial base implications of the programs; potential implications for miscalculation or escalation at sea; the personnel implications of the programs; and whether the Navy has accurately priced the work it is proposing to do in FY2021 on the programs.

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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 FY2021 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 new fleet architecture (i.e., a new combination of ships and other platforms) that is more widely distributed than the Navy's current fleet architecture. The Navy is requesting $579.9 million in FY2021 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 FY2021 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, and cyber capabilities—that the Navy says it is 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.[3] They can be individually less expensive to procure

[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 Report R45392, *U.S. Ground Forces Robotics and Autonomous Systems (RAS) and Artificial Intelligence (AI): Considerations for Congress*, coordinated by Andrew Feickert.

[2] See, for example, Department of the Navy, *Highlights of the Department of the Navy FY 2021 Budget*, inside front cover ("The Bottom Line"). For a CRS report on Navy lasers, electromagnetic railguns, and the gun-launched guided projectile (also known as the hypervelocity projectile), see CRS Report R44175, *Navy Lasers, Railgun, and Gun-Launched Guided Projectile: Background and Issues for Congress*, by Ronald O'Rourke. For a CRS report on advanced military technologies, see CRS In Focus IF11105, *Defense Primer: Emerging Technologies*, by Kelley M. Sayler.

[3] For more on autonomous UVs, see CRS In Focus IF11150, *Defense Primer: U.S. Policy on Lethal Autonomous Weapon Systems*, by Kelley M. Sayler.

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 human operators, or missions that pose a high risk of injury, death, or capture of onboard human operators. Consequently UVs are sometimes said to be particularly suitable for so-called "three D" missions, meaning missions that are "dull, dirty, or dangerous."[4]

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. The Department of the Navy states, for example, that its inventory of 4,094 aircraft at the end of FY2019 included 99 UAVs, that its projected inventory of 3,912 aircraft at the end of FY2020 will include 45 UVs, and that its projected inventory of 4,075 aircraft at the end of FY2021 will include 57 UVs.[5] 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.

Navy USV and UUV Categories

As shown in **Figure 1** and **Figure 2**, the Navy organizes its USV acquisition programs into four size-based categories that the Navy calls large, medium, small, and very small, and its UUV acquisition programs similarly into four size-based categories that the Navy calls extra-large, large, medium, and small. The large UVs discussed in this CRS report fall into the top two USV categories in **Figure 1** and the top UUV category in **Figure 2**.

The smaller UVs shown in the other categories of **Figure 1** and **Figure 2**, which are not covered in this report, 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

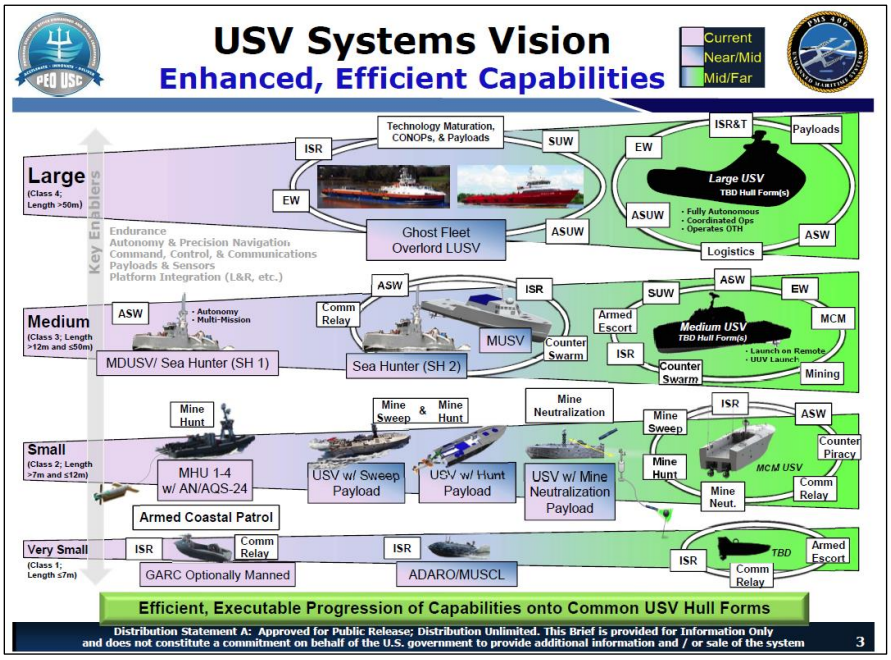
Because the large UVs covered in this report can be deployed directly from pier to perform missions that might otherwise be assigned to manned ships and submarines, some observers have a raised a question as to whether the large UVs covered in this report should be included in the top-level count of the number of ships in the Navy. Navy officials state that they have not yet decided whether to modify the top-level count of the number of ships in the Navy to include these large UVs.[6]

[4] 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.

[5] Department of the Navy, *Highlights of the Department of the Navy FY 2021 Budget*, Figure 3.7 on page 3-7.

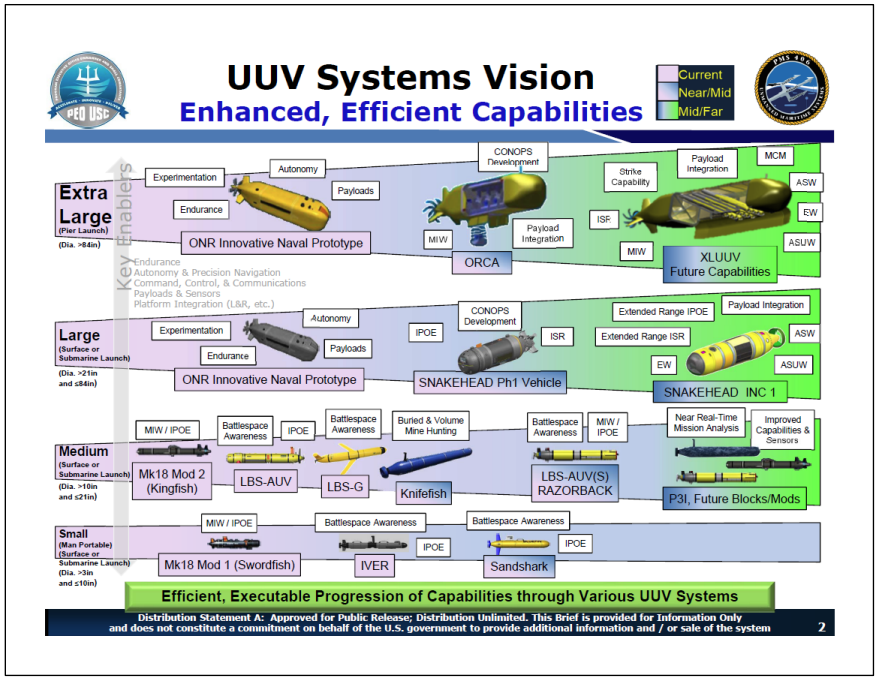
[6] For additional discussion of this question, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by Ronald O'Rourke.

Figure 1. Navy USV Systems Vision



Source: Slide 3 of briefing by Captain Pete Small, Program Manager, Unmanned Maritime Systems (PMS 406), entitled "Unmanned Maritime Systems Update," January 15, 2019, accessed May 22, 2019, at https://www.navsea.navy.mil/Portals/103/Documents/Exhibits/SNA2019/UnmannedMaritimeSys-Small.pdf?ver=2019-01-15-165105-297.

Figure 2. Navy UUV Systems Vision



Source: Slide 2 of briefing by Captain Pete Small, Program Manager, Unmanned Maritime Systems (PMS 406), entitled "Unmanned Maritime Systems Update," January 15, 2019, accessed May 22, 2019, at https://www.navsea.navy.mil/Portals/103/Documents/Exhibits/SNA2019/UnmannedMaritimeSys-Small.pdf?ver=2019-01-15-165105-297.

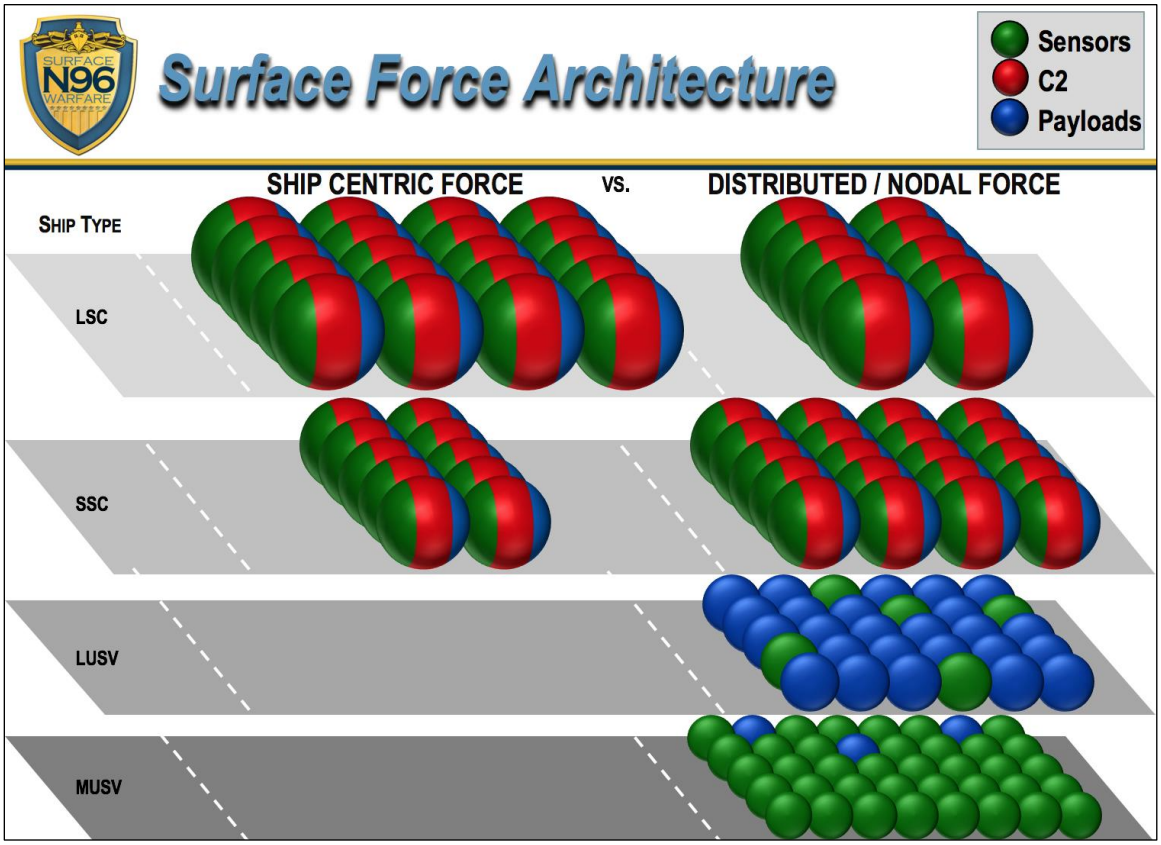
Part of More Distributed Navy Fleet Architecture

The Navy wants to acquire the large UVs covered in this report as part of an effort to shift the Navy to a new fleet architecture that is more widely distributed than the Navy's current architecture. Compared to the current fleet architecture, this more distributed architecture is to include proportionately fewer large surface combatants (or LSCs, meaning cruisers and destroyers), proportionately more small surface combatants (or SSCs, meaning frigates and Littoral Combat Ships), and the addition of significant numbers of large UVs.

Figure 3 provides, for the surface combatant portion of the Navy,[7] a conceptual comparison of the current fleet architecture (shown on the left as the "ship centric force") and the new, more distributed architecture (shown on the right as the "distributed/nodal force"). The figure does not depict the entire surface combatant fleet, but rather a representative portion of it.

Figure 3. Navy Briefing Slide on Surface Combatant Force Architecture

Each sphere represents a ship or a USV



Source: Illustration accompanying Megan Eckstein, "Sea Hunter Unmanned Ship Continues Autonomy Testing as NAVSEA Moves Forward with Draft RFP," *USNI News*, April 29, 2019. The illustration was also included as Slide 2 in a Navy briefing entitled "Designing & Building the Surface Fleet: Unmanned and Small Combatants," by Rear Admiral Casey Moton at a June 20, 2019, conference of the American Society of Naval Engineers (ASNE).

Notes: Each sphere represents a ship or a USV. LSC means large surface combatant (i.e., cruiser or destroyer), and SSC means small surface combatant (i.e., frigate or Littoral Combat Ship). As shown in the color coding, the LSCs and SSCs are equipped with a combination of sensors (green), command and control (C2) equipment (red),

[7] Other major parts of the Navy include submarines, aircraft carriers, amphibious ships, logistics (resupply) ships, and support ships.

and payloads other than sensors and C2 equipment, meaning principally weapons (blue). LUSVs and MUSVs, in contrast, are equipped primarily with weapons (blue) or sensors (green).

In the figure, each sphere represents a manned ship or USV. (Since the illustration focuses on the surface combatant force, it does not include UUVs.) As shown in the color coding, under both the current fleet architecture and the more distributed architecture, the manned ships (i.e., the LSCs and SSCs) are equipped with a combination of sensors (green), command and control (C2) equipment (red), and payloads other than sensors and C2 equipment, meaning principally weapons (blue).

Under the more distributed architecture, the manned ships would be on average smaller (because a greater share of them would be SSCs), and this would be possible because some of the surface combatant force's weapons and sensors would be shifted from the manned ships to USVs, with weapon-equipped LUSVs acting as adjunct weapon magazines and sensor-equipped MUSVs contributing to the fleet's sensor network.

As shown in **Figure 3**, under the Navy's current surface combatant force architecture, there are to be 20 LSCs for every 10 SSCs (i.e., a 2:1 ratio of LSCs to SSCs), with no significant contribution from LUSVs and MUSVs. This is consistent with the Navy's current force-level objective, which calls for achieving a 355-ship fleet that includes 104 LSCs and 52 SSCs (a 2:1 ratio). Under the more distributed architecture, the ratio of LSCs to SSCs would be reversed, with 10 LSCs for every 20 SSCs (a 1:2 ratio), and there would also now be 30 LUSVs and 40 MUSVs. A January 15, 2019, press report states

> The Navy plans to spend this year taking the first few steps into a markedly different future, which, if it comes to pass, will upend how the fleet has fought since the Cold War. And it all starts with something that might seem counterintuitive: It's looking to get smaller.
>
> "Today, I have a requirement for 104 large surface combatants in the force structure assessment; [and] I have [a requirement for] 52 small surface combatants," said Surface Warfare Director Rear Adm. Ronald Boxall. "That's a little upside down. Should I push out here and have more small platforms? I think the future fleet architecture study has intimated 'yes,' and our war gaming shows there is value in that."[8]

Another way of summarizing **Figure 3** would be to say that the surface combatant force architecture (reading vertically down the figure) would change from 20+10+0+0 (i.e., a total of 30 surface combatant platforms, all manned, and a platform ratio of 2-1-0-0) for a given portion of the surface combatant force, to 10+20+30+40 (i.e., a total of 100 surface combatant platforms, 70 of which would be LUSVs and MUSVs, and a platform ration of 1-2-3-4) for a given portion of the surface combatant force. The Navy refers to the more distributed architecture's combination of LSCs, SSCs, LUSVs, and MUSVs as the Future Surface Combatant Force (FSCF).

Figure 3 is conceptual, so the platform ratios for the more distributed architecture should be understood as notional or approximate rather than exact. The point of the figure is not that relative platform numbers under the more distributed architecture would change to the exact ratios shown in the figure, but that they would evolve over time toward something broadly resembling those ratios.

Some observers have long urged the Navy to shift to a more distributed fleet architecture, on the grounds that the Navy's current architecture—which concentrates much of the fleet's capability into a relatively limited number of individually larger and more expensive surface ships—is

[8] David B. Larter, "US Navy Moves Toward Unleashing Killer Robot Ships on the World's Oceans," *Defense News*, January 15, 2019.

increasingly vulnerable to attack by the improving maritime anti-access/area-denial (A2/AD) capabilities (particularly anti-ship missiles and their supporting detection and targeting systems) of potential adversaries, particularly China.[9] Shifting to a more distributed architecture, these observers have argued, would

- complicate an adversary's targeting challenge by presenting the adversary with a larger number of Navy units to detect, identify, and track;
- reduce the loss in aggregate Navy capability that would result from the destruction of an individual Navy platform;
- give U.S. leaders the option of deploying USVs and UUVs in wartime to sea locations that would be tactically advantageous but too risky for manned ships; and
- increase the modularity and reconfigurability of the fleet for adapting to changing mission needs.[10]

For a number of years, Navy leaders acknowledged the views of those observers but continued to support the current fleet architecture. More recently, however, Navy have shifted their thinking, with comments from Navy officials like the one quoted above and Navy briefing slides like **Figure 3** indicating that Navy leaders now support moving the fleet to a more distributed architecture. The views of Navy leaders appear to have shifted in favor of a more distributed architecture because they now appear to believe that such an architecture will be

- increasingly needed—as the observers have long argued—to respond effectively to the improving maritime A2/AD capabilities of other countries, particularly China;
- technically feasible as a result of advances in technologies for UVs and for networking widely distributed maritime forces that include significant numbers of UVs; and
- no more expensive, and possibly less expensive, than the current architecture.

The more distributed architecture that Navy leaders now appear to support may differ in its details from distributed architectures that the observers have been advocating, but the general idea of shifting to a more distributed architecture, and of using large UVs as a principal means of achieving that, appears to be similar. The Navy's FY2020 30-year shipbuilding plan mentions a new overarching operational concept for the Navy (i.e., a new general concept for how to employ Navy forces) called Distributed Maritime Operations (DMO).[11] A December 2018 document from the Chief of Naval Operations states that the Navy will "continue to mature the Distributed Maritime Operations (DMO) concept and key supporting concepts" and "design and implement a comprehensive operational architecture to support DMO."[12] While Navy officials have provided few details in public about DMO,[13] the Navy does state in its FY2021 budget submission that

[9] For more on China's maritime A2/AD capabilities, see CRS Report RL33153, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, by Ronald O'Rourke.

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

[11] U.S. Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2020*, March 2019, pp. 3, 4, 7, 8, 15, 17, 24.

[12] U.S. Navy, Chief of Naval Operations, *A Design for Maintaining Maritime Superiority, Version 2.0*, December 2018, pp. 8, 10.

[13] Then-Chief of Naval Operations Admiral John Richardson, in explaining DMO, stated in December 2018 that "Our

"MUSV and LUSV are key enablers 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. Fielding of MUSV and LUSV will provide the Navy increased capability and necessary capacity at lower procurement and sustainment costs, reduced risk to sailors and increased readiness by offloading missions from manned combatants."[14]

Accelerated Acquisition Strategies and Enabling Technologies

The Navy wants to employ accelerated acquisition strategies for procuring large UVs, so as to get them into service more quickly. The Navy's desire to employ these accelerated acquisition strategies can be viewed as an expression of the urgency that the Navy attaches to fielding large UVs for meeting future military challenges from countries such as China.[15]

The LUSV and MUSV programs are building on USV development work done by the Strategic Capabilities Office (SCO) within the Office of the Secretary of Defense (OSD). SCO's effort to develop USVs is called Ghost Fleet, and its LUSV development effort within Ghost Fleet is called Overlord.

As shown in **Figure 4**, the Navy has identified five key enabling groups of technologies for its USV and UUV programs.[16] Given limitations on underwater communications (most radio-frequency electromagnetic waves do not travel far underwater), technologies for autonomous operations (such as artificial intelligence) will be particularly important for the XLUUV program (and other UUV programs).[17]

In May 2019, the Navy established a surface development squadron to help develop operational concepts for LUSVs and MUSVs. The squadron will initially consist of a Zumwalt (DDG-1000) class destroyer and one Sea Hunter prototype medium displacement USV (**Figure 5**). A second Sea Hunter prototype will reportedly be added around the end of FY2020, and LUSVs and MUSVs will then be added as they become available.[18]

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fundamental force element right now in many instances is the [individual] carrier strike group. We're going to scale up so our fundamental force element for fighting is at the fleet[-wide] level, and the [individual] strike groups plug into those [larger] numbered fleets. And they will be, the strike groups and the fleet together, will be operating in a distributed maritime operations way." (Chief of Naval Operations Admiral John Richardson, as quoted in Megan Eckstein, "Navy Planning for Gray-Zone Conflict; Finalizing Distributed Maritime Operations for High-End Fight," *USNI News*, December 19, 2018.)

[14] *Department of Defense Fiscal Year (FY) 2021 Budget Estimates, Navy Justification Book Volume 2 of 5, Research, Development, Test & Evaluation*, February 2020, PDF page 90 of 1,538. The statement also appears on PDF page 324 of 1,538. See also Kevin Eyer and Steve McJessy, "Operationalizing Distributed Maritime Operations," Center for International Maritime Security (CIMSEC), March 5, 2019; Christopher H. Popa et al., *Distributed Maritime Operations and Unmanned Systems Tactical Employment*, Naval Postgraduate School, June 2018, 171 pp. (Systems Engineering Capstone Report); Lyla Englehorn, *Distributed Maritime Operations (DMO) Warfare Innovation Continuum (WIC) Workshop September 2017 After Action Report*, Naval Postgraduate School, December 2017, 99 pp.

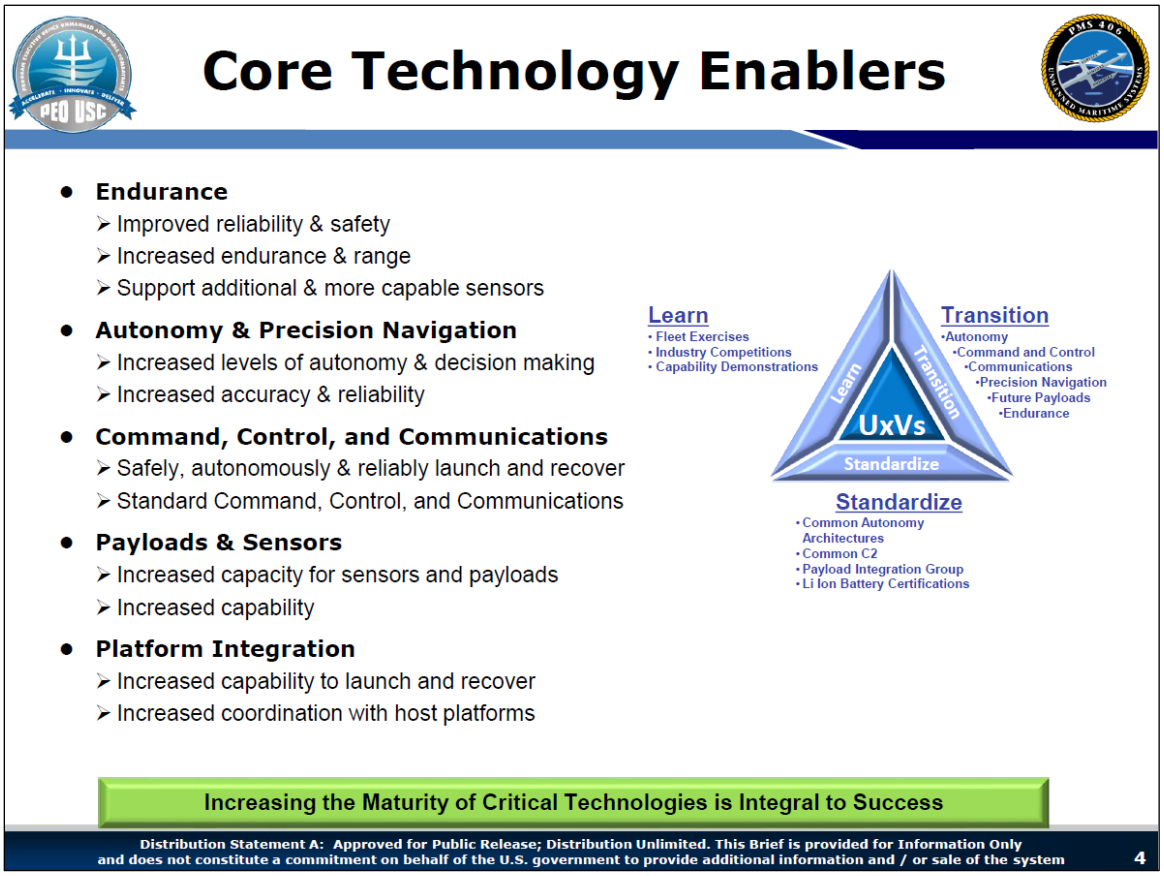
[15] A number of other DOD acquisition programs are also employing rapid or accelerated acquisition strategies of one kind or another, in some cases using special acquisition authorities that Congress has granted to DOD. For additional discussion, see CRS Report R45068, *Acquisition Reform in the FY2016-FY2018 National Defense Authorization Acts (NDAAs)*, by Moshe Schwartz and Heidi M. Peters.

[16] For additional discussion of some of the enabling technologies shown in **Figure 4**, see Pete Small, "Empowering the Unmanned Maritime Revolution," Undersea Warfare, Spring 2019: 12-13.

[17] For more on the use of artificial intelligence in defense programs, see CRS Report R45178, *Artificial Intelligence and National Security*, by Kelley M. Sayler.

[18] 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

Figure 4. Enabling Technologies for USVs and UUVs



Source: Slide 4 of briefing by Captain Pete Small, Program Manager, Unmanned Maritime Systems (PMS 406), entitled "Unmanned Maritime Systems Update," January 15, 2019, accessed May 22, 2019, at https://www.navsea.navy.mil/Portals/103/Documents/Exhibits/SNA2019/UnmannedMaritimeSys-Small.pdf?ver=2019-01-15-165105-297.

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. **Figure 6** shows a detail from a Navy briefing slide showing images of prototype LUSVs and silhouettes of a notional LUSV and a notional MUSV. **Figure 7** and **Figure 8** show ships that have been used as LUSV prototypes. In unclassified presentations on the program, the Navy has used images of

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.

offshore support ships used by the oil and gas industry to illustrate the kinds of ships that might be used as the basis for LUSVs.[19]

The Navy wants LUSVs to be low-cost, high-endurance, reconfigurable ships based on commercial ship designs, with ample capacity for carrying various modular payloads—particularly anti-surface warfare (ASuW) and strike payloads, meaning principally anti-ship and land-attack missiles.[20]

Figure 5. 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.

The Navy wants LUSVs to be capable of operating with human operators in the loop,[21] or semi-autonomously (with human operators on the loop),[22] or fully autonomously, and to be capable of operating either independently or in conjunction with manned surface combatants. 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.[23]

[19] Sam LaGrone, "Navy Wants 10-Ship Unmanned 'Ghost Fleet' to Supplement Manned Force," *USNI News*, March 13, 2019.

[20] The Navy states that the LUSV "provides distributed fires" and will include an "offensive missile capability." See Slide 5 of briefing by Captain Pete Small, Program Manager, Unmanned Maritime Systems (PMS 406), entitled "Unmanned Maritime Systems Update," January 15, 2019, accessed May 22, 2019, at https://www.navsea.navy.mil/Portals/103/Documents/Exhibits/SNA2019/UnmannedMaritimeSys-Small.pdf?ver=2019-01-15-165105-297.

[21] The Navy states that having the operator in the loop can be understood as referring to continuous or near-continuous observation and/or control of the UV by the operator. (Source: Navy email to CRS dated June 4, 2019.)

[22] The Navy states that having the operator on the loop can be understood as referring to a UV that is operating semi-autonomously, with the UV controlling its own actions much of the time, but with a human operator potentially intervening from time to time in response to either a prompt from the UV or data sent from the UV or other sources. (Source: Navy email to CRS dated June 4, 2019.)

[23] See, for example, David B. Larter, "US Navy Looks to Ease into Using Unmanned Robot Ships with a Manned Crew," *Defense News*, January 29, 2019.

LUSVs are to feature both built-in capabilities and an ability to accept modular payloads, and are to use existing Navy sensors and weapon launchers.

Figure 6. Prototype and Notional LUSVs and MUSVs

Source: Detail from Navy briefing slide entitled Unmanned Maritime Systems, slide 5 in a Navy briefing entitled "Designing & Building the Surface Fleet: Unmanned and Small Combatants," by Rear Admiral Casey Moton at a June 20, 2019, conference of the American Society of Naval Engineers (ASNE).

FY2020 Legislative Activity

In marking up the Navy's proposed FY2020 budget, some of the congressional defense committees expressed concerns over whether the Navy's accelerated acquisition strategies provided enough time to adequately develop concepts of operations and key technologies for large UVs, particularly the LUSV. In its report (S.Rept. 116-48 of June 11, 2019) on the FY2020 National Defense Authorization Act (S. 1790), the Senate Armed Services Committee stated

> The committee is concerned that the budget request's concurrent approach to LUSV design, technology development, and integration as well as a limited understanding of the LUSV concept of employment, requirements, and reliability for envisioned missions pose excessive acquisition risk for additional LUSV procurement in fiscal year 2020. The committee is also concerned by the unclear policy implications of LUSVs, including ill-defined international unmanned surface vessel standards and the legal status of armed or potentially armed LUSVs.
>
> Additionally, the committee notes that the Navy's "Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2020" acknowledges similar issues: "Unmanned and optionally-manned systems are not accounted for in the

overall battle force[.] ... The physical challenges of extended operations at sea across the spectrum of competition and conflict, the concepts of operations for these platforms, and the policy challenges associated with employing deadly force from autonomous vehicles must be well understood prior to replacing accountable battle force ships."

The committee believes that further procurement of LUSVs should occur only after the lessons learned from the current SCO initiative have been incorporated into the next solicitation to enable incremental risk reduction.

In addition, the committee believes that the LUSV program, which appears likely to exceed the Major Defense Acquisition Program cost threshold, would benefit from a more rigorous requirements definition process, analysis of alternatives, and deliberate acquisition strategy.[24]

Figure 7. 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.

S.Rept. 116-48 also stated

> While recognizing the need for prototypes to reduce acquisition risk, the committee is concerned that the acquisition strategies for the Large USV, Medium USV, Orca UUV, and Snakehead UUV could lead to procurement of an excessive number of systems before the Navy is able to determine if the USVs and UUVs meet operational needs.
>
> Therefore, the committee directs the Secretary of the Navy to submit a report to the congressional defense committees, not later than November 1, 2019, that provides acquisition roadmaps for the Large USV, Medium USV, Orca UUV, and Snakehead UUV.[25]

[24] S.Rept. 116-48, p. 80.

[25] S.Rept. 116-48, p. 106. The report stated further on pages 106-107 that

> Each roadmap shall: (1) Identify the applicable requirements document (e.g., Top Level Requirements); (2) Describe the threshold and objective values for each characteristic, key performance parameter (KPP), or other measure in the applicable requirements document; (3) Identify increments of vessels in each program; (4) For each such increment, identify specific entrance and exit criteria that build toward the specified requirements (e.g., characteristic, KPP, or other measure), including demonstrated hardware and software functionality; (5) Identify the quantity of vessels needed in each increment to perform the required testing or meet operational

Figure 8. 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.

In its report (S.Rept. 116-103 of September 12, 2019) on the FY2020 Department of Defense (DOD) Appropriations Act (S. 2474), the Senate Appropriations Committee stated that

> the Committee is concerned that for several unmanned programs the Navy is pursuing acquisition strategies that would limit future competitive opportunities by awarding system-level prototypes early in the acquisition process and failing to articulate capability, requirements or technology roadmaps to encourage industrial innovation. The Assistant Secretary of the Navy (Research, Development and Acquisition) is directed to submit to the congressional defense committees with the fiscal year 2021 President's budget request such acquisition roadmaps for each unmanned acquisition program that include no less than mission requirements, program requirements for each increment, key technologies, acquisition strategies, test strategies, sub-system and system-level prototyping plans, and cost estimates.[26]

S.Rept. 116-103 also stated

> The Committee fully supports additional investments in unmanned and autonomous technologies, systems and sub-systems, including surface and sub-surface vessels. However, the Committee is concerned with the proposed acquisition and funding strategies for the MUSV and LUSV in this budget request, to include the Future Years Defense Program. Therefore, the Committee recommends several adjustments, as detailed elsewhere in this report, and directs the Assistant Secretary of the Navy (Research, Development and Acquisition) to review the acquisition strategies for these programs to

needs; (6) Describe the concept of operations for each increment; (7) Identify the key pieces of hardware and software needed for each increment, including communications security material, off-board line-of-sight and satellite communications, and military datalinks; (8) Describe the extent to which each increment of vessels will be equipped with weapons, enumerate such weapons, and describe the associated target detect-to-engage sequence of events for each such weapon; (9) Provide the subsystem-level prototyping plan for each increment, including for each such effort the planned cost, schedule, and performance; and (10) Provide the acquisition plan for each increment, including the planned cost, schedule, and performance.

[26] S.Rept. 116-103, p. 191.

> address congressional concerns, as appropriately balanced with warfighter needs. (Page 194)[27]

The explanatory statement for the final version of the FY2020 DOD Appropriations Act (Division A of H.R. 1158/P.L. 116-93 of December 20, 2020) stated

> The Secretary of the Navy is directed to comply with the full funding policy for LUSVs in future budget submissions. Further, the agreement recommends $50,000,000 for the design of future LUSVs without a vertical launch system [VLS] capability in fiscal year 2020. Incremental upgrade capability for a vertical launch system may be addressed in future fiscal years. It is directed that no funds may be awarded for the conceptual design of future LUSVs until the Assistant Secretary of the Navy (Research, Development and Acquisition) briefs the congressional defense committees on the updated acquisition strategy for unmanned surface vessels.[28]

FY2021 Budget Submission

In response to the markups from the congressional defense committees, the Navy's FY2021 budget submission proposes to modify the acquisition strategy for the LUSV program so as to provide more time for developing operational concepts and key technologies before entering into serial production of deployable units. Under the Navy's proposed modified LUSV acquisition strategy, the Navy is proposing to use research and development funding to acquire two additional prototypes in FY2021 and one more additional prototype in FY2022 before shifting in FY2023 to the use of procurement funding for the procurement of deployable LUSVs at annual procurement rates in FY2023-FY2025 of 2-2-3. The Navy's FY2021 budget submission states

> Major changes [in the LUSV program] from [the] FY 2020 President's Budget request to [the] FY 2021 President's Budget request [include the following]:
>
> (1) The program will award Conceptual Design (CD) contracts to multiple vendors in FY20. The CD effort will support refinement of a LUSV Performance Specification that does not include the Vertical Launch System (VLS). The final Performance Specification will define a LUSV with reservations in the design to support integration of a variety of capabilities and payloads. This effort, which was originally planned to award in Q2 [the second quarter of] FY 2020 will be delayed until early Q4 [the fourth quarter of] FY 2020 in order to support amendment of the CD Request for Proposals (RFP), Performance Specification, and associated artifacts.
>
> (2) The delay in award of the LUSV CD effort will delay follow-on activities (RFP [Request for Proposals], [and] source selection) leading up to the award of the LUSV Detail Design and Construction (DD&C) contract. DD&C award will be delayed one year, from FY 2021 to FY 2022. The DD&C award will deliver a non-VLS LUSV prototype based on the Performance Specification developed during the CD effort.
>
> (3) In lieu of the FY 2020 President's Budget request plan of awarding the LUSV DD&C contract in FY21, the Navy is planning to procure up to two additional Overlord prototypes, building on the lessons learned through the Ghost Fleet program and advances in C4I and combat system prototyping efforts.

[27] S.Rept. 116-103, p. 194.

[28] Explanatory statement for Division A of H.R. 1158, PDF page 274 of 414.

> (4) The Navy plans to transition LUSV to a program of record in FY 2023 and align [the program's] procurement funding to the Shipbuilding and Conversion, Navy (SCN) account.[29]

A January 13, 2020, press report stated that the Navy planned to submit a report on the Navy's concepts of operations for LUSVs and MUSVs in April 2020.[30]

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.
>
> 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.[31]

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

[29] See also Justin Katz, "Navy Says It Will Adjust to LUSV Restrictions; New Plan Will Be Part of Next Budget," *Inside Defense*, January 16, 2020; Vivienne Machi, "FY '21 Budget Request to Include 'Adjustment' to LUSV Procurement Schedule, PEO Says," *Defense Daily*, January 16, 2020.

[30] Mallory Shelbourne, "Navy to Submit Report in April on Unmanned CONOPS Development," *Inside Defense*, January 13, 2020. See also David B. Larter, "Fleet Commander Directs US Navy's Surface Force to Develop Concepts for Unmanned Ships," *Defense News*, January 2, 2019.

[31] 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.

> 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.[32]

MUSV Program

The Navy defines MUSVs as being 45 feet to 190 feet long, with displacements of roughly 500 tons. 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 is pursuing the MUSV program as a rapid prototyping effort under what is known as Section 804 middle tier acquisition authority.[33] The first MUSV prototype was funded in FY2019 and the Navy wants fund the second prototype in FY2023.

The MUSV program is building on development work by the Defense Advanced Research Projects Agency (DARPA) under its Anti-Submarine Warfare Continuous Trail Unmanned Vessel (ACTUV) effort and the Office of Naval Research (ONR) under its Medium Displacement USV effort. As shown in **Figure 1**, this work led to the design, construction, and testing of the prototype Sea Hunter medium displacement USV, which has a reported length of 132 feet (about 40.2 meters) and a displacement of about 140 tons.[34] The Navy's MUSV program is also to employ a fleet-ready command and control (C2) solution for USVs that was developed by the Strategic Capabilities Office for the LUSV program.

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."[35] The Navy reportedly stated that there were five competitors

[32] 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.

[33] This is a reference to Section 804 of the FY2016 National Defense Authorization Act (S. 1356/P.L. 114-92 of November 25, 2015). The rapid prototyping authority provided by that section is now codified at 10 U.S.C. 2302 note. For more on this authority, see "Middle Tier Acquisition (Section 804)," MITRE, undated, accessed May 24, 2019, at https://aida.mitre.org/middle-tier/; and "Acquisition Process, Middle Tier Acquisition (Section 804)," AcqNotes, updated March 26, 2019, accessed May 24, 2019, at http://acqnotes.com/acqnote/acquisitions/middle-tier-acquisitions.

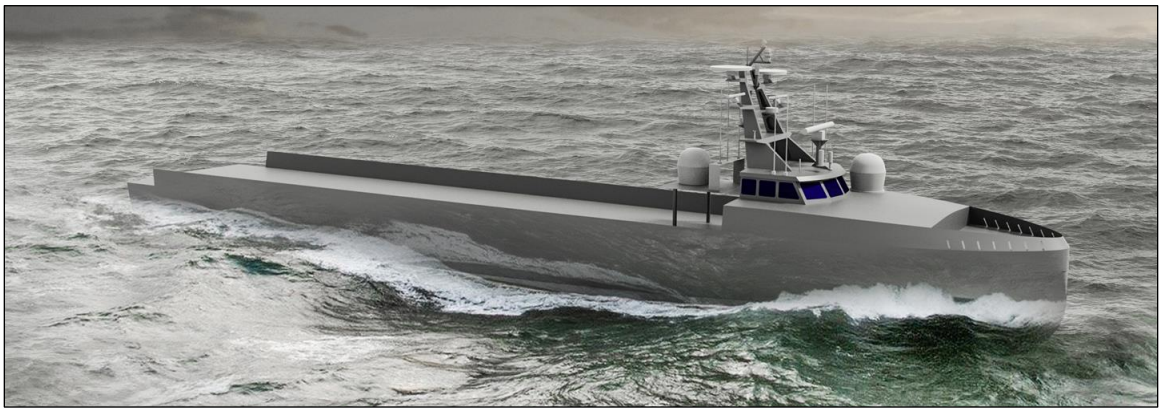
[34] See, for example, Megan Eckstein, "Sea Hunter Unmanned Ship Continues Autonomy Testing as NAVSEA Moves Forward with Draft RFP," *USNI News*, April 29, 2019; Evan Milberg, "DARPA "Sea Hunter," World's Largest Autonomous Ship, Transferred to U.S. Navy," *Composites Manufacturing Magazine*, February 12, 2018; Sydney J. Freedberg Jr., "DSD [Deputy Secretary of Defense] Work Embraces DARPA's Robot Boat, Sea Hunter," *Breaking Defense*, April 7, 2016.

[35] PEO Unmanned and Small Combatants Public Affairs, "Navy Awards Contract for Medium Unmanned Surface

for the contract, but did not identify the other four.[36] **Figure 9** 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 & Cox and Incat Crowther who will provide the ship design and Swiftships will complete the construction of the vehicle.
>
> L3Harris is a world leader in actively powered Unmanned Surface Vehicle (USV) systems, with over 115 USVs delivered worldwide. L3Harris' USVs are actively serving the Navy, universities, research institutions and commercial businesses.[37]

Figure 9. 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

The XLUUV program, also known as the Orca program, was established to address a Joint Emergent Operational Need (JEON). As shown in **Figure 2**, 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.[38] Consequently, XLUUVs instead will transported to a forward operating port and then launched from pier. The Navy wants XLUUVs to be equipped with a modular payload bay for carrying mines and other payloads.

Vehicle Prototype," Naval Sea Systems Command, July 13, 2020.

[36] 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.

[37] L3Harris Technologies, "L3Harris Technologies Awarded Medium Unmanned Surface Vehicle Program from US Navy," August 18, 2020.

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

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 announced on February 13, 2019, that it had selected Boeing to fabricate, test, and deliver the first four Orca XLUUVs and associated support elements.[39] (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.[40] Boeing has partnered with the Technical Solutions division of Huntington Ingalls Industries (HII) to build Orca XLUUVs.[41] (A separate division of HII—Newport News Shipbuilding (NNS) of Newport News, VA—is one of the Navy's two submarine builders.)

The Navy wants procure additional XLUUVs at a rate of two per year starting in FY2023. The Navy's FY2021 budget submission does not include funding for the procurement of additional XLUUVs in FY2021 or FY2022. The Navy is proposing to fund the procurement of XLUUVs in FY2023 and subsequent years through the Other Procurement, Navy (OPN) appropriation account.

In June 2020, it was reported that a study of future Navy force-level requirements led by the Cost Assessment and Program Evaluation (CAPE) office within the Office of the Secretary of Defense (OSD) recommended a future Navy with, among other things, up to 50 XLUUVs.[42]

Boeing's Orca XLUUV design will be informed by (but likely differ in certain respects from) the design of Boeing's Echo Voyager UUV (**Figure 10**, **Figure 11**, and **Figure 12**).[43] Echo Voyager is 51 feet long and has a rectangular cross section of 8.5 feet 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.[44]

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

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

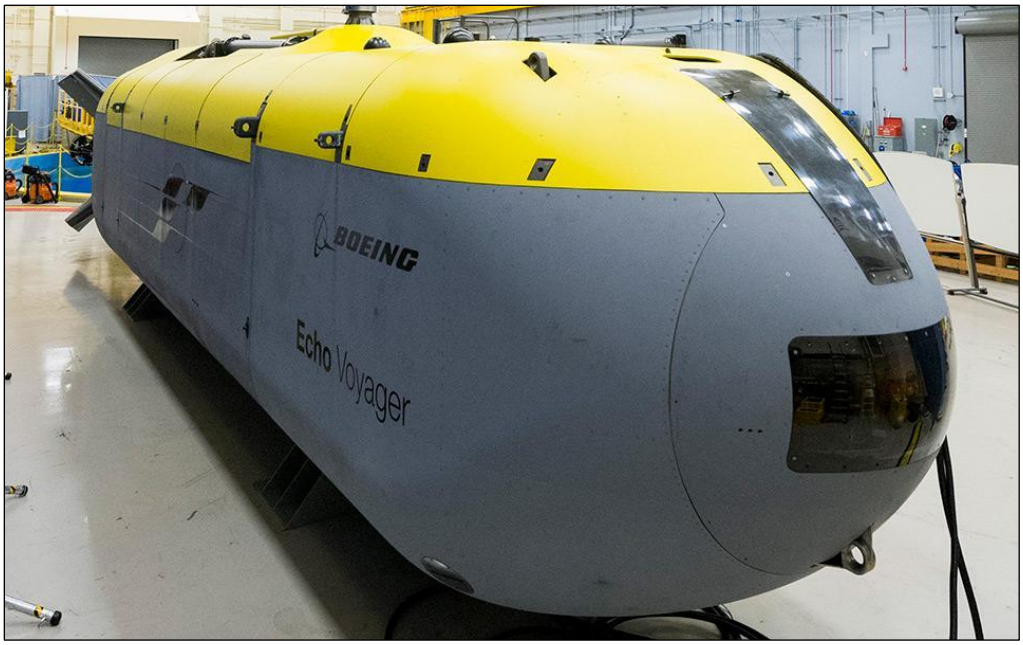
[41] See, for example, Hugh Lessig, "Shipbuilder Lends a Hand with Rise of Robot Submarines," *Defense News*, May 26, 2019.

[42] David B. Larter, "To Compete with China, An Internal Pentagon Study Looks to Pour Money into Robot Submarines," *Defense News*, June 1, 2020.

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

[44] 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.

Figure 10. Boeing Echo Voyager UUV



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

Figure 11. Boeing Echo Voyager UUV

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

Figure 12. 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.

FY2021-FY2025 Funding

Table 1 shows FY2021-FY2025 requested and programmed funding for the large UV programs covered in this report.

Table 1. FY2021-FY2025 Requested and Programmed Funding for Large UVs

Millions of dollars, rounded to nearest tenth

Program	FY21	FY22	FY23	FY24	FY25	FY21-FY25 total
LUSV research and development funding	238.6	377.2	144.5	198.7	134.9	1,093.9
(Quantity—prototype LUSVs)	*(2)*	*(1)*	*(0)*	*(0)*	*(0)*	*(3)*
LUSV (procurement funding	0	0	455.0	373.6	536.6	1,365.2
(Quantity—deployable LUSVs)	*(0)*	*(0)*	*(2)*	*(2)*	*(3)*	*(7)*
MUSV research and development funding	26.3	30.0	43.0	43.9	44.7	187.9
(Quantity—prototype MUSVs)	*(0)*	*(0)*	*(1)*	*(0)*	*(0)*	*(1)*
LUSV and MUSV enabling technologies research and development funding	199.1	122.8	192.8	77.9	80.9	673.9
XLUUV research and development funding	115.9	43.0	78.5	77.0	7.7	322.1
(Quantity)	*(0)*	*(0)*	*(0)*	*(0)*	*(0)*	*(0)*
XLUUV procurement funding	0	0	158.5	162.6	232.8	552.9
(Quantity)	*(0)*	*(0)*	*(2)*	*(2)*	*(2)*	*(6)*

Source: Navy FY2021 budget submission. LUSV is Project 3066 within PE (Program Element) 0603178N (line 27 in the Navy's FY2021 research and development account). MUSV is Project 3428 within PE 0603178N (line 27). LUSV and MUSV enabling technologies is Project 3067 within PE 0603178N (line 27). XLUUV is Project 3394 within PE 0604536N (line 89).

Note: Totals may not add due to rounding.

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 More Distributed Fleet Architecture

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

- What Navy analyses led to the Navy's decision to shift toward a more distributed architecture?
- What did these analyses show regarding the relative costs, capabilities, and risks of the Navy's current architecture and the more distributed architecture?
- How well developed, and how well tested, are the operational concepts associated with the more distributed architecture?

Accelerated Acquisition Strategies and Funding Method

Another potential oversight issue for Congress concerns the accelerated acquisition strategies that the Navy wants to use for these large UV programs. Potential oversight questions for Congress include the following:

- What are the potential costs, benefits, and risks of pursuing these accelerated strategies rather than a more traditional acquisition approach that would spend more time developing the technologies and operational concepts for these UVs prior to putting them into serial production? How are those considerations affected by the shift in the international security environment from the post-Cold War era to the new era of renewed major power competition?[45]
- Are the Navy's proposed changes to the LUSV's accelerated acquisition strategy appropriate and sufficient?
- 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?

Technical, Schedule, and Cost Risk

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. Potential oversight questions for Congress include the following:

- How much risk of this kind do these programs pose, particularly given the enabling technologies that need to be developed for them?
- In addition to the Navy's proposed changes to the LUSV's acquisition strategy, what is the Navy doing to mitigate or manage cost, schedule, and technical risks

[45] For more on this shift, see CRS Report R43838, *Renewed Great Power Competition: Implications for Defense—Issues for Congress*, by Ronald O'Rourke.

while it seeks to deploy these UVs on an accelerated acquisition timeline? Are these risk-mitigation and risk-management efforts appropriate and sufficient?

- 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?

A June 1, 2020, press report states

> The U.S. military is banking on unmanned surface and subsurface vessels to boost its capacity in the face of a tsunami of Chinese naval spending. But before it can field the systems, it must answer some basic questions.
>
> How will these systems deploy? How will they be supported overseas? Who will support them? Can the systems be made sufficiently reliable to operate alone and unafraid on the open ocean for weeks at a time? Will the systems be able to communicate in denied environments?
>
> As the Navy goes all-in on its unmanned future, with billions of dollars of investments planed, how the service answers those questions will be crucial to the success or failure of its unmanned pivot.[46]

A June 23, 2020, press report states

> The Navy's transition from prototype to program of record for its portfolio of unmanned surface and undersea systems is being aided by industry, international partners and developmental squadrons, even as the program office seeks to ease concerns that the transition is happening too fast, the program executive officer for unmanned and small combatants said today.
>
> Rear Adm. Casey Moton said he's aware of concerns regarding how unmanned systems – particularly the Large Unmanned Surface Vessel – will be developed and used by the fleet, but he's confident in his team's path forward.
>
> "From my standpoint we are making a lot of great progress in working out the technical maturity, answering those kinds of questions (about how to employ and sustain the vessels) and getting the requirements right before we move into production," he said in a virtual event today co-hosted by the U.S. Naval Institute and the Center for Strategic and International Studies.[47]

An August 17, 2020, press report states

> As the U.S. Navy pushes forward with developing its large unmanned surface vessel, envisioned as a kind of external missile magazine that will tag along with larger manned surface combatants, a growing consensus is forming that the service needs to get its requirements and systems right before making a big investment.…
>
> In an exclusive July 16 interview with Defense News, Chief of Naval Operations Adm. Michael Gilday said that while the [congressional] marks [on the program] were frustrating, he agreed with Congress that requirements must be concrete right up front.
>
> "The approach has to be deliberate," Gilday said. "We have to make sure that the systems that are on those unmanned systems with respect to the [hull, mechanical and electrical

[46] David B. Larter, "US Navy Embraces Robot Ships, But Some Unresolved Issues Are Holding Them Back," *Defense News*, June 1, 2020. See also Bryan Clark, "Pentagon Needs To Go Faster—And Slower—On Unmanned Systems," *Forbes*, June 11, 2020.

[47] Megan Eckstein, "Program Office Maturing USVs, UUVs With Help From Industry, International Partners," *USNI News*, June 23, 2020.

> system], that they are designed to requirement, and perform to requirement. And most importantly, are those requirements sound?
>
> "I go back to [a question from years ago relating to the development of the Navy's Littoral Combat Ship (LCS)]: Do I really need a littoral combat ship to go 40 knots? That's going to drive the entire design of the ship, not just the engineering plant but how it's built. That becomes a critical factor. If you take your eye off the ball with respect to requirements, you can find yourself drifting. That has to be deliberate."
>
> Gilday has called for the Navy to pursue a comprehensive "Unmanned Campaign Plan" that creates a path forward for developing and fielding unmanned systems in the air, on the sea and under the water. Right now, the effort exists in a number of different programs that may not all be pulling in the same direction, he said.
>
> "What I've found is that we didn't necessarily have the rigor that's required across a number of programs that would bring those together in a way that's driven toward objectives with milestones," Gilday told Defense News. "If you took a look at [all the programs], where are there similarities and where are there differences? Where am I making progress in meeting conditions and meeting milestones that we can leverage in other experiments?
>
> "At what point do I reach a decision point where I drop a program and double down on a program that I can accelerate?"[48]

A September 8, 2020, press report states:

> Several Navy program officials and resource sponsors today outlined how they'll spend the next couple years giving Congress enough confidence in unmanned surface and underwater vehicles to allow the service to move from prototyping into programs of record.
>
> Across the entire family of USVs and UUVs, the Navy has prototypes in the water today for experimentation and in tandem is making plans to design and buy the next better vehicle or more advanced payloads, with the idea that the service will iterate its way to achieve congressional confidence and authorization to move forward on buying these unmanned systems in bulk.
>
> Rear Adm. Casey Moton, the program executive officer for unmanned and small combatants, spoke today at the Association for Unmanned Vehicle Systems International (AUVSI) annual defense conference and provided an update on the status of his portfolio of UUVs and USVs, some of which have run into trouble with lawmakers not convinced of their technical maturity and their tactical utility.
>
> Anticipating audience questions, he said in his speech, "what about Congress? What about the marks and the report language and the questions? So I'm going to put some of that into context from my perspective. I believe the discussion with Congress has not been about if unmanned vessels will be part of the Navy. 'If' has not been the focus. I don't even believe right now that 'if' is a major question. The focus has been on 'how,' with a healthy dose of 'what,' in terms of requirements and mission type. And of course, 'how many' is a question. How many, I will not focus on today. How many is dependent on Navy and [Office of the Secretary of Defense] force structure work. But for PEO USC, how many is ultimately important, but our focus now in this prototyping and experimentation and development phase is on the how, and working with our requirements sponsors and the fleet on the what."

[48] David B. Larter, "In Developing Robot Warships, US Navy Wants to Avoid Another Littoral Combat Ship," *Defense News*, August 17, 2020. See also Loren Thompson, "U.S. Navy Mounts Campaign To Convince Congress That Unmanned Vessels Are Critical To Winning Future Wars," *Forbes*, August 17, 2020.

> The most ambitious part of the Navy's current plan calls for the start of a Large USV program of record in Fiscal Year 2023, despite the LUSV being the piece of the family of USVs that Congress takes issue with the most. The Navy intends for these ships to be armed with vertical launch system cells to fire off defensive and offensive missiles—with sailors onboard manned ships overseeing targeting and firing decisions, since there would be no personnel on the LUSV.[49]

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.[50]

Annual Procurement Rates

Another oversight issue for Congress concerns the Navy's planned annual procurement rates for the LUSV and XLUUV programs during the period FY2021-FY2025. Potential oversight questions for Congress include, What factors did the Navy consider in arriving at them, and in light of these factors, are these rates too high, too low, or about right?

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 implications would the more distributed architecture have for required numbers, annual procurement rates, and maintenance workloads for large surface combatants (i.e., cruisers and destroyers) and small surface combatants (i.e., frigates and Littoral Combat Ships)?

[49] Megan Eckstein, "Navy Pushing to Maintain 2023 USV Program of Record Timeline," *USNI News*, September 8, 2020.

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

- What portion of these UVs might be built or maintained by facilities other than shipyards that currently build the Navy's major combatant ships?
- To what degree, if any, might the more distributed architecture and 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[51] 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 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

[51] 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.

> 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.[52]

Personnel Implications

Another oversight issue for Congress concerns the potential personnel implications of incorporating a significant number of large UVs into the Navy's fleet architecture. Potential questions for Congress include the following:

- What implications might these large UVs have for the required skills, training, and career paths of Navy personnel?
- Within the Navy, what will be the relationship between personnel who crew manned ships and those who operate these large UVs?

FY2021 Funding

Another oversight issue for Congress concerns the funding amounts for these programs that the Navy has requested for these programs for FY2021. Potential oversight questions for Congress include the following:

- Has the Navy accurately priced the work on these programs that it is proposing to do in FY2021?
- To what degree, if any, has funding been requested ahead of need? To what degree, if any, is the Navy insufficiently funding elements of the work to be done in FY2021?
- How might the timelines for these programs be affected by a decision to reduce (or add to) the Navy's requested amounts for these programs?

[52] 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 FY2021

Summary of Congressional Action on FY2021 Funding Request

Table 2 summarizes congressional action on the Navy's FY2021 funding request for the LUSV, MUSV, and XLUUV programs and their enabling technologies.

Table 2. Congressional Action on FY2021 Large UV Funding Request

Millions of dollars, rounded to the nearest tenth

		Authorization			Appropriation		
	Request	HASC	SASC	Conf.	HAC	SAC	Conf.
Navy research and development account							
LUSV	238.6	0	0		79.3		
Conversion of EPFs to LUSV prototypes	0	45.0	0		0		
MUSV	26.3	26.3	0		26.3		
LUSV and LUSV enabling technologies	199.1	199.1	0		153.6		
XLUUV	115.9	105.9	95.9		80.2		

Sources: Table prepared by CRS based on FY2021 Navy budget submission, committee and conference reports, and explanatory statements on the FY2021 National Defense Authorization Act and the FY2021 DOD Appropriations Act.

Notes: LUSV is Project 3066 within PE (Program Element) 0603178N (line 27 in the Navy's FY2021 research and development account). **MUSV** is Project 3428 within PE 0603178N (line 27). **LUSV** and **MUSV** enabling technologies is Project 3067 within PE 0603178N (line 27). **XLUUV** is Project 3394 within PE 0604536N (line 89). **HASC** is House Armed Services Committee; **SASC** is Senate Armed Services Committee; **HAC** is House Appropriations Committee; **SAC** is Senate Appropriations Committee; **Conf.** is conference agreement.

FY2021 National Defense Authorization Act (H.R. 6395/S. 4049)

House

The House Armed Services Committee, in its report (H.Rept. 116-442 of July 9, 2020) on H.R. 6395, recommended the funding levels shown in the HASC column of **Table 2**. The recommended reduction of $238.6 million (the entire requested amount) for LUSV is for "Two additional Overlord vessels [being] excess to need." The recommended increase of $45.0 million is for converting two Navy Expeditionary Fast Transport ships (EPF) into LUSV prototypes. (Page 391) The recommended reduction of $10 million for XLUUV is for "XLUUV late test and evaluation award." (Page 393)

Regarding the recommended funding for converting two EPFs into LUSV prototypes, H.Rept. 116-442 states

> *Expeditionary Fast Transport conversion to an unmanned surface vessel*
>
> The committee recognizes that unmanned surface vessels will play an essential role in future fleets of the Navy and supports the development of this capability in a manner that responsibly fields this new capability. The committee continues to believe that the Navy's current acquisition strategy incorporates an excessive amount of concurrency and is overly focused on the hull. The desire to move immediately from development into serial

production will only yield similar misfortunes as past shipbuilding programs with similar strategies. The committee believes the Navy should be primarily focused on the autonomy piece of this capability and ensuring that technologies that will need to be developed to support autonomous operations are mature before being incorporated on a purpose built vessel. A strategy that includes prototyping and test-of-ship systems such as propulsion, Command, Control, Communications, Computers and Intelligence, and other major Hull, Mechanical and Engineering systems prior to hull form decisions is a more prudent strategy that may actually field this capability sooner. The committee is also concerned with what level of manning if any will be required for these vessels. In briefings, the Navy has stated that initially these vessels will need to be minimally manned rather than fully unmanned in order to maximize Concept of Operations (CONOPS) development. The committee believes that the Navy should modify existing mature manned ships to support autonomous operations in order to develop CONOPS rather than procuring new ships that will need to support manned operations, but will eventually be fully unmanned.

Therefore, the committee recommends $45.0 million in PE 0603178N for the conversion of two Expeditionary Fast Transport (EPF) ships to support autonomous operations and accelerate CONOPS development. (Pages 43-44)

Section 230 of H.R. 6395 as reported by the committee states

SEC. 230. LIMITATIONS RELATING TO LARGE UNMANNED SURFACE VESSELS AND ASSOCIATED OFFEN SIVE WEAPON SYSTEMS.

(a) LIMITATION ON AVAILABILITY OF FUNDS FOR LUSV.—

(1) LIMITATION.—None of the funds authorized to be appropriated by this Act or otherwise made available for fiscal year 2021 for the Department of the Navy for the procurement of a large unmanned surface vessel may be obligated or expended until a period of 60 days has elapsed following the date on which the Secretary of the Navy submits to the congressional defense committees the certification described in paragraph (2).

(2) CERTIFICATION DESCRIBED.—The certification described in this paragraph is a written statement of the Secretary of the Navy certifying, with respect to any large unmanned surface vessel to be procured by the Secretary, the following:

(A) A hull system, a mechanical system, and an electrical system have been developed for the vessel and each system—

(i) has attained a technology readiness level of seven or greater; and

(ii) can be operated autonomously for a minimum of 30 days.

(B) A command control system has been developed for the vessel and the system—

(i) can be operated autonomously;

(ii) includes autonomous detection; and

(iii) has attained a technology readiness level of seven or greater.

(C) A detailed plan has been developed for measuring and demonstrating the reliability of the vessel.

(D) All payloads expected to be carried on the vessel have attained a technology readiness level of seven or greater.

(b) LIMITATION ON LUSV WEAPON INTEGRATION.—

The Secretary of the Navy may not integrate any offensive weapon system into a large unmanned surface vessel until the date on which the Secretary of the Defense certifies to

the congressional defense committees that any large unmanned surface vessel that employs offensive weapons will comply with the law of armed conflict. Such certification shall include a detailed explanation of how such compliance will be achieved.

Senate

The Senate Armed Services Committee, in its report (S.Rept. 116-236 of June 24, 2020) on S. 4049, recommended the funding levels shown in the SASC column of **Table 2**. The recommended reductions to zero funding for LUSV, MUSV, and LUSV and MUSV enabling technologies are for "Excess procurement ahead of satisfactory testing." (Page 504) The recommended reduction of $20 million for XLUUV is for "Orca UUV [XLUUV] testing delay and uncertified test strategy" ($10.0 million) and "Snakehead UUV uncertified test strategy" ($10 million). (Page 507)

Section 122 of S. 4049 as reported by the committee states

SEC. 122. LIMITATION ON NAVY MEDIUM AND LARGE UNMANNED SURFACE VESSELS.

(a) MILESTONE B APPROVAL REQUIREMENTS.—Milestone B approval may not be granted for a covered program unless such program accomplishes prior to and incorporates into such approval—

(1) qualification by the Senior Technical Authority of—

(A) at least two different main propulsion engines and ancillary equipment, including the fuel and lube oil systems; and

(B) at least two different electrical genera tors and ancillary equipment;

(2) final results of test programs of engineering development models or prototypes for critical systems specified by the Senior Technical Authority in their final form, fit, and function and in a realistic environment; and

(3) a determination by the milestone decision authority of the minimum number of vessels, discrete test events, performance parameters to be tested, and schedule required to complete initial operational test and evaluation and demonstrate operational suitability and operational effectiveness.

(b) QUALIFICATION REQUIREMENTS.—The qualification required in subsection (a)(1) shall include a land-based operational demonstration of such equipment in the vessel-representative form, fit, and function for not less than 1,080 continuous hours without preventative maintenance, corrective maintenance, emergent repair, or any other form of repair or maintenance.

(c) REQUIREMENT TO USE QUALIFIED ENGINES AND GENERATORS.—The Secretary of the Navy shall require that covered programs use only main propulsion engines and electrical generators that are qualified under sub section (a)(1).

(d) LIMITATION.—The Secretary of the Navy may not release a detail design or construction request for proposals or obligate funds from a procurement account for a covered program until such program receives Milestone B approval and the milestone decision authority notifies the congressional defense committees, in writing, of the actions taken to comply with the requirements under this section.

(e) DEFINITIONS.—In this section:

(1) The term ''covered program'' means a program for—

(A) medium unmanned surface vessels; or

(B) large unmanned surface vessels.

(2) The term ''Milestone B approval'' has the meaning given the term in section 2366(e)(7) of title 10, United States Code.

(3) The term ''milestone decision authority'' means the official within the Department of Defense designated with the overall responsibility and authority for acquisition decisions for the program, including authority to approve entry of the program into the next phase of the acquisition process.

(4) The term ''Senior Technical Authority'' has the meaning given the term in section 8669b of title 10, United States Code.

Regarding Section 122, S.Rept. 116-236 states

Limitation on Navy medium and large unmanned surface vessels (sec. 122)

The committee recommends a provision that would require that certain technical conditions be met prior to Milestone B approval for medium and large unmanned surface vessels.

The committee notes that the budget request provides for the prototyping and testing of Medium and Large Unmanned Surface Vessels (MUSVs and LUSVs), including procurement of up to two additional LUSVs in conjunction with a Strategic Capabilities Office (SCO) initiative. The committee understands that the four LUSVs procured by the SCO beginning in fiscal year 2018, at a cost of more than $510 million, are sufficient to achieve the objectives of the SCO initiative, which is scheduled to be completed in the fourth quarter of fiscal year 2021.

The committee further notes that the budget request includes plans to award the LUSV Detail Design and Construction (DD&C) contract in fiscal year 2022 and transition LUSV to a program of record in fiscal year 2023.

The committee remains concerned that the budget request's concurrent approach to LUSV design, technology development, and integration as well as a limited understanding of the LUSV concept of employment, requirements, and reliability for envisioned missions pose excessive acquisition risk for additional LUSV procurement in fiscal year 2021. The committee is also concerned by the unclear policy implications of LUSVs, including ill-defined international unmanned surface vessel standards and the legal status of armed or potentially armed LUSVs.

Additionally, the committee notes that the Navy's most recent shipbuilding plan, ''Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2020,'' acknowledges similar issues: ''Unmanned and optionally-manned systems are not accounted for in the overall battle force[.] ... The physical challenges of extended operations at sea across the spectrum of competition and conflict, the concepts of operations for these platforms, and the policy challenges associated with employing deadly force from autonomous vehicles must be well understood prior to replacing accountable battle force ships.''

The committee believes that further procurement of MUSVs and LUSVs should occur only after the lessons learned from the current SCO initiative have been incorporated into the system specification and additional risk reduction actions are taken.

A specific area of technical concern for the committee is the Navy requirement for MUSVs and LUSVs to operate continuously at sea for at least 30 days without preventative maintenance, corrective maintenance, or emergent repairs. The committee is unaware of any unmanned vessel of the size or complexity envisioned for MUSV or LUSV that has demonstrated at least 30 days of such operation.

The committee understands that the SCO prototype vessels that are intended to provide risk reduction for this program have demonstrated between 2 to 3 days of continuous

operation. The committee also understands that the SCO vessels are approximately 25 percent the size by tonnage of a LUSV, which may limit the applicability of lessons learned and risk reduction from the SCO vessels to the MUSV and LUSV programs. Among other critical subsystems, the committee views the main engines and electrical generators as key USV mechanical and electrical subsystems whose reliability is critical to ensuring successful operations at sea for at least 30 continuous days.

Accordingly, this provision would require at least two main engines and electrical generators, including ancillary equipment, to be formally qualified by the Navy, including a successful demonstration of at least 30 days of continuous operation prior to the LUSV or MUSV Milestone B approval and would require the use of such engines and generators in future USVs. The provision would also require the Senior Technical Authority and Milestone Decision Authority to take additional actions related to reducing the technical risk of these programs prior to a Milestone B approval.

The committee views the qualification of these critical subsystems as an essential prototyping step necessary to provide a solid technical foundation for the MUSV and LUSV programs. Rather than delaying these programs, the committee believes that qualified engines and generators will enable the delivery of capable, reliable, and sustainable USVs that meet the needs of fleet commanders faster than the plan contained in the budget request. (Pages 9-10)

Section 237 of S. 4049 as reported by the committee states

SEC. 237. LIMITATION ON CONTRACT AWARDS FOR CERTAIN UNMANNED VESSELS.

(a) LIMITATION.—None of the funds authorized to be appropriated for fiscal year 2021 by section 201 for research, development, test, and evaluation may be used for the award of a contract for a covered vessel until the date that is 30 days after the date on which the Under Secretary of Defense for Research and Engineering submits to the congressional defense committees a report and certification described in subsection (c) for such contract and covered vessel.

(b) COVERED VESSELS.—For purposes of this section, a covered vessel is one of the following:

(1) A large unmanned surface vessel (LUSV).

(2) A medium unmanned surface vehicle (MUSV).

(3) A large displacement unmanned undersea vehicle (LDUUV).

(4) An extra-large unmanned undersea vehicle (XLUUV).

(c) REPORT AND CERTIFICATION DESCRIBED.—A report and certification described in this subsection regarding a contract for a covered vessel is—

(1) a report—

(A) submitted to the congressional defense committees not later than 60 days after the date of the completion of an independent technical risk assessment for such covered vessel; and

(B) on the findings of the Under Secretary with respect to such assessment; and

(2) a certification, submitted to the congressional defense committees with the report described in paragraph (1), that certifies that—

(A) the Under Secretary has determined, in conjunction with the Senior Technical Authority designated under section 8669b(a)(1) of title 10, United States Code, for the class of naval vessels that includes the covered vessel, that the critical mission, hull, mechanical, and electrical subsystems of the covered vessel—

(i) have been demonstrated in vessel representative form, fit, and function; and

(ii) have achieved performance levels equal to or greater than applicable Department of Defense threshold requirements for such class of vessels; and

(B) such contract is necessary to meet Department research, development, test, and evaluation objectives for such covered vessel that cannot otherwise be met through further land-based subsystem prototyping or other demonstration approaches.

(d) CRITICAL MISSION, HULL, MECHANICAL, AND ELECTRICAL SUBSYSTEMS DEFINED.—In this section, the term ''critical mission, hull, mechanical, and electrical subsystems'', with respect to a covered vessel, includes the following subsystems:

(1) Command, control, communications, computers, intelligence, surveillance, and reconnaissance.

(2) Autonomous vessel navigation, vessel control, contact management, and contact avoidance.

(3) Communications security, including cryptopgraphy, encryption, and decryption.

(4) Main engines, including the lube oil, fuel oil, and other supporting systems.

(5) Electrical generation and distribution, including supporting systems.

(6) Military payloads.

(7) Any other subsystem identified as critical by the Senior Technical Authority designated under section 8669b(a)(1) of title 10, United States Code, for the class of naval vessels that includes the cov red vessel.

Regarding Section 237, S.Rept. 116-236 states

Limitation on contract awards for certain unmanned vessels (sec. 237)

The committee recommends a provision that would require the submission of a certification by the Under Secretary of Defense for Research and Engineering to the congressional defense committees prior to the Department of Defense's contracting for certain vessels.

The committee is concerned that an excessive number of unmanned surface and undersea vessels (USVs and UUVs) are being acquired prematurely using Research, Development, Test, and Evaluation funds and that these vessels may include subsystems that lack sufficient technical reliability and technological maturity to allow the vessels to meet threshold requirements.

The committee seeks to avoid contracting for USVs and UUVs when the technical reliability and technological maturity of subsystems critical to propulsion and electrical distribution or the military purposes of the vessels are either unknown or known to be insufficient. For example, the committee notes the Navy requirement for Medium and Large USVs (MUSV and LUSV) to operate continuously at sea for at least 30 days without preventative maintenance, corrective maintenance, or emergent repairs. The committee is unaware of any unmanned vessel of the size or complexity envisioned for MUSV or LUSV that has demonstrated at least 30 days of such operation.

The committee understands that the Strategic Capabilities Office (SCO) prototype vessels intended to provide risk reduction for the Navy's LUSV program have demonstrated a maximum of 2 to 3 days of continuous operation. The committee also understands that the SCO vessels are approximately 25 percent the size by tonnage of a Navy LUSV. As a result, the committee is concerned that the applicability of lessons learned and risk reduction from the SCO vessels to the Navy MUSV and LUSV programs will be limited.

The committee views prior and successful land-based prototyping of individual critical subsystems as essential to providing a solid technical foundation for USV and UUV programs. Rather than delaying these programs, the committee believes that a deliberate engineering-based subsystem prototyping approach will enable the delivery of capable, reliable, and sustainable USVs and UUVs that meet the needs of fleet commanders faster than the plan contained in the budget request, which assumes that several unproven or non-existent subsystems will rapidly materialize to meet the Navy's requirements for these vessels. (Pages 76-77)

S.Rept. 116-236 also states

Testbed for autonomous ship systems

The budget request included $122.3 million in Research, Development, Test, and Evaluation (RDT&E), Navy, for PE 62123N Force Protection Applied Research.

The committee notes that a key technology gap for long-duration autonomous ship operation lies in the robustness and resiliency of the hull and machinery plant. The committee also notes that autonomous ships will be expected to operate for months between human-assisted maintenance and that autonomous machinery must be robust and resilient in order to avoid failure, repair damage, or redirect platforms as needed. The committee notes the development of digital-twin technologies that allow for predictive or automated maintenance and improved operations and logistics and help fill a critical gap that has been identified in autonomous systems.

Therefore, the committee recommends an increase of $3.0 million, in RDT&E, Navy, for PE 62123N for the development of a testbed for autonomous ship systems. (Page 95)

S.Rept. 116-236 also states

Unmanned surface vessel development

The budget request included $21.5 billion in Research, Development, Test, and Evaluation (RDT&E), Navy, of which $464.0 million was for PE 63178N Medium and Large Unmanned Surface Vehicles and $38.4 million was for PE 63573N Advanced Surface Machinery Systems.

The committee notes that the budget request provides for the prototyping and testing of Medium and Large Unmanned Surface Vessels (MUSVs and LUSVs), including procurement of up to two additional LUSVs in conjunction with a Strategic Capabilities Office (SCO) initiative. The committee understands that the 4 LUSVs procured by the SCO beginning in fiscal year 2018, at a cost of more than $510 million, are sufficient to achieve the objectives of the SCO initiative, which is scheduled to be completed in the fourth quarter of fiscal year 2021.

The committee believes that further procurement of MUSVs and LUSVs should occur only after the lessons learned from the current SCO initiative have been incorporated into the system specification and additional risk reduction actions are taken.

A specific area of technical concern for the committee is the Navy requirement for MUSVs and LUSVs to operate continuously at sea for at least 30 days without preventative maintenance, corrective maintenance, or emergent repairs. The committee is unaware of any unmanned vessel of the size or complexity envisioned for MUSV or LUSV that has demonstrated at least 30 days of such operation.

The committee understands that the SCO prototype vessels that are intended to provide risk reduction for these programs have demonstrated between 2 to 3 days of continuous operation. The committee also understands that the SCO vessels are approximately 25 percent the size by tonnage of a LUSV, which may limit the applicability of lessons learned and risk reduction from the SCO vessels to the MUSV and LUSV programs. Among other critical subsystems, the committee views the main engines and electrical generators in

> particular as key USV mechanical and electrical subsystems whose reliability is critical to ensuring successful operations at sea for at least 30 continuous days.
>
> The committee also notes that additional funding is necessary to accelerate completion of the Integrated Power and Energy Systems test facility (ITF) to achieve full test capability in fiscal year 2023, consistent with section 131 of the National Defense Authorization Act for Fiscal Year 2020 (Public Law 116–92), as well as the qualification of silicon carbide power modules.
>
> Accordingly, the committee recommends a decrease of $464.0 million, for a total of $0, in RDT&E, Navy, for PE 63178N, and an increase of $200.0 million, for a total of $238.4 million in RDT&E, Navy, for PE 63573N.
>
> The committee's intent is that the increased funding in PE 63178N be used for: the USV main engine and electrical generator qualification testing directed elsewhere in this Act ($70.0 million); USV autonomy development, which may include conversion of existing vessels ($45.0 million); accelerating ITF testing ($75.0 million); and accelerating the qualification of silicon carbide power modules ($10.0 million). (Pages 97-98)

S.Rept. 116-236 also states

> **Advanced undersea prototyping**
>
> The budget request included $21.5 billion in Research, Development, Test, and Evaluation (RDT&E), Navy, of which $115.9 million was for PE 64536N advanced undersea prototyping.
>
> The committee notes that the Snakehead and Orca [XLUUV] test strategies require updates to enable certification by the Director of Operational Test and Evaluation in accordance with the Senate report accompanying the Department of Defense Appropriations Bill, 2020, incorporated into the Consolidated Appropriations Act, 2020 (S. Rept. 116–103). Additionally, the committee is aware of Orca testing delays.
>
> Accordingly, the committee recommends a decrease of $20.0 million, for a total of $95.9 million, in RDT&E, Navy, for PE 64536N. (Page 100)

A September 14, 2020, letter and enclosure from the Office of Budget Management (OMB) to the chairmen and ranking members of the Senate and House Armed Services Committee about concerns that the Administration has with certain provisions in S. 4049 stated in part:

> The Administration strongly objects to the absence of authorization language and funding to procure critical prototype vessels. The Administration believes that rigorous land-and sea-based testing is needed for a successful Large Unmanned Surface Vessel Program (LUSV), providing a lethal, distributed new capability to the fleet. These funds are critical to reduce risk and conduct integration and testing to ensure DOD is postured to transition LUSV to a program of record in FY 2023. The Administration urges Congress to fully support this critical capability at the levels in the FY 2021 President's Budget Request.[53]

[53] Letter dated September 14, 2020, from Russell T. Vought, Director, Office of Management and Budget, to Senator James M. Inhofe, Senator Jack Reed, Representative Adam Smith, and Representative Mac Thornberry with respect to the National Defense Authorization Act (NDAA) for FY2021, PDF page 9 of 14, accessed September 17, 2020, at https://www.whitehouse.gov/omb/legislative/letters/.

FY2021 DOD Appropriations Act (H.R. 7617)

House

The House Appropriations Committee, in its report (H.Rept. 116-453 of July 16, 2020) on H.R. 7617, recommended the funding levels shown in the HAC column of **Table 2**. The recommended

reduction of $159.3 million for LUSV is for "LUSV additional prototypes." (Page 266) The recommended reduction of $45.5 million for LUSV and MUSV enabling technologies is for "Unmanned surface vehicle enabling capabilities—payload program reduction." (Page 266) The recommended reduction of $35.626 million for XLUUV is for "Test and evaluation delays." (Page 268)

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