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Navy Columbia (SSBN-826) Class Ballistic Missile Submarine Program: Background and Issues for Congress

Updated April 27, 2022

Congressional Research Service
https://crsreports.congress.gov
R41129

CRS REPORT
Prepared for Members and
Committees of Congress

Summary

The Navy's Columbia (SSBN-826) class ballistic missile submarine (SSBN) program is a program to design and build a class of 12 new SSBNs to replace the Navy's current force of 14 aging Ohio-class SSBNs. Since 2013, the Navy has consistently identified the Columbia-class program as the Navy's top priority program. The Navy procured the first Columbia-class boat in FY2021 and wants to procure the second boat in the class in FY2024.

The Navy's proposed FY2023 budget requests $3,079.2 million (i.e., $3.1 billion) in continued procurement funding for the first Columbia-class boat and $2,778.6 million (i.e., about $2.8 billion) in advance procurement (AP) funding for subsequent boats in the class, for a combined FY2023 procurement and AP funding request of $5,857.8 million (i.e., about $5.9 billion).

The Navy's FY2023 budget submission estimates the procurement cost of the first Columbia-class boat at $15,179.1 million (i.e., about $15.2 billion) in then-year dollars, including $6,557.6 million (i.e., about $6.6 billion) in costs for plans, meaning (essentially) the detail design/nonrecurring engineering (DD/NRE) costs for the Columbia class. (It is a long-standing Navy budgetary practice to incorporate the DD/NRE costs for a new class of ship into the total procurement cost of the first ship in the class.) Excluding costs for plans, the estimated hands-on construction cost of the first ship is $8,621.5 million (i.e., about $8.6 billion). The Navy's FY2023 budget submission estimates the total procurement cost of a 12-ship class at $112.7 billion in then-year dollars.

Issues for Congress for the Columbia-class program include the following:

- the risk—due to technical challenges and/or funding-related issues—of a delay in designing and building the lead Columbia-class boat, which could put at risk the Navy's ability to have the boat ready for its first scheduled deterrent patrol in 2031, when it is to deploy in the place of the first retiring Ohio-class SSBN;
- the risk of cost growth in the program;
- the potential impact of the Columbia-class program on funding that will be available for other Navy programs, including other shipbuilding programs; and
- potential industrial-base challenges of building both Columbia-class boats and Virginia-class attack submarines (SSNs) at the same time.

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Introduction

This report provides background information and potential oversight issues for Congress on the Navy's Columbia (SSBN-826) class program, a program to design and build a class of 12 new ballistic missile submarines (SSBNs) to replace the Navy's current force of 14 aging Ohio-class SSBNs. Since 2013, the Navy has consistently identified the Columbia-class program as the Navy's top priority program. The Navy procured the first Columbia-class boat in FY2021 and wants to procure the second boat in the class in FY2024. The Navy's proposed FY2023 budget requests $5,857.8 million (i.e., about $5.9 billion) in procurement and advance procurement (AP) funding for the program.

The program poses a number of funding and oversight issues for Congress. Decisions that Congress makes on the Columbia-class program could substantially affect U.S. military capabilities and funding requirements, and the U.S. shipbuilding industrial base.

This report focuses on the Columbia-class program as a Navy shipbuilding program. Another CRS report—CRS Report RL33640, *U.S. Strategic Nuclear Forces: Background, Developments, and Issues*, by Amy F. Woolf—discusses the Columbia class as an element of future U.S. strategic nuclear forces in the context of strategic nuclear arms modernization efforts and arms control agreements.

Background

U.S. Navy SSBNs in General

Mission of SSBNs

The U.S. Navy operates three kinds of submarines—nuclear-powered attack submarines (SSNs), nuclear-powered cruise missile submarines (SSGNs), and nuclear-powered ballistic missile submarines (SSBNs).[1] The SSNs and SSGNs are multi-mission ships that perform a variety of peacetime and wartime missions.[2] They do not carry nuclear weapons.[3]

The SSBNs, in contrast, perform a singular mission of strategic nuclear deterrence. To perform this mission, SSBNs are armed with submarine-launched ballistic missiles (SLBMs), which are large, long-range missiles armed with multiple nuclear warheads. SSBNs launch their SLBMs

[1] In the designations SSN, SSGN, and SSBN, the SS stands for submarine, N stands for nuclear-powered (meaning the ship is powered by a nuclear reactor), G stands for guided missile (such as a cruise missile), B stands for ballistic missile. As shown by the "Ns" in SSN, SSGN, and SSBN, all U.S. Navy submarines are nuclear-powered. Other navies operate nonnuclear powered submarines, which are powered by energy sources such as diesel engines. A submarine's use of nuclear or nonnuclear power as its energy source is not an indication of whether it is armed with nuclear weapons—a nuclear-powered submarine can lack nuclear weapons, and a nonnuclear-powered submarine can be armed with nuclear weapons.

[2] For more on the Navy's SSNs and SSGNs, see CRS Report RL32418, *Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress*, by Ronald O'Rourke; and CRS Report RS21007, *Navy Trident Submarine Conversion (SSGN) Program: Background and Issues for Congress*, by Ronald O'Rourke.

[3] The Navy's nonstrategic nuclear weapons—meaning all of the service's nuclear weapons other than submarine-launched ballistic missiles (SLBMs)—were removed from Navy surface ships and submarines under a unilateral U.S. nuclear initiative announced by President George H. W. Bush in September 1991. The initiative reserved a right to rearm SSNs with nuclear-armed cruise missiles at some point in the future should conditions warrant.

from large-diameter vertical launch tubes located in the middle section of the boat.[4] The SSBNs' basic mission is to remain hidden at sea with their SLBMs, so as to deter a nuclear attack on the United States by another country by demonstrating to other countries that the United States has an assured second-strike capability, meaning a survivable system for carrying out a retaliatory nuclear attack.

Navy SSBNs, which are sometimes referred to informally as "boomers,"[5] form one leg of the U.S. strategic nuclear deterrent force, or "triad," which also includes land-based intercontinental ballistic missiles (ICBMs) and land-based long-range bombers. At any given moment, some of the Navy's SSBNs are conducting nuclear deterrent patrols. The Department of Defense's (DOD's) report on the 2018 Nuclear Posture Review (NPR), released on February 2, 2018, states the following:

> Ballistic missile submarines are the most survivable leg of the triad. When on patrol, SSBNs are, at present, virtually undetectable, and there are no known, near-term credible threats to the survivability of the SSBN force. Nevertheless, we will continue to hedge against the possibility that advances in anti-submarine warfare could make the SSBN force less survivable in the future.[6]

Current Ohio-Class SSBNs

The Navy currently operates 14 Ohio (SSBN-726) class SSBNs (see **Figure 1**). The boats are commonly called Trident SSBNs or simply Tridents because they carry Trident D-5 SLBMs. They were procured in FY1977-FY1991 and entered service in 1984-1997. They were designed and built by General Dynamics' Electric Boat Division (GD/EB) of Groton, CT, and Quonset Point, RI. They were originally designed for 30-year service lives but were later certified for 42-year service lives, consisting of two approximately 19-year periods of operation separated by an approximately four-year midlife nuclear refueling overhaul, called an engineered refueling overhaul (ERO). The nuclear refueling overhaul includes both a nuclear refueling and overhaul work on the ship that is not related to the nuclear refueling.[7]

The boats were originally designed to each carry 24 SLBMs. As part of DOD's plan for complying with U.S.-Russia strategic nuclear arms control limits, four SLBM launch tubes on each boat have been deactivated, reducing to 20 the number of SLBMs they can each carry.

Eight of the 14 Ohio-class SSBNs are homeported at Bangor, WA, in Puget Sound; the other six are homeported at Kings Bay, GA, close to the Florida border. Unlike most Navy ships, which are

[4] SSBNs, like other Navy submarines, are also equipped with horizontal torpedo tubes in the bow for firing torpedoes or other torpedo-sized weapons.

[5] This informal name is a reference to the large boom that would be made by the detonation of an SLBM nuclear warhead.

[6] Department of Defense, *Nuclear Posture Review 2018*, released February 2, 2018, pp. 44-45.

[7] A total of 18 Ohio-class SSBNs were procured in FY1974-FY1991. The ships entered service in 1981-1997. The first eight boats in the class were originally armed with Trident I C-4 SLBMs; the final ten were armed with larger and more-capable Trident II D-5 SLBMs. The Clinton Administration's 1994 Nuclear Posture Review (NPR) recommended a strategic nuclear force for the START II strategic nuclear arms reduction treaty that included 14 Ohio-class SSBNs, all armed with D-5s. This recommendation prompted interest in the idea of converting the first four Ohio-class boats (SSBNs 726-729) into SSGNs, so as to make good use of the 20 years of potential operational life remaining in these four boats, and to bolster the U.S. SSN fleet. The first 4 Ohio-class boats were converted into SSGNs in 2002-2008, and the next four (SSBNs 730-733) were backfitted with D-5 SLBMs in 2000-2005, producing the current force of 14 Ohio-class SSBNs, all of which are armed with D-5 SLBMs. For more on the SSGN conversion program, see CRS Report RS21007, *Navy Trident Submarine Conversion (SSGN) Program: Background and Issues for Congress*, by Ronald O'Rourke.

operated by single crews, Navy SSBNs are operated by alternating crews (called the Blue and Gold crews) so as to maximize the percentage of time that they spend at sea in deployed status.

Figure 1. Ohio (SSBN-726) Class SSBN

With the hatches to some of its SLBM launch tubes open

Source: Cropped version of U.S. Navy photograph.

The first of the 14 Ohio-class SSBNs (SSBN-730) will reach the end of its 42-year service life in 2027. The remaining 13 will reach the ends of their service lives at a rate of roughly one ship per year thereafter, with the 14th reaching the end of its service life in 2040.

The Navy has initiated a program to refurbish and extend the service lives of D-5 SLBMs to about 2040. As Columbia-class SSBNs begin to replace Ohio-class boats in 2031, refurbished D-5s carried by retiring Ohio-class boats will be transferred to new Columbia-class boats. Columbia-class boats will continue to be armed with these refurbished D-5s until about 2040, at which time the D-5s are to be replaced by a successor SLBM.

Including the Ohio class, the Navy has operated four classes of SSBNs since 1959. For a table summarizing these four classes, see **Appendix A**.

U.S.-UK Cooperation on SLBMs and the New UK SSBN

As one expression of U.S.-UK cooperation on nuclear weapon matters that dates back to World War II, the UK's four Vanguard-class SSBNs, which entered service in 1993-1999, each carry 16 Trident II D-5 SLBMs, and previous classes of UK SSBNs similarly carried earlier-generation U.S. SLBMs.[8] The UK plans to replace the four Vanguard-class boats with three or four Dreadnought-class next-generation SSBNs. Dreadnought-class boats are to be equipped with 12 missile launch tubes, but current UK plans call for each boat to carry eight D-5 SLBMs, with the other four tubes not being used for SLBMs. The United States is providing technical assistance to the United Kingdom for the Dreadnought-class program, as it has over the years for some other UK submarine programs; for additional discussion, see **Appendix B**.

Submarine Construction Industrial Base

U.S. Navy submarines are built at two shipyards—General Dynamics' Electric Boat Division (GD/EB) of Groton, CT, and Quonset Point, RI, and Huntington Ingalls Industries' Newport News Shipbuilding (HII/NNS), of Newport News, VA. GD/EB and HII/NNS are the only two

[8] Although the SLBMs on UK SSBNs are U.S.-made, the nuclear warheads on the missiles are of UK design and manufacture.

shipyards in the country capable of building nuclear-powered ships. GD/EB builds submarines only, while HII/NNS also builds nuclear-powered aircraft carriers and is capable of building other types of surface ships. The two yards currently are jointly building Virginia-class attack submarines.[9]

In addition to GD/EB and HII/NNS, the submarine construction industrial base includes hundreds of supplier firms, as well as laboratories and research facilities, in numerous states. Much of the total material procured from supplier firms for the construction of submarines comes from sole-source suppliers. For nuclear-propulsion component suppliers, an additional source of stabilizing work is the Navy's nuclear-powered aircraft carrier construction program.[10]

Much of the design and engineering portion of the submarine construction industrial base is resident at GD/EB. Smaller portions are resident at HII/NNS and some of the component makers.

Columbia-Class Program

Navy's Top Priority Program

Navy officials have stated consistently since September 2013 that the Columbia-class program is the Navy's top priority program, and that this means, among other things, that from the Navy's perspective, the Columbia-class program *will* be funded, even if that comes at the expense of funding for other Navy programs.[11]

Program Name, Origin, and Milestones

Until 2016, the Columbia-class program was known as the Ohio replacement program (ORP) or SSBN(X) program,[12] and boats in the class were referred to as Ohio replacement boats or SSBNXs. For information on the Columbia-class program's origin and milestones, see **Appendix C**.

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[9] For more on the arrangement for jointly building Virginia-class boats, see CRS Report RL32418, *Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress*, by Ronald O'Rourke.

[10] For more on this program, see CRS Report RS20643, *Navy Ford (CVN-78) Class Aircraft Carrier Program: Background and Issues for Congress*, by Ronald O'Rourke. In terms of work provided to nuclear-propulsion component suppliers, a carrier nuclear propulsion plant is roughly equivalent to five submarine propulsion plants.

[11] On September 18, 2013, Admiral Jonathan Greenert, then-Chief of Naval Operations, testified that the Columbia-class program "is the top priority program for the Navy." (Statement of Admiral Jonathan Greenert, U.S. Navy, Chief of Naval Operations, Before the House Armed Services Committee on Planning for Sequestration in FY2014 and Perspectives of the Military Services on the Strategic Choices and Management Review, September 18, 2013, p. 10.) Navy officials since then have reiterated this statement on numerous occasions. At a September 12, 2013, hearing before the Seapower and Projection Forces subcommittee of the House Armed Services Committee on undersea warfare, a Navy official stated the following:

> The CNO has stated, his number one priority as the chief of Naval operations, is our—our strategic deterrent—our nuclear strategic deterrent. That will trump all other vitally important requirements within our Navy, but if there's only one thing that we do with our ship building account, we—we are committed to sustaining a two ocean national strategic deterrent that protects our homeland from nuclear attack, from other major war aggression and also access and extended deterrent for our allies.
>
> (Transcript of hearing. (Spoken remarks of Rear Admiral Richard Breckenridge. The other witness at the hearing was Rear Admiral David Johnson.)

[12] In the designation SSBN(X), the (X) meant that the design of the boat had not yet been determined.

Planned Procurement Quantity and Schedule

Planned Procurement Quantity of 12

Navy plans call for procuring 12 Columbia-class boats to replace the current force of 14 Ohio-class SSBNs. In explaining the planned procurement quantity of 12 boats, the Navy states the following:

- Ten operational SSBNs—meaning boats not encumbered by lengthy maintenance actions—are needed to meet strategic nuclear deterrence requirements for having a certain number of SSBNs at sea at any given moment.
- Fourteen Ohio-class boats were needed to meet the requirement for 10 operational boats because, during the middle years of the Ohio class life cycle, three and sometimes four of the boats were nonoperational at any given moment on account of being in the midst of lengthy midlife nuclear refueling overhauls or other extended maintenance actions.
- Twelve (rather than 14) Columbia-class boats will be needed to meet the requirement for 10 operational boats because the midlife overhauls of Columbia-class boats, which will not include a nuclear refueling, will require less time (about two years) than the midlife refueling overhauls of Ohio-class boats (which require about four years from contract award to delivery), the result being that only two Columbia-class boats (rather than three or sometimes four) will be in the midst of midlife overhauls or other extended maintenance actions at any given moment during the middle years of the Columbia-class life cycle.[13]

The Trump Administration's Nuclear Posture Review (NPR), released in February 2018, states the following: "The COLUMBIA-class program will deliver a minimum of 12 SSBNs to replace the current OHIO fleet and is designed to provide required capabilities for decades."[14] The use of the word "minimum" in that sentence can be viewed as signaling a possibility that the required number of Columbia-class boats might at some point be increased to something more than 12 boats.[15]

Relationship of Planned Procurement Quantity to Navy's Current 355-Ship Force-Level Goal and Navy's New Battle Force 2045 Plan

The Navy's existing force-level goal, which the Navy released on December 15, 2016, calls for achieving and maintaining a fleet of 355 ships, including, among other things, 12 Columbia-class ballistic missile submarines. The force-level goal of 12 Columbia-class boats was determined by the calculations described in the previous section. These calculations, which relate to the specialized mission strategic nuclear deterrence performed by SSBNs, are largely separate from

[13] For additional discussion, see "Navy Responds to Debate Over the Size of the SSBN Force," Navy Live, May 16, 2013, accessed July 26, 2013, at http://navylive.dodlive.mil/2013/05/16/navy-responds-to-debate-over-the-size-of-the-ssbn-force/, and Richard Breckenridge, "SSBN Force Level Requirements: It's Simply a Matter of Geography," Navy Live, July 19, 2013, accessed July 26, 2013, at http://navylive.dodlive.mil/2013/07/19/ssbn-force-level-requirements-its-simply-a-matter-of-geography/.

[14] Department of Defense, *Nuclear Posture Review 2018*, released February 2, 2018, p. 49. A similar statement (which differs only in saying "COLUMBIA program" rather than "COLUMBIA-class program") appears on p. x.

[15] See, for example, Marc Selinger, "Navy Might Someday Consider Buying More Than 12 Columbia-Class Submarines," *Defense Daily*, April 12, 2018: 2-3; Jason Sherman, "Navy Keeping Options Open to 'Tack On' Additional Submarines to 12-Boat Columbia Buy," *Inside Defense*, November 18, 2020.

the calculations that the Navy uses to determine force-level goals for the other types of ships that make up the Navy.

Planned Procurement Schedule

As noted earlier, the Navy procured the first Columbia-class boat in FY2021. The Navy wants to procure the second boat in the class in FY2024, and the remaining 10 at a rate of one per year from FY2026 through FY2035. Under the Navy's FY2023 budget submission, the first boat is to be delivered in October 2027, the second boat in October 2030, the third boat in July 2032, and the fourth boat in July 2033. After being delivered in October 2027, the lead boat is to undergo substantial testing, with the aim of having it be ready for its first deterrent patrol in 2031.

Taking into account both projected delivery dates for Columbia-class boats and projected retirement dates for Ohio-class boats, the Navy's FY2023 30-year (FY2023-FY2053) shipbuilding plan projects that the SSBN force will include 14 boats through FY2026, 13 boats in FY2027-FY2028, 12 boats in FY2029, 11 boats in FY2030-2032, and 12 boats in FY2033-FY2052 (except for FY2040-FY2041, when it is projected to include 13 boats).[16] The Navy has stated in earlier years that a reduction of the SSBN force to 11 boats during the transition of the force from the Ohio class to the Columbia class would be acceptable in terms of meeting strategic nuclear deterrence requirements, because during those transition years, all 11 of the SSBNs in service will be operational (i.e., none of them will be in the midst of a lengthy midlife overhaul). The Navy acknowledged that there would be some risk in having the SSBN force drop to 11 boats, because it would provide little margin for absorbing an unforeseen event that might force an SSBN into an unscheduled and lengthy maintenance action. The Navy is examining options for slightly extending the service lives of a few Ohio-class boats so as to minimize the period during which the SSBN force drops below 12 boats.[17]

Columbia-Class Design

The Columbia-class design (see **Figure 2** and **Figure 3**) includes 16 SLBM tubes, as opposed to 24 SLBM tubes (of which 20 are now used for SLBMs) on Ohio-class SSBNs. Although the Columbia-class design has fewer SLBM tubes than the Ohio-class design, it is larger than the Ohio-class design in terms of submerged displacement. The Columbia-class design, like the Ohio-class design before it, will be the largest submarine ever built by the United States.

Current U.S. and UK plans call for the Columbia-class and the UK's Dreadnought-class SSBN to use a missile compartment—the middle section of the boat with the SLBM launch tubes—of the same general design called the Common Missile Compartment (CMC).[18] As mentioned earlier,

[16] For more on the FY2023 30-year shipbuilding plan, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by Ronald O'Rourke.

[17] Source: Navy information paper on the FY2022 Fiscal Planning Framework and submarine service life extensions, February 5, 2021, provided by Navy Office of Legislative Affairs to Congressional Budget Office (CBO) and CRS on February 5, 2021. See also Megan Eckstein, "Navy May Extend Life of Ohio SSBNs to Provide Cushion for Introduction of Columbia-class," *USNI News*, November 16 (updated December 24), 2020; Aidan Quigley, "Navy Considering Expanding Life Cycles of Some Ohio-class Submarines to Ease Columbia Transition," *Inside Defense*, July 7, 2021; Megan Eckstein, "US Navy Reorganizes Submarine Enterprise to Address Challenges in Construction, Maintenance," *Defense News*, September 27, 2021.

[18] Statement of Rear Admiral Stephen Johnson, USN, Director, Strategic Systems Programs, Before the Subcommittee on Strategic Forces of the Senate Armed Services Committee [on] FY2011 Strategic Systems, March 17, 2010, p. 6, which states the following: "The OHIO Replacement programs includes the development of a common missile compartment that will support both the OHIO Class Replacement and the successor to the UK Vanguard Class."

Dreadnought-class SSBNs are to each be armed with eight D-5 SLBMs, or half the number to be carried by the Columbia class. The modular design of the CMC will accommodate this difference. The UK provided some of the funding for the design of the CMC, including a large portion of the initial funding.[19]

For additional background information on the Columbia-class design, see **Appendix D**.

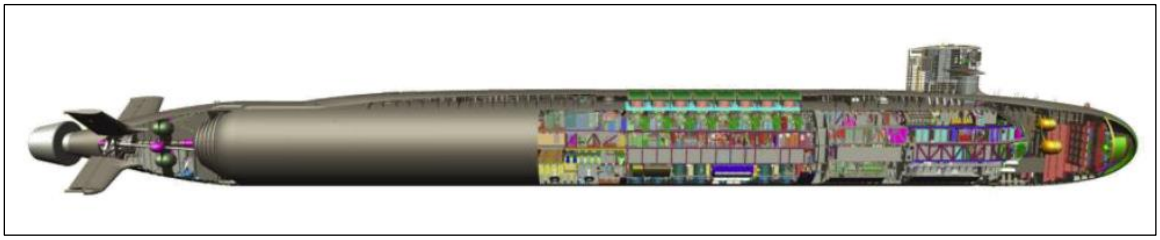
Figure 2. Columbia (SSBN-826) Class SSBN

Artist's rendering

Source: Cropped version of illustration accompanying David B. Larter, "US Navy Inks $9.4B Contract for two Columbia-class Nuclear Missile Submarines," Defense News, November 5, 2020. A caption to the image credits it to the U.S. Navy.

Figure 3. Columbia (SSBN-826) Class SSBN

Notional cutaway illustration



Source: Detail of slide 2, entitled "OHIO Replacement Program System Description," in Navy briefing on Columbia-class program presented by Captain William J. Brougham, Program Manager of PMS 397 (i.e., Project Manager Shipbuilding, Office Code 397, the office for the Columbia-class program), at the Sea, Air, and Space Symposium, April 8, 2014, posted at InsideDefense.com (subscription required), April 9, 2014.

[19] See Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-10-388SP, March 2010, p. 152; Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-11-233SP, March 2011, p. 147; Sam LaGrone and Richard Scott, "Deterrent Decisions: US and UK Wait on Next Steps for SSBN Replacements," *Jane's Navy International*, May 2010, pp. 10-11.

Tight Schedule for Designing and Building Lead Boat

The schedule for designing and building the lead Columbia-class boat and having it ready for its scheduled first deterrent patrol in 2031 has little margin for absorbing unforeseen delays due to technical challenges or funding-related issues. A delay in designing and building the lead boat could put at risk the Navy's ability to have the boat ready for its first scheduled deterrent patrol in 2031, when it is to deploy in the place of the first retiring Ohio-class SSBN. The tightness in the lead boat's design and construction schedule has been a principal feature of the program (along with the program's high priority) for several years. Much of the management time and attention that the Navy devotes to the program is focused on anticipating, monitoring, and mitigating risks to the lead boat's construction schedule, so as to ensure that the schedule will be executed without significant delay.

Program Cost

Program Acquisition Cost

Estimates of the procurement cost or acquisition cost (i.e., the research and development cost plus procurement cost) of the Columbia-class program include the following:

- The Navy's FY2023 budget submission estimated the total procurement cost of the 12-ship class at $112.7 billion in then-year dollars.
- The Navy in August 2017 estimated the total procurement cost of the Columbia-class program at $109.2 billion in then-year dollars and the program's research and development cost at $13.0 billion in then-year dollars, for a total acquisition (research and development plus procurement) cost of $122.3 billion in then-year dollars.[20]
- The Navy as of January 2017 estimated the procurement cost of the lead ship in the Columbia class at $8.2 billion in constant 2017 dollars, not including several billion dollars in additional cost for plans for the class, and the average unit procurement cost of ships 2 through 12 in the program at $6.5 billion each in constant FY2017 dollars.[21]
- A June 2021 Government Accountability Office (GAO) report assessing selected major DOD weapon acquisition programs stated that the estimated total acquisition (development plus procurement) cost of the Columbia-class program as of July 2020 was $107,761.4 million (about $107.8 billion) in constant

[20] Source: Navy briefing to CRS and CBO on the Columbia-class program, August 1, 2017. The Navy's FY2019 budget submission, submitted in February 2018, estimates the total procurement cost of 12 Columbia-class boats at $109.0 billion in then-year dollars.

[21] *Columbia Class MS [Milestone] B, Congressional Notification*, January 6, 2017, p. 1. The Navy in February 2010 preliminarily estimated the procurement cost of each Columbia-class boat at $6 billion to $7 billion in FY2010 dollars. (Source: U.S. Navy, *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY 2011*, February 2010, p. 20.) Following the Columbia-class program's December 9, 2010, Milestone A acquisition review meeting (see **Appendix C**), DOD issued an Acquisition Decision Memorandum (ADM) that, among other things, established a target average unit procurement cost for boats 2 through 12 in the program of $4.9 billion in constant FY2010 dollars. (Christopher J. Castelli, "DOD: New Nuclear Subs Will Cost $347 Billion To Acquire, Operate," *Inside the Navy*, February 21, 2011; Elaine M. Grossman, "Future U.S. Nuclear-Armed Vessel to Use Attack-Submarine Technology," *Global Security Newswire*, February 24, 2011; Jason Sherman, "Navy Working To Cut $7.7 Billion From Ohio Replacement Program," *Inside the Navy*, February 28, 2011. See also Christopher J. Castelli, "DOD Puts 'Should-Cost' Pressure On Major Weapons Programs," *Inside the Navy*, May 2, 2011.)

- FY2021 dollars, including $13,681.0 million (about $13.7 billion) in research and development costs and $94,080.4 million (about $94.1 billion) in procurement costs.[22]

The above estimates do not include estimated costs for refurbishing D-5 SLBMs so as to extend their service lives to about 2040.

Estimated Procurement Costs of First Four Boats

The Navy's FY2023 budget submission estimates the procurement cost of the first Columbia-class boat at $15,179.1 million (i.e., about $15.2 billion) in then-year dollars, including $6,557.6 million (i.e., about $6.6 billion) in costs for plans, meaning (essentially) the detail design/nonrecurring engineering (DD/NRE) costs for the Columbia class. (It is a long-standing Navy budgetary practice to incorporate the DD/NRE costs for a new class of ship into the total procurement cost of the first ship in the class.) Excluding costs for plans, the estimated hands-on construction cost of the first ship is $8,621.5 million (i.e., about $8.6 billion).

In then-year dollars, the Navy's FY2023 budget submission estimates the procurement cost of the second boat in the class at $9,280.2 million (i.e., about $9.3 billion), the third boat at $8,260.7 million (i.e., about $8.3 billion), and the fourth boat at $8,190.9 million (i.e., about $8.2 billion).

Operation and Support (O&S) Cost

The Navy as of January 2017 estimated the average annual operation and support (O&S) cost of each Columbia-class boat at $119 million per year.[23]

National Sea-Based Deterrence Fund (NSBDF)

The National Sea-Based Deterrence Fund (NSBDF) is a fund in DOD's budget separate from the Navy's shipbuilding account for holding and executing procurement funding for the construction of new SSBNs. It was created by Congress in 2014 originally with the aim of helping to financially insulate other Navy shipbuilding programs from the potential cost impact of the Columbia-class program, and to encourage U.S. policymakers to finance the procurement of Columbia-class boats from across DOD's budget rather than solely from the Navy's budget.

In more recent years, the statute establishing and governing the fund (10 U.S.C. 2218a) has been amended to give the NSBDF an additional function of acting as a vehicle or repository for certain special acquisition authorities that have the potential for reducing at the margin the cost of Columbia-class boats and other Navy nuclear-powered ships (i.e., aircraft carriers and attack submarines). For additional background information on the NSBDF, see **Appendix E**.

Integrated Enterprise Plan (IEP)

The Navy, under a plan it calls the Integrated Enterprise Plan (IEP), plans to build Columbia-class boats jointly at GD/EB and HII/NNS, with most of the work going to GD/EB. (The IEP was previously called the Submarine Unified Build Strategy, or SUBS.) As part of this plan, the Navy is adjusting the division of work on the Virginia-class attack submarine program (in which boats

[22] Government Accountability Office, *Weapon Systems Annual Assessment[:] Updated Program Oversight Approach Needed*, GAO-21-222, June 2021, p. 184.

[23] *Columbia Class MS [Milestone] B, Congressional Notification*, January 6, 2017, p. 1.

are jointly built at GD/EB and HII/NNS),[24] so that HII/NNS will receive a larger share of the final-assembly work for that program than it has received in the past.[25]

Cost-Plus Incentive Fee (CPIF) Contract for First Two Ships

The Navy is using a cost-plus incentive fee (CPIF) contract to procure the first two Columbia-class ships. The contract includes a single option for both ships, but the Navy states that this is not a block buy contract,[26] even though the ships are to be procured in differing fiscal years (FY2021 and FY2024), because, with regard to the second ship, the option relates to the execution of the ship's advance procurement (AP) funding and the Navy technically is not making a commitment to continuing with construction of the second ship beyond what is funded with AP funding until that ship is authorized in FY2024 and full funding (as opposed to AP funding) is provided for the ship.[27]

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[24] For more on the arrangement for jointly building Virginia-class boats, see CRS Report RL32418, *Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress*, by Ronald O'Rourke.

[25] Key elements of the Navy's plan include the following:

- GD/EB is to be the prime contractor for designing and building Columbia-class boats;
- HII/NNS is to be a subcontractor for designing and building Columbia-class boats;
- GD/EB is to build certain parts of each Columbia-class boat—parts that are more or less analogous to the parts that GD/EB builds for each Virginia-class attack submarine;
- HII/NNS is to build certain other parts of each Columbia-class boat—parts that are more or less analogous to the parts that HII/NNS builds for each Virginia-class attack submarine;
- GD/EB is to perform the final assembly on all 12 Columbia-class boats;
- as a result of the three previous points, the Navy estimates that GD/EB would receive an estimated 77%-78% of the shipyard work building Columbia-class boats, and HII/NNS would receive 22%-23%;
- GD/EB is to continue as prime contractor for the Virginia-class program, but to help balance out projected submarine-construction workloads at GD/EB and HII/NNS, the division of work between the two yards for building Virginia-class boats is to be adjusted so that HII/NNS would perform the final assembly on a greater number of Virginia-class boats than it would have under a continuation of the current Virginia-class division of work (in which final assemblies are divided more or less evenly between the two shipyards); as a consequence, HII/NNS would receive a greater share of the total work in building Virginia-class boats than it would have under a continuation of the current division of work.

See Julia Bergman, "Congressmen Visit EB A Day After It Is Named Prime Contractor for Ohio Replacement Program," *The Day (New London)*, March 29, 2016; Sydney J. Freedberg Jr., "Ohio Replacement Plan Is Good News For Electric Boat," *Breaking Defense*, March 29, 2016; Robert McCabe, "Newport News Shipbuilding's Share of Virginia-Class Submarine Deliveries to Grow," *Virginian-Pilot (Newport News)*, March 29, 2016; Valerie Insinna, "GD Electric Boat Chosen To Take Lead Role for Ohio Replacement Sub," *Defense Daily*, March 30, 2016: 1-3; Hugh Lessig, "Navy: More Submarine Work Coming to Newport News Shipyard," *Military.com*, March 30, 2016; Lee Hudson, "Work on Ohio-Class Replacement Will Be 80-20 Split Between GDEB, HII-NNS," *Inside the Navy*, April 4, 2016. See also Richard R. Burgess, "Submarine Admirals: 'Unified Build Strategy' Seeks Affordability for Future Sub Fleet," *Seapower*, July 8, 2016. See also Statement of the Honorable Sean J. Stackley, Assistant Secretary of the Navy (Research, Development and Acquisition), and Vice Admiral Joseph P. Mulloy, Deputy Chief of Naval Operations for Integration of Capabilities and Resources, and Lieutenant General Robert S. Walsh, Deputy Commandant, Combat Development and Integration & Commanding General, Marine Corps Combat Development Command, before the Subcommittee on Seapower and Projection Forces of the House Armed Services Committee on Department of the Navy Seapower and Projection Forces Capabilities, February 25, 2016, p. 12.

[26] For more on block buy contracting, see CRS Report R41909, *Multiyear Procurement (MYP) and Block Buy Contracting in Defense Acquisition: Background and Issues for Congress*, by Ronald O'Rourke.

[27] Source: Telephone discussion with Navy Office of Legislative Affairs, June 24, 2020.

FY2023 Procurement Funding Request

Table 1 presents FY2023-FY2027 procurement and advance procurement (AP) funding for the Columbia-class program under the Navy's FY2023 budget submission. As shown in the table, the Navy's proposed FY2023 budget requests $3,079.2 million (i.e., $3.1 billion) in continued procurement funding for the first Columbia-class boat and $2,778.6 million (i.e., about $2.8 billion) in advance procurement (AP) funding for subsequent boats in the class, for a combined FY2023 procurement and AP funding request of $5,857.8 million (i.e., about $5.9 billion).

Table 1. Columbia-Class Program FY2023-FY2027 Procurement Funding

(Millions of then-year dollars, rounded to nearest tenth; totals may not add due to rounding)

	FY23 (req.)	FY24 (proj.)	FY25 (proj.)	FY26 (proj.)	FY27 (proj.)
Procurement	3,079.2	2,440.3	3,341.7	4,997.8	5,121.5
Advance procurement (AP)	2,778.6	3,375.0	3,881.2	3,479.3	3,833.4
TOTAL	**5,857.8**	**5,815.3**	**7,222.9**	**8,477.2**	**8,955.0**

Source: Table prepared by CRS based on Navy's FY2023 budget submission.

Issues for Congress

Risk of Schedule Delay in Designing and Building Lead Boat

Overview

One oversight issue for Congress is the risk of a delay in designing and building the lead Columbia-class boat. As mentioned earlier, the schedule for designing and building the lead boat and having it ready for its scheduled first deterrent patrol in 2031 has little margin for absorbing unforeseen delays due to technical challenges or funding-related issues. A delay in designing and building the lead boat could put at risk the Navy's ability to have the boat ready for its first scheduled deterrent patrol in 2031, when it is to deploy in the place of the first retiring Ohio-class SSBN. Risks of a delay in designing and building the lead boat relate to technical challenges or funding-related issues, such as lapses in appropriations or restrictions on spending during periods when DOD is funded under continuing resolutions.

At least two technical challenges have already been reported in the Columbia-class program, one first reported in 2017 involving an electric motor,[28] and another first reported in 2018 involving faulty welds in the first missile tube sections being built for the lead boat.[29] Navy officials have

[28] See, for example, John Grady, "Navy to Congress: Columbia-class Submarine Program Still on Schedule with Little Margin for Error," *USNI News*, March 21, 2018; Julia Bergman, "Columbia Submarine Prototype Has First Glitch," *The Day (New London)*, May 5, 2017; Anthony Capaccio, "Navy Sub's Overheating Motor First Glitch in $126 Billion System," *Bloomberg*, May 4, 2017. See also Government Accountability Office, *Columbia Class Submarine[:] Overly Optimistic Cost Estimate Will Likely Lead to Budget Increases*, GAO-19-497, April 2019, p. 19.

[29] See, for example, David B. Larter, "The US Navy's Top Acquisition Priority Stumbles Out of the Gate," *Defense News*, August 6, 2018; Colin Clark and Sydney J. Freedberg Jr., "Nuke Sub Launch Tube Problems Found: 'Warning Flags Are Up,'" *Breaking Defense*, August 7, 2018; Ben Werner, "Navy Evaluating Possible Columbia-class Sub Delays Caused by Missile Tube Weld Issues," *USNI News*, August 8, 2018; Jason Sherman, "Supplier of Faulty Welding on Subs Working to Understand Scope of Defects," *Inside the Navy*, August 10, 2018; Ben Werner, "'Substantial' Columbia-class Missile Tube Weld Fix Will Cost $27 Million, Take a Year," *USNI News*, November 7,

stated that neither of these challenges jeopardized the leads boat's schedule for being ready for its first patrol in 2031, in part because the Navy—recognizing that it had not built SSBN missile tube sections in many years—had built 23 months of margin into the schedule for manufacturing the missile tube sections. (This is in part why manufacturing of missile tube sections began well ahead of fabrication work on other parts of the submarine.) The problem with the welds reportedly absorbed up to 15 months of that margin, but even after absorbing that delay, 8 or more months of margin remained, and the Navy is working to regain some of the lost margin.

Technical challenges could arise in various parts of the ship. One area that may bear close watching is the ship's electric-drive propulsion system, which is quite different than the mechanical-drive system used in other Navy nuclear-powered submarines.[30]

Until such time that the Navy can find ways to generate additional margin inside the program's schedule, the program appears to be in a situation where many things need to go right, and few things can go wrong, between now and 2031 for the lead boat to be ready for its first patrol in 2031.[31] In assessing this situation, it can be noted on the one hand that the Columbia-class program's status as the Navy's top priority program means that the program can be a high claimant for funding and personnel (including engineers, supervisors, and managers) that can be used to reduce the risk of occurrence of technical challenges that could threaten the lead boat's 2031 first-patrol date. On the other hand, it can be noted that the lead ship in the Columbia-class program, like the lead ships in most Navy shipbuilding programs, is serving as the program's prototype, creating an inherent risk of technical challenges.

Navy Perspective

A November 18, 2021, press report states

> The Navy's Columbia-class submarine program could be down to as little as two months of margin, the admiral in charge of the program told the Navy Submarine League's Annual Symposium on Thursday [November 18].

2019; Megan Eckstein, "Columbia-class Program Upping Oversight of Vendors, Components to Stave Off Further Delays," *USNI News*, November 8, 2019; Paul McLeary, "Navy Rushes To Check Contractors After Submarine 'Debacle,'" *Breaking Defense*, November 8, 2018; Dan Leone, "Welding Mistake With Columbia Missile Tubes Was Bigger Problem Than BWXT Thought," *Defense Daily*, November 9, 2018; Marjorie Censer, "BWX Technologies Takes $27 Million Charge for Missile Tube Rework," *Inside the Navy*, November 12, 2018; Justin Katz and Mallory Shelbourne, "Navy Conducting New Inspections of Columbia-Class Submarine Vendors," *Inside the Navy*, November 12, 2018.

See also Government Accountability Office, *Columbia Class Submarine[:] Overly Optimistic Cost Estimate Will Likely Lead to Budget Increases*, GAO-19-497, April 2019, pp. 19-20.

[30] The Navy in the past has built two electric-drive nuclear-powered submarines—the one-of-a-kind attack submarine Tullibee (SSN-597), which was commissioned in 1960 and decommissioned in 1988, and the one-of-a-kind attack submarine Glenard P. Lipscomb (SSN-685) which was commissioned in 1974 and decommissioned in 1990. Those two submarines, however, were designed many years ago, and used electric-drive technology that was different from that in the Columbia-class design. The Navy in recent years has built some surface ships with electric-drive propulsion systems, including 14 Lewis and Clark (TAKE-1) dry cargo ships and three Zumwalt (DDG-1000) destroyers, but the electric-drive technology in those ships, though more modern than that of SSNs 597 and 685, is different and in some respects less advanced than that planned for the Columbia-class design. The Navy has never before built a series-production nuclear-powered submarine class with electric-drive propulsion, and has never built a ship of any kind (surface or submarine) using the combination of advanced electric-drive technologies planned for the Columbia-class design.

[31] For additional discussion, see, for example, Jon Harper, "Columbia-Class Program Must Navigate Sea of Risks," *National Defense*, November 5, 2018; Dan Leone, "Officers Send Conflicting Signals on Columbia Program Margin," *Defense Daily*, February 28, 2019.

> "There's really not much margin there," Rear Adm. Scott Pappano, the Navy's program executive officer for strategic submarines, told the industry-heavy audience in Arlington, Va. "There's really none."...
>
> On Thursday, Pappano said the Navy was considering ways to extend the life of the Ohio fleet by between three and five years to hedge against a delay in the Columbia program.[32]

Another November 18, 2021, press report states

> The admiral in charge of building the Navy's next-generation ballistic-missile submarine (SSBN) said the fragility of the submarine industrial base supply chain is the main risk to the Columbia SSBN going on patrol on time in October 2030.
>
> "The supply chain is the No. 1 risk to Columbia and 1 + 2," said Rear Adm. Scott Pappano, program executive officer for Strategic Submarines, speaking Nov. 18 at the Naval Submarine League's annual symposium in Arlington.
>
> The "1+2" refers to the current submarine building load of one Columbia-class SSBN and two Virginia-class attack submarines (SSNs) per year.
>
> Pappano also said because the Columbia-class SSBN is the Navy's No.1 procurement priority, any schedule adjustment to the submarine programs would be borne by the Virginia-class SSNs before it would affect Columbia.
>
> The admiral noted that in the post-Cold War period the submarine industrial base had 17,000 suppliers, a number that has declined to 5,000 today. He said the fragility is greatest with components such as castings, fittings, valves and electrical equipment.
>
> Pappano said the Navy needs some sort of tripwire to warn the service when a supplier is faltering.
>
> PEO Submarines soon is standing up a new directorate, PMS-396, to manage sustainment of in-service SSBNs.
>
> He said there is no margin in the build schedule, so the Navy is not going to sponsor competitions for many components and systems already proven but will leave some room for competition.
>
> The admiral also said that the Ohio-class SSBNs—designed for 30-year careers and extended to 42 years—may be extended even longer on an individual basis.
>
> "Individual extensions are being looked at for targeted work," he said.
>
> The admiral also said that the patrol and refit cycles of the Ohio class may be adjusted "to better maximize" their service until the boats are retired in the late 2030s.[33]

A November 16, 2020, press report, stated that

> the Navy and industry are taking steps to take risk out of the tight Columbia construction schedule.
>
> "In August we completed full-scale testing of the prototypical Columbia electric drive components. We call it the integrated power system. Think of it in terms of power generation, switchboards, distribution, controllers and a full-size electric motor. During a

[32] Dan Leone, "Columbia Could be Down to 2 Months of Margin, Navy Program Exec Says," *Defense Daily*, November 18 (updated November 19), 2021.

[33] Richard R. Burgess, "Rear Adm. Pappano: Supply Chain Fragility is No. 1 Risk to Columbia SSBN Program," *Seapower*, November 18, 2021. See also Aidan Quigley, "Navy Considering Ohio-class Submarine Maintenance Options to Ease Columbia Transition," *Inside Defense*, November 18, 2021; Aidan Quigley, "Electric Boat Working Through Workforce, Industrial Base Concerns as Columbia Construction Progresses," *Inside Defense*, November 22, 2021.

> full-power run, the fully integrated system was operated under the most stressing conditions that we think we would encounter, and I'm proud to say that the system performed flawlessly. It exceeded all of our design expectations," the [Admiral Frank Caldwell, the director of the Naval Nuclear Propulsion Program] said.
>
> He added that the Navy and industry had also already conducted an early setup and qualification of all facilities and equipment needed to build the quad-packs of missile tubes, as well as prototyped the construction of a propulsion lube oil system to prove out digital design and other tools being used for Columbia design and construction.
>
> Caldwell said government-furnished equipment – most importantly, perhaps, the reactor core, steam generators and other large reactor plant components – had been on order since Fiscal Year 2019 and are on pace to deliver to the construction yards early.
>
> Caldwell said the Navy continues to look at additional de-risking activities such as pulling more work into the advance construction phase for the second in the class and beyond, as well as buying additional components early.[34]

A November 12, 2020, press report stated

> The Navy is working through challenges with its Columbia-class ballistic missile submarine program as it tries to meet a tight delivery schedule for its next generation of nuclear-armed boats, said the commander of Naval Sea Systems Command Nov. 12….
>
> "The program is on plan," said Vice Adm. William Galinis. However, "we are seeing … some challenges as we come through the final parts of the design and get into construction a little bit."
>
> This stage of the process is often where issues can spring up, he told reporters during a meeting hosted by George Washington University's Project for Media and National Security.
>
> For "new ship construction programs in general that's always kind of a challenge point … to get that design completed and get into construction," he said. "And then you're building the first vessel and you're going to have production issues along the way. And then the next phase is when you start to activate the systems, bring the submarine online and then get it delivered to the fleet. So that will really be our next challenge."
>
> Galinis gave the two main shipbuilders involved with the program—General Dynamics Electric Boat and Huntington Ingalls Industries Newport News Shipbuilding—high marks for working with the program executive office to keep the project on schedule.
>
> About 350 companies in the industrial base and supply chain are considered to be critical for the program, Galinis said. Among those, the Navy believes about 5 to 10 percent are "somewhat challenged" in one area or another to be able to meet the demand for the submarines, he noted.
>
> "The supplier base is something that we continue to watch pretty closely," he said. PEO Submarines "has done a pretty good job reaching out and working with their supply base through the shipyards to really kind of get a good understanding of where ... the risks are."
>
> Across the supplier base, the Navy is most concerned about welding and non-destructive testing skills.

[34] Megan Eckstein, "Navy May Extend Life of Ohio SSBNs to Provide Cushion for Introduction of Columbia-class," *USNI News*, November 16 (updated December 24), 2020. See also Dan Leone, "Early Buys for Columbia Submarine Components Possible, Caldwell Says," *Defense Daily*, November 16, 2020.

> "That's a big part of shipbuilding—and that's not just for Columbia, that's sort of across the enterprise," Galinis said. "I'm seeing some challenges there."
>
> The sea service is working to ensure it has enough electricians and mechanics to meet the demand, he said."[35]

A November 6, 2020, press report stated that the Navy and GD/EB have agreed to an 84-month build sequence for the lead boat but are working to shorten that scheduled construction period to 78 months to provide 6 months of additional margin in the schedule for absorbing unforeseen delays (and also to help reduce the ship's construction cost).[36]

GAO Perspective

A June 2021 GAO report assessing selected major DOD weapon acquisition programs additionally stated the following regarding the Columbia-class program:

> **Production Readiness**
>
> The program considers all of its critical technologies to be mature, though three systems remain below our definition of maturity. Based on leading acquisition practices, we consider technologies to be mature after successful testing of a prototype near or at the planned operational system configuration in a realistic environment. Until this testing is complete, the program risks costly, time-intensive rework if deficiencies emerge in these immature technologies during testing or production.
>
> The shipbuilder completed basic and functional design before the lead submarine's start of major construction—consistent with leading practices for ensuring design stability—but design risks remain. Design stability assumes mature critical technologies, which the program has yet to fully demonstrate. Further, the program's cost estimate assumed that design disclosures—a more detailed design phase—would be 83 percent complete by October 2020, which the program did not achieve due to problems with the shipbuilder's design software. As a result, the program will likely not realize the cost savings it estimated would result from achieving this detailed design completion goal. Program officials reported that the shipbuilder added design staff in an effort to recover its schedule, at greater cost. Further, problems with the design software slowed early construction progress.
>
> The Navy began major construction efforts in October 2020, but had already begun some advanced construction work in 2016 in an effort to meet the lead submarine's 84-month construction schedule. However, as of July 2020, some advance construction efforts were behind schedule. For example, advance construction on the submarine's missile tube section was considerably behind schedule. The program office told us that by November 2020, it had met its schedule. However, based on our analysis, the program adjusted the schedule and delayed some work on the common missile compartment. As a result, the program will need to complete more work in less time to meet its planned delivery date. As we reported in January 2021, the program experienced delays that affected this section's progress because some missile tubes had weld defects requiring repair and rework. The program also encountered early construction delays for the submarine's other sections, which it will now need to complete as part of major construction efforts. The program's inability to recover the planned schedule during early construction could affect its ability to accomplish its already aggressive construction goals.

[35] Yasmin Tadjdeh, "Just In: Navy Working Through Columbia Submarine 'Challenges' on Tight Schedule," *National Defense*, November 12, 2020.

[36] Rich Abott, "Navy And GD Target Shorter Build Sequence For Columbia, Aim To Fix Virginia Delays By Block V," *Defense Daily*, November 6, 2020.

Software and Cybersecurity

The program does not track software development cost separately because, according to program officials, some of its software was developed by another Navy program, or is reused with minor modifications.

The shipbuilder estimated the cost to implement a portion of the new DOD cybersecurity requirements for the first two submarines. The program has yet to determine the cost to implement the remaining cybersecurity requirements.

Other Program Issues

In June 2020, the program modified the design contract to include a contract option for constructing the first two submarines. The program reported that it exercised this option in November 2020. However, the associated budget request for fiscal year 2021 underestimated the most likely cost to construct these submarines and did not reflect the updated cost estimate in order to preserve a competitive negotiating position with the contractor. As a result, the program will likely require additional funding in future budget years to accommodate the expected cost increase. In September 2020, the program reported providing Congress with an update on the program's most recent cost estimate, which reflects increasing costs. These costs will be incorporated into the program's fiscal year 2022 budget request and subsequent budget requests.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office stated that it took measures to reduce program risk through actions such as ensuring stable operational and technical requirements; executing manufacturing readiness and supplier base efforts to support construction; and pursuing cost reduction actions. The program office stated that it exceeded 83 percent overall design maturity required by the milestone decision authority by the start of lead ship construction and it worked through initial design tool development and implementation issues. Further, the program office added that the Navy updated its cost estimate in 2020, including information from DOD's Office of Cost Assessment and Program Evaluation. According to the program office, construction is on track. The program office also stated that the program continues to comply with all Navy, DOD, and statutory requirements associated with managing critical technologies and engineering integration efforts.[37]

A May 2021 GAO report on DOD's plans for maintaining and modernizing the U.S. strategic nuclear triad stated

We have previously reported on several risks to an on-time delivery of the Columbia class submarine, including immature technologies, design challenges, production quality challenges, and an aggressive production schedule. The Navy has acknowledged that the Columbia class program's 84-month construction schedule is aggressive and that it is important to minimize the risk of schedule delays….

—**Immature technologies**. We previously reported that additional development and testing are required to demonstrate the maturity of several technologies critical to performance. If any of these systems do not develop as planned, the Navy and the shipyards could be required to complete some redesign. Or, if risks manifest later, they may force costly workarounds or rework during ship construction. In 2017, the Navy awarded a contract for detail design; however, critical technologies remained unproven. We reported in June 2020 that some critical technologies remain immature. Our work on shipbuilding

[37] Government Accountability Office, *Weapon Systems Annual Assessment[:] Updated Program Oversight Approach Needed*, GAO-21-222, June 2021, p. 185.

best practices has found that proceeding into detail design and construction with immature technologies can lead to design instability, delays, and cost growth.

—Design challenges. In 2019, we reported that the Navy faces delays in completing the design of the submarine. The Navy has stated its priority is to achieve a high level of design completion by the start of formal lead submarine construction in October 2020 to mitigate the risk of costly rework and schedule delays due to design changes. According to program officials, the program met its design maturity goal in advance of formal construction. However, the shipbuilder had not met the goal for design disclosures—a detailed design product—hampered in large part by implementation of a new design software tool.

—Production quality challenges. Quality problems with materials produced by some suppliers—which, according to the Navy, were discovered by the shipbuilder and supplier representatives—have affected the Columbia program's early construction schedule, increasing the risk that formal construction will not proceed as planned. Going forward, the shipbuilder anticipates having to rely on some suppliers that will need improvement to meet quality expectations. The shipbuilder also identified specific products and processes that continue to present quality risks for the supplier base. Ongoing delays resulting from the additional time needed to repair or replace deficient materials highlight the risk that persistent quality problems that could affect the program's schedule and the timely delivery of the lead submarine.

—Aggressive production schedule. We previously reported that the program has an aggressive schedule planned to enable delivering the lead submarine in time to begin patrols in fiscal year 2031. The Navy began building parts of the submarine in advance of its formal construction start. Following these early construction efforts, the Navy plans to build the lead submarine over 7 years—or 84 months. We reported in December 2017 that this duration is shorter than what the Navy achieved on any recent lead submarine construction effort—including during high levels of Cold War submarine production. The average construction time for the first of class submarine for the last four classes has been approximately 91 months. In addition, the Navy and the two shipyards will try to attain this level of schedule performance for the lead submarine while the shipbuilders also start work on the first few Virginia class submarines built in a new configuration, which adds complexity. In 2011, the Navy increased submarine production from starting work on one submarine to two submarines per year. Virginia class program officials told us that this increase resulted in recent cost and schedule growth at the shipyards. The shipyard may experience additional challenges associated with the start of additional construction activities on the lead Columbia class in October 2020—the third submarine to start construction that year. During the subsequent decade, the Navy and shipbuilders plan to build an adequate workforce to accommodate construction of both Columbia class and Virginia class submarines at the same shipyards. We will continue to monitor these efforts as part of our ongoing work on the Columbia class program.[38]

A January 2021 GAO report on the Columbia-class program stated

The Navy's schedule for constructing the first submarine of the new Columbia class is threatened by continuing challenges with the computer-aided software tool that Electric Boat, the lead shipbuilder, is using to design the submarine. These challenges will likely impede construction because the shipbuilder is late in completing design products used for building the submarine. To ensure construction begins on schedule, the Navy modified its design contract with Electric Boat to include an option for constructing the first two submarines and requested sufficient authority from Congress for fiscal year 2021 to exercise it. Navy officials stated, however, that the Navy's budget request is lower than its

[38] Government Accountability Office, *Nuclear Triad[:] DOD and DOE Face Challenges Mitigating Risks to U.S. Deterrence Efforts*, GAO-21-210, pp. 30-33.

> current cost estimate, and it is not informed by an independent cost assessment. As a result, the program will likely need more funding to reflect the increased estimate.
>
> Quality problems with supplier materials caused delays during early construction. These quality problems included missile tubes… with defective welds. As the shipbuilders expand outsourcing to suppliers, quality assurance oversight at supplier facilities will be critical for avoiding further delays.
>
> However, the Navy has not comprehensively reassessed when to seek additional inspections at supplier facilities that could better position it to identify quality problems early enough to limit delays.[39]

Risk of Cost Growth

Overview

Another oversight issue for Congress is the risk of cost growth in the program. As detailed by CBO[40] and GAO,[41] lead ships in Navy shipbuilding programs in many cases have turned out to be more expensive to build than the Navy had estimated. As discussed in further detail below, CBO and GAO have concluded that there is a significant risk of cost growth in the Columbia-class program.

As mentioned earlier, Navy officials have stated consistently since 2013 that the Columbia-class program is the Navy's top priority program, and that this means, among other things, that from the Navy's perspective, the Columbia-class program *will* be funded, even if that comes at the expense of funding for other Navy programs. Given this, the impact of cost growth in the Columbia-class program in a situation of finite DOD funding might be not so much on the execution of the Columbia-class program itself as on the consequent affordability of other DOD programs, perhaps particularly other Navy shipbuilding programs. The issue of the potential impact of the Columbia-class program on the affordability of other DOD programs is discussed in a subsequent section of this report.

Navy Perspective

A June 24, 2021, Navy information paper provided to CRS and CBO states that as of August 2020, the Navy had assigned a confidence level of 45% to its estimated procurement cost for the lead ship in the Columbia class and a confidence level of 51% to its estimated average procurement cost for ships 2 through 12 in program. What this means is that the Navy as of August 2020 had calculated that there was a 55% chance that the procurement cost of the first Columbia-class boat, and a 49% chance that the estimated average procurement cost for ships 2 through 12 in the program, would turn out to be greater than what the Navy estimates. The June 24, 2021, Navy information paper states the following:

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[39] Government Accountability Office, Columbia *Class Submarine[:] Delivery Hinges on Timely and Quality Materials from an Atrophied Supplier Base*, GAO-21-257 of January 2021, summary page. See also Anthony Capaccio, "Next-Generation U.S. Nuclear Sub Facing Cost Overruns, Delays," *Bloomberg*, December 23, 2020.

[40] See Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2019 Shipbuilding Plan*, October 2018, p. 25, including Figure 10.

[41] See Government Accountability Office, *Navy Shipbuilding[:] Past Performance Provides Valuable Lessons for Future Investments*, GAO-18-238SP, June 2018, p. 8.

> The 2020 NAVSEA 05C[42] Cost Estimate, done in support of the COLUMBIA Construction Authorization In Progress Review (IPR) with the Milestone Decision Authority in August 2020, is the most recent analysis for the COLUMBIA program. It included updated risk estimates for Lead Ship End Cost less [the cost of] Plans and the Average Follow Ship End Cost. The confidence levels associated with the 2020 Cost Estimate for Lead Ship End Cost less Plans and Average Follow Ship End Cost estimates are approximately 45% and 51% respectively.[43]

The June 24, 2021, Navy information paper provided the confidence levels and corresponding estimated unit procurement costs shown in **Table 2**.

Table 2. Navy Confidence Levels for Estimated Columbia-Class Unit Procurement Costs

(Billions of constant 2021 dollars)

Confidence level decile	End cost of lead ship (less plans)	Average end cost of ships 2-12
30%	$8.3	$6.5
40%	$8.5	$6.8
50%	$8.8	$7.1
60%	$9.0	$7.4
70%	$9.2	$7.7
80%	$9.5	$8.1

Source: Navy information paper, "Update on Confidence Levels for COLUMBIA Lead Ship and Follow Ship," June 24, 2021, received by CRS and CBO from Navy Legislative Affairs Office, July 29, 2021.

Note: End cost of lead ship includes cost for the ship's missile tube module, which was funded through the Navy's research and development account.

CBO Perspective

An October 2019 CBO report on the cost of the Navy's shipbuilding programs stated the following (emphasis added):

> The cost of the 12 Columbia class submarines included in the 2020 shipbuilding plan is one of the most significant uncertainties in the Navy's and CBO's analyses of future shipbuilding costs….
>
> According to the Navy's estimate, the cost per thousand tons for the first Columbia would be 14 percent less than that of the first Virginia class attack submarine—an improvement that would affect costs for the entire new class of ballistic missile submarines. The Navy anticipates lower costs per thousand tons for the Columbia because it plans to recycle, to the extent possible, the design, technology, and components used for the Virginia class. Furthermore, because ballistic missile submarines like the Columbia class tend to be larger and less densely built than attack submarines like the Virginia class, the Navy maintains that they will be easier to build and thus less expensive per thousand tons. The Navy has stated, however, that there is a 50 percent chance that the cost of the first Columbia and

[42] The 05C office is the part of the Naval Sea Systems Command (NAVSEA) that provides cost engineering and industrial analysis.

[43] Navy information paper, "Update on Confidence Levels for COLUMBIA Lead Ship and Follow Ship," June 24, 2021, received by CRS and CBO from Navy Legislative Affairs Office, July 29, 2021.

subsequent ships of the class will exceed its estimates, and CBO's cost estimates are about 9 percent greater than the Navy's.

The costs of lead ships of new classes of submarines built in the 1970s and 1980s provide little evidence that ballistic missile submarines are cheaper per ton to build than attack submarines…. The first Ohio class submarine was more expensive to build than the lead ships of the two classes of attack submarines built during the same period—the Los Angeles and the Improved Los Angeles. (The design of the Improved Los Angeles included the addition of 12 vertical-launch system cells.) In addition, the average cost-to-weight ratio of the first 12 or 13 ships of the class was virtually identical for the Ohio, Los Angeles, and Improved Los Angeles classes.

Moreover, although the cost by weight of lead ships for submarines had grown substantially by the 1990s, there was still little evidence that submarine size affected the cost per thousand tons. The first Virginia class submarine, which was ordered in 1998, cost about the same per thousand tons as the first Seawolf submarine even though the Seawolf is 20 percent larger and was built nine years earlier.

CBO estimates that purchasing the first Columbia class submarine would cost $14.0 billion, $700 million more than the Navy estimates. Estimating the cost of the lead ship of a class with a new design is particularly difficult because of uncertainty about how much the Navy will spend on nonrecurring engineering and detailed design. **Including appropriations from 2017 to 2019, CBO estimates that, all told, 12 Columbia class submarines would cost $95 billion (of which $90 billion would occur between 2020 and 2036), or an average of $7.9 billion each—$700 million more per submarine than the Navy estimates. That average is based on the $14.0 billion estimated cost of the lead submarine and an average cost of $7.4 billion estimated for the 2nd through 12th submarines. Research and development would cost between $14 billion and $18 billion, CBO estimates.**

Overall, the Navy expects a 14 percent improvement in the cost-to-weight ratio of the Columbia class compared with the first 12 submarines in the Virginia class. Given the history of submarine construction, however, CBO is less optimistic than the Navy. CBO estimates that the Navy would realize a 6 percent improvement, stemming in part from the projected savings attributable to the concurrent production of the Columbia and Virginia class submarines.

The costs for the Columbia class submarines could be lower than the Navy and CBO project, depending on the acquisition strategy. The Navy is purchasing the submarines through the National Sea-Based Deterrence Fund, which was established by the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015 (P.L. 113-291). The Congress appropriates money for the program in the Navy's main shipbuilding account, and then DoD transfers money into the fund. The Navy could realize savings from special procurement authorities associated with that fund, such as the ability to purchase components and materials for several submarines, and possibly for other ships, at the same time.

Further savings could be considerable if, for example, lawmakers authorized the Navy to use a block-buy strategy—an approach it has used with other types of ships. A block-buy strategy allows the Navy to purchase a group of submarines over a specified period (effectively lowering the price of the ships by promising a steady stream of work for the shipyards) and to buy components and materials for the submarines in optimal amounts that minimize costs (known as economic order quantities).[22] One disadvantage of the strategy is that if lawmakers later decided not to build all the submarines, materials that were purchased for the unbuilt ships might go unused. A block-buy strategy might also leave the Congress with less flexibility to change procurement plans or to purchase fewer submarines if lawmakers did not approve of how the program was progressing.

> Costs for the Columbia class submarines could, however, exceed both the Navy's and CBO's estimates. The new SSBN would be the largest submarine that the United States has ever built. It is expected to reuse some technology and components from the Virginia class submarine, but it would also include many new elements, such as an all-electric drive system, an X-stern ship control system (where the rear rudders and dive planes are shaped like an X, rather than a + as on the Ohio class), a new missile compartment, and a nuclear reactor that is designed to last the entire 42-year service life of the submarine. One production challenge that has already occurred on the new SSBN is that its missile tubes required many welds to be redone, further tightening the Columbia class schedule. Such challenges are not uncommon on lead ships, and they may indicate future difficulties. First ships of a new class often experience substantial cost growth….[44]

GAO Perspective

An April 2019 GAO report on the Columbia-class program stated the following:

> The Navy's $115 billion procurement cost estimate is not reliable partly because it is based on overly optimistic assumptions about the labor hours needed to construct the submarines. While the Navy analyzed cost risks, it did not include margin in its estimate for likely cost overruns. The Navy told us it will continue to update its lead submarine cost estimate, but an independent assessment of the estimate may not be complete in time to inform the Navy's 2021 budget request to Congress to purchase the lead submarine. Without these reviews, the cost estimate—and, consequently, the budget—may be unrealistic. A reliable cost estimate is especially important for a program of this size and complexity to help ensure that its budget is sufficient to execute the program as planned.
>
> The Navy is using the congressionally-authorized National Sea-Based Deterrence Fund to construct the Columbia class. The Fund allows the Navy to purchase material and start construction early on multiple submarines prior to receiving congressional authorization and funding for submarine construction. The Navy anticipates achieving savings through use of the Fund, such as buying certain components early and in bulk, but did not include the savings in its cost estimate. The Navy may have overestimated its savings as higher than those historically achieved by other such programs. Without an updated cost estimate and cost risk analysis, including a realistic estimate of savings, the fiscal year 2021 budget request may not reflect funding needed to construct the submarine.[45]

Cost-Plus Incentive Fee (CPIF) Contract

Another aspect of the issue of the risk of cost growth in the program concerns the Navy's intent to use a cost-plus incentive fee (CPIF) contract rather than a fixed-priced contract to procure the first two ships in the class. Skeptics could argue that using a CPIF contract will increase the risk of cost growth on the first two ships because it will insulate the builders from much of the financial risk of cost growth, providing them with a reduced incentive to control costs. They could argue that while the Navy has used cost-plus type contracts for lead ships in other shipbuilding programs, the Navy in this case is proposing to use one for a two-ship contract, extending the risk of cost growth to the second ship in the program. They could argue that while insulating builders from the risks and uncertainties of building lead ships has been a traditional shipbuilding consideration, the risks in this case are to be reduced by the Navy's strategy of

[44] Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2020 Shipbuilding Plan*, October 2019, pp. 19-22.

[45] Government Accountability Office, *Columbia Class Submarine[:] Overly Optimistic Cost Estimate Will Likely Lead to Budget Increases*, GAO-19-497, April 2019, summary page.

bringing the Columbia-class design to a high state of completion prior to starting construction on the lead ship.

Supporters of using a cost-plus type contract could argue that doing so is a traditional approach for procuring a lead ship in a Navy shipbuilding program that recognizes that the lead ship in effect serves as the program's prototype and thus presents the builders with substantial risks and uncertainties regarding construction costs, even with a design that has been brought to a high state of completion prior to starting construction. They could argue that this is particularly true in this case, given that this is the first lead ship in a Navy SSBN program to start construction in about 47 years.[46] They could argue that builders will still have an incentive to control costs because of the incentive fee in the contract, and because they understand that cost growth in the Columbia-class program could reduce funding available for other Navy priorities, including procurement of Virginia-class attack submarines that these firms also build.

Change in Estimated Procurement Costs Since FY2021 Budget Submission

Table 3 shows changes in the estimated procurement costs of the first and second Columbia-class boats (SSBNs 826 and 827, respectively) since the Navy's budget submission for FY2021, when the first Columbia-class boat was procured.

Table 3. Change in Estimated Procurement Costs Since FY2021 Budget

(Millions of then-year dollars, rounded to nearest tenth)

Boat and budget	Estimated cost	Change from prior year	Cumulative change since FY2021
SSBN-826 (first boat)			
FY21 budget	14,393.4	—	—
FY22 budget	15,030.5	+637.1 (+4.4%)	+637.1 (+4.4%)
FY23 budget	15,179.1	+148.6 (+1.0%)	+785.7 (+5.5%)
SSBN-827 (second boat)			
FY21 budget	9,326.1	—	—
FY22 budget	n/a	n/a	n/a
FY23 budget	9,280.2	n/a	-45.9 (-0.5%)

Source: Table prepared by CRS based on Navy's FY2021-FY2023 budget submissions.

Note: n/a means not available.

As can be seen in the table, the estimated cost of the first Columbia-class boat increased by $637.1 million, or 4.4%, from the FY2021 budget submission to the FY2022 budget submission. Of the $637.1 million increase, $549.8 million (more than 86% of the increase) was in the estimated cost of the boat's plans. As discussed earlier, the cost of plans for the first Columbia-class boat means (essentially) the detail design/nonrecurring engineering (DD/NRE) costs for the Columbia class. (It is a long-standing Navy budgetary practice to incorporate the DD/NRE costs for a new class of ship into the total procurement cost of the first ship in the class.) Because the cost for plans for the first boat in a class is largely a nonrecurring expense, the increase in the estimated cost of the first boat's plans might not imply a similar increase in the (much smaller)

[46] The lead ship in the Ohio-class SSBN program was procured in FY1974—47 years before the scheduled FY2021 procurement date for the lead ship in the Columbia-class program.

plans costs for the second and subsequent boats in the class. Excluding the change in the estimated cost for plans, the estimated cost of the first Columbia-class boat increased in the Navy's FY2022 budget submission by $87.3 million, or about 0.6%, from the FY2021 submission to the FY2022 submission.

As can also be seen in the table, the estimated cost of the second boat in the class has decreased 0.5% from the FY2021 budget submission to the FY2023 budget submission.

Program Affordability and Impact on Other Navy Shipbuilding Programs

Another issue for Congress—one that observers have focused on for several years—concerns the potential impact of the Columbia-class program on funding that will be available for other Navy programs, including other shipbuilding programs, particularly during the 10-year period FY2026-FY2035, when the Navy plans to procure one Columbia-class boat per year. Other things held equal, cost growth in the Columbia-class program (see the earlier discussion of the risk of cost growth in the program) could reinforce concerns about the potential impact of the Columbia-class program on funding that will be available for other Navy programs, including other shipbuilding programs. Even without such cost growth, however, this issue would remain as a matter of concern.

As shown in **Table 1**, the Navy projects that the Columbia-class program will require more than $8 billion per year in then-year dollars in procurement and advance procurement (AP) funding each year beginning in FY2026. About a decade ago, when the Navy's shipbuilding budget was being funded at a level of roughly $14 billion per year, observers were concerned that the Columbia-class program during the period FY2026-FY2035 could absorb as much as half of the Navy's shipbuilding budget, leaving relatively little funding available for all other Navy shipbuilding programs. Since then, the Navy's shipbuilding budget has increased to more than $20 billion per year. (For FY2023, the Navy is requesting a total shipbuilding budget of $27.9 billion.) In a context of a shipbuilding budget of more than $20 billion per year, a Columbia-class requirement of more than $8 billion per year does not loom as large proportionately as it once did. Even so, concern remains about funding that will be available for the procurement of other kinds of ships. The Navy's report on its FY2023 30-year (FY2023-FY2052) shipbuilding plan states that "the fiscal impact of the Columbia class increased significantly in FY2021 with procurement of the lead SSBN. The impact grows across the FYDP to FY2026 when annual full procurements will be required to support serial production through FY2035."[47]

The creation of the National Sea-Based Deterrence Fund (NSBDF) and the amending of the statute governing the fund to include special acquisition authorities can be viewed as one response to concerns about the potential impact of the Columbia-class program on funding that will be available for other Navy programs, including other shipbuilding programs. For additional information about the NSBDF, see **Appendix E**.

Another potential option for reducing the potential impact of the Columbia-class program on funding that will be available for other Navy programs, including other shipbuilding programs, would be to reduce the Columbia-class program to something fewer than 12 boats. Over the years, for various reasons, some observers have advocated or presented options for an SSBN force of fewer than 12 SSBNs. A November 2013 CBO report on options for reducing the federal

[47] See U.S. Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2023*, April 2022, p. 17.

budget deficit, for example, presented an option for reducing the SSBN force to 8 boats as a cost-reduction measure.[48] Earlier CBO reports have presented options for reducing the SSBN force to 10 boats as a cost-reduction measure.[49] CBO reports that present such options also provide notional arguments for and against the options. A June 2010 report by a group known as the Sustainable Defense Task Force recommended reducing the SSBN force to 7 boats,[50] a September 2010 report from the Cato Institute recommended reducing the SSBN force to 6 boats,[51] and a September 2013 report from a group organized by the Stimson Center recommended reducing the force to 10 boats.[52]

Views on whether a force of fewer than 12 Columbia-class boats would be appropriate could depend on, among other things, assessments of strategic nuclear threats to the United States and the role of SSBNs in deterring such threats as a part of overall U.S. strategic nuclear forces, as influenced by the terms of strategic nuclear arms control agreements.[53] Reducing the number of SSBNs below 12 could also raise a question as to whether the force should continue to be homeported at both Bangor, WA, and Kings Bay, GA, or consolidated at a single location. The Navy's position is that the current requirement for having a certain number of SSBNs on patrol translates into a need for a force of 14 Ohio-class boats, and that this requirement can be met in the future by a force of 12 Columbia-class boats.

Industrial-Base Challenges of Building Both Columbia- and Virginia-Class Boats

Another oversight issue for Congress concerns potential industrial-base challenges of building both Columbia-class boats and Virginia-class attack submarines (SSNs) at the same time, particularly as procurement of Virginia-class submarines shifts to production of a new and larger version of the Virginia-class design that incorporates an additional mid-ship section called the Virginia Payload Module (VPM).[54] Observers have expressed concern about the industrial base's capacity for building both Columbia- and Virginia-class boats without encountering bottlenecks or other production problems in one or both of these programs.

Concerns about the ability of the submarine construction industrial base to execute an eventual procurement rate of two VPM-equipped Virginia-class boats and one Columbia-class boat per year have been heightened by reports of challenges faced by the two submarine-construction shipyards (GD/EB and HII/NNS), as well as submarine component supplier firms in meeting scheduled delivery times for Virginia-class boats as the Virginia-class program transitions over

[48] Congressional Budget Office, *Options for Reducing the Deficit: 2014 to 2023*, November 2013, pp. 68-69.

[49] See, for example, Congressional Budget Office, *Rethinking the Trident Force*, July 1993, 78 pp.; and Congressional Budget Office, *Budget Options*, March 2000, p. 62.

[50] *Debt, Deficits, and Defense, A Way Forward[:] Report of the Sustainable Defense Task Force*, June 11, 2010, pp. 19-20.

[51] Benjamin H. Friedman and Christopher Preble, Budgetary Savings from Military Restraint, Washington, Cato Institute, September 23, 2010 (Policy Analysis No. 667), p. 8.

[52] *Strategic Agility: Strong National Defense for Today's Global and Fiscal Realities*, Stimson, Washington, DC, 2013, p. 29. (Sponsored by the Peter G. Peterson Foundation, Prepared by Stimson, September 2013.)

[53] For further discussion, see CRS Report RL33640, *U.S. Strategic Nuclear Forces: Background, Developments, and Issues*, by Amy F. Woolf.

[54] For more on the VPM, see CRS Report RL32418, *Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress*, by Ronald O'Rourke.

time from production of two "regular" Virginia-class boats per year to two VPM-equipped boats per year.[55]

The Navy's report on its FY2023 30-year (FY2023-FY2052) shipbuilding plan states:

> Within the overall industrial base, including both shipyards and suppliers, varying levels of capacity and risk exist. Nuclear powered ship production, a unique capacity with little to no opportunity for commercial or dual use production, is provided by two private shipyards that are currently facilitized and certified to construct nuclear powered ships and will be at capacity for the next 15 years building Columbia class SSBNs, Virginia class SSNs, next generation SSNs, and Ford class CVNs. The PB2023 request included additional industrial base funding to reduce the production risk, stabilize the more than 350 critical suppliers, and help enable recruitment and retention of the skilled production workforce. [56]

Potential oversight questions for Congress include the following:

- Do the Navy and the submarine builders agree on the question of the capacity of the industrial base to support various potential Columbia- and Virginia-class workloads?
- What steps are the Navy, the submarine builders, and submarine supplier firms taking to bring the capacity of the industrial base more into alignment with desired submarine procurement rates? What are the costs of these steps, and what portion of these costs will be borne by the government?

Legislative Activity for FY2023

Summary of Congressional Action on FY2023 Funding Request

Table 4 summarizes congressional action on the Navy's FY2023 procurement and advance procurement (AP) funding request for the Columbia-class program.

[55] See, for example, Government Accountability Office, *Columbia Class Submarine[:] Overly Optimistic Cost Estimate Will Likely Lead to Budget Increases*, GAO-19-497, April 2019, pp. 20-23; David B. Larter, "Late Is the New Normal for Virginia-Class Attack Boats," *Defense News*, March 20, 2019; Megan Eckstein, "Navy: Lack of Submarine Parts Slowing Down Maintenance, New Construction," *USNI News*, March 26, 2019; David B. Larter, "The US Navy, Seeking Savings, Shakes Up Its Plans for More Lethal Attack Submarines," *Defense News*, April 3, 2019; Anthony Capaccio, "U.S. Navy Sub Firepower Upgrade Delayed by Welding Flaws," *Bloomberg*, August 13, 2019; Paul McLeary, "Weld Problems Spread To Second Navy Sub Program," *Breaking Defense*, August 14, 2019; David B. Larter, "Questions About US Navy Attack Sub Program Linger as Contract Negotiations Drag," *Defense News*, August 16, 2019; Emma Watkins, "Will the U.S. Navy Soon Have a Missile-Tube Problem?" *National Interest*, August 19, 2019; David B. Larter, "As CNO Richardson Departs, US Submarine Builders Face Pressure," *Defense News*, August 22, 2019; David B. Larter, "After a Leadership Shakeup at General Dynamics, a Murky Future for Submarine Building," *Defense News*, October 28, 2019; Rich Abott, "Navy Says Virginia Sub Delays Due To Faster Production Rate," *Defense Daily*, November 6, 2019.

[56] See U.S. Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2023*, April 2022, p. 10.

Table 4. Congressional Action on FY2023 Funding Request

(Millions of then-year dollars, rounded to nearest tenth; totals may not add due to rounding)

		Authorization			Appropriation		
	Request	**HASC**	**SASC**	**Enacted**	**HAC**	**SAC**	**Enacted**
Procurement							
Advance procurement (AP)							
TOTAL							

Source: Navy FY2023 budget submission and committee and conference reports, and explanatory statements on FY2023 National Defense Authorization Act and FY2023 DOD Appropriations Act.

Notes: HASC is House Armed Services Committee; **SASC** is Senate Armed Services Committee; **HAC** is House Appropriations Committee; **SAC** is Senate Appropriations Committee.

Appendix A. Summary of Past U.S. SSBN Designs

This appendix provides background information on the four SSBN classes that the United States has operated since 1959. The four classes are summarized in **Table A-1**. As shown in the table, the size of U.S. SSBNs has grown over time, reflecting in part a growth in the size and number of SLBMs carried on each boat. The Ohio class carries an SLBM (the D-5) that is much larger than the SLBMs carried by earlier U.S. SSBNs, and it carries 24 SLBMs, compared to the 16 on earlier U.S. SSBNs.[57] In part for these reasons, the Ohio-class design, with a submerged displacement of 18,750 tons, is more than twice the size of earlier U.S. SSBNs.

Table A-1. U.S. SSBN Classes

	George Washington (SSBN-598) class	Ethan Allen (SSBN-608) class	Lafayette/Benjamin Franklin (SSBN-616/640) class	Ohio (SSBN-726) class
Number in class	5	5	31	18/14
Fiscal years procured	FY1958-FY1959	FY1959 and FY1961	FY1961-FY1964	FY1974/FY1977 - FY1991
Years in commission	1959-1985	1961-1992	1963-2002	1981/1984-present
Length	381.7 feet	410.5 feet	425 feet	560 feet
Beam	33 feet	33 feet	33 feet	42 feet
Submerged displacement	6,700 tons	7,900 tons	8,250 tons	18,750 tons
Number of SLBM launch tubes	16	16	16	24 (to be reduced to 20 by 2018)
Final type(s) of SLBM carried	Polaris A-3	Polaris A-3	Poseidon C-3/ Trident I C-4	Trident II D-5
Diameter of those SLBMs	54 inches	54 inches	74 inches	83 inches
Length of those SLBMs	32.3 feet	32.3 feet	34 feet	44 feet
Weight of each SLBM (pounds)	36,000 pounds	36,000 pounds	65,000/73,000 pounds	~130,000 pounds
Range of SLBMs	~2,500 nm	~2,500 nm	~2,500 nm/~4,000 nm	~4,000 nm

Sources: Prepared by CRS based on data in Norman Polmar, *The Ships and Aircraft of the U.S. Fleet*, Annapolis, Naval Institute Press, various editions, and (for SSBN decommissioning dates) U.S. Naval Vessel Register.

Notes: Beam is the maximum width of a ship. For the submarines here, which have cylindrical hulls, beam is the diameter of the hull.

The range of an SLBM can vary, depending on the number and weight of nuclear warheads it carries; actual ranges can be lesser or greater than those shown.

The George Washington-class boats were procured as modifications of SSNs that were already under construction. Three of the boats were converted into SSNs toward the ends of their lives and were

[57] The larger size of the Ohio-class design also reflects a growth in size over time in U.S. submarine designs due to other reasons, such as providing increased interior volume for measures to quiet the submarine acoustically, so as to make it harder to detect.

decommissioned in 1983-1985. The two boats that remained SSBNs throughout their lives were decommissioned in 1981.

All five Ethan Allen-class boats were converted into SSNs toward the ends of their lives. The boats were decommissioned in 1983 (two boats), 1985, 1991, and 1992.

Two of the Lafayette/Benjamin Franklin-class boats were converted into SSNs toward the ends of their lives and were decommissioned in 1999 and 2002. The 29 that remained SSBNs throughout their lives were decommissioned in 1986-1995. For 19 of the boats, the Poseidon C-3 was the final type of SLBM carried; for the other 12, the Trident I C-4 SLBM was the final type of SLBM carried.

A total of 18 Ohio-class SSBNs were built. The first four, which entered service in 1981-1984, were converted into SSGNs in 2002-2008. The remaining 14 boats entered service in 1984-1997. Although Ohio-class SSBNs are designed to each carry 24 SLBMs, by 2018, four SLBM launch tubes on each boat are to be deactivated, and the number of SLBMs that can be carried by each boat consequently is to be reduced to 20, so that the number of operational launchers and warheads in the U.S. force will comply with strategic nuclear arms control limits.

Appendix B. U.S.-UK Cooperation on SLBMs and the New UK SSBN

This appendix provides background information on U.S.-UK cooperation on SLBMs and the UK's next-generation SSBN, previously called the Successor-class SSBN and now called the Dreadnought-class SSBN.

The UK's four Vanguard-class SSBNs, which entered service in 1993-1999, each carry 16 Trident II D-5 SLBMs. Previous classes of UK SSBNs similarly carried earlier-generation U.S. SLBMs.[58] The UK's use of U.S.-made SLBMs on its SSBNs is one element of a long-standing close cooperation between the two countries on nuclear-related issues that is carried out under the 1958 Agreement for Cooperation on the Uses of Atomic Energy for Mutual Defense Purposes (also known as the Mutual Defense Agreement). Within the framework established by the 1958 agreement, cooperation on SLBMs in particular is carried out under the 1963 Polaris Sales Agreement and a 1982 Exchange of Letters between the two governments.[59] The Navy testified in

[58] Although the SLBMs on UK SSBNs are U.S.-made, the nuclear warheads on the missiles are of UK design and manufacture.

[59] A March 18, 2010, report by the UK Parliament's House of Commons Foreign Affairs Committee stated the following:

> During the Cold War, the UK's nuclear co-operation with the United States was considered to be at the heart of the [UK-U.S.] 'special relationship'. This included the 1958 Mutual Defence Agreement, the 1963 Polaris Sales Agreement (PSA) (subsequently amended for Trident), and the UK's use of the US nuclear test site in Nevada from 1962 to 1992. The co-operation also encompassed agreements for the United States to use bases in Britain, with the right to store nuclear weapons, and agreements for two bases in Yorkshire (Fylingdales and Menwith Hill) to be upgraded to support US missile defence plans.
>
> In 1958, the UK and US signed the Mutual Defence Agreement (MDA). Although some of the appendices, amendments and Memoranda of Understanding remain classified, it is known that the agreement provides for extensive co-operation on nuclear warhead and reactor technologies, in particular the exchange of classified information concerning nuclear weapons to improve design, development and fabrication capability. The agreement also provides for the transfer of nuclear warhead-related materials. The agreement was renewed in 2004 for another ten years.
>
> The other major UK-US agreement in this field is the 1963 Polaris Sales Agreement (PSA) which allows the UK to acquire, support and operate the US Trident missile system. Originally signed to allow the UK to acquire the Polaris Submarine Launched Ballistic Missile (SLBM) system in the 1960s, it was amended in 1980 to facilitate purchase of the Trident I (C4) missile and again in 1982 to authorise purchase of the more advanced Trident II (D5) in place of the C4. In return, the UK agreed to formally assign its nuclear forces to the defence of NATO, except in an extreme national emergency, under the terms of the 1962 Nassau Agreement reached between President John F. Kennedy and Prime Minister Harold Macmillan to facilitate negotiation of the PSA.
>
> Current nuclear co-operation takes the form of leasing arrangements of around 60 Trident II D5 missiles from the US for the UK's independent deterrent, and long-standing collaboration on the design of the W76 nuclear warhead carried on UK missiles. In 2006 it was revealed that the US and the UK had been working jointly on a new 'Reliable Replacement Warhead' (RRW) that would modernise existing W76-style designs. In 2009 it emerged that simulation testing at Aldermaston on dual axis hydrodynamics experiments had provided the US with scientific data it did not otherwise possess on this RRW programme.
>
> The level of co-operation between the two countries on highly sensitive military technology is, according to the written submission from Ian Kearns, "well above the norm, even for a close alliance relationship". He quoted Admiral William Crowe, the former US Ambassador to London, who likened the UK-US nuclear relationship to that of an iceberg, "with a small tip of it sticking out, but beneath the water there is quite a bit of everyday business that goes on between our two governments in a fashion that's unprecedented in the world." Dr Kearns also commented that the

March 2010 that "the United States and the United Kingdom have maintained a shared commitment to nuclear deterrence through the Polaris Sales Agreement since April 1963. The U.S. will continue to maintain its strong strategic relationship with the UK for our respective follow-on platforms, based upon the Polaris Sales Agreement."[60]

The first Vanguard-class SSBN was originally projected to reach the end of its service life in 2024, but an October 2010 UK defense and security review report states that the lives of the Vanguard class ships will now be extended by a few years, so that the four boats will remain in service into the late 2020s and early 2030s.[61]

The UK plans to replace the four Vanguard-class boats with three or four next-generation Dreadnought-class boats are to be equipped with 12 missile launch tubes, but current UK plans call for each boat to carry eight D-5 SLBMs, with the other four tubes not being used for SLBMs. The report states that "'Main Gate'—the decision to start building the submarines—is required around 2016."[62] The first new boat is to be delivered by 2028, or about four years later than previously planned.[63]

The United States is assisting the UK with certain aspects of the Dreadnought SSBN program. In addition to the modular Common Missile Compartment (CMC), the United States is assisting the UK with the new PWR-3 reactor plant[64] to be used by the Dreadnought SSBN. A December 2011 press report states that "there has been strong [UK] collaboration with the US [on the Dreadnought program], particularly with regard to the CMC, the PWR, and other propulsion technology," and that the design concept selected for the Dreadnought class employs "a new propulsion plant based on a US design, but using next-generation UK reactor technology (PWR-3) and modern secondary propulsion systems."[65] The U.S. Navy states that

> Naval Reactors, a joint Department of Energy/Department of Navy organization responsible for all aspects of naval nuclear propulsion, has an ongoing technical exchange with the UK Ministry of Defence under the US/UK 1958 Mutual Defence Agreement. The

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> personal bonds between the US/UK scientific and technical establishments were deeply rooted.
>
> (House of Commons, Foreign Affairs Committee, *Sixth Report Global Security: UK-US Relations*, March 18, 2010, paragraphs 131-135; http://www.publications.parliament.uk/pa/cm200910/cmselect/cmfaff/114/11402.htm; paragraphs 131-135 are included in the section of the report available at http://www.publications.parliament.uk/pa/cm200910/cmselect/cmfaff/114/11406.htm.)

See also "U.K. Stays Silent on Nuclear-Arms Pact Extension with United States," *Global Security Newswire*, July 30, 2014.

[60] Statement of Rear Admiral Stephen Johnson, USN, Director, Strategic Systems Programs, Before the Subcommittee on Strategic Forces of the Senate Armed Services Committee [on] FY2011 Strategic Systems, March 17, 2010, p. 6.

[61] *Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review*, Presented to Parliament by the Prime Minister by Command of Her Majesty, October 2010, p. 39.

[62] *Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review*, Presented to Parliament by the Prime Minister by Command of Her Majesty, October 2010, pp. 5, 38-39. For more on the UK's Dreadnought SSBN program as it existed prior to the October 2010 UK defense and security review report, see Richard Scott, "Deterrence At A Discount?" *Jane's Defence Weekly*, December 23, 2009: 26-31.

[63] *Securing Britain in an Age of Uncertainty: The Strategic Defence and Security Review*, Presented to Parliament by the Prime Minister by Command of Her Majesty, October 2010, p. 39.

[64] PWR3 means pressurized water reactor, design number 3. U.S. and UK nuclear-powered submarines employ pressurized water reactors. Earlier UK nuclear-powered submarines are powered by reactor designs that the UK designated PWR-2 and PWR-1. For an article discussing the PWR3 plant, see Richard Scott, "Critical Mass: Re-Energising the UK's Naval Nuclear Programme," *Jane's International Defence Review*, July 2014: 42-45, 47.

[65] Sam LaGrone and Richard Scott, "Strategic Assets: Deterrent Plans Confront Cost Challenges," *Jane's Navy International*, December 2011: 17 and 18.

> US/UK 1958 Mutual Defence Agreement is a Government to Government Atomic Energy Act agreement that allows the exchange of naval nuclear propulsion technology between the US and UK.
>
> Under this agreement, Naval Reactors is providing the UK Ministry of Defence with US naval nuclear propulsion technology to facilitate development of the naval nuclear propulsion plant for the UK's next generation SUCCESSOR ballistic missile submarine. The technology exchange is managed and led by the US and UK Governments, with participation from Naval Reactors prime contractors, private nuclear capable shipbuilders, and several suppliers. A UK based office comprised of about 40 US personnel provide full-time engineering support for the exchange, with additional support from key US suppliers and other US based program personnel as needed.
>
> The relationship between the US and UK under the 1958 mutual defence agreement is an ongoing relationship and the level of support varies depending on the nature of the support being provided. Naval Reactors work supporting the SUCCESSOR submarine is reimbursed by the UK Ministry of Defence.[66]

U.S. assistance to the UK on naval nuclear propulsion technology first occurred many years ago: To help jumpstart the UK's nuclear-powered submarine program, the United States transferred to the UK a complete nuclear propulsion plant (plus technical data, spares, and training) of the kind installed on the U.S. Navy's six Skipjack (SSN-585) class nuclear-powered attack submarines (SSNs), which entered service between 1959 and 1961. The plant was installed on the UK Navy's first nuclear-powered ship, the attack submarine *Dreadnought*, which entered service in 1963.

The December 2011 press report states that "the UK is also looking at other areas of cooperation between Dreadnought and the Ohio Replacement Programme. For example, a collaboration agreement has been signed off regarding the platform integration of sonar arrays with the respective combat systems."[67]

A June 24, 2016, press report states the following:

> The [U.S. Navy] admiral responsible for the nuclear weapons component of ballistic missile submarines today praised the "truly unique" relationship with the British naval officers who have similar responsibilities, and said that historic cooperation would not be affected by Thursday's vote to have the United Kingdom leave the European Union.
>
> Vice Adm. Terry Benedict, director of the Navy's Strategic Systems Programs, said that based on a telephone exchange Thursday morning with his Royal Navy counterpart, "I have no concern." The so-called Brexit vote—for British exit—"was a decision based on its relationship with Europe, not with us. I see yesterday's vote having no effect."[68]

[66] Source: Email to CRS from Navy Office of Legislative Affairs, June 25, 2012. See also Jon Rosamond, "Next Generation U.K. Boomers Benefit from U.S. Relationship," *USNI News* (http://news.usni.org), December 17, 2014.

[67] Sam LaGrone and Richard Scott, "Strategic Assets: Deterrent Plans Confront Cost Challenges," *Jane's Navy International*, December 2011: 19. See also Jake Wallis Simons, "Brits Keep Mum on US Involvement in Trident Nuclear Program," *Politico*, April 30, 2015.

[68] Otto Kreisher, "Benedict: UK Exit From European Union Won't Hinder Nuclear Sub Collaboration," *USNI News*, June 24, 2016.

Appendix C. Columbia-Class Program Origin and Milestones

This appendix provides background information on the Columbia-class program's origin and milestones.

Program Origin and Early Milestones

Although the eventual need to replace the Ohio-class SSBNs has been known for many years, the Columbia-class program can be traced more specifically to an exchange of letters in December 2006 between President George W. Bush and UK Prime Minister Tony Blair concerning the UK's desire to participate in a program to extend the service life of the Trident II D-5 SLBM into the 2040s, and to have its next-generation SSBNs carry D-5s. Following this exchange of letters, and with an awareness of the projected retirement dates of the Ohio-class SSBNs and the time that would likely be needed to develop and field a replacement for them, DOD in 2007 began studies on a next-generation sea-based strategic deterrent (SBSD).[69] The studies used the term sea-based strategic deterrent (SBSD) to signal the possibility that the new system would not necessarily be a submarine.

An Initial Capabilities Document (ICD) for a new SBSD was developed in early 2008[70] and approved by DOD's Joint Requirements Oversight Committee (JROC) on June 20, 2008.[71] In July 2008, DOD issued a Concept Decision providing guidance for an analysis of alternatives (AOA) for the program; an acquisition decision memorandum from John Young, DOD's acquisition executive, stated the new system would, barring some discovery, be a submarine.[72] The Navy established an Columbia-class program office at about this same time.[73]

The AOA reportedly began in the summer or fall of 2008.[74] The AOA was completed, with final brief to the Office of the Secretary of Defense (OSD), on May 20, 2009. The final AOA report was completed in September 2009. An AOA Sufficiency Review Letter was signed by OSD's Director, Cost Assessment & Program Evaluation (CAPE) on December 8, 2009.[75] The AOA concluded that a new-design SSBN was the best option for replacing the Ohio-class SSBNs. (For

[69] In February 2007, the commander of U.S. Strategic Command (STRATCOM) commissioned a task force to support an anticipated Underwater Launched Missile Study (ULMS). On June 8, 2007, the Secretary of the Navy initiated the ULMS. Six days later, the commander of STRATCOM directed that a Sea Based Strategic Deterrent (SBSD) capability-based assessment (CBA) be performed. In July 2007, the task force established by the commander of STRATCOM provided its recommendations regarding capabilities and characteristics for a new SBSD. (Source: Navy list of key events relating to the ULMS and SBSD provided to CRS and the Congressional Budget Office (CBO) on July 7, 2008.)

[70] On February 14, 2008, the SBSD ICD was approved for joint staffing by the Navy's Resources and Requirements Review Board (R3B). On April 29, 2008, the SBSD was approved by DOD's Functional Capabilities Board (FCB) to proceed to DOD's Joint Capabilities Board (JCB). (Source: Navy list of key events relating to the ULMS and SBSD provided to CRS and CBO on July 7, 2008.)

[71] Navy briefing to CRS and CBO on the SBSD program, July 6, 2009.

[72] Navy briefing to CRS and CBO on the SBSD program, July 6, 2009.

[73] An August 2008 press report states that the program office, called PMS-397, "was established within the last two months." (Dan Taylor, "Navy Stands Up Program Office To Manage Next-Generation SSBN," *Inside the Navy*, August 17, 2008.

[74] "Going Ballistic," *Defense Daily*, September 22, 2008, p. 1.

[75] *Department of Defense Fiscal Year (FY) 2012 Budget Estimates, Navy, Justification Book Volume 2, Research, Development, Test & Evaluation, Navy Budget Activity 4*, entry for PE0603561N, Project 3220 (PDF page 345 of 888).

a June 26, 2013, Navy blog post discussing options that were examined for replacing the Ohio-class SSBNs, see **Appendix D**.)

The program's Milestone A review meeting was held on December 9, 2010. On February 3, 2011, the Navy provided the following statement to CRS concerning the outcome of the December 9 meeting:

> The OHIO Replacement Program achieved Milestone A and has been approved to enter the Technology Development Phase of the Dept. of Defense Life Cycle Management System as of Jan. 10, 2011.
>
> This milestone comes following the endorsement of the Defense Acquisition Board (DAB), chaired by Dr. Carter (USD for Acquisition, Technology, and Logistics) who has signed the program's Milestone A Acquisition Decision Memorandum (ADM).
>
> The DAB endorsed replacing the current 14 Ohio-class Ballistic Missile Submarines (SSBNs) as they reach the end of their service life with 12 Ohio Replacement Submarines, each comprising 16, 87-inch diameter missile tubes utilizing TRIDENT II D5 Life Extended missiles (initial loadout). The decision came after the program was presented to the Defense Acquisition Board (DAB) on Dec. 9, 2010.

The ADM validates the program's Technology Development Strategy and allows entry into the Technology Development Phase during which warfighting requirements will be refined to meet operational and affordability goals. Design, prototyping, and technology development efforts will continue to ensure sufficient technological maturity for lead ship procurement in 2019.[76]

January 2017 Milestone B Approval

On January 4, 2017, DOD gave Milestone B approval to the Columbia-class program. Milestone B approval, which permits a program to enter the engineering and manufacturing development (EMD) phase, is generally considered a major milestone for a defense acquisition program, permitting the program to transition, in effect, from a research and development effort into a procurement program of record. A January 6, 2017, Navy notification to Congress on the Milestone B approval for the Columbia-class program states the following:

> On 4 November 2016, Under Secretary of Defense for Acquisition, Technology and Logistics Frank Kendall chaired the Milestone B Defense Acquisition Board, and on 4 January, 2017 signed the acquisition decision memorandum approving COLUMBIA Class program's Milestone B and designating the program as an Acquisition Category ID major defense acquisition program. Milestone B also establishes the Acquisition Program Baseline against which the program's performance will be assessed. Additionally, this decision formally authorizes entry into the Engineering and Manufacturing Development Phase of an acquisition program, permitting the transition from preliminary design to detail design, using Shipbuilding and Conversion, Navy (SCN) funds. Cost estimates for this program have been rebaselined from CY2010 dollars to CY2017 dollars in accordance with DoDI 5000.02, Rev p, dated 7 January 2015.
>
> The MS B Navy Cost Estimate for Average Follow Ship End Cost (hulls 2-12) in 2010$ using specific shipbuilding indices is $5.0 billion, a $600 million reduction from the MS A estimate, which nearly achieves the affordability target of $4.9 billion set at MS A. To continue cost control, the Navy will focus on:
>
> • Stable operational and technical requirements
>
> • High design maturity at construction start

[76] Source: Email from Navy Office of Legislative Affairs to CRS, February 3, 2011.

• Detailed plans to ensure manufacturing readiness including robust prototyping efforts and synergies with other nuclear shipbuilding programs

• Aggressive cost reduction actions

Affordability caps have been assigned that are consistent with current cost estimates and reasonable margins for cost growth. Relative to Milestone A, these estimates have been updated to adjust Base Year from 2010 to 2017, a standard practice to match Base Year with the year of Milestone B approval. The MS A unit cost affordability target ($4.9 billion in CY2010$ using Navy indices) used a unique metric, "Average Follow-on Ship End Cost," which accounted for hulls 2-12. From Milestone B forward, the affordability cap for the unit cost will be measured by using the Average Procurement Unit Cost (APUC), which includes all 12 hulls. The Affordability Cap of $8.0 billion in CY2017$ is based upon the approved APUC estimate of $7.3 billion plus 10%....

The Navy and industry are currently negotiating the detail design and construction (DD&C) contract, which is expected to award in early 2017. With negotiations continuing on the DD&C contract, the Navy has ensured the COLUMBIA Program design effort will continue without interruption. The Navy issued a contract modification to allow execution of SCN for detail design on the existing R&D contract. With this modification in place, detail design efforts that had initially planned to transition to the DD&C contract, will continue on the current R&D contract to ensure continued design progress. With the Milestone B approval and the appropriation of $773M in FY17 SCN under the second Continuing Resolution, funding is now available to execute detail design. In accordance with 10 U.S.C. §2218a and the FY17 National Defense Authorization Act, the Navy deposited the FY17 SCN into the National Sea-Based Deterrence Fund (NSBDF). The first installment of funding will be executed on the existing R&D contract, which allows transition into detail design and continued design progress until the award of the DD&C contract.[77]

[77] *Columbia Class MS [Milestone] B, Congressional Notification*, January 6, 2017, pp. 1-2. See also Megan Eckstein, "Columbia-class Submarine Program Passess Milestone B Decision, Can Begin Detail Design," *USNI News*, January 4, 2017.

Appendix D. Design of Columbia-Class Boats

This appendix provides additional background information on the design for the Columbia-class boats.

Some Key Design Features

The Columbia-class design will reflect the following:

- The Columbia class is being designed for a 42-year expected service life.[78]
- Unlike the Ohio-class design, which requires a midlife nuclear refueling,[79] the Columbia class is to be equipped with a life-of-the-ship nuclear fuel core (a nuclear fuel core that is sufficient to power the ship for its entire expected service life).[80] Although the Columbia class will not need a midlife nuclear refueling, it will still need a midlife nonrefueling overhaul (i.e., an overhaul that does not include a nuclear refueling) to operate over its full 42-year life.
- The Columbia class is to be equipped with an electric-drive propulsion train, as opposed to the mechanical-drive propulsion train used on other Navy submarines. The electric-drive system is expected to be quieter (i.e., stealthier) than a mechanical-drive system.[81]
- The Columbia class is to have SLBM launch tubes that are the same size as those on the Ohio class (i.e., tubes with a diameter of 87 inches and a length sufficient to accommodate a D-5 SLBM).
- The Columbia class will have a beam (i.e., diameter)[82] of 43 feet, compared to 42 feet on the Ohio-class design,[83] and a length of 560 feet, the same as that of the Ohio-class design.[84]

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[78] Rear Admiral David Johnson, briefing to Naval Submarine League Annual Symposium [on] Expanding Undersea Dominance, October 23, 2014, briefing slide 19. See also William Baker et al., "Design for Sustainment: The Ohio Replacement Submarine," *Naval Engineers Journal*, September 2015: 89-96.

[79] As mentioned earlier (see "Current Ohio-Class SSBNs"), the Ohio-class boats receive a midlife nuclear refueling overhaul, called an Engineered Refueling Overhaul (ERO), which includes both a nuclear refueling and overhaul work on the ship that is not related to the nuclear refueling.

[80] U.S. Navy, *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY 2011*, February 2010, p. 5.

[81] Source: Rear Admiral David Johnson, briefing to Naval Submarine League Annual Symposium [on] Expanding Undersea Dominance, October 23, 2014, briefing slide 19. See also the spoken testimony of Admiral Kirkland Donald, Deputy Administrator for Naval Reactors, and Director, Naval Nuclear Propulsion, National Nuclear Security Administration, at a March 30, 2011, hearing before the Strategic Forces Subcommittee of the Senate Armed Services Committee, as shown in the transcript of the hearing, and Dave Bishop, "What Will Follow the Ohio Class?" *U.S. Naval Institute Proceedings*, June 2012: 31; and Sam LaGrone and Richard Scott, "Strategic Assets: Deterrent Plans Confront Cost Challenges," *Jane's Navy International*, December 2011: 16. For more on electric drive propulsion, see CRS Report RL30622, *Electric-Drive Propulsion for U.S. Navy Ships: Background and Issues for Congress*, by Ronald O'Rourke.

[82] Beam is the maximum width of a ship. For Navy submarines, which have cylindrical hulls, beam is the diameter of the hull.

[83] Dave Bishop, "What Will Follow the Ohio Class?" *U.S. Naval Institute Proceedings*, June 2012: 31. (Bishop was program manager for the Columbia-class program.) See also Sam LaGrone and Richard Scott, "Strategic Assets: Deterrent Plans Confront Cost Challenges," *Jane's Navy International*, December 2011: 15 and 16.

[84] Sydney J. Freedberg, "Navy Seeks Sub Replacement Savings: From NASA Rocket Boosters To Reused Access

- Instead of 24 SLBM launch tubes, as on the Ohio-class design, the Columbia class is to have 16 SLBM launch tubes.
- As noted earlier, although the Columbia-class design has fewer SLBM tubes than the Ohio-class design, it is larger than the Ohio-class design in terms of submerged displacement. The Columbia-class design has a reported submerged displacement of 20,815 tons (as of August 2014), compared to 18,750 tons for the Ohio-class design.[85] The Columbia-class design, like the Ohio-class design before it, will be the largest submarine ever built by the United States.
- The Navy states that "owing to the unique demands of strategic relevance, [Columbia-class boats] must be fitted with the most up-to-date capabilities and stealth to ensure they are survivable throughout their full 40-year life span."[86]

June 2013 Navy Blog Post Regarding Ohio Replacement Options

A June 26, 2013, blog post by Rear Admiral Richard Breckenridge, the Navy's Director for Undersea Warfare (N97), discussing options that were examined for replacing the Ohio-class SSBNs, stated the following:

> Over the last five years, the Navy–working with U.S. Strategic Command, the Joint Staff and the Office of the Secretary of Defense–has formally examined various options to replace the Ohio ballistic missile submarines as they retire beginning in 2027. This analysis included a variety of replacement platform options, including designs based on the highly successful Virginia-class attack submarine program and the current Ohio-class ballistic missile submarine. In the end, the Navy elected to pursue a new design that leverages the lessons from the Ohio, the Virginia advances in shipbuilding and improvements in cost-efficiency.
>
> Recently, a variety of writers have speculated that the required survivable deterrence could be achieved more cost effectively with the Virginia-based option or by restarting the Ohio-class SSBN production line. Both of these ideas make sense at face value–which is why they were included among the alternatives assessed–but the devil is in the details. When we examined the particulars, each of these options came up short in both military effectiveness and cost efficiency.
>
> **Virginia-based SSBN design with a Trident II D5 missile.** An SSBN design based on a Virginia-class attack submarine with a large-diameter missile compartment was rejected due to a wide range of shortfalls. It would:

Doors," *Breaking Defense* (http://breakingdefense.com), April 7, 2014.

[85] Navy information paper on Columbia-class program dated August 11, 2014, provided to CBO and CRS on August 11, 2014.

[86] U.S. Navy, *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY 2011*, February 2010, p. 24. See also Mike McCarthy, "Navy Striving To Reduce Detectability Of Next Boomers," *Defense Daily*, February 6, 2015: 1. In an article published in June 2012, the program manager for the Columbia-class program stated that "the current configuration of the Ohio replacement is an SSBN with 16 87-inch-diameter missile tubes, a 43-foot-diamater hull, electric-drive propulsion, [an] X-stern, accommodations for 155 personnel, and a common submarine radio room tailored to the SSBN mission." (Dave Bishop, "What Will Follow the Ohio Class?" *U.S. Naval Institute Proceedings*, June 2012: 31. See also Sam LaGrone and Richard Scott, "Strategic Assets: Deterrent Plans Confront Cost Challenges," *Jane's Navy International*, December 2011: 15 and 16. The X-stern is also shown in Rear Admiral David Johnson, briefing to Naval Submarine League Annual Symposium [on] Expanding Undersea Dominance, October 23, 2014, briefing slide 19.) The term X-stern means that the steering and diving fins at the stern of the ship are, when viewed from the rear, in the diagonal pattern of the letter X, rather than the vertical-and horizontal pattern of a plus sign (which is referred to as a cruciform stern). The common submarine radio room is a standardized (i.e., common) suite of submarine radio room equipment that is being installed on other U.S. Navy submarines.

• Not meet survivability (stealth) requirements due to poor hull streamlining and lack of a drive train able to quietly propel a much larger ship

• Not meet at-sea availability requirements due to longer refit times (since equipment is packed more tightly within the hull, it requires more time to replace, repair and retest)

• Not meet availability requirements due to a longer mid-life overhaul (refueling needed)

• Require a larger number of submarines to meet the same operational requirement

• Reduce the deterrent value needed to protect the country (fewer missiles, warheads at-sea)

• Be more expensive than other alternatives due to extensive redesign of Virginia systems to work with the large missile compartment (for example, a taller sail, larger control surfaces and more robust support systems)

We would be spending more money (on more ships) to deliver less deterrence (reduced at-sea warhead presence) with less survivability (platforms that are less stealthy).

Virginia-based SSBN design with a smaller missile. Some have encouraged the development of a new, smaller missile to go with a Virginia-based SSBN. This would carry forward many of the shortfalls of a Virginia-based SSBN we just discussed, and add to it a long list of new issues. Developing a new nuclear missile from scratch with an industrial base that last produced a new design more than 20 years ago would be challenging, costly and require extensive testing. We deliberately decided to extend the life of the current missile to decouple and de-risk the complex (and costly) missile development program from the new replacement submarine program. Additionally, a smaller missile means a shorter employment range requiring longer SSBN patrol transits. This would compromise survivability, require more submarines at sea and ultimately weaken our deterrence effectiveness. With significant cost, technical and schedule risks, there is little about this option that is attractive.

Ohio-based SSBN design. Some have argued that we should re-open the Ohio production line and resume building the Ohio design SSBNs. This simply cannot be done because there is no Ohio production line. It has long since been re-tooled and modernized to build state-of-the-art Virginia-class SSNs using computerized designs and modular, automated construction techniques. Is it desirable to redesign the Ohio so that a ship with its legacy performance could be built using the new production facilities? No, since an Ohio-based SSBN would:

• Not provide the required quieting due to Ohio design constraints and use of a propeller instead of a propulsor (which is the standard for virtually all new submarines)

• Require 14 instead of 12 SSBNs by reverting to Ohio class operational availability standards (incidentally creating other issues with the New START treaty limits)

• Suffer from reduced reliability and costs associated with the obsolescence of legacy Ohio system components

Once again, the end result would necessitate procuring more submarines (14) to provide the required at-sea presence and each of them would be less stealthy and less survivable against foreseeable 21st century threats.

The Right Answer: A new design SSBN that improves on Ohio: What has emerged from the Navy's exhaustive analysis is an Ohio replacement submarine that starts with the foundation of the proven performance of the Ohio SSBN, its Trident II D5 strategic weapons system and its operating cycle. To this it adds:

• Enhanced stealth as necessary to pace emerging threats expected over its service life

> • Systems commonality with Virginia (pumps, valves, sonars, etc.) wherever possible, enabling cost savings in design, procurement, maintenance and logistics
>
> • Modular construction and use of COTS equipment consistent with those used in today's submarines to reduce the cost of fabrication, maintenance and modernization. Total ownership cost reduction (for example, investing in a life-of-the-ship reactor core enables providing the same at-sea presence with fewer platforms).
>
> Although the Ohio replacement is a "new design," it is in effect an SSBN that takes the best lessons from 50 years of undersea deterrence, from the Ohio, from the Virginia, from advances in shipbuilding efficiency and maintenance, and from the stern realities of needing to provide survivable nuclear deterrence. The result is a low-risk, cost-effective platform capable of smoothly transitioning from the Ohio and delivering effective 21st century undersea strategic deterrence.[87]

16 vs. 20 SLBM Tubes

Overview

The Navy's decision to design Columbia-class boats with 16 SLBM tubes rather than 20 was one of several decisions the Navy made to reduce the estimated average procurement cost of boats 2 through 12 in the program toward a Navy target cost of $4.9 billion in FY2010 dollars.[88] Some observers were concerned that designing the Columbia class with 16 tubes rather than 20 would create a risk that U.S. strategic nuclear forces might not have enough capability in the 2030s and beyond to fully perform their deterrent role. These observers noted that to comply with the New Start Treaty limiting strategic nuclear weapons, DOD plans to operate in coming years a force of 14 Trident SSBNs, each with 20 operable SLBM tubes (4 of the 24 tubes on each boat are to be rendered inoperable), for a total of 280 tubes, whereas the Navy in the Columbia-class program is

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[87] "Facts We Can Agree Upon About Design of Ohio Replacement SSBN," Navy Live, accessed July 3, 2013, at http://navylive.dodlive.mil/2013/06/26/facts-we-can-agree-upon-about-design-of-ohio-replacement-ssbn/.

[88] At a March 30, 2011, hearing before the Strategic Forces subcommittee of the Senate Armed Services Committee, Admiral Kirkland Donald, Deputy Administrator for Naval Reactors and Director, Naval Nuclear Propulsion, National Nuclear Security Administration, when asked for examples cost efficiencies that are being pursued in his programs, stated the following:

> The—the Ohio replacement [program] has been one that we've obviously been focused on here for—for several years now. But in the name of the efficiencies, and one of the issues as we work through the Defense Department's acquisition process, we were the first program through that new process that Dr. [Aston] Carter [the DOD acquisition executive] headed up.
>
> But we were challenged to—to drive the cost of that ship down, and as far as our part was concerned, one of the key decisions that was made that—that helped us in that regard was a decision to go from 20 missile tubes to 16 missile tubes, because what that allowed us to do was to down rate the—the propulsion power that was needed, so obviously, it's a–it's a small[er] the reactor that you would need.
>
> But what it also allowed us to do was to go back [to the use of existing components]. The size [of the ship] fell into the envelope where we could go back and use components that we had already designed for the Virginia class [attack submarines] and bring those into this design, not have to do it over again, but several of the mechanical components, to use those over again.
>
> And it enabled us to drive the cost of that propulsion plant down and rely on proven technology that's—pumps and valves and things like that don't change like electronics do.
>
> So we're pretty comfortable putting that in ship that'll be around 'til 2080. But we were allowed to do that.
>
> (Source: Transcript of hearing.)

planning a force of 12 SSBNs each with 16 tubes, for a total of 192 tubes, or about 31% less than 280. These observers also cited the uncertainties associated with projecting needs for strategic deterrent forces out to the year 2080, when the final Columbia-class boat is scheduled to leave service. These observers asked whether the plan to design the Columbia class with 16 tubes rather than 20 was fully supported within all parts of DOD, including U.S. Strategic Command (STRATCOM).

In response, Navy and other DOD officials stated that the decision to design the Columbia class with 16 tubes rather than 20 was carefully considered within DOD, and that they believe a boat with 16 tubes will give U.S. strategic nuclear forces enough capability to fully perform their deterrent role in the 2030s and beyond.

Testimony in 2011

At a March 1, 2011, hearing before the House Armed Services Committee, Admiral Gary Roughead, then-Chief of Naval Operations, stated the following:

> I'm very comfortable with where we're going with SSBN-X. The decision and the recommendation that I made with regard to the number of tubes—launch tubes are consistent with the new START treaty. They're consistent with the missions that I see that ship having to perform. And even though it may be characterized as a cost cutting measure, I believe it sizes the ship for the missions it will perform.[89]

At a March 2, 2011, hearing before the Strategic Forces subcommittee of the House Armed Services Committee, the following exchange occurred:

> REPRESENTATIVE TURNER:
>
> General Kehler, thank you so much for your continued thoughts and of course your leadership. One item that we had a discussion on was the triad, of looking to—of the Navy and the tube reductions of 20 to 16, as contained in other hearings on the Hill today. I would like your thoughts on the reduction of the tubes and what you see driving that, how you see it affecting our strategic posture and any other thoughts you have on that?
>
> AIR FORCE GENERAL C. ROBERT KEHLER, COMMANDER, U.S. STRATEGIC COMMAND
>
> Thank you, Mr. Chairman. Well, first of all, sir, let me say that the—in my mind anyway, the discussion of Trident and Ohio-class replacement is really a discussion in the context of the need to modernize the entire triad. And so, first of all, I think that it's important for us to recognize that that is one piece, an important piece, but a piece of the decision process that we need to go through.
>
> Second, the issue of the number of tubes is not a simple black-and-white answer. So let me just comment here for a minute.
>
> First of all, the issue in my mind is the overall number of tubes we wind up with at the end, not so much as the number of tubes per submarine.
>
> Second, the issue is, of course, we have flexibility and options with how many warheads per missile per tube, so that's another consideration that enters into this mixture.
>
> Another consideration that is important to me is the overall number of boats and the operational flexibility that we have with the overall number of boats, given that some number will need to be in maintenance, some number will need to be in training, et cetera.

[89] Source: Transcript of hearing.

> And so those and many other factors—to include a little bit of foresight here, in looking ahead to 20 years from now in antisubmarine warfare environment that the Navy will have to operate in, all of those bear on the ultimate sideways shape configuration of a follow-on to the Ohio.
>
> At this point, Mr. Chairman, I am not overly troubled by going to 16 tubes. As I look at this, given that we have that kind of flexibility that I just laid out; given that this is an element of the triad and given that we have some decision space here as we go forward to decide on the ultimate number of submarines, nothing troubles me operationally here to the extent that I would oppose a submarine with 16 tubes.
>
> I understand the reasons for wanting to have 20. I understand the arguments that were made ahead of me. But as I sit here today, given the totality of the discussion, I am—as I said, I am not overly troubled by 16. Now, I don't know that the gavel has been pounded on the other side of the river yet with a final decision, but at this point, I am not overly troubled by 16.[90]

At an April 5, 2011, hearing before the Strategic Forces subcommittee of the House Armed Services Committee, the following exchange occurred:

> REPRESENTATIVE LARSEN:
>
> General Benedict, we have had this discussion, not you and I, I am sorry. But the subcommittee has had a discussion in the past with regards to the Ohio-class replacement program.
>
> The new START, though, when it was negotiated, assumed a reduction from 24 missile tubes per hole to, I think, a maximum a maximum of 20.
>
> The current configuration [for the Columbia class], as I understand it, would move from 24 to 16.
>
> Can you discuss, for the subcommittee here, the Navy's rationale for that? For moving from 24 to 16 as opposed to the max of 20?
>
> NAVY REAR ADMIRAL TERRY BENEDICT, DIRECTOR, STRATEGIC SYSTEMS PROGRAMS (SSP):
>
> Sir, as part—excuse me, as part of the work-up for the milestone A [review for the Columbia class program] with Dr. Carter in OSD, SSP supported the extensive analysis at both the OSD level as well as STRATCOM's analysis.
>
> Throughout that process, we provided, from the SWS [strategic weapon system] capability, our perspective. Ultimately that was rolled up into both STRATCOM and OSD and senior Navy leadership and in previous testimony, the secretary of the Navy, the CNO, and General Chilton have all expressed their confidence that the mission of the future, given their perspectives, is they see the environment today can be met with 16.
>
> And so, as the acquisition and the SWS provider, we are prepared to support that decision by leadership, sir.
>
> REPRESENTATIVE LARSEN:
>
> Yes.
>
> And your analysis supports—did your analysis that fed into this, did you look at specific numbers then?
>
> REARD ADMIRAL BENEDICT:

[90] Source: Transcript of hearing.

> Sir, we looked at the ability of the system, again, SSP does not look at specific targets with...
>
> REPRESENTATIVE LARSEN:
>
> Right. Yes, yes, yes.
>
> REAR ADMIRAL BENEDICT:
>
> Our input was the capability of the missile, the number of re-entry bodies and the throw weight that we can provide against those targets and based on that analysis, the leadership decision was 16, sir.[91]

At an April 6, 2011, hearing before the Strategic Forces subcommittee of the Senate Armed Services Committee, the following exchange occurred:

> SENATOR SESSIONS:
>
> Admiral Benedict, according to recent press reports, the Navy rejected the recommendations of Strategic Command to design the next generation of ballistic missile submarines with 20 missile tubes instead of opting for only 16 per boat.
>
> What is the basis for the Navy's decision of 16? And I'm sure cost is a factor. In what ways will that decision impact the overall nuclear force structure associated with the command?
>
> NAVY REAR ADMIRAL TERRY BENEDICT, DIRECTOR, STRATEGIC SYSTEMS PROGRAMS (SSP):
>
> Yes, sir. SSP supported the Navy analysis, STRATCOM's analysis, as well as the OSD analysis, as we proceeded forward and towards the Milestone A decision [on the Columbia class program] that Dr. Carter conducted.
>
> Based on our input, which was the technical input as the—as the director of SSP, other factors were considered, as you stated. Cost was one of them. But as the secretary, as the CNO, and I think as General Kehler submitted in their testimony, that given the threats that we see today, given the mission that we see today, given the upload capability of the D-5, and given the environment as they saw today, all three of those leaders were comfortable with the decision to proceed forward with 16 tubes, sir.
>
> SENATOR SESSIONS:
>
> And is that represent your judgment? To what extent were you involved—were you involved in that?
>
> REAR ADMIRAL BENEDICT:
>
> Sir, we were involved from technical aspects in terms of the capability of the missile itself, what we can throw, our range, our capability. And based on what we understand the capability of the D-5 today, which will be the baseline missile for the Ohio Replacement Program, as the director of SSP I'm comfortable with that decision.[92]

Section 242 Report

Section 242 of the FY2012 National Defense Authorization Act (H.R. 1540/P.L. 112-81 of December 31, 2011) required DOD to submit a report on the Columbia-class program that includes, among other things, an assessment of various combinations of boat quantities and numbers of SLBM launch tubes per boat. The text of the section is as follows:

[91] Source: Transcript of hearing.

[92] Source: Transcript of hearing.

SEC. 242. REPORT AND COST ASSESSMENT OF OPTIONS FOR OHIO-CLASS REPLACEMENT BALLISTIC MISSILE SUBMARINE.

(a) Report Required- Not later than 180 days after the date of the enactment of this Act, the Secretary of the Navy and the Commander of the United States Strategic Command shall jointly submit to the congressional defense committees a report on each of the options described in subsection (b) to replace the Ohio-class ballistic submarine program. The report shall include the following:

(1) An assessment of the procurement cost and total life-cycle costs associated with each option.

(2) An assessment of the ability for each option to meet—

(A) the at-sea requirements of the Commander that are in place as of the date of the enactment of this Act; and

(B) any expected changes in such requirements.

(3) An assessment of the ability for each option to meet—

(A) the nuclear employment and planning guidance in place as of the date of the enactment of this Act; and

(B) any expected changes in such guidance.

(4) A description of the postulated threat and strategic environment used to inform the selection of a final option and how each option provides flexibility for responding to changes in the threat and strategic environment.

(b) Options Considered- The options described in this subsection to replace the Ohio-class ballistic submarine program are as follows:

(1) A fleet of 12 submarines with 16 missile tubes each.

(2) A fleet of 10 submarines with 20 missile tubes each.

(3) A fleet of 10 submarines with 16 missile tubes each.

(4) A fleet of eight submarines with 20 missile tubes each.

(5) Any other options the Secretary and the Commander consider appropriate.

(c) Form- The report required under subsection (a) shall be submitted in unclassified form, but may include a classified annex.

Subsection (c) above states the report "shall be submitted in unclassified form, but may include a classified annex."

The report as submitted was primarily the classified annex, with a one-page unclassified summary, the text of which is as follows (underlining as in the original):

The National Defense Authorization Act (NDAA) for Fiscal Year 2012 (FY12) directed the Secretary of the Navy and the Commander of U.S. Strategic Command (USSTRATCOM) to jointly submit a report to the congressional defense committees comparing four different options for the OHIO Replacement (OR) fleet ballistic missile submarine (SSBN) program. Our assessment considered the current operational requirements and guidance. The four SSBN options analyzed were:

1. 12 SSBNs with 16 missile tubes each

2. 10 SSBNs with 20 missile tubes each

3. 10 SSBNs with 16 missile tubes each

4. 8 SSBNs with 20 missile tubes each

The SSBN force continues to be an integral part of our nuclear Triad and contributes to deterrence through an assured second strike capability that is survivable, reliable, and credible. The number of SSBNs and their combined missile tube capacity are important factors in our flexibility to respond to changes in the threat and uncertainty in the strategic environment.

We assessed each option against the ability to meet nuclear employment and planning guidance, ability to satisfy at-sea requirements, flexibility to respond to future changes in the postulated threat and strategic environment, and cost. In general, options with more SSBNs can be adjusted downward in response to a diminished threat; however, options with less SSBNs are more difficult to adjust upward in response to a growing threat.

Clearly, a smaller SSBN force would be less expensive than a larger force, but for the reduced force options we assessed, they fail to meet current at-sea and nuclear employment requirements, increase risk in force survivability, and limit flexibility in response to an uncertain strategic future. Our assessment is the program of record, 12 SSBNs with 16 missile tubes each, provides the best balance of performance, flexibility, and cost meeting commander's requirements while supporting the Nation's strategic deterrence mission goals and objectives.

The classified annex contains detailed analysis that is not releasable to the public.[93]

[93] Report and Cost Assessment of Options for OHIO-Class Replacement Ballistic Missile Submarine, Unclassified Summary, received from Navy Legislative Affairs Office, August 24, 2012. See also Christopher J. Castelli, "Classified Navy Assessment On SSBN(X) Endorses Program Of Record," *Inside the Navy*, September 10, 2012.

For more recent discussions of this issue, see Patty-Jane Geller and Brent D. Sadler, "Faulty Assumptions About the Global Nuclear Threat May Require Changes in U.S. SeaBased Nuclear Force," Heritage Foundation, February 22, 2022, 11 pp.; Frank Miller, "Don't Even Think About Redesigning the Columbia SSBN," *RealClearDefense*, March 31, 2022.

Appendix E. National Sea-Based Deterrence Fund (NSBDF)

This appendix provides additional background information on the National Sea-Based Deterrence Fund (NSBDF).

Created by P.L. 113-291

Section 1022 of the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015 (H.R. 3979/P.L. 113-291 of December 19, 2014) created the National Sea-Based Deterrence Fund (NSBDF), a fund in the DOD budget, codified at 10 U.S.C. 2218a, that is separate from the Navy's regular shipbuilding account (which is formally known as the Shipbuilding and Conversion, Navy, or SCN, appropriation account).

Amended by Subsequent Legislation

Section 1022 of the FY2016 National Defense Authorization Act (S. 1356/P.L. 114-92 of November 25, 2015), Section 1023 of the FY2017 National Defense Authorization Act (S. 2943/P.L. 114-328 of December 23, 2016), Section 1022 of the FY2018 National Defense Authorization Act (H.R. 2810/P.L. 115-91 of December 12, 2017), and Section 1023 of the FY2021 National Defense Authorization Act (H.R. 6395/P.L. 116-283 of January 1, 2021) amended 10 U.S.C. 2218a to provide additional acquisition authorities for the NSBDF.

Text as Amended

The text of 10 U.S.C. 2218a, as amended through December 31, 2020 (i.e., prior to the final amendment listed above, from the FY2021 National Defense Authorization Act), is as follows:

> §2218a. National Sea-Based Deterrence Fund
>
> (a) Establishment.-There is established in the Treasury of the United States a fund to be known as the "National Sea-Based Deterrence Fund".
>
> (b) Administration of Fund.-The Secretary of Defense shall administer the Fund consistent with the provisions of this section.
>
> (c) Fund Purposes.-(1) Funds in the Fund shall be available for obligation and expenditure only for construction (including design of vessels), purchase, alteration, and conversion of national sea-based deterrence vessels.
>
> (2) Funds in the Fund may not be used for a purpose or program unless the purpose or program is authorized by law.
>
> (d) Deposits.-There shall be deposited in the Fund all funds appropriated to the Department of Defense for construction (including design of vessels), purchase, alteration, and conversion of national sea-based deterrence vessels.
>
> (e) Expiration of Funds After 5 Years.-No part of an appropriation that is deposited in the Fund pursuant to subsection (d) shall remain available for obligation more than five years after the end of fiscal year for which appropriated except to the extent specifically provided by law.
>
> (f) Authority to Enter Into Economic Order Quantity Contracts.-(1) The Secretary of the Navy may use funds deposited in the Fund to enter into contracts known as "economic order quantity contracts" with private shipyards and other commercial or government

entities to achieve economic efficiencies based on production economies for major components or subsystems. The authority under this subsection extends to the procurement of parts, components, and systems (including weapon systems) common with and required for other nuclear powered vessels under joint economic order quantity contracts.

(2) A contract entered into under paragraph (1) shall provide that any obligation of the United States to make a payment under the contract is subject to the availability of appropriations for that purpose, and that total liability to the Government for termination of any contract entered into shall be limited to the total amount of funding obligated at time of termination.

(g) Authority to Begin Manufacturing and Fabrication Efforts Prior to Ship Authorization.-(1) The Secretary of the Navy may use funds deposited into the Fund to enter into contracts for advance construction of national sea-based deterrence vessels to support achieving cost savings through workload management, manufacturing efficiencies, or workforce stability, or to phase fabrication activities within shipyard and manage sub-tier manufacturer capacity.

(2) A contract entered into under paragraph (1) shall provide that any obligation of the United States to make a payment under the contract is subject to the availability of appropriations for that purpose, and that total liability to the Government for termination of any contract entered into shall be limited to the total amount of funding obligated at time of termination.

(h) Authority to Use Incremental Funding to Enter Into Contracts for Certain Items.-(1) The Secretary of the Navy may use funds deposited into the Fund to enter into incrementally funded contracts for advance procurement of high value, long lead time items for nuclear powered vessels to better support construction schedules and achieve cost savings through schedule reductions and properly phased installment payments.

(2) A contract entered into under paragraph (1) shall provide that any obligation of the United States to make a payment under the contract is subject to the availability of appropriations for that purpose, and that total liability to the Government for termination of any contract entered into shall be limited to the total amount of funding obligated at time of termination.

(i) Authority for Multiyear Procurement of Critical Components to Support Continuous Production.-(1) To implement the continuous production of critical components, the Secretary of the Navy may use funds deposited in the Fund, in conjunction with funds appropriated for the procurement of other nuclear-powered vessels, to enter into one or more multiyear contracts (including economic ordering quantity contracts), for the procurement of critical contractor-furnished and Government-furnished components for critical components of national sea-based deterrence vessels. The authority under this subsection extends to the procurement of equivalent critical components common with and required for other nuclear-powered vessels.

(2) In each annual budget request submitted to Congress, the Secretary shall clearly identify funds requested for critical components and the individual ships and programs for which such funds are requested.

(3) Any contract entered into pursuant to paragraph (1) shall provide that any obligation of the United States to make a payment under the contract is subject to the availability of appropriations for that purpose and that the total liability to the Government for the termination of the contract shall be limited to the total amount of funding obligated for the contract as of the date of the termination.

(j) Budget Requests.-Budget requests submitted to Congress for the Fund shall separately identify the amount requested for programs, projects, and activities for construction

(including design of vessels), purchase, alteration, and conversion of national sea-based deterrence vessels.

(k) Definitions.-In this section:

(1) The term "Fund" means the National Sea-Based Deterrence Fund established by subsection (a).

(2) The term "national sea-based deterrence vessel" means any submersible vessel constructed or purchased after fiscal year 2016 that is owned, operated, or controlled by the Department of Defense and that carries operational intercontinental ballistic missiles.

(3) The term "critical component" means any of the following:

(A) A common missile compartment component.

(B) A spherical air flask.

(C) An air induction diesel exhaust valve.

(D) An auxiliary seawater valve.

(E) A hovering valve.

(F) A missile compensation valve.

(G) A main seawater valve.

(H) A launch tube.

(I) A trash disposal unit.

(J) A logistics escape trunk.

(K) A torpedo tube.

(L) A weapons shipping cradle weldment.

(M) A control surface.

(N) A launcher component.

(O) A propulsor.

Precedents for Funding Navy Acquisition Programs Outside Navy Appropriation Accounts

Prior to the establishment of the NSBDF, some observers had suggested funding the procurement of Columbia-class boats outside the Navy's shipbuilding budget so as to preserve Navy shipbuilding funds for other Navy shipbuilding programs. There was some precedent for such an arrangement.

- Construction of certain DOD sealift ships and Navy auxiliary ships was funded in past years in the National Defense Sealift Fund (NDSF), a part of DOD's budget that is outside the Shipbuilding and Conversion, Navy (SCN) appropriation account, and also outside the procurement title of the DOD appropriations act.
- Most spending for ballistic missile defense (BMD) programs (including procurement-like activities) is funded through the Defense-Wide research and development and procurement accounts rather than through the research and development and procurement accounts of the individual military services.

A rationale for funding DOD sealift ships in the NDSF had been that DOD sealift ships perform a transportation mission that primarily benefits services other than the Navy, and therefore should not be forced to compete for funding in a Navy budget account that funds the procurement of ships central to the Navy's own missions. A rationale for funding BMD programs together in the Defense-Wide research and development account is that this makes potential trade-offs in spending among various BMD programs more visible and thereby helps to optimize the use of BMD funding.

Potential Implications of NSBDF on Funding Available for Other Programs

The NSBDF has at least two potential implications for the impact that the Columbia-class program may have on funding available in coming years for other DOD acquisition programs:

- A principal apparent intent in creating the NSBDF is to help preserve funding in coming years for other Navy programs, and particularly Navy shipbuilding programs other than the Columbia-class program, by placing funding for the Columbia-class program in a location within the DOD budget that is separate from the Navy's shipbuilding account and the Navy's budget in general. Referring to the fund as a national fund and locating it outside the Navy's budget appears intended to encourage a view (consistent with an argument made by supporters of the Columbia-class program that the program is intended to meet a national military need rather than a Navy-specific need) that funding for the Columbia-class program should be resourced from DOD's budget as a whole, rather than from the Navy's budget in particular.
- The acquisition authorities in subsections (f), (g), (h), and (i) of 10 U.S.C. 2218a, which were added by P.L. 114-92 and P.L. 114-328, could marginally reduce the procurement costs of not only Columbia-class boats, but also other nuclear-powered ships, such as Virginia-class attack submarines and Gerald R. Ford (CVN-78) class aircraft carriers, by increasing economies of scale in the production of ship components and better optimizing ship construction schedules.

The joint explanatory statement for the FY2016 National Defense Authorization Act (S. 1356/P.L. 114-92 of November 25, 2015) directed DOD to submit a report on the "acquisition strategy to build Ohio-class replacement submarines that will leverage the enhanced procurement authorities provided in the [NSBDF] ... ." Among other things, the report was to identify "any additional authorities the Secretary [of Defense] may need to make management of the Ohio-class replacement more efficient...."[94] The Navy submitted the report on April 18, 2016. The report states in part that

> the high cost for this unique, next generation strategic deterrent requires extraordinary measures to ensure its affordability. Further, procuring the OHO Replacement (OR), the next generation SSBN, within the current shipbuilding plan presents an extreme challenge to the Navy's shipbuilding budget. To minimize this challenge and reduce OR schedule risk, the Navy proposes to leverage those authorities provided by the National Sea-Based Deterrence Fund (NSBDF) in conjunction with the employment of best acquisition practices on this critical program....

[94] Joint explanatory statement for H.R. 1735, p. 165 (PDF page 166 of 542). Following the veto of H.R. 1735, a modified bill, S. 1356, was passed and enacted into law. Except for the parts of S. 1356 that differ from H.R. 1735, the joint explanatory statement for H.R. 1735 in effect serves as the joint explanatory statement for S. 1356.

... the Navy is continuing to identify opportunities to further acquisition efficiency, reduce schedule risk, and improve program affordability. Most notably in this regard, the Navy is currently assessing [the concept of] Continuous Production [for producing components of Columbia-class boats more efficiently than currently scheduled] and will keep Congress informed as we quantify the benefits of this and other initiatives that promise substantial savings....

... the Navy's initial assessment is that the authorities and further initiatives described [in this report] will be essential to achieving the reductions to acquisition cost and schedule risk that are so critical to success on the OR program....

Section 1022 of the FY2016 NDAA authorized the use of funds in the NSBDF to enter into contracts for EOQ [Economic Order Quantity purchases of materials and equipment] and AC [advance construction activities in shipyards], and to incrementally fund contracts for AP [advance procurement] of specific components. These authorities are essential to successfully executing the OR acquisition strategy. The Navy is able to take advantage of these authorities largely due to how its submarine shipbuilding plan is phased....

Economic Order Quantity contracts provide substantial cost savings to the Navy from procuring materials and equipment in bulk quantities. In addition to the cost savings typically associated with EOQ authority, the Navy has identified an opportunity to implement EOQ procurements to achieve OR schedule efficiencies and commonality contract actions with VCS [Virginia-class submarine] Block V [boats] and CVN [nuclear-powered aircraft carriers]....

Advance Construction is the authority to begin [shipyard] construction [work] in fiscal years of AP [advance procurement] budget requests prior to the full funding/authorization year of a hull. Early manufacturing activities help retire construction risk for first-of-a-kind efforts, ease transition from design to production, and provide efficiencies in shipyard construction workload. Advance Construction would allow the shipbuilders to begin critical path construction activities earlier, thus reducing risk to the OR delivery schedule....

The FY2016 NDAA allows the Navy and shipbuilders to enter into incrementally funded procurements for long lead components that employ both AP and Full Funding (FF) SCN increments. This funding approach will provide significant schedule improvements and cost savings by maximizing the utilization of limited funding....

Maximum economic advantage can be obtained through Continuous Production. Procuring components and systems necessary for Continuous Production lines [as opposed to production lines that experience periods during which they are without work] would provide opportunities for savings through manufacturing efficiencies, increased [production-line] learning and the retention of critical production skills. In addition to lowering costs, Continuous Production would reduce schedule risk for both the U.S. and UK SSBN construction programs and minimize year-to-year funding spikes. To execute Continuous Production, the Navy requires authority to enter into contracts to procure contractor furnished and government furnished components and systems for OR SSBNs.

OR Missile Tube and Missile Tube Module component procurement through Continuous Production lines have been identified as the most efficient and affordable procurement strategy.... Missile Tube Continuous Production could achieve an average reduction of 25 percent in Missile Tube procurement costs across the [Columbia] Class. These savings are compared to [the] single shipset procurement costs [that are] included in the PB17 PoR [the program of record reflected in the President's (proposed) Budget for FY2017]....

The Navy estimates that procuring Missile Tube Modules in Continuous Production lines would result in a cumulative one year schedule reduction in Missile Tube Module manufacturing for the OR Class. This schedule reduction, on a potential critical path assembly, would reduce ship delivery risk and increase schedule margin for follow ship deliveries. In addition to improving schedule, Missile Tube Module Continuous Production

(including Strategic Weapon System (SWS) Government Furnished Equipment (GFE)) would produce savings as high as 20 percent compared to single shipset procurement costs included in the PB17 PoR. Executing Continuous Production of Missile Tubes or Missile Tube Modules requires re-phasing of funding from outside the PB17 Future Year's Defense Program (FYDP) [to years that are within the FYDP] but results in significant overall program reductions. The Navy is evaluating additional Continuous Production opportunities for nuclear and nonnuclear components with common vendors required for VIRGINIA Class submarines and FORD Class aircraft carriers. Some examples include spherical air flasks, hull valves, pressure hull hemi heads, bow domes, castings, and torpedo tubes. The prerequisite to Continuous Production in each of these cases would be an affirmation of design stability consistent with completion of first article testing, or its equivalent....

The Navy's position on the cost benefits of these authorities is not fully developed. However, the Congressional Budget Office stated in its *Analysis of the Navy's FY2016 Shipbuilding Plan*, " ... the Navy could potentially save several hundred million dollars per submarine by purchasing components and materials for several submarines at the same time."... The Navy's initial cost analysis aligns with CBO's projections, and the cost reductions from employing these acquisition authorities will be further evaluated to support the Navy's updated OR Milestone B cost estimate in August 2016....

The Under Secretary of Defense for Acquisition, Technology and Logistics (USD AT&L) approved the OR Program Acquisition Strategy on January 4, 2016. This strategy emphasizes using alternative acquisition tools and cross-platform contracting to reduce schedule risk and lower costs in support of the Navy's shipbuilding programs....

To reduce costs and help alleviate fiscal pressures, the Navy will work with Congress to implement granted authorities and explore the additional initiatives identified in this report.... The cost reductions from employing the granted and proposed acquisition authorities will be further evaluated to support the Navy's updated OR Milestone B cost estimate in August 2016.... These authorities are needed with the National Sea-Based Deterrence Fund, RDTEN [research, development, test, and evaluation, Navy], and SCN appropriations accounts. Together, these acquisition tools will allow the Navy, and the shipbuilders, to implement the procurement strategy which will reduce total OR acquisition costs and shorten construction schedules for a program with no margin for delay.[95]

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[95] U.S. Navy, *Report to Congress on Ohio Replacement Acquisition Strategy and National Sea-Based Deterrence Fund Accountability*, April 2016, with cover letters dated April 18, 2016, pp. 1-8.

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