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

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Summary

The Columbia (SSBN-826) class program is 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. The Navy has identified the Columbia-class program as the Navy's top priority program. The Navy wants to procure the first Columbia-class boat in FY2021. Research and development work on the program has been underway for several years, and advance procurement (AP) funding for the program began in FY2017. The Navy's proposed FY2020 budget requests $1,698.9 million in advance procurement (AP) funding and $533.1 million in research and development funding for the program.

The Navy's FY2020 budget submission estimates the total procurement cost of the 12-ship class at $109.0 billion in then-year dollars. An April 2018 Government Accountability Office (GAO) report assessing selected major DOD weapon acquisition programs stated that the estimated total acquisition cost of the Columbia-class program is $102,075.3 million (about $102.1 billion) in constant FY2018 dollars, including $12,901.0 million (about $12.9 billion) in research and development costs and $89,174.3 million (about $89.2 billion) in procurement costs.

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

- whether to approve, reject, or modify the Navy's FY2020 funding requests for the program;
- the risk of cost growth in the program;
- the risk of technical challenges or funding-related issues that could lead to delays in designing and building the lead boat in the program and having it ready for its scheduled initial deterrent patrol in 2031;
- 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.

This report focuses on the Columbia-class program as a Navy shipbuilding program. 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 control agreements.

Contents

Introduction 1
Background 1
U.S. Navy SSBNs in General 1
Mission of SSBNs 1
Current Ohio-Class SSBNs 2
U.S.-UK Cooperation on SLBMs and the New UK SSBN 3
Submarine Construction Industrial Base 4
Columbia-Class Program 4
Navy's Top Priority Program 4
Program Name 5
Program Origin and Milestones 5
Planned Procurement Quantity and Schedule 5
Columbia Class Design 6
Program Cost 7
National Sea-Based Deterrence Fund (NSBDF) 8
Submarine Unified Build Strategy (SUBS) 8
Block Buy Contracting Strategy 9
Columbia-Class Program Funding 9
Issues for Congress 10
FY2020 Funding Request 10
Risk of Cost Growth 10
Navy Perspective 11
CBO Perspective 12
GAO Perspective 14
Risk of Schedule Delay in Designing and Building Lead Boat 14
Overview 14
Technical Challenges 14
Industrial-Base Challenges 16
Navy Efforts to Mitigate Schedule Risk 16
GAO Perspective on Schedule Risk 18
Program Affordability and Impact on Other Navy Shipbuilding Programs 20
Legislative Activity for FY2020 22
Summary of Congressional Action on FY2020 Funding Request 22
FY2020 National Defense Authorization Act (H.R. 2500/S. 1790) 23
House 23
Senate 24
FY2020 DOD Appropriations Act (H.R. 2968/S. 2474) 26
House 26
Senate 27
FY2020 Energy and Water Development and Related Agencies Appropriations Act (H.R. 2960/S. 2470) 28
House 28
Senate 28

Figures

Figure 1. Ohio (SSBN-726) Class SSBN 3
Figure 2. Columbia (SSBN-826) Class SSBN 7

Tables

Table 1. Columbia-Class Program Funding 10
Table 2. Navy Confidence Levels for Estimated Columbia-Class Unit Procurement Costs 12
Table 3. Congressional Action on FY2020 Funding Request 23

Table A-1. U.S. SSBN Classes 29

Appendixes

Appendix A. Summary of Past U.S. SSBN Designs 29
Appendix B. U.S.-UK Cooperation on SLBMs and the New UK SSBN 31
Appendix C. Columbia-Class Program Origin and Milestones 34
Appendix D. Design of Columbia-Class Boats 37
Appendix E. National Sea-Based Deterrence Fund (NSBDF) 46

Contacts

Author Information 51

Introduction

This report provides background information and potential oversight issues for Congress on the Columbia-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. The Navy has identified the Columbia-class program as the Navy's top priority program. The Navy wants to procure the first Columbia-class boat in FY2021. The Navy's proposed FY2020 budget requests $1,698.9 million in advance procurement (AP) funding and $533.1 million in research and development 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.

For an overview of the strategic and budgetary context in which the Columbia-class program and other Navy shipbuilding programs may be considered, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by Ronald O'Rourke.

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 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 specialized mission of strategic nuclear deterrence. To perform this mission, SSBNs are armed with submarine-launched ballistic missiles (SLBMs), which are

[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.

large, long-range missiles armed with multiple nuclear warheads. SSBNs launch their SLBMs 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 4-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: U.S. Navy file photo accessed by CRS on February 24, 2011, at http://www.navy.mil/management/photodb/photos/101029-N-1325N-005.jpg.

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

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

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 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]

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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 FY 2014 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.)

Program Name

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.

Program Origin and Milestones

For information on the Columbia-class program's origin and milestones, see **Appendix C**.

Planned Procurement Quantity and Schedule

Planned Procurement Quantity

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.
- A total of 14 Ohio-class boats was 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.
- A total of 12 (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

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

[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.

number of Columbia-class boats might at some point be increased to something more than 12 boats.[15]

Planned Procurement Schedule

The Navy wants to procure the first Columbia-class boat in FY2021, the second in FY2024, and the remaining 10 at a rate of one per year from FY2026 through FY2035. Under this schedule, the Navy projects that the lead boat (i.e., first boat) would be delivered in FY2028, the second in FY2031, and the remaining 10 at a rate of one per year from FY2033 through FY2042. After being delivered in FY2028, the lead boat would undergo substantial testing, with the aim of having it be ready for its first deterrent patrol in 2031.

Under this schedule, and given planned retirement dates for Ohio-class boats, the Navy projects that the SSBN force would decline to 13 boats in FY2027-FY2028, 12 boats in FY2029, 11 boats in FY2030-FY2036 and 10 boats in FY2037-FY2040, and then increase back to 11 boats in FY2041 and 12 boats in FY2042.[16] The Navy states that the reduction to 11 or 10 boats during the period FY2030-FY2041 is acceptable in terms of meeting strategic nuclear deterrence requirements, because during these years, all 11 or 10 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 acknowledges that there is some risk in having the SSBN force drop to 11 or 10 boats, because it provides little margin for absorbing an unforeseen event that might force an SSBN into an unscheduled and lengthy maintenance action.

The projected minimum level of 11 or 10 boats can be increased to 12 or 11 boats (providing some additional margin for absorbing an unforeseen event that might force an SSBN into an unscheduled and lengthy maintenance action) by accelerating by about one year the planned procurement dates of boats 2 through 12 in the program. Under this option, the second boat in the program would be procured in FY2023 rather than FY2024, the third boat in the program would be procured in FY2025 rather than FY2026, and so on. Implementing this option could affect the Navy's plan for funding the procurement of other Navy shipbuilding programs during the period FY2022-FY2025.

Columbia Class Design

The Columbia-class design (see **Figure 2**) 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. For additional background information on the Columbia-class design, see **Appendix D**.

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.[17] As mentioned earlier, Dreadnought-class SSBNs are to each be armed with

[15] See, for example, Marc Selinger, "Navy Might Someday Consider Buying More Than 12 Columbia-Class Submarines," *Defense Daily*, April 12, 2018: 2-3.

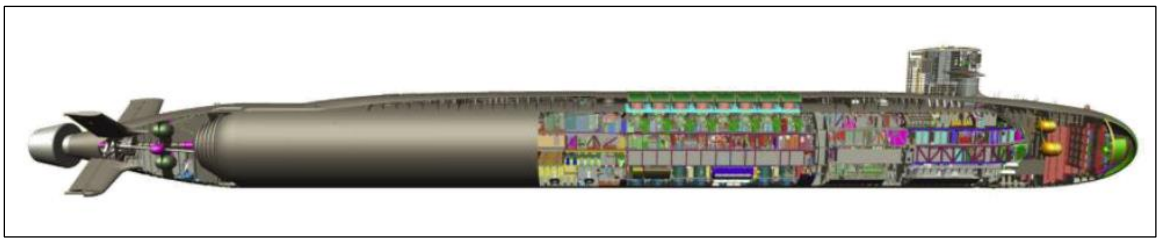
[16] Source: U.S. Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2019*, February 2018, Tables A3-1 through A3-4 on p. 12.

[17] 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

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.[18]

Figure 2. 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.

Program Cost

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 FY2020 budget submission estimates the total procurement cost of the 12-ship class at $109.0 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.[19]
- 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.[20]

compartment that will support both the OHIO Class Replacement and the successor to the UK Vanguard Class."

[18] 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.)

[19] 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.

[20] *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

- A May 2019 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 June 2018 was $103,035.2 million (about $103.0 billion) in constant FY2019 dollars, including $13,103.0 million (about $13.1 billion) in research and development costs and $89,932.2 million (about $89.9 billion) in procurement costs.[21]

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

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.[22]

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.SC. 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**.

Submarine Unified Build Strategy (SUBS)

The Navy, under a plan it calls the Submarine Unified Build Strategy (SUBS), plans to build Columbia-class boats jointly at GD/EB and HII/NNS, with most of the work going to GD/EB. As part of this plan, the Navy is also proposing to adjust the division of work on the Virginia-class attack submarine program (in which boats are jointly built at GD/EB and HII/NNS),[23] so that

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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.)

[21] Government Accountability Office, *Weapon Systems Annual Assessment[:] Limited Use of Knowledge-Based Practices Continues to Undercut DOD's Investments*, GAO-19-336SP, May 2019, p. 123.

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

[23] 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.

HII/NNS would receive a larger share of the work for that program than it has received in the past.[24]

Block Buy Contracting Strategy

A May 13, 2019, press report stated the following:

> Capt. John Rucker, program manager for the Columbia-class program, said on [sic] the program's next contract will be the Block I construction contract. That is expected to cover the first two boats and "we will award that no later than Oct. 1, 2019 to build the ships on schedule," Rucker said at the Navy League's annual Sea Air Space Expo.[25]

Columbia-Class Program Funding

Table 1 shows FY2020-FY2024 funding for the Columbia-class program under the Navy's FY2020 budget submission.

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[24] Key elements of the Navy's proposed 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.

[25] "Columbia Contract," Defense Daily, May 13, 2019. 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 and Moshe Schwartz.

Table 1. Columbia-Class Program Funding

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

	FY20 (req.)	FY21 (proj.)	FY22 (proj.)	FY23 (proj.)	FY24 (proj.)
Department of Defense (DOD) funding					
Research and development (R&D) funding					
PE0603570N/Project 3219	*114.0*	*80.1*	*60.1*	*56.8*	*54.4*
PE0603595N/Project 3220	*419.1*	*313.6*	*196.3*	*171.8*	*187.2*
Subtotal R&D funding	**533.1**	**393.7**	**256.4**	**228.6**	**241.6**
Procurement funding					
Advance procurement (AP)	*1,698.9*	*1,074.8*	*1,136.5*	*1,794.5*	*2,092.3*
Procurement	*0*	*2,846.4*	*3,059.5*	*2,077.1*	*2,697.2*
Subtotal procurement funding	**1,698.9**	**3,921.2**	**4,196.0**	**3,871.5**	**4,789.5**
TOTAL R&D and procurement	**2,232.0**	**4,314.9**	**4,452.4**	**4,100.1**	**5,031.1**
Department of Energy (DOE) funding					
Naval Reactors—Columbia-class reactor systems development	75.5	64.7	55.0	53.9	52.9

Source: Table prepared by CRS based on Navy and Department of Energy FY2020 budget submissions.

Notes: PE means Program Element, that is, a research and development line item. A Program Element may include several projects. **PE0603570N/Project 3219** is the SSBN(X) reactor plant project within the PE for Advanced Nuclear Power Systems. **PE0603595N/Project 3220** is the Sea-Based Strategic Deterrent (SBSD) Advanced Submarine System Development project within the PE for Ohio Replacement.

Issues for Congress

FY2020 Funding Request

One issue for Congress is whether to approve, reject, or modify the Navy's FY2020 funding request for the program. In assessing this question, Congress may consider whether the Navy has accurately priced the work that is proposed to be done with FY2020 funding, as well as broader issues, including those discussed in some of the sections below.

Risk of Cost Growth

Another oversight issue for Congress is the risk of cost growth in the program. As detailed by CBO[26] and GAO,[27] 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.

Navy officials, as discussed earlier, 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

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

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

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

Navy Confidence Level at Milestone B Was Less Than 50%

A January 24, 2017, Navy information paper provided to CRS and CBO in March 2017 stated that, at the time of Milestone B for the Columbia-class program, the Navy had assigned a confidence level of 43% to its estimated procurement cost for the lead ship in the Columbia class and a confidence level of 46% to its estimated average procurement cost for ships 2 through 12 in program. What this meant was that the Navy at the time of Milestone B had calculated that there was more than a 50% chance that the procurement costs of Columbia-class boats would turn out to be greater than what the Navy estimates. The January 24, 2017, Navy information paper stated the following:

> The confidence levels associated with the Milestone B Lead Ship End Cost (Less Plans) and Average Follow Ship End Cost estimate are approximately 43 percent and 46 percent respectively. The risk analysis was performed on 54 parameters influencing shipbuilder labor and material, changes, plans, and government furnished equipment costs.[28]

Reflecting confidence levels that had been calculated at the time of Milestone B, a December 1, 2017, Navy information paper provided the confidence levels and corresponding estimated unit procurement costs shown in **Table 2**.

Navy Confidence Level as of May 2019 Was 50%

Navy officials stated in May 2019 that during the time that has transpired since Milestone B, certain risk elements affecting the calculation of confidence levels have been retired, and that as a result, the Navy's confidence level for its costs estimates had increased to 50%, meaning that the Navy as of May 2019 calculated that there is a 50% chance that the procurement costs of Columbia-class boats will turn out to be greater than what the Navy estimates, and a 50% chance that it will turn out to be less than what the Navy estimates. Navy officials also stated in May 2019 that a confidence level of 50% is where they want the Navy's estimate to be.[29]

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[28] Navy information paper, "Confidence Level of Milestone B Cost Estimate," January 24, 2017, received by CRS and CBO from Navy Legislative Affairs Office, March 1, 2017. A subsequent Navy information paper—"Update on Confidence Level for COLUMBIA Lead Ship and Follow Ship," June 13, 2018, received by CRS and CBO from the Navy Legislative Affairs Office on June 13, 2018—states the following:

> The Milestone B Service Cost Position established January 2017 is the most recent analysis for the COLUMBIA program that updated risk estimates for Lead Ship End Cost less Plans and the Average Follow Ship End Cost. The confidence levels associated with the Milestone B Service Cost Position for Lead Ship End Cost less Plans and Average Follow Ship End Cost estimates are approximately 43% and 46% respectively and are calculated based on 54 parameters.

[29] Source: Navy briefing on Columbia class program for CRS and CBO, May 13, 2019.

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

(dollars figures in billions of constant FY2017 dollars)

Confidence level decile	End cost of lead ship	Average end cost of ships 2-12
30%	$7.8	$6.0
40%	$8.1	$6.3
50%	$8.3	$6.6
60%	$8.6	$6.8
70%	$8.9	$7.1
80%	$9.2	$7.5

Source: Navy information paper dated December 1, 2017, provided by Navy Office of Legislative Affairs to CRS and CBO on December 22, 2017.

Notes: 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….
>
> The Navy currently estimates that the first Columbia would cost $13.4 billion in 2019 dollars and that subsequent ships would have an average cost of $6.7 billion. The total procurement cost for the 12 submarines is $87 billion (which includes appropriations of $4.5 billion from 2017 to 2019), or an average of $7.2 billion for each ship…. Of that amount, $82 billion would be funded between 2020 and 2035. The Navy estimates that research and development costs would amount to $13 billion, bringing the total acquisition cost to $100 billion.
>
> 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 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 (Public Law 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). 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….[30]

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.[31]

Risk of Schedule Delay in Designing and Building Lead Boat

Overview

Another oversight issue for Congress is the risk of technical challenges, funding-related issues (such as lapses in appropriations or restrictions on spending during periods when DOD is funded under continuing resolutions), or industrial-base challenges that could lead to delays in designing and building the lead Columbia-class boat and having it ready for its scheduled initial deterrent patrol in 2031, when it is to deploy in the place of the first retiring Ohio-class SSBN. The schedule for designing and building the lead boat and having it ready for its scheduled first deterrent patrol in 2031 has little slack for absorbing unforeseen delays due to technical challenges or funding-related issues.

Technical Challenges

At least two technical challenges have already occurred in the Columbia-class program, one first reported in 2017 involving an electric motor,[32] and another first reported in 2018 involving faulty

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

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

[32] 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*

welds in the first missile tube sections being built for the lead boat.[33] Navy officials have stated that neither of these challenges jeopardized the lead's 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.[34]

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.[35] 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.

Optimistic Cost Estimate Will Likely Lead to Budget Increases, GAO-19-497, April 2019, p. 19.

[33] 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, 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.

[34] 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.

[35] 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.

Industrial-Base Challenges

Some observers have expressed concern about the 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).[36] 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, as currently planned under the Navy's FY2020 30-year shipbuilding plan, have been heightened by recent 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 time from production of two "regular" Virginia-class boats per year to two VPM-equipped boats per year.

If the industrial base is stressed by its combined Virginia-Columbia workload, the Navy plans to protect the Columbia-class effort by giving it priority. Even so, observers are concerned that demands associated with building Virginia-class boats could nevertheless add risk to the timely execution of the Columbia-class program. The Navy acknowledges that there is risk in this situation, particularly regarding supplier firms, and (as discussed further below) is working to mitigate this risk.[37]

Navy Efforts to Mitigate Schedule Risk

To help mitigate the risk of technical challenges causing delays that threaten the lead boat's 2031 first-patrol date, the Navy has been working to generate additional margin inside the schedule for designing and building the lead boat, so as to provide more ability for absorbing delays and thereby make the schedule less brittle and more resilient.[38] At a March 27, 2019, hearing before the Seapower subcommittee of the Senate Armed Services Committee on Navy shipbuilding programs, Navy officials testified that for the Columbia-class program,

> the Navy is implementing Continuous Production on selected shipyard-manufactured items to reduce cost and schedule risk and help strengthen the industrial base with a focus on critical vendors. Advance Construction activities are set to start in June 2019 at General Dynamics Electric Boat and Huntington Ingalls Industries-Newport News to proactively manage schedule margin and reduce controlling path risks for COLUMBIA.[39]

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[36] 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.

[37] For additional discussion, see, for example, Richard R. Burgess, "Columbia Program Manager: Missile Sub Still on Schedule, But Suppliers Present Biggest Risk for Delay," *Seapower*, October 8, 2019; Daniel P. Taylor, "Smooth Sailing for the Columbia Class?: Navy Working to Keep Sub on Track for 2028 Delivery," *Seapower*, September 26, 2019; Megan Eckstein, "Electric Boat Preparing for Columbia-Class, But Supply Base Remains a Challenge," *USNI News*, September 17, 2019; David B. Larter, "As CNO Richardson Departs, US Submarine Builders Face Pressure," *Defense News*, August 22, 2019; 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. See also David B. Larter, "The US Navy, Seeking Savings, Shakes Up Its Plans for More Lethal Attack Submarines," *Defense News*, April 3, 2019.

[38] See, for example, Megan Eckstein, "PEO Subs Working To Buy Back Schedule in Ohio Replacement Program," *USNI News*, November 1, 2016.

[39] Statement of The Honorable James F. Geurts, Assistant Secretary of the Navy for Research, Development and

The Navy has been working for years to mitigate the risks associated with the Columbia-class design's electric-drive system through a technology-development process that includes testing and validation with land-based component prototypes.[40]

A May 8, 2019, press report states the following:

> The Navy will have the most complete design ever and will be well into construction when the "official start" of construction on the lead Columbia-class ballistic missile submarine occurs on Oct. 1, 2020, the service's program manager said.
>
> Capt. Jon Rucker said this week that his Columbia class of SSBNs is on a tight schedule—not just to deliver the lead ship in time for an October 2030 first patrol, but to deliver each subsequent ship on time for their own patrols too, as the Ohio-class boomers retire in rapid succession. But his program is managing the risks associated with the tight timeline as best as it can, including bumping up quite a bit of work before the construction phase officially begins.
>
> While October 2020 is the official start of construction, Newport News Shipbuilding will kick off its advance construction efforts on June 7, he said, and prime contractor General Dynamics' Electric Boat is already doing prototyping and advance construction work. Whereas lead ship USS Virginia (SSN-774) was only 1 percent complete when its construction officially began, USS Columbia (SSBN-826) will be 11 percent complete, Rucker said while speaking at the Navy League's annual Sea Air Space conference.
>
> "We are trying to get ahead of that curve to de-risk this program so we can achieve that schedule," he said, noting that the Columbia-class boomers would be the largest submarines ever built in the United States.
>
> The approximately 420 ship specifications and requirements are completed, he said, and the 4,100 design arrangements are about 97.5 percent complete. The Navy is already 44 percent through finalizing the 4.650 design disclosures and is on track to be 83 percent done with the disclosures at the start of construction. In comparison, USS Ohio (SSGN-726) was just 2 percent through disclosures when its construction began; USS Seawolf (SSN-575) was 4 percent complete, USS Gerald R. Ford (CVN-78) was 27 percent complete and Virginia was 43 percent complete.
>
> Rucker called this drive to be largely done with the design disclosures—which outline not just the design but the measurements, details about the material, how to build the component and more—an effort to save time and money and to reduce risk, since it will avoid changes later on that will cost time and money.
>
> Rucker also announced that, in support of the propeller and propulsor, which take four to five years to build, "the first component of the lead ship Columbia was poured on May 1. So 175,000 pounds—I won't tell you what it is, I'm not allowed to—175,000 pounds, first component for Columbia, on schedule."
>
> The captain made clear there is still risk in this program, which Navy leadership regularly acknowledges is the service's top priority and will continue to get all the funding it needs,

Acquisition ASN(RD&A) and Vice Admiral William R. Merz, Deputy Chief of Naval Operations for Warfare Systems (OPNAV N9) and Lieutenant General David H. Berger, Deputy Commandant, Combat Development and Integration & Commanding General, Marine Corps Combat Development Command, before the Subcommittee on Seapower of the Senate Armed Services Committee on the Department of the Navy Fiscal Year 2020 Budget Request for Shipbuilding Programs, March 27, 2019, p. 7.

[40] It might also be argued that while developing the electric-drive system involves overcoming certain technical challenges, developing a mechanical-drive system for the Columbia-class program would have involved not-insignificant technical challenges of its own, and in the end might have produced a system that could not meet the Columbia-class's performance requirements, which are more demanding in certain respects than those of the Ohio class.

> but still remains risky due to the tight schedule it's on. Chief of Naval Operations Adm. John Richardson told lawmakers recently that "we are on schedule, but just on schedule. We are on cost, but just on cost."
>
> Rucker said in his speech that "there are risks—however, they are risks that we understand and we're proactively managing."
>
> Perhaps somewhat counterintuitively, the Navy is reducing some schedule risk by adding concurrency to the program—crunching the amount of time between the design process and the construction process in certain areas of the submarine where the design is simpler and needs less time for review before construction begins.
>
> Rucker told USNI News during his presentation that the Navy likes to have 52 weeks between design and construction. However, "there are cases where we made a conscious decision to reduce that down to about 30 to 40 weeks. So we reduced it, but in those areas we are micromanaging it every day as we go through, and so we feel that risk is perfectly manageable. Most of the stuff isn't the complex stuff—it would be like the structural stuff, it's the basic building a deck, building a foundation, building a tank."
>
> Pulling some of this construction ahead despite what on paper looks like more concurrency risk is what will allow the program to reach 11-percent completion before construction officially starts.
>
> "That concurrency is not what you would think that, a person's designing it and they're building it in parallel," Rucker made clear.…
>
> Richardson said in his recent testimony to lawmakers that he and Navy Secretary Richard V. Spencer "have made it very clear that, looking forward and anticipating those things that will inevitably arise during testing and everything in such a complex program, we need to work diligently to build more margin into the program."[41]

GAO Perspective on Schedule Risk

An April 2019 GAO report states the following:

> We found that the Navy continues to experience problems with the electric drive of the integrated power system that could potentially affect construction of the lead submarine. A manufacturing defect that affected the system's first production-representative propulsion motor required extensive repair that consumed 9 months of schedule margin at the land-based test facility. The Navy now plans to test the motor at the same time it had originally scheduled to make any final design changes before starting production. This could constrain opportunities to implement timely, corrective actions if problems are discovered during testing.[42]

More generally, regarding the risk of delays in designing and building the lead boat, the April 2019 GAO report stated the following:

> The Navy's goal is to complete a significant amount of the Columbia class submarine's design—83 percent—before lead submarine construction begins in October 2020. The Navy established this goal based on lessons learned from another submarine program in an effort to help mitigate its aggressive construction schedule. Achieving this goal may prove to be challenging as the shipbuilder has to use a new design tool to complete an increasingly higher volume of complex design products…. The shipbuilder has hired additional designers to improve its design progress. The Navy also plans to start advance construction

[41] Megan Eckstein, "Navy: USS Columbia Will Have Most Complete Design Ever at Official Construction Start," *USNI News*, May 8, 2019.

[42] 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.

> of components in each major section of the submarine, beginning in fiscal year 2019, when less of the design will be complete….
>
> The Navy is attempting to mitigate an aggressive schedule for lead submarine construction by (1) setting a goal to mature a significant amount of the submarine's design prior to the start of construction and (2) beginning advance construction of submarine modules prior to October 2020. The shipbuilder is working to improve design performance and would have to maintain this increased pace to achieve its design goal, which is necessary to mitigate schedule risk associated with constructing the lead submarine. This may prove challenging as it must complete an increasingly higher volume and complexity of design products. At the same time, the Navy is continuing to develop several critical technologies and recent manufacturing defects with the integrated power system and missile tubes are among the challenges that the Navy is facing in ensuring timely delivery of critical components to the shipyard.[43]

A May 2019 GAO report assessing selected major DOD weapon acquisition programs additionally stated the following regarding the Columbia-class program:

> **Technology Maturity**
>
> The Columbia class program identified two critical technologies—a carbon dioxide removal system and the stern area system, the details of which are classified. The program expects the carbon dioxide removal system to reach full maturity in late 2019, while the stern area system is still immature.
>
> In December 2017, we reported that several Columbia class technologies that met GAO's definition of a critical technology element were not identified by the Navy as critical technologies. Specifically, the Navy did not follow best practices for assessing critical technologies. When we applied these best practices, we identified four additional critical technologies that the Navy excluded. These include the integrated power system, the propulsor/coordinated stern, the common missile compartment (CMC), and the nuclear reactor. Of these, only the nuclear reactor is fully mature as of late 2018.
>
> The Navy expects the CMC to reach full maturity in 2019. However, officials reported that in July 2018 the shipbuilder identified significant weld defects in CMC missile tubes from one of three suppliers after the supplier had already delivered seven tubes to the shipyard and installation work had begun, resulting in rework. Officials further report that the shipbuilder found defects affected five additional tubes. Program officials attributed these defects to inexperienced welders and weld inspectors. The Navy estimates that, as of January 2019, the CMC consumed 52 percent of its schedule margin. Should the Navy discover additional CMC deficiencies, the planned construction sequence for the lead submarine will be jeopardized.
>
> Further, manufacturing defects have delayed delivery of the integrated power system's (IPS) first production-representative motor. The Navy plans to recover the motor's schedule margin by testing it while the supplier updates the motor's production design. Consequently, any new deficiencies discovered in testing may require the supplier to modify its design, which could delay the lead ship's IPS motor production schedule.
>
> **Design Stability**
>
> The program office plans to complete the basic and functional design prior to the lead submarine's scheduled construction start, in October 2020. However, Navy officials report the shipbuilder has already begun building sections of the submarine, with 95 percent of the basic and functional design complete—a level slightly below best practices. Further, the Navy has determined that the shipbuilder needs to complete 83 percent of the detail

[43] Government Accountability Office, *Columbia Class Submarine[:] Overly Optimistic Cost Estimate Will Likely Lead to Budget Increases*, GAO-19-497, April 2019, summary page and page 12.

design—the most complex design phases down to the lowest level of the submarine—by October 2020 to meet its cost and schedule goals. Currently, the shipbuilder is behind schedule because it has yet not achieved planned efficiencies with new design software. The shipbuilder increased its design staff by 18 percent in an effort to reach the design goal on schedule. However, the program's plan for achieving design stability is premised on assumptions about the final form, fit, and function of critical technologies—and how those technologies will perform in a realistic environment—that the program has yet to demonstrate.

Production Readiness

By beginning to build sections of the submarine starting in December 2018, the Navy believes that the builder can achieve an aggressive 84-month construction schedule. However, this is 2 years prior to the planned request for fiscal year 2021 authorization to start construction of the lead ship.

Other Program Issues

In a April 2019 report, we made several recommendations to improve the program's cost estimate. Specifically, we found that the program's $115 billion procurement cost estimate is not reliable because its estimate is based on overly optimistic assumptions about the labor hours needed to construct Columbia class submarines and did not include any cost margin in case these assumptions are not met. While the Navy analyzed program cost risks, it did not include enough margin in its estimate for likely cost growth. The Navy plans to update the cost estimate for the lead ship, but it may not complete this update in time for its fiscal year 2021 budget request, which will seek authorization and funding for lead submarine construction.

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 intends to provide needed capabilities on schedule and at an affordable price by committing to stable requirements, achieving high design maturity at the start of construction for the lead submarine, improving manufacturing and construction readiness, and aggressively working to reduce costs. It also said it plans to complete 83 percent of the design by construction start—more than other recent submarine programs. The program also stated that it plans to update its cost estimate in 2019 to inform lead submarine funding. The program noted that the Navy recognizes its supplier base remains a high risk to construction readiness and continues to devote increased oversight on manufacturing issues and readiness assessments. The program said it continues to comply with all Navy, Department of Defense, and statutory requirements for managing critical technologies.[44]

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

[44] Government Accountability Office, *Weapon Systems Annual Assessment[:] Limited Use of Knowledge-Based Practices Continues to Undercut DOD's Investments*, GAO-19-336SP, May 2019, p. 124.

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.

Starting in FY2026, when the Navy plans to procure one Columbia-class boat per year for a period of 10 years, the Navy estimates that the Columbia-class program will require, in constant FY2019 dollars, roughly $7 billion per year in procurement funding.[45] Several years 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. Over the last several years, the Navy's shipbuilding budget has been increased to an annual funding level of roughly $24 billion per year. In a context of a shipbuilding budget of roughly $24 billion per year, a Columbia-class requirement for roughly $7 billion per year does not loom as large proportionately as it once did. Concerns remain, however, about funding that will be available for the procurement of other kinds of ships. The Navy's report on its FY2020 30-year shipbuilding plan states the following:

> The fiscal impact of the new SSBN begins in FY2023 with advanced procurement [funding], and then increases in FY2026 with full annual procurements. This represents Navy's largest fiscal challenge for near-term budgets and could impact the pace of procuring other ship types – potentially causing a drop below the steady profiles [shown elsewhere in this report].[46]

At a March 27, 2019, hearing before the Seapower subcommittee of the Senate Armed Services Committee on Navy shipbuilding programs, Navy officials testified that

> the COLUMBIA Class program remains the Navy's number one acquisition priority program and is on track to start construction in October 2020 and deliver to pace the retirement of our current ballistic missile submarines, deploying for its first patrol in FY 2031. To better align focus and resources and ensure successful delivery of this program to the Fleet, DON has established Program Executive Office COLUMBIA. Additional resources above the Navy's [budget] topline will be required for the Navy to fund serial production of the COLUMBIA Class SSBN and maintain its planned shipbuilding profile.[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**.

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[45] See U.S. Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2020*, Figure A4-1 on p. 18.

[46] See U.S. Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2020*, p. 7. A similar statement appears on page 17. See also Megan Eckstein, "Navy Wants Alternative Funding for Columbia SSBNs to Accelerate 355-Ship Fleet," *USNI News*, November 27, 2018; Rich Abott, "Navy Looking For Separate Funding For Columbia Subs," *Defense Daily*, November 30, 2018.

[47] Statement of The Honorable James F. Geurts, Assistant Secretary of the Navy for Research, Development and Acquisition ASN(RD&A) and Vice Admiral William R. Merz, Deputy Chief of Naval Operations for Warfare Systems (OPNAV N9) and Lieutenant General David H. Berger, Deputy Commandant, Combat Development and Integration & Commanding General, Marine Corps Combat Development Command, before the Subcommittee on Seapower of the Senate Armed Services Committee on the Department of the Navy Fiscal Year 2020 Budget Request for Shipbuilding Programs, March 27, 2019, p. 6.

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 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.

Legislative Activity for FY2020

Summary of Congressional Action on FY2020 Funding Request

Table 3 below summarizes congressional action on the Navy's FY2020 funding request for the Columbia-class program.

[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.

Table 3. Congressional Action on FY2020 Funding Request

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

		Authorization			Appropriation		
	Request	HASC	SASC	Conf.	HAC	SAC	Conf.
Department of Defense (DOD) Funding							
Research and development (R&D)							
PE0603570N (line 046)/Project 3219	114.0	114.0	114.0		114.0	114.0	
PE0603595N (line 051)/Project 3220	419.1	419.1	434.1		419.1	434.1	
Subtotal R&D	***533.1***	***533.1***	***548.1***		***533.1***	***548.1***	
Advance procurement (AP)	**1,698.9**	**1,823.9**	**1,823.9**		**1,612.0**	**1,821.9**	
TOTAL DOD Funding	**2,232.0**	**2,357.0**	**2,372.0**		**2,145.1**	**2,370.0**	
Department of Energy (DOE) funding							
Naval Reactors—Columbia-class reactor systems development	75.5	75.5	75.5		75.5	75.5	

Source: Navy FY2020 budget submission and committee and conference reports, explanatory statements on FY2020 National Defense Authorization Act and FY2020 DOD Appropriations Act, and (for appropriations figures for DOE Naval Reactors funding), committee and conference reports on the FY2020 Energy and Water Development and Related Agencies Appropriations Act.

Notes: PE means Program Element, that is, a research and development line item. A Program Element may include several projects. **PE0603570N/Project 3219** is the SSBN(X) reactor plant project within the PE for Advanced Nuclear Power Systems. **PE0603595N/Project 3220** is the Sea-Based Strategic Deterrent (SBSD) Advanced Submarine System Development project within the PE for Ohio Replacement. **HASC** is House Armed Services Committee; **SASC** is Senate Armed Services Committee; **HAC** is House Appropriations Committee; **SAC** is Senate Appropriations Committee; **Conf.** is conference agreement. SCN is Shipbuilding and Conversion, Navy; NSBDF is National Sea-Based Deterrence Fund. The procurement funding requested for FY2018 is advance procurement (AP) funding.

FY2020 National Defense Authorization Act (H.R. 2500/S. 1790)

House

The House Armed Services Committee, in its report (H.Rept. 116-120 of June 19, 2019) on H.R. 2500, recommended the funding levels shown in the HASC column of **Table 3**. The recommended increase of $125.0 million in advance procurement (AP) funding is for "Submarine supplier development." (Page 378)

Section 809 of H.R. 2500 as reported by the committee states the following:

> SEC. 809. APPLICATION OF MISCELLANEOUS TECHNOLOGY BASE POLICIES AND PROGRAMS TO THE COLUMBIA-CLASS SUBMARINE PROGRAM.
>
> Notwithstanding subchapter V of chapter 148 of title 10, United States Code (except for sections 2534, 2533a, and 2533b of such title), for a period of one year beginning on the date of the enactment of this Act, the milestone decision authority (as defined in section 2366a of title 10, United States Code) for the Columbia-class submarine program shall ensure that such program maintains the schedule approved under the Milestone B approval (as defined in such section).

H.Rept. 116-120 states the following:

> *Classified Briefing on Funding Requirements for Strategic Weapons Systems*

> The committee notes the Navy provides the most survivable leg of the triad with Ohio Class SSBNs and the Trident II (D5) strategic weapon systems (SWS) they carry. SSBNs are responsible for a significant majority of the United States' operationally deployed nuclear warheads. The Chief of Naval Operations has made clear the priority the Navy places on the sustainment and modernization of the undersea leg of the triad, directing the Navy to ''be ready to deploy USS Columbia (SSBN 826) as quickly as possible-beating the current schedule-in order to preserve our ability to defeat the threat.''
>
> If critical and necessary programs such as Increment 8 are further delayed due to funding issues, the Columbia class will be without critical subsystems such as a navigator and the United States will fail to meet international commitments to the United Kingdom under the Polaris Sales Agreement by not delivering inertial navigation equipment to the United Kingdom Shipyard in 2025.
>
> If critical and necessary programs such as Increment 15 are further delayed due to funding issues, future integration on the Columbia and Dreadnought systems and delivery of a required network cross-domain solution capability to meet DOD cyber requirements will not be met in time. Elimination of this funding will result in significant obsolescence-related risk to the Ohio fire control system in addition to increasing cybersecurity-related risk.
>
> Proposed reductions in Navy Strategic Systems Programs (SSP) support equipment impacts include additional maintenance costs on the current support equipment and an increase in the risk of being able to support missile processing and disposal requirements at the strategic weapon facilities. This, in turn, increases the risk of being unable to support SSBN onload/offload requirements.
>
> If the Life Extension 2 funding cuts are sustained, the Navy's ability to field the next life extended missile on the Columbia Class is at significant risk. Additionally, the delay in schedule could impact international agreements with the United Kingdom as that government will procure the TRIDENT II D5LE2 SWS missiles for their Dreadnought platform.
>
> The committee directs the Secretary of the Navy to provide a classified briefing to the House Committee on Armed Services no later than December 1, 2019, on the ramifications of failing to adequately fund its strategic weapons system. (Page 17)

Senate

The Senate Armed Services Committee, in its report (S.Rept. 116-48 of June 11, 2019) on S. 1790, recommended the funding levels shown in the SASC column of **Table 3**. The recommended increase of $15.0 million for PE0603595N (line 051)/Project 3220 is for "Accelerate advanced propulsor development." (Page 489) The recommended increase of $125.0 million in advance procurement (AP) funding is for "Submarine industrial base expansion." (Page 432) S.Rept. 116-48 further states the following:

> **Columbia-class submarines**
>
> The budget request included $20.3 billion in Research, Development, Test, and Evaluation (RDT&E), Navy, of which $419.1 million was for PE 63595N Columbia-class submarines.
>
> The committee understands that additional funding could enable reductions in the production time and cost of propulsor components for Columbia-class submarines through development of composites technology.
>
> Accordingly, the committee recommends an increase of $15.0 million, for a total of $434.1 million, in RDT&E, Navy, for PE 63595N. (Page 82)

S.Rept. 116-48 further states the following:

> **Columbia-class submarine advance procurement**
>
> The budget request included $1. 7 billion in line number 1 of Shipbuilding and Conversion, Navy (SCN), for Columbia-class submarine advance procurement.
>
> The committee believes that expanding the capabilities of the second- and third-tier contractors in the submarine industrial base should lead to greater cost savings and improved efficiency as production increases to meet the Columbia-class procurement schedule and higher requirement for Virginia-class attack submarines in the Navy's latest Force Structure Assessment.
>
> The committee notes that the budget request includes some funding for submarine industrial base expansion to ensure that second- and third-tier contractors are able to meet increased production requirements. The committee understands that an additional $125.0 million could be executed to further address such requirements.
>
> Therefore, the committee recommends an increase of $125.0 million in line number 1 of SCN for Columbia-class submarine advance procurement.
>
> The committee directs the Secretary of the Navy to notify the congressional defense committees, in writing, within 30 days of obligating funds provided for submarine industrial base expansion. The notification shall include: obligation date, contractor name or names, location, description of the shortfall to be addressed, actions to be undertaken, desired end state, usable end items to be procured, period of performance, dollar amount, projected associated savings including business case analysis if applicable, contract name, and contract number. (Page 21)

Regarding a defense-wide (rather than Navy) research and development account funding line item that is not shown in **Table 3**, S.Rept. 116-48 states the following:

> **Submarine industrial base workforce development**
>
> The budget request included $92.1 million in Research, Development, Test, and Evaluation (RDT&E), Defense-wide, for PE 61120D8Z National Defense Education Program.
>
> The committee notes the current shortfall in Columbia-class technical workforce and supports increased submarine industrial base workforce training and education to make up for this shortfall.
>
> Therefore, the committee recommends an increase of $10.0 million, for a total of $102.1 million, in RDT&E, Defense-wide, for PE 61120D8Z for submarine industrial base workforce development. (Page 97)

S.Rept. 116-48 also states the following:

> **Columbia-class schedule**
>
> The committee continues to have great interest in actions taken by the Department of Defense (DOD) to develop, build, and deploy Columbia-class ballistic missile submarines.
>
> The committee notes that a Government Accountability Office (GAO) report, published on April 8, 2019, titled "Columbia Class Submarine: Overly Optimistic Cost Estimate Will Likely Lead To Budget Increases" (GA0-19-947), found that challenges with critical new systems, including the integrated power system and common missile compartment, have eroded available lead ship schedule margin such that there is less time available to address issues without resulting in overall lead ship schedule delays.
>
> The committee is concerned by these challenges, as well as several other findings in this report, and the associated potential for delays in delivering the lead ship of the Columbia-class in fiscal year 2028 and deploying the lead ship in fiscal year 2031.

> The committee also notes that the GAO published a report on June 6, 2018, titled "Navy Shipbuilding: Past Performance Provides Valuable Lessons for Future Investments" (GA0-18-238SP), which assessed Navy shipbuilding performance over the past 10 years and found that each of the 8 most recently delivered lead combatant ships (CVN-78, DDG-1000, LCS-1, LCS-2, LHA-6, LPD-17, SSN-774, and SSN-775) was delivered to the fleet at least 6 months late and 5 of these 8 lead ships were delayed by more than 2 years.
>
> Therefore, not later than December 1, 2019, the committee directs the Secretary of the Navy to submit a report to the congressional defense committees on the Columbia-class schedule and impact of potential lead ship delays. The report shall include a description of the: (1) Current schedule margin and critical path(s) for the lead ship in order to meet planned delivery and deployment dates; (2) Potential risks to the lead ship schedule, including the associated potential schedule impact for each such risk; (3) Potential operational impacts, shipbuilding impacts, and mitigation options if the lead ship delivery date is delayed by 6 months, 12 months, 2 years, or 3 years; and (4) Recommendations for congressional or DOD action to reduce the likelihood or mitigate the impact of potential lead ship schedule delays. (Page 43)

S.Rept. 116-48 also states the following:

> **Supporting and expanding the submarine sub-contracting industrial base**
>
> The committee believes that expanding the capability and capacity of the submarine industrial base workforce is imperative to keeping pace with Navy shipbuilding requirements. Numerous manufacturing capabilities must be addressed, including the need for more qualified and Navy-certified welders.
>
> The committee is concerned that the Navy-certified welding workforce may be insufficient to meet Navy demands on time with the required quality. The committee understands that Navy-certified welders must undergo significant training and possess a higher level of job skills compared to the standard welding workforce. The committee further understands that the welding of high strength submarine steel requires welders to be qualified to MILSTD-1688 and that this work must be performed in Navy-certified facilities.
>
> The committee is aware of the need to support the specific skill sets necessary to enable the Navy to achieve the submarine build plan. The committee encourages the Navy to conduct a thorough assessment of the current workforce and produce a plan for closing the gaps in capability and capacity. (Page 54)

FY2020 DOD Appropriations Act (H.R. 2968/S. 2474)

House

The House Appropriations Committee, in its report (H.Rept. 116-84 of May 23, 2019) on H.R. 2968, recommended the funding levels for the Columbia-class program shown in the HAC column of the DOD funding portion of **Table 3**. The recommended reduction of $86.918 million in advance procurement (AP) funding is for "Plans excess growth" ($66.461 million), "Missile tube continuous production early to need" ($19.477 million), and "Shipyard manufactured items continuous production early to need" ($0.98 million). (Page 175)

In H.R. 2968 as reported by the committee, the paragraph that makes appropriations for the Shipbuilding and Conversion, Navy (SCN) appropriations account includes this provision:

> … *Provided further*, That funds appropriated or otherwise made available by this Act for production of the common missile compartment of nuclear-powered vessels may be available for multiyear procurement of critical components to support continuous production of such compartments only in accordance with the provisions of subsection (i)

> of section 2218a of title 10, United States Code (as added by section 1023 of the National Defense Authorization Act for Fiscal Year 2017 (Public Law 114–328)).

Senate

The Senate Appropriations Committee, in its report (S.Rept. 116-103 of September 12, 2019) on S. 2474, recommended the funding levels for the Columbia-class program shown in the SAC column of the DOD funding portion of **Table 3**. The recommended increase of $123.0 million in advance procurement (AP) funding is for "Program increase: Submarine industrial base expansion." (Page 120) The recommended increase of $15.0 million for line 51 is for "Program increase: Materials for submarine propulsor applications." (Page 187)

In S. 2474 as reported by the committee, the paragraph that makes appropriations for the Shipbuilding and Conversion, Navy (SCN) appropriations account includes this provision:

> … *Provided further*, That funds appropriated or otherwise made available by this Act for Ohio Replacement Submarine (AP) may be available for the purposes authorized by subsections (f), (g), (h) or (i) of section 2218a of title 10, United States Code, only in accordance with the provisions of the applicable subsection….

S.Rept. 116-103 states:

> *Congressional Reporting on Submarine Construction Programs*.—Consistent with direction accompanying the Department of Defense Appropriations Act, 2016, the Assistant Secretary of the Navy (Research, Development and Acquisition) submits to the congressional defense committees quarterly reports describing actions the Navy is taking to minimize costs on the Virginia Payload Module [VPM] program. Additionally, the Program Executive Officer, Submarines provides quarterly construction metrics on the Columbia Class Submarine, Virginia Class Submarine and VPM programs. The Committee directs the Assistant Secretary of the Navy (Research, Development and Acquisition) to consolidate and update these reporting requirements in accordance with congressional guidance regarding key metrics for these programs beginning in the second quarter, fiscal year 2020. (Page 121)

S.Rept. 116-103 also states:

> *Submarine Workforce Development*.—The Committee notes the need to enhance the workforce pipeline for manufacturing in the defense sector for certain technical professions, including welding, pipefitting, electrical, machining, shipfitting, carpentry, and others specialties to support the 2018 National Defense Strategy. The Committee believes that expanding and improving the capability and capacity of the submarine industrial base workforce is critical to keep pace with current Navy shipbuilding programs. However, the Committee is concerned that the Navy-certified welding workforce may be insufficient to meet Navy demands for the submarine build plan on time with the required quality. In particular, the Committee notes the current shortfall in the Virginia and Columbia- class technical workforce and supports increased submarine industrial base workforce training and education to address this shortfall. Therefore, the Committee recommends an increase of $8,000,000 in Research, Development, Test and Evaluation, Defense-Wide for submarine workforce development, and directs the Secretary of Defense to work with the Secretaries of Labor, Education, and Commerce to develop and implement a strategy for strengthening the workforce pipeline for critical defense industries, including new submarine construction. (Pages 166-167)

FY2020 Energy and Water Development and Related Agencies Appropriations Act (H.R. 2960/S. 2470)

House

The House Appropriations Committee, in its report (H.Rept. 116-83 of May 23, 2019) on H.R. 2960, recommended the funding level for the Columbia-class program shown in the HAC column of the DOE funding portion of **Table 3**.

Senate

The Senate Appropriations Committee, in its report (S.Rept. 116-102 of September 12, 2019) on S. 2470, recommended the funding level for the Columbia-class program shown in the HAC column of the DOE funding portion of **Table 3**. S.Rept. 116-102 states:

> *COLUMBIA*-CLASS REACTOR SYSTEMS DEVELOPMENT
>
> The Committee recommends $75,500,000 for *Columbia*-Class Reactor Systems Development. *Columbia*-class submarines are vital to maintain our survivable deterrent. The Committee remains concerned about on-time delivery of the first *Columbia*-Class submarine, in part because Naval Reactors claims to have the same amount of schedule margin despite multiple challenges in the propulsion plant. The Committee directs Naval Reactors to provide quarterly updates to the Committees on Appropriations for both Houses of Congress on the progress of the propulsion plant. (Page 129)

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.[54] 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

[54] 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.[55] 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.[56] The Navy testified in

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

[56] 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."[57]

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.[58]

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."[59] The first new boat is to be delivered by 2028, or about four years later than previously planned.[60]

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[61] 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."[62] 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.

[57] 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.

[58] *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.

[59] *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.

[60] *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.

[61] 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.

[62] 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.[63]

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."[64]

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."[65]

[63] 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.

[64] 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.

[65] 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).[66] 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[67] and approved by DOD's Joint Requirements Oversight Committee (JROC) on June 20, 2008.[68] 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.[69] The Navy established an Columbia-class program office at about this same time.[70]

The AOA reportedly began in the summer or fall of 2008.[71] 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.[72] The AOA concluded that a new-design SSBN was the best option for replacing the Ohio-class SSBNs. (For

[66] 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.)

[67] 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.)

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

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

[70] 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.

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

[72] *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.[73]

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

[73] 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.[74]

[74] *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.[75]
- Unlike the Ohio-class design, which requires a midlife nuclear refueling,[76] 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).[77] 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.[78]
- 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)[79] of 43 feet, compared to 42 feet on the Ohio-class design,[80] and a length of 560 feet, the same as that of the Ohio-class design.[81]

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[75] 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.

[76] 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.

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

[78] 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.

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

[80] 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.

[81] 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.[82] 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."[83]

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.

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

[83] 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.[84]

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.[85] 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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[84] "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/.

[85] 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.[86]

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.

[86] 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.[87]

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:

[87] 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.[88]

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.[89]

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:

[88] Source: Transcript of hearing.

[89] 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.[90]

[90] 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.

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 P.L. 114-92, P.L. 114-328, and P.L. 115-91

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), and Section 1022 of the FY2018 National Defense Authorization Act (H.R. 2810/P.L. 115-91 of December 12, 2017) 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, 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...."[91] 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....
>
> ... 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

[91] 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.

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.[92]

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[92] 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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