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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, previously known as the Ohio replacement program (ORP) or SSBN(X) program, is a program to design and build a new class of 12 ballistic missile submarines (SSBNs) to replace the Navy's current force of 14 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 FY2019 budget requests $3,005.3 million in advance procurement (AP) funding and $704.9 million in research and development funding for the program.

The Navy as of January 2017 estimated the procurement cost of the lead ship in the 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. A March 2017 GAO report assessing selected major Department of Defense (DOD) weapon acquisition programs stated that the estimated total acquisition cost of the Columbia-class program is $100,221.9 million (about $100.2 billion) in constant FY2017 dollars, including $12,648.1 million (about $12.6 billion) in research and development costs and $87,426.5 million (about $87.4 billion) in procurement costs. Observers are concerned about the impact the Columbia-class program will have on the Navy's ability to fund the procurement of other types of ships at desired rates in the 2020s and early 2030s.

Issues for Congress for the Columbia-class program for FY2019 include the following:

- whether to approve, reject, or modify the Navy's FY2019 funding requests for the program;
- cost, schedule, and technical risk in the Columbia-class program; and
- the prospective affordability of the Columbia-class program and its potential impact on funding available for other Navy programs.

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 (name redacted), discusses the Columbia class as an element of future U.S. strategic nuclear forces in the context of strategic nuclear arms control agreements.

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Introduction

This report provides background information and potential oversight issues for Congress on the Columbia-class program, a program to design and build a new class of 12 ballistic missile submarines (SSBNs) to replace the Navy's current force of 14 Ohio-class SSBNs. The program was previously known as the Ohio replacement program (ORP) or SSBN(X) program. 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 FY2019 budget requests $3,005.3 million in advance procurement (AP) funding and $704.9 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 (name redacted) .

This report focuses on the Columbia-class program as a Navy shipbuilding program. Another CRS report discusses the Columbia class as an element of future U.S. strategic nuclear forces in the context of strategic nuclear arms control agreements.[1]

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).[2] The SSNs and SSGNs are multi-mission ships that perform a variety of peacetime and wartime missions.[3] They do not carry nuclear weapons.[4]

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[1] CRS Report RL33640, *U.S. Strategic Nuclear Forces: Background, Developments, and Issues*, by (name redacted)

[2] 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 non-nuclear powered submarines, which are powered by energy sources such as diesel engines. A submarine's use of nuclear or non-nuclear 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 non-nuclear-powered submarine can be armed with nuclear weapons.

[3] These missions include covert intelligence, surveillance, and reconnaissance (ISR), much of it done for national-level (as opposed to purely Navy) purposes; covert insertion and recovery of special operations forces (SOF); covert strikes against land targets with the Tomahawk cruise missiles; covert offensive and defensive mine warfare; anti-submarine warfare (ASW); and anti-surface ship warfare. The Navy's four SSGNs, which are converted former SSBNs, can carry larger numbers of Tomahawks and SOF personnel than can the SSNs. SSGN operations consequently may focus more strongly on Tomahawk and SOF missions than do SSN operations. 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 (name redacted) , and CRS Report RS21007, *Navy Trident Submarine Conversion (SSGN) Program:* (continued...)

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 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.[5] 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,"[6] 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.[7]

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 SLBMs. A total of 18 Ohio-class SSBNs were procured in FY1974-FY1991. The ships entered service in 1981-1997. The boats 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.

(...continued)

Background and Issues for Congress, by (name redacted) .

[4] The Navy's non-strategic 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 at some point in the future with nuclear-armed Tomahawk land attack missiles (TLAM-Ns) should conditions warrant. Navy TLAM-Ns were placed in storage to support this option. DOD's report on the 2010 Nuclear Posture Review (NPR), released on April 6, 2010, states that the United States will retire the TLAM-Ns. (Department of Defense, *Nuclear Posture Review Report*, April 2010, pp. xiii and 28.)

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

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

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

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.

Ohio-class SSBNs are designed to each carry 24 SLBMs, although 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.

The first 8 boats in the class were originally armed with Trident I C-4 SLBMs; the final 10 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 4 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 4 boats, and to bolster the U.S. SSN fleet. The first 4 Ohio-class boats were converted into SSGNs in 2002-2008,[8] and the 4 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.

Eight of the 14 Ohio-class SSBNs are homeported at Bangor, WA, in Puget Sound; the other 6 are homeported at Kings Bay, GA, close to the Florida border.

Unlike most Navy ships, which are 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.

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.

[8] For more on the SSGN conversion program, see CRS Report RS21007, *Navy Trident Submarine Conversion (SSGN) Program: Background and Issues for Congress*, by (name redacted) .

The Navy has initiated a program to refurbish and extend the service lives of D-5 SLBMs to 2042 "to match the OHIO Class submarine service life."[9]

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

SSBNs are also operated by the United Kingdom, France, Russia, China, and India. 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.[10] The UK plans to replace the four Vanguard-class boats with three or four next-generation SSBNs, previously called Successor-class SSBNs and now called Dreadnought-class SSBNs.[11] Dreadnought-class boats are to be equipped with 12 missile launch tubes, but current UK plans call for each boat to carry eight D-5 SLBMs, with the other four tubes not being used for SLBMs. The United States is providing technical assistance to the United Kingdom for the Dreadnought-class program; 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.[12]

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 single or sole source suppliers. For nuclear-propulsion component suppliers, an additional source of stabilizing work is the Navy's nuclear-powered aircraft carrier construction program.[13]

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.

[9] 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. 4.

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

[11] On October 21, 2016, the UK Ministry of Defence announced that the first of its planned new SSBNs will be named Dreadnought, and the class will be referred to as the Dreadnought class. See Jon Rosamond, "U.K. Revives Dreadnought Name for Successor SSBNs," *USNI News*, October 21, 2016.

[12] 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 (name redacted).

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

Columbia-Class Program

Program Name

For several years, the Columbia-class program was known as the Ohio replacement program (ORP) or SSBN(X) program,[14] and boats in the class were referred to as Ohio replacement boats or SSBNXs. On July 28, 2016, it was reported that the first boat in the class will be named *Columbia* in honor of the District of Columbia.[15] As a consequence, the program is now referred to as the Columbia-class program, and the boats are referred to as Columbia-class boats. Terms such as Ohio replacement boat, Ohio replacement program, ORP, and SSBNX may continue to be used as well, at least for some time.

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. For more on the Columbia-class program's origin and early 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.
- Fourteen Ohio-class boats are needed to meet this requirement because, during the middle years of the Ohio class life cycle, three and sometimes four of the boats are non-operational at any given moment on account of being in the midst

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

[15] Sam LaGrone, "Navy Ohio Replacement Sub Class to Be Named for D.C.," *USNI News*, July 28, 2016. See also Jacqueline Klimas, "Navy's Next Sub Class to Be Named after D.C.," *Washington Examiner*, July 29, 2016, and "Document: Notice to Congress on 8 Proposed Navy Ship Names," *USNI News*, August 3, 2016. The July 28, 2016, press report states the following:

> While the name Columbia for a U.S. ships and aircraft is not new—at least eight U.S. ships, a Space Shuttle and the Apollo 11 command module have all shared the name—it will be the first time the name has been used to commemorate the U.S. capital, the sources told USNI News.
>
> The fleet's current USS Columbia (SSN-771)—a Los Angeles attack submarine—is named in honor of Columbia, S.C., Columbia, Ill and Columbia, Mo. The submarine is expected to decommission before the first SSBN(X) enters service.
>
> Other ships in the fleet were named after the romantic female personification of the Americas—Columbia.

of lengthy midlife nuclear refueling overhauls or other extended maintenance actions.

- Twelve (rather than 14) Columbia-class boats will be needed to meet the requirement for 10 operational boats because the midlife overhauls of Columbia-class boats, which will not include a nuclear refueling, will require less time (about 2 years) than the midlife refueling overhauls of Ohio-class boats (which require about 4 years from contract award to delivery),[16] the result being that only 2 Columbia-class boats (rather than 3 or sometimes 4) 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.[17]

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 first boat would be delivered in FY2027, the second in FY2030, and the remaining 10 at a rate of one per year from FY2032 through FY2041. (After being delivered in FY2027, the first 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 11 boats in FY2030-FY2036 and then to 10 boats in FY2037-FY2040, and then increase back to 11 boats in FY2041 and 12 boats in FYFY2042.[18]

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.[19] (See also "Planned Procurement Quantity" above.) The minimum level of 11 or 10 boats can be increased to 12 or 11 boats (providing some margin for absorbing an unforeseen event that might force an SSBN into an unscheduled and lengthy maintenance action) by accelerating by

[16] Navy budget submissions show that Ohio-class midlife nuclear refueling overhauls have contract-award-to-delivery periods generally ranging from 47 months to 50 months.

[17] Source: Navy update briefing on Columbia-class program to CRS and CBO, September 17, 2012. See also "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/.

[18] 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.

[19] Source: Navy update briefing on Columbia-class program to CRS and CBO, September 17, 2012. A September 28, 2012, press report similarly quotes Rear Admiral Barry Bruner, the Navy's director of undersea warfare, as stating that "During this time frame, no major SSBN overhauls are planned, and a force of 10 SSBNs will support current at-sea presence requirements," and that "This provides a low margin to compensate for unforeseen issues that may result in reduced SSBN availability. The reduced SSBN availability during this time frame reinforces the importance of remaining on schedule with the Columbia-class program to meet future strategic requirements. As the Ohio Replacement ships begin their midlife overhauls in 2049, 12 SSBNs will be required to offset ships conducting planned maintenance." (Michael Fabey, U.S. Navy Defends Boomer Submarine Replacement Plans," *Aerospace Daily & Defense Report*, September 28, 2012: 3.)

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

Some Key Design Features

The design of the Columbia class, now being developed (see **Figure 2**), will reflect the following:

- The Columbia class is to be designed for a 42-year expected service life.[20]
- Unlike the Ohio-class design, which requires a midlife nuclear refueling,[21] 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).[22] 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.[23]
- 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)[24] of 43 feet, compared to 42 feet on the Ohio-class design,[25] and a length of 560 feet, the same as that of the Ohio-class design.[26]

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[20] 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.

[21] 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.

[22] U.S. Navy, *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY 2011*, February 2010, p. 5. The two most recent classes of SSNs—the Seawolf (SSN-21) and Virginia (SSN-774) class boats—are built with cores that are expected to be sufficient for their entire 33-year expected service lives.

[23] 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.

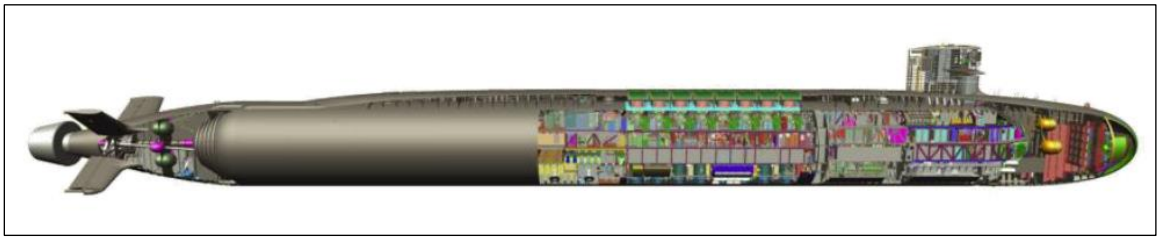
[24] Beam is the maximum width of a ship. For Navy submarines, which have cylindrical hulls, beam is the diameter of the hull.

[25] 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.

- Instead of 24 SLBM launch tubes, as on the Ohio-class design, the Columbia class is to have 16 SLBM launch tubes. (For further discussion of the decision to equip the boat with 16 tubes rather than 20, see **Appendix D**.)
- Although the Columbia class is to have fewer launch tubes than the Ohio-class SSBN, it is to be larger than the Ohio-class SSBN design, with a reported submerged displacement of 20,815 tons (as of August 2014), compared to 18,750 tons for the Ohio-class design.[27]
- 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."[28]

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.

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,[29] accommodations for 155 personnel, and a common submarine radio room[30] tailored to the SSBN mission."[31]

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

(...continued)

[26] Sydney J. Freedberg, "Navy Seeks Sub Replacement Savings: From NASA Rocket Boosters To Reused Access Doors," *Breaking Defense* (http://breakingdefense.com), April 7, 2014.

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

[28] 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.

[29] 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).

[30] 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.

[31] 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.

Common Missile Compartment (CMC)

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.[32] As mentioned earlier, Dreadnought-class SSBNs are to each be armed with eight D-5 SLBMs, or half the number to be carried by the Columbia class. The modular design of the CMC will accommodate this difference.

Since the UK's first Vanguard-class SSBN was originally projected to reach the end of its service life in 2024—three years before the first Ohio-class SSBN is projected to reach the end of its service life—design work on the CMC began about three years sooner than would have been required to support the Columbia-class program alone. The UK has provided some of the funding for the design of the CMC, including a large portion of the initial funding.[33] Under the October 2010 UK defense and security review report (see **Appendix B**), the UK now plans to deliver its first Dreadnought class SSBN in 2028, or about four years later than previously planned.

Program Cost

Acquisition Cost

The Navy as of 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.[34] 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,

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

[33] A March 2010 Government Accountability office (GAO) report stated the following:

> According to the Navy, in February 2008, the United States and United Kingdom began a joint effort to design a common missile compartment. This effort includes the participation of government officials from both countries, as well as industry officials from Electric Boat Corporation and BAE Systems. To date, the United Kingdom has provided a larger share of funding for this effort, totaling just over $200 million in fiscal years 2008 and 2009.
>
> (Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-10-388SP, March 2010, p. 152.)

A March 2011 GAO report stated the following:

> The main focus of OR [Ohio Replacement program] research and development to date has been the CMC. The United Kingdom has provided $329 million for this effort since fiscal year 2008. During fiscal years 2009 and 2010, the Navy had allocated about $183 million for the design and prototyping of the missile compartment.
>
> (Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-11-233SP, March 2011, p. 147.)

A May 2010 press report stated that "the UK has, to date, funded the vast majority of [the CMC's] upfront engineering design activity and has established a significant presence in Electric Boat's Shaw's Cove CMC design office in New London, CT." (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.)

[34] 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.

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.[35]

A November 6, 2017, press report states the following:

> The Columbia-class ballistic missile submarine program (SSBN-826) is coming down in cost and staying on schedule despite an early challenge, program officials said last week.
>
> After moving into engineering and manufacturing development (EMD) at the beginning of 2017 and beginning early construction prototyping activities, the SSBN program is proving it can leverage all the tools at its disposal to take cost and schedule out of the Navy's top acquisition priority.
>
> The program was giving a $8-billion affordability cap, and when the Milestone B decision was made in January to move into EMD, the program was sitting at about $7.3 billion for the average procurement unit cost (APUC) across all 12 planned submarines, Program Executive Officer for Submarines Rear Adm. Michael Jabaley said at the Naval Submarine League's annual conference.
>
> "Through innovative legislative authority and contracting techniques, we've already reduced cost by $80 million per hull, to bring APUC down to $7.21 (billion)," Jabaley said.
>
> "So that was a combination of missile tube continuous production … and advance construction, which is pulling key construction activities to the left. Really the focus of that was to reduce the risk of not delivering on time, but it had an added benefit of savings as well."...
>
> Jabaley said the Navy still hopes for a few additional authorities, including continuous production for components beyond the missile tubes–but leveraging the existing authorities plus potentially adding a few more creates a situation where "we have the ability to get the APUC below $7 billion. That is a stretch goal, but again, as I said, when you understand that the cost of this program is significant, then we really need to do everything we can to buy margin back into the program both in terms of cost and schedule."
>
> Jabaley would not elaborate on what other authorities he wanted from Congress, but he told USNI News that "what you always have to balance is the opportunity cost, because nothing comes for free–all of those efforts require investment in the near-term. You have to put money in to pull activities to the left, to smooth the workload at the shipbuilders and the vendors, and you get it back in savings beyond the [five-year Future Years Defense Program], but from a budgetary standpoint that's money you have to invest and you can't buy something else, whether it's another ship, another squadron of airplanes, whatever. So those trades are made all the time, first in the Navy. The work that we do

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

> with Congress is to ensure they understand what our intention is, and then if necessary provide the legislative authority to do it."[36]

A March 2017 GAO report assessing selected major DOD weapon acquisition programs stated that the estimated total acquisition cost of the Columbia-class program is $100,221.9 million (about $100.2 billion) in constant FY2017 dollars, including $12,648.1 million (about $12.6 billion) in research and development costs and $87,426.5 million (about $87.4 billion) in procurement costs.[37]

The above cost figures do not include costs for refurbishing D-5 SLBMs so as to extend their service lives to 2042.

Operation and Support (O&S) Cost

The Navy as of January 2017 estimates the average annual operation and support (O&S) cost of each Columbia class boat at $119 million per year.[38]

National Sea-Based Deterrence Fund

Created by P.L. 113-291; Amended by P.L. 114-92

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).

Section 1022 of the FY2016 National Defense Authorization Act (S. 1356/P.L. 114-92 of November 25, 2015) amended 10 U.S.C. 2218a to provide additional acquisition authorities for the NSBDF. Section 1023 of the FY2017 National Defense Authorization Act (S. 2943/P.L. 114-328 of December 23, 2016 further amended 10 U.S.C. 2218a to provide further acquisition authorities for the NSBDF. The text of 10 U.S.C. 2218a, as amended by P.L. 114-92 and P.L. 114-328, 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.

[36] Megan Eckstein, "Columbia Class Ballistic Missile Sub On Schedule, Down to $7.2 Billion Apiece," *USNI News*, November 6, 2017. See also Richard Abott, "Navy Reduced Columbia Submarine Cost By $80 Million Per Unit," *Defense Daily*, November 9, 2017: 4-5.

[37] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapons Programs*, GAO-17-333SP, March 2017, p. 117.

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

(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 of the Common Missile Compartment.-(1) To implement the continuous production of the common missile compartment, 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 the common missile compartments of national sea-based deterrence vessels. The authority under this subsection extends to the procurement of equivalent critical parts, components, systems, and subsystems 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 the common missile compartment 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.

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 tradeoffs 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 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.

Submarine Unified Build Strategy (SUBS)

The Navy, under a plan it calls the Submarine Unified Build Strategy (SUBS), is proposing 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),[39] so that HII/NNS would receive a larger share of the work for that program than it has received in the past. 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

[39] 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 (name redacted) .

> 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.[40]

The Navy described the plan in February 25, 2016, testimony before the Seapower and Projection Forces subcommittee of the House Armed Services Committee. At that hearing, Navy officials testified that

> In 2014, the Navy led a comprehensive government-Industry assessment of shipbuilder construction capabilities and capacities at GDEB and HII-NNS to formulate the Submarine Unified Build Strategy (SUBS) for concurrent OR and Virginia class submarine production. This build strategy's guiding principles are: affordability, delivering OR on time and within budget, maintaining Virginia class performance with a continuous reduction in costs, and maintaining two shipbuilders capable of delivering nuclear-powered submarines. To execute this strategy, GDEB has been selected as the prime contractor for OR with the responsibilities to deliver the twelve OR [Ohio replacement] submarines [i.e., GD/EB will perform final assembly on all 12 boats in the program]. HII-NNS will design and construct major assemblies and OR modules leveraging their expertise with Virginia construction [i.e., HII/NNS will build parts of Ohio replacement boats that are similar to the parts it builds for Virginia-class boats]. Both shipbuilders will continue to deliver [i.e., perform final assembly of] Virginia class submarines throughout the period with GDEB continuing its prime contractor responsibility for the program. Given the priority of the OR Submarine Program, the delivery [i.e., final assembly] of Virginia class submarines will be adjusted with HII-NNS performing additional deliveries. Both shipbuilders have agreed to this build strategy.[41]

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

[40] 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.

[41] 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.

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

• 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.[42]

Columbia-Class Program Funding

Table 1 shows FY2019-FY2023 funding for the Columbia-class program. The table shows U.S. funding only; it does not include funding provided by the UK to help pay for the design of the CMC.

[42] *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.

Table 1. Columbia-Class Program Funding

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

	FY19 (req.)	FY20 (proj.)	FY21 (proj.)	FY22 (proj.)	FY23 (proj.)
Research and development (R&D) funding					
PE0603570N/Project 3219	*190.1*	*114.0*	*80.1*	*60.1*	*56.8*
PE0603595N/Project 3220	*514.8*	*433.3*	*313.4*	*196.1*	*173.6*
Subtotal R&D funding	**704.9**	**547.3**	**393.5**	**256.2**	**230.4**
Procurement funding					
Advance procurement (AP)	*3,005.3*	*1,453.2*	*1,041.8*	*1,246.1*	*1,825.3*
Procurement	*0*	*0*	*3,172.8*	*2,951.9*	*2,049.7*
Subtotal procurement funding	**3,005.3**	**1,453.2**	**4,214.6**	**4,198.0**	**3,875.0**
TOTAL R&D and procurement	**3,710.2**	**2,000.5**	**4,608.1**	**4,454.2**	**4,105.4**

Source: Navy FY2019 budget submission. The FY2019 budget also requests $71.1 million in military construction (MilCon) funding for a submarine propulsor manufacturing support facility for the Columbia-class program.

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. **PE0603561N/Project 3220** is the Sea-Based Strategic Deterrent (SBSD) Advanced Submarine System Development project within the PE for Ohio Replacement.

Issues for Congress

FY2019 Funding Request

One issue for Congress is whether to approve, reject, or modify the Navy's FY2019 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 FY2019 funding, as well as broader issues, including those discussed in some of the sections below.

Cost, Schedule, and Technical Risk

Another potential issue for Congress concerns cost, schedule, and technical risk in the Columbia-class program.

Cost Risk

Overview

The accuracy of the Navy's estimate is a key consideration in assessing the potential affordability of the Columbia-class program, including its potential impact on the Navy's ability to procure other kinds of ships during the years of Columbia-class procurement. Some of the Navy's ship designs in recent years, such as the Gerald R. Ford (CVN-78) class aircraft carrier,[43] the San

[43] For more on the CVN-78 program, see CRS Report RS20643, *Navy Ford (CVN-78) Class Aircraft Carrier Program: Background and Issues for Congress*, by (name redacted) .

Antonio (LPD-17) class amphibious ship,[44] and the Littoral Combat Ship (LCS),[45] have proven to be substantially more expensive to build than the Navy originally estimated. An October 2015 Congressional Budget Office (CBO) report on the cost of the Navy's shipbuilding programs states that the Navy in recent years has underestimated the cost of lead ships in new classes by a weighted average of 27%.[46]

The accuracy of the Navy's procurement cost estimate for the Columbia-class program can be assessed in part by examining known procurement costs for other recent Navy submarines—including Virginia (SSN-774) class attack submarines (which are currently being procured), Seawolf (SSN-21) class attack submarines (which were procured prior to the Virginia class), and Ohio (SSBN-726) class ballistic missile submarines—and then adjusting these costs for the Columbia-class program so as to account for factors such as differences in ship displacement and design features, changes over time in submarine technologies (which can either increase or reduce a ship's procurement cost, depending on the exact technologies in question), advances in design for producibility (i.e., design features that are intended to make ships easier to build), advances in shipyard production processes (such as modular construction), and changes in submarine production economies of scale (i.e., changes in the total number of attack submarines and ballistic missile submarines under construction at any one time).

The Navy's estimated unit procurement cost for the program at any given point will reflect assumptions on, among other things, the division of work between GD/EB and HII/NNS in building the boats, and how much Virginia-class construction will be taking place in the years when Columbia-class boats are being built. If shipbuilding affordability pressures result in Virginia-class boats being removed from the 30-year shipbuilding plan during the years of Columbia-class procurement, the resulting reduction in submarine production economies of scale could make Columbia-class boats more expensive to build than the Navy estimates.

Navy Confidence Levels for Its Cost Estimates

A January 24, 2017, Navy information paper provided to CRS and CBO in March 2017 stated that the Navy 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 means is that the Navy had calculated that there was more than a 50% chance that the procurement costs of Columbia-class boats will turn out to be greater than what the Navy currently estimates. (The Navy's costs estimates are shown earlier in this report—see the section entitled "Acquisition Cost.") 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.[47]

[44] For more on the LPD-17 program, see CRS Report RL34476, *Navy LPD-17 Amphibious Ship Procurement: Background, Issues, and Options for Congress*, by (name redacted) .

[45] For more on the LCS program, see CRS Report RL33741, *Navy Littoral Combat Ship (LCS) Program: Background and Issues for Congress*, by (name redacted) .

[46] Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2016 Shipbuilding Plan*, October 2015, p. 30 (Figure 10).

[47] 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 December 1, 2017, Navy information paper provided the confidence levels for Columbia class unit procurement costs shown in **Table 2**.

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.

A December 2017 GAO report stated the following:

> **Columbia Class Is Not Funded Adequately to Address Program Risks**
>
> Our analysis determined that it is more likely than not that the Columbia class program will exceed the Navy's $128 billion (then-year dollars) estimate of total acquisition cost to which the program will be funded. Specifically, the program's 2017 Milestone B cost estimates are optimistic because they do not account for a sufficient amount of program risk due to ongoing technology development, as well as the likely costs to design and construct the submarines. In addition, the Navy has budgeted the program to a confidence level for the program that is lower than what experts recommend, with a particularly optimistic estimate for the lead ship. While there may be situations when this would be appropriate, this is not the case for the Columbia class program due to the technical and design risks that we identified above. As a result, program costs will more likely than not exceed requested funding, particularly for lead ship construction. Due to the significant level of funding required for this program, even a small percentage of cost growth could have far-reaching consequences on the Navy's long-range plans to fund construction of its future fleet. For this review we conducted an initial analysis of the Navy's cost estimate but did not assess if it was conducted in accordance with all of the best practices identified in our cost estimating guide. We plan to more fully assess the Navy's life-cycle cost estimate for the entire Columbia class, including the program's risk analyses, in future work.
>
> **Confidence Levels and the Navy's Estimate**
>
> From early on, the Navy recognized the need to control costs for the Columbia class. In fact, the program's cost estimates have decreased significantly since the program's inception due to Navy decisions early in the program to trade off some capabilities and the incorporation of updated actual cost data from the continued procurement of Virginia class submarines. At Milestone B, OSD determined that Columbia class procurement costs had fallen almost 40 percent since the program's original estimate. However, while the Navy did conduct a risk analysis for its recent Columbia class cost estimates, the confidence level of the Navy's estimate at Milestone B for acquisition of the entire class

is 45 percent. This means that it is more likely than not that actual costs to research, develop, and buy the submarines will exceed the Navy's $128 billion estimate.

This situation is particularly apparent at this point with regard to costs to design the class and build the lead submarine. Any difficulties in ongoing technology development efforts would likely worsen the picture. At Milestone B, the Navy's point estimate to develop the technologies, design the class, and build the lead Columbia was at a 43 percent confidence level.

Experts agree that programs should be budgeted to at least the 50 percent confidence level, but budgeting to a higher level (e.g., 70 to 80 percent, or the mean) is a common practice to cover increased costs resulting from unexpected design complexity and technology uncertainty, among other things. Navy cost guidance recommends using the "risk adjusted mean" for the cost for the program, which usually lies between 50 and 60 percent. If the Navy budgeted to an estimate at a higher confidence level like the risk adjusted mean, its Milestone B point estimates—meaning the selected estimate of cost—would be higher, reducing the probability of overruns occurring. According to Navy cost analysts, the program's total acquisition cost, which the Navy estimated at Milestone B at $128 billion (then-year dollars), would exceed $131 billion (then-year dollars) at 50 percent confidence, which is the bottom range of the risk adjusted mean confidence level.

Cost Growth Potential Based on the Navy's Estimate

Even if the Navy budgeted to the 90 percent—a "worst-case" scenario where significant programmatic challenges are realized and the probability of cost overruns is low—confidence level, Columbia class lead ship costs would not be dissimilar to cost outcomes on other lead ship programs. We have observed in prior work that cost growth for recent lead ships across the Navy's shipbuilding portfolio is 28 percent on average. For example, the Navy's lead Virginia class submarines (SSN 774 and SSN 775)—the most similar class to Columbia in terms of technology and component development as well as aspects of its design and build plans—experienced 15 and 24 percent budget growth respectively, with average cost growth of 28 percent for the three most recent lead submarines....

The 28 percent cost growth we have observed is slightly more than the 22 percent cost increase between the Navy's point estimate and the 90 percent confidence level, meaning that even if the Navy budgeted the program to the 90 percent confidence level there would still be historical shipbuilding precedence for further cost growth. In particular, if costs to build the lead Columbia class submarine grow similar to the lead Seawolf and Virginia class submarines, the cost to construct the submarine would exceed the Navy's Milestone B estimate by more than $2.5 billion. This would represent a total approaching $12 billion (then-year dollars) versus the current estimate of $9.2 billion for the lead submarine. Due to the magnitude of the Columbia class program's expected cost, any cost growth, including for design and construction of the lead ship could impact the availability of funds for other Navy priorities.

The Congressional Budget Office (CBO) and CAPE also analyzed Columbia class program costs. CBO predicted higher costs than the Navy estimate. In its 2017 assessment of the Navy's long-term shipbuilding plans, CBO concluded that the Navy underestimated the cost of the total Columbia class procurement by $8 billion (2017 dollars). [see next section on the February 2017 CBO report]

CAPE estimated a lower cost, but also identified areas where reliable cost data were unavailable. The independent cost estimate prepared by CAPE in support of the program's Milestone B reflects a 3 percent lower total program life-cycle cost (2017 dollars) than the Navy estimate. In setting the program baseline in January 2017, DOD pragmatically opted to use the Navy's higher estimate ($7.3 billion) instead of CAPE's $7 billion estimate for the average unit cost to procure a Columbia class submarine

(calendar year 2017 dollars). According to CAPE officials, this difference in estimates is largely due to CAPE incorporating more recent Virginia class actual cost data into its estimate than the Navy. However, CAPE also identified that there is a lack of reliable cost data on some contractor-furnished materials and government furnished equipment (GFE) for the Columbia class program, which limited the quality of the estimate. GFE comprises critical areas of the Columbia class submarine, including the strategic weapon system managed by Strategic Systems Program and the IPS developed by Naval Reactors.[48]

February 2017 CBO Report

The February 2017 CBO report on the cost of the Navy's shipbuilding programs stated the following:

> The design, cost, and capabilities of the 12 Columbia class submarines included in the 2017 shipbuilding plan are among the most significant uncertainties in the Navy's and CBO's analyses of the cost of shipbuilding in the future....
>
> The Navy currently estimates that the first Columbia will cost $12.2 billion in 2016 dollars and that the subsequent ships will have an average cost of $5.9 billion. (The Navy has stated that it aims to reduce that cost to $5.7 billion.) The implied total cost for the 12 submarines is $77 billion, or an average cost of $6.4 billion for each ship.... The Navy estimates that research and development costs will amount to $13 billion, bringing the total acquisition cost to $90 billion....
>
> According to the Navy's estimate, the cost per thousand tons for the first Columbia will be 17 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 by weight 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 (such as the Columbia class) tend to be larger and less densely built ships than attack submarines (like the Virginia class), they will be easier to build and thus less expensive per thousand tons, the Navy asserts. The Navy has stated, however, that there is a greater than 50 percent probability that the cost of the first Columbia and of subsequent ships of the class will exceed its estimates.
>
> 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 by weight 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. By the 1990s, although the cost by weight of lead ships for submarines had grown substantially, there was still little evidence that size makes a difference in the cost per thousand tons of submarines. The first Virginia class submarine, which was ordered in 1998, cost about the same by weight as the first Seawolf submarine even though the Seawolf is 20 percent larger and was built nine years earlier.
>
> Using data from the Virginia class submarine program, CBO estimates that the first Columbia class submarine will cost $13.3 billion in 2016 dollars. (The Navy estimates that it will cost $12.2 billion.) Estimating the cost of the lead ship of a class with a new

[48] Government Accountability Office, *Columbia Class Submarine[:] Immature Technologies Present Risks to Achieving Cost, Schedule, and Performance Goals*, GAO-18-158, December 2017, pp. 40-44.

> design is particularly difficult because of uncertainty about how much the Navy will spend on nonrecurring engineering and detailed design. CBO estimates that, all told, 12 Columbia class submarines would cost $87 billion, or an average of $7.3 billion each—$0.9 billion more per submarine than the Navy estimates. That average is based on the $13.3 billion estimated cost of the lead submarine and an average cost of $6.7 billion estimated for the 2nd through 12th submarines. Research and development will cost between $13 billion and $17 billion, CBO estimates, for a total program cost of $100 billion to $104 billion.
>
> Overall, the Navy expects a 19 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. It estimates that the Navy will realize an 8 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 savings could be considerable if, for example, lawmakers authorized the Navy to use a block-buy strategy—an approach that it has used with other types of ships—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 shipyard) and allowed the service to purchase components and materials for the submarines in optimal amounts that minimize costs (known as economic order quantities). However, some benefits of a block-buy strategy are already incorporated into the Navy's and CBO's estimates because they are based in part on the costs of the Virginia class, the first few ships of which the Navy purchased using a block-buy strategy. Similarly, if the Congress funded the purchase of the Columbia class submarines through the National Sea-Based Deterrence Fund, which was established in the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015, the Navy could potentially save several hundred million dollars per submarine by purchasing components and materials for several submarines, and possibly for other ships, at the same time. One disadvantage of such an acquisition strategy is that if lawmakers later decided not to build all the submarines for which the Navy purchased materials, the materials that were to be used for them might go unused. A second disadvantage is that under a block-buy strategy, if the Congress did not approve of how the program was progressing, it might have less flexibility to change procurement plans or to purchase fewer submarines.
>
> Costs for the Columbia class submarines could, however, exceed both the Navy's and CBO's estimates. The new SSBN will be the largest submarine that the United States has ever built. It will reuse technology and components from the Virginia class submarine, but it will also include many new elements, such as a new missile compartment and a nuclear reactor designed to last the entire 42-year service life of the submarine.[49]

The February 2017 CBO report also states the following:

> On January 4, 2017, the Department of Defense (DoD) approved the Columbia class ballistic missile submarine for production. Specifically, the Under Secretary of Defense for Acquisition signed the acquisition decision memorandum (ADM) that launched the program into engineering and manufacturing development—known as Milestone B in DoD's complex acquisition process. That development is notable for several reasons, but the ADM is particularly significant because it included an updated cost estimate for the 12-ship program. Although the new ADM estimate appears to be significantly higher

[49] Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2017 Shipbuilding Plan*, February 2017, pp. 24-25, 27.

than the costs estimated in the Navy's 2017 shipbuilding plan, the Navy states that the real (inflation-adjusted) costs in the ADM are actually similar. The Congressional Budget Office did not include the new ADM estimates in presenting the Navy's estimates of the 2017 plan because detailed information is not yet available; the updated estimates in the ADM would not affect CBO's projections of the costs of the plan.

In the ADM, the Navy estimates that the 12 submarines will cost an average of $7.1 billion each in 2017 dollars ($7.3 billion including outfitting and postdelivery costs). To compare that estimate with those in the Navy's 2017 shipbuilding plan, CBO adjusted the amounts to 2016 dollars to match the dollars reported in that plan. The result is that the average cost per vessel for the 12-ship program under the Navy's new estimate—excluding outfitting and postdelivery costs—would be $6.8 billion in 2016 dollars.... That amount is about $400 million more than what the Navy reported in its 2017 shipbuilding plan and closer to CBO's estimates of $7.3 billion.

According to the information about DoD's new Milestone B cost estimate that is available to CBO, most of the difference between the Navy's estimates should not be interpreted as a change in the underlying cost of the program; rather, it is the result of the two different methods that the Navy used to convert its constant-dollar estimates for the Columbia class program from the 2010 dollars in which they were expressed at Milestone A into 2016 dollars for the 2017 shipbuilding plan and 2017 dollars for the estimates in the ADM. The Navy used an inflation index based specifically on the Columbia class program to adjust its estimates for the ADM, whereas it had used the broader naval shipbuilding cost index discussed in Box 2 to prepare its estimates for the 2017 shipbuilding plan. The Navy's method for preparing the estimates in the ADM accounts for the fact that inflation in the submarine shipbuilding industry has been greater than gross domestic product price inflation. It is similar to the method that CBO used throughout its analysis.... and explains why the Navy's estimate in the ADM is much closer to CBO's estimate for the Columbia class than its estimate in the 2017 shipbuilding plan.

In addition, the Navy's estimate in the ADM is higher than its estimate in the 2017 shipbuilding plan for another reason: The ADM represents the Navy's most current estimate of the costs of the submarines, whereas for the 2017 shipbuilding plan, the Navy based its estimates on its cost target for the ships, which is lower.

The ADM also includes an "affordability cap" of $8.0 billion per ship, essentially allowing for the possibility of cost growth of as much as 10 percent above the Navy's estimate of $7.3 billion. According to Navy officials, all major acquisition programs at Milestone B must include an affordability cap or growth margin. If a program's costs exceed its cap, DoD will review the program to determine whether major changes or other corrective actions are needed.[50]

Schedule and Technical Risk

Navy's Schedule Has Limited Slack

The Navy's schedule for designing, building, and testing the lead Columbia-class boat, and making it ready for its scheduled first deterrent patrol in 2031, currently includes limited slack between now and 2031 for absorbing delays due to things such as funding issues caused by CRs or lapses in appropriations, or problems in developing and testing new technologies intended for the Columbia class (such as its electric-drive propulsion system). The Navy is currently working

[50] Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2017 Shipbuilding Plan*, February 2017, p. 26 (Box 3).

to make the Columbia-class program's schedule more resilient in terms of being able to absorb delays without jeopardizing the 2031 deadline for having the lead boat in the class be ready for the first deterrent patrol. A November 1, 2016, press report states the following:

> The Program Executive Office for Submarines is working to create schedule and cost efficiencies on the Ohio Replacement (Columbia class) Program to counteract inevitable delays during construction, he said last week.
>
> Rear Adm. Michael Jabaley said at the Naval Submarine League's annual symposium that the first ship in the Navy's most important acquisition program absolutely had to deliver on time—even though previous delays during early design work complicated that task.
>
> "The biggest problem we have is there is no margin between the decommissioning of Ohios and the delivery of Ohio Replacements. And anyone who has been involved in shipbuilding knows that there will be unknowns that pop up and cause delays to the schedule," he said.
>
> "So my job is to try to buy margin back into that schedule so that when the inevitable unknown presents itself it's not a fatal collision within the construction plan. So to buy that margin back into the schedule, we're looking at targeted elements of the ship where we can accelerate construction through the use of advance procurement funding or advance construction authority to start those parts earlier and de-risk that schedule."
>
> PEO Subs is working with Congress to get needed contracting authorities and advance procurement and advance construction funding, and Jabaley said that effort will ultimately "provid[e] a significant benefit for schedule de-risking."
>
> To reduce the risk of the program from a cost standpoint, Jabaley said the Ohio Replacement and Virginia-class attack submarine program officials—as well as nuclear-powered aircraft carrier personnel in some cases, and the prime contractors and vendor base that support all three ship programs—are working together to align material purchases and construction schedules.
>
> On materials, Jabaley said "we the government have to get the volume discount that should accrue by combined purchasing of all the things you're going to need for the two different classes of submarines, and here's where the carrier comes in because a lot of the components are similar or identical on the carrier when you get to the nuclear power plant, nuclear shipbuilding concerns. … That's a volume discount price that we need to take advantage of. In order to do that, we have to reinforce with our vendor base that this mountain of work is facing them as well and that they need to ensure that their quality, their cost and their capacity is ready to accomplish that."
>
> The admiral noted that PEO Subs has conducted an analysis of the top 25 suppliers to the submarine programs and is working with them to make sure they are ready to execute an increased workload and provide fair volume discounts. Within the government, Jabaley said the program offices are working to ensure that requirements are written such that the SSBNs, SSNs and nuclear carriers can all share parts such as chilled water pumps. This type of multi-program procurement would require special contracting authority that the Navy will brief lawmakers on and seek approval in the next year or two, Jabaley said.
>
> As the Ohio Replacement Program moves towards construction—and as the Virginia subs become larger and more complex with the addition of the Virginia Payload Module and acoustic superiority design changes, the Navy is working closely with builders General Dynamics Electric Boat and Newport News Shipbuilding to finalize plans for facility expansions, manpower and training plans, and simulations of how components

for two or three ship classes will move through the yards without conflicting with each other.[51]

December 2017 GAO Report

A December 2017 GAO report on the Columbia-class program stated the following:

> Additional development and testing are required to demonstrate the maturity of several Columbia class submarine technologies that are critical to performance, including the Integrated Power System, nuclear reactor, common missile compartment, and propulsor and related coordinated stern technologies (see figure). As a result, it is unknown at this point whether they will work as expected, be delayed, or cost more than planned. Any unexpected delays could postpone the deployment of the lead submarine past the 2031 deadline.
>
> Further, the Navy underrepresented the program's technology risks in its 2015 Technology Readiness Assessment (TRA) when it did not identify these technologies as critical. Development of these technologies is key to meeting cost, schedule, and performance requirements. A reliable TRA serves as the basis for realistic discussions on how to mitigate risks as programs move forward from the early stages of technology development. Not identifying these technologies as critical means Congress may not have had the full picture of the technology risks and their potential effect on cost, schedule, and performance goals as increasing financial commitments were made. The Navy is not required to provide Congress with an update on the program's progress, including its technology development efforts, until fiscal year 2020—when $8.7 billion for lead ship construction will have already been authorized. Periodic reporting on technology development efforts in the interim could provide decision makers assurances about the remaining technical risks as the Navy asks for increasing levels of funding....
>
> Consistent with GAO's identified best practices, the Navy intends to complete much of the submarine's overall design prior to starting construction to reduce the risk of cost and schedule growth. However, the Navy recently awarded a contract for detail design while critical technologies remain unproven—a practice not in line with best practices that has led to cost growth and schedule delays on other programs. Proceeding into detail design and construction with immature technologies can lead to design instability and cause construction delays. The Navy plans to accelerate construction of the lead submarine to compensate for an aggressive schedule, which may lead to future delays if the technologies are not fully mature before construction starts, planned for 2021.[52]

A December 21, 2017, Navy point paper responding to the GAO report stated the following:

> **Background:** The report is a review of the Navy's Technology Readiness Assessment, Technology Development Plan, and the status of key prototyping efforts for COLUMBIA, and compared efforts with GAO's best practices for shipbuilding programs and technology readiness assessments. GAO submitted a draft report on 1 November 2017 for DoD/Navy comment. In the report GAO contends that the COLUMBIA Class program technologies are immature based on the GAO guidelines of Technology Readiness Level (TRL) 7 at Milestone B (MS B). The Assistant Secretary of Defense letter dated 1 December 2017 responded to the report disagreeing with the GAO findings.

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

[52] Government Accountability Office, *Columbia Class Submarine[:] Immature Technologies Present Risks to Achieving Cost, Schedule, and Performance Goals*, GAO-18-158, December 2017, summary page.

Discussion:

Department of Defense (DoD) programs are required to meet Technology Readiness Level (TRL) 6 (system/subsystem model or prototype demonstration in a relevant environment) while the GAO's "best practices" recommends TRL 7 (system prototype near or at the planned operational system demonstrated in an operational environment). The COLUMBIA program complied with all Navy, DoD, and statutory requirements for conducting its 2015 Technology Readiness Assessment (TRA) to TRL 6 and achieved Milestone B in January 2017.

GAO's draft report identified additional efforts which they considered Critical Technology Elements (CTE); Integrated Power System (IPS), Propulsor / Coordinated Stern, nuclear reactor, and Common Missile Compartment. These components are engineering and integration efforts, rather than technology maturity efforts and labeling them as critical technologies would have been contrary to DoD guidance. In the 2015 TRA, the Navy identified two critical technologies that were not yet at TRL 6, consistent with statutory requirements and DoD policy. Those two CTEs were the Stern Area System (SAS) and a carbon dioxide removal system. The Navy received a waiver at MS B for the SAS. The carbon dioxide removal system had matured to TRL 6 prior to MS B.

GAO also contends that immature COLUMBIA technologies will present risks to achieving the program cost, schedule, and performance goals. The COLUMBIA Class Submarine Program is well positioned to provide needed capability at an affordable price on the timeline needed to meet national strategic deterrent requirements. The Navy's management attention is focused on four main areas: stable operational and technical requirements, high design maturity at construction start, detailed plans to ensure manufacturing readiness including robust prototyping efforts, and aggressive cost reduction actions. The Navy continues to actively manage all COLUMBIA program cost, schedule, and performance goals including engineering and integration risks and routinely briefs Navy/DoD leadership, and Congress to ensure risks are transparent and fully understood.[53]

March 2017 GAO Report

A March 2017 GAO report assessing selected major DOD weapon acquisition programs stated the following regarding the Columbia-class program:

Technology Maturity

The Columbia Class program's most recent Technology Readiness Assessment (TRA) identifies only two critical technologies—one carbon dioxide removal system and one major technical feature of the stern. The Navy has subsequently determined the carbon dioxide removal system is no longer a critical technology based on testing in a relevant environment. Only the stern feature remains as a critical technology, and the Navy does not expect to start detail design for this technology until fiscal year 2018. According to DOD's guidance for conducting TRAs, a technology is critical if it may pose major technological risk during development, particularly during the Engineering and Manufacturing Development (EMD) phase of acquisition. Prior to starting EMD, the program obtained a waiver as required by statute in order to proceed with technology that has not been demonstrated in a relevant environment. As a result, the program will continue technology development activities concurrent with detail design-this strategy is inconsistent with best practices.

[53] Navy information paper dated December 21, 2017, provided by Navy Office of Legislative Affairs (NOLA) to CRS and CBO on December 22, 2017. NOLA confirmed in an email to CRS on January 10, 2018, that the information paper could be reprinted in this CRS report.

Design Maturity

The Navy plans to include up to 70 percent of Virginia Class submarine parts and components in the Columbia Class design. It is also designing the Columbia Class to accommodate the existing Trident II D-5 strategic weapon system, and has already completed design work for the first article quad pack of missile tubes. The program is relying on a new three dimensional (3-D) computer model design tool, which it anticipates will produce electronic instructions in support of fabrication and assembly activities. In 2016, the design shipbuilder experienced a delay in issuing early design products due to problems with this software. According to the design shipbuilder, it has largely resolved the issue and is working to recover schedule. The program aims to complete 83 percent of the 3-D design model prior to the start of lead ship construction in fiscal year 2021.

Production Maturity

The Navy plans to award a contract to start detail design in 2017, with lead ship construction scheduled to begin in fiscal year 2021. The Navy expects to build the lead ship in 84 months with follow-on ships progressively decreasing to 70 months construction time. This schedule is aggressive, considering that it is approximately the same duration as the lead Virginia class submarine, even though the Columbia Class is over two times larger and the first ballistic missile submarine built in decades. According to the Navy, a decision in 2012 to delay construction start from 2018 to 2020 eliminated flexibility to accommodate delays during construction, given that the lead ship's first strategic deterrent patrol remains scheduled for 2030. In an effort to gain back some schedule margin, the Navy is working with the future Columbia Class construction shipyards to identify production efficiencies and is requesting funding authorities from Congress to begin some construction work prior to authorization of the lead ship. Under the Navy's current plans, the shipyards will construct two submarines per year (one Virginia Class and one Columbia Class) through the 2030s.

Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.[54]

March 20, 2018, Navy Testimony

At a March 20, 2018, hearing on the submarine industrial base before the Seapower and Projection Forces subcommittee of the House Armed Services Committee, the following exchange occurred:

REPRESENTATIVE ROB WITTMAN, CHAIRMAN (continuing):

I did—I did want to close with—with one question concerning Columbia class. We got into a little bit of it with the permanent magnet induction motor and the challenges that we face there. As you know, that has consumed a significant amount of the flex time that's in the schedule for delivery of that submarine.

I just wanted to get your perspective on our ability to contain technical challenges. This is a very, very complex platform, obviously going down the road of developing this.

The question is is with the significant amount of time that we lost with this particular motor dysfunction that we had, are we in a place to where we're confident that we can manage the technical challenges that we're going to face going forward with Columbia

[54] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapons Programs*, GAO-17-333SP, March 2017, p. 118.

class? Because we have become precariously close to what you would expect as other, you know, challenges that we've faced in other technically complex programs.

So I want to get your perspective if you feel like we have our arms around that and if we are going to be able to make sure that we manage within timeframes for delivery of this boat on time. As we know, we—we don't have a choice. There is no—there's no alternative. We have to deliver this because Ohio class will be retiring.

JAMES F. GEURTS, ASSISTANT SECRETARY OF THE NAVY FOR RESEARCH, DEVELOPMENT AND ACQUISITION

Yes, sir. I'll start and then ask the PEO [program executive officer] to—to join in.

From my perspective, yes, we've had some challenges on the motor in particular. I think in the good news category that didn't stop us from retiring risk in a lot of the other areas of the submarine, particularly, again, some of the work we've done in this early work on the missile tubes and what not.

And—and a lot of folks probably don't understand how much Virginia is—is actually helping us retire risk on Columbia, so getting this production rate up to Virginia two-per-year, getting a larger workforce trained, a lot of the subsystems cut across all the different platforms. So while it's a new submarine, not all the pieces of the submarine are new, and that is giving us a lot of—it gives me a lot of comfort from what would normally be a, you know, tremendously challenging activity.

It's still a very challenging and complex activity. I don't want to—I don't want to push that down. But we've been working really hard and the advanced procurement funding that we've been able to secure has been critical.

To—to your point of schedule, one thing we will be watching really closely is next year getting full funding as soon as the fiscal year starts. And that may be an area where we will need some help if we're in a continuing resolution so that that doesn't become a—a schedule impact to us of which will take more of that margin out.

So we'll work very closely with you. That is a sensitive area, from an authorities and just fiscal timing perspective.[55]

Later in the hearing, the following exchange occurred:

REPRESENATIVE VICKY HARTZLER (continuing):

The Columbia class has several technology development programs that are challenging design and construction efforts, including the coordinated stern, electric drive, and the nuclear propulsion system. What is the Navy's assessment of risk associated with the development of these technologies and recovery efforts to regain schedule?

REAR ADM. MICHAEL E. JABALEY, PROGRAM EXECUTIVE OFFICER FOR SUBMARINES:

Thank you for the question, Congresswoman.

The Navy's assessment is that the risk is manageable and well in hand. We—we have done things on this program to account for technology development risk that are—that are beyond what we've done on previous submarine construction programs.

As Secretary Geurts alluded to previously, one of the biggest ones is the amount of design pull-through from the Virginia program. Many of the components are either identical or simply scaled up from the Virginia.

[55] Source: Transcript of hearing. Rear Admiral Michael E. Jabaley, Program Executive Officer for submarines, did not add to Guerts' reply to this question.

> The second thing is the level of design readiness at construction start. We are targeting and are on track to achieve 83 percent complete design when we start construction in October of 2020. That compares to 42 percent on Virginia and even lower percentages on Seawolf.
>
> So having that design stability and execution allows us to be more confident in the ability to build it in the timespan necessary.
>
> Finally, the—many of the—the items that you discuss—the coordinated stern, the integrated power system, and the nuclear reactor—are well on their way through a series of prototyping effort and confirmation models to ensure that they are well ready for—for ship construction. And they are—they are beyond technology development now and into simply integration and—engineering and integration efforts.
>
> So although there—there's been a lot of discussion about this recently, we are—we are confident that we are well positioned to start construction on the first ship in October of 2021 and have very few technological risks through the development program.[56]

Press Reports on Problem with Electric Drive System Motor

A May 4, 2017, press report states the following:

> The first known glitch in a $126 billion nuclear-armed submarine program—overheating of a prototype motor—was disclosed by a key U.S. lawmaker this week and confirmed by the Navy, which said it has fixed the problem.
>
> The flaw in the main propulsion motor was discovered earlier this year, the Navy said in a statement Thursday [May 4]....
>
> "It's a technical hiccup in the performance of a motor," Representative Rob Wittman, the Republican chairman of the House Armed Services seapower panel, told reporters Wednesday [May 3]. "There's a motor that didn't perform properly. It overheated."
>
> The Navy said in its statement that the issue with the motor designed by a General Dynamics subcontractor isn't expected to delay planned delivery—anticipated for around 2028—of the first of 12 submarines that the service needs to have on patrol by 2031. Construction of the vessel is set to begin in fiscal 2021.
>
> "Recovery from this manufacturing problem will result in late delivery of the prototype motor to the test facility" but "sufficient margin exists in the test program to accommodate" recovering from the issue "without impacting delivery of the shipboard motor" to the first ship, Captain Thurraya Kent, a Navy spokeswoman, said in an emailed statement....
>
> Wittman said he planned to meet with the head of the Navy's Nuclear Propulsion division Admiral James Caldwell and some of the contractors to ask "why did this happen?"[57]

A July 21, 2017, press report states the following:

> Bryan Clark, a naval analyst at the Center for Strategic and Budgetary Assessments, a Washington, D.C.-based think tank, said one of the reasons for the boat's [risk of] delay is because of the new electric propulsion system.
>
> "That's a big change for U.S. nuclear submarines," he said. "We've only built one that had all-electric propulsion, where you have an electric generator that then powers an electric motor that drives the ship, instead of using a steam turbine."

[56] Source: Transcript of hearing.

[57] Anthony Capaccio, "Navy Sub's Overheating Motor First Glitch in $126 Billion System," *Bloomberg*, May 4, 2017.

> During the Cold War, the [nuclear powered attack submarine] USS Glenard P. Lipscomb used such a turbine, he said.[58] Electric systems are quieter since reduction gears are not needed, as they are with steam turbines, Clark added.
>
> "The most efficient speed for the steam turbine to rotate is like 10,000 rpm, but the most efficient rate for the propeller to move at is maybe 15 or 20 rpm," he said. "You got to have reduction gears to take that really high speed turbine and gear it down to a speed that you can actually turn that prop at."
>
> The Navy has had trouble perfecting the prototype version of the system, which has in turn caused delays, he said.
>
> The electric turbine is one of the only components that gives Clark pause.
>
> "The rest of the submarine has a lot of commonality with the Virginia-class, so there's not a lot of new technology being incorporated into it," he said. "They are doing some improvements in terms of sound silencing and sonar systems, but it's all technology that has been tested out and has been proven.
>
> "I'm not too worried about the rest of the submarine," he added.[59]

A November 6, 2017, press report states the following:

> [Naval Reactors Director Admiral James] Caldwell said the [Columbia-class] program is still on track despite a challenge earlier this year with the electric drive's motor—not one intended for use on a submarine, but the pre-production model meant to support testing.
>
> "We have faced a challenge in the manufacturing of the pre-production full-sized motor that we're going to use for testing. It was not a technology challenge; it was a manufacturing challenge. We addressed the cause on that and modified (the schedule)– we built the schedule, by the way, to have a good amount of margin in it, meaning months that we could use if we had a challenge that we found," he told USNI News during a question and answer session [at a conference].
>
> "We've re-torqued that schedule, we've approached the scheduling in an alternate way, and we still are on track to deliver the final motor well before the required in-yard date for the shipyard. So the testing … will start on the components that we have available in December of this year and will continue through next year. So there is a delay—and again, that's the pre-production motor. That's the motor we're going to use to learn from, full-sized, just like we would pretend to build if we're building the ship; we're going to do a design turn, and then we're going to build a final production motor, and that will be the one that will also be tested in our test facility."
>
> Caldwell told USNI News after his speech that Naval Reactors is responsible for the life-of-ship fuel and the electric drive, both of which are still on track to deliver ahead of need at the shipyards. He said the Navy and Congress are supporting the program with adequate funding but added that the submarine community needs to keep being vocal about what it needs to keep the Columbia program on track.
>
> "It's a complex project, it's a very big submarine—it's two and a half times the size of a Virginia-class submarine, and we're going to build it in the same timeframe as the first Virginia class that we built—so the challenge is big," he said.[60]

[58] The *Glenard P. Lipscomb* (SSN-685) entered service in 1974 and was decommissioned in 1990.

[59] Yasmin Tadjdeh, "No Wiggle Room in Schedule For Columbia-Class Submarine," *National Defense*, July 21, 2017.

[60] Megan Eckstein, "Columbia Class Ballistic Missile Sub On Schedule, Down to $7.2 Billion Apiece," *USNI News*, November 6, 2017.

Program Affordability and Impact on Other Navy Shipbuilding Programs

Overview

Another issue for Congress concerns the prospective affordability of the Columbia-class program and its potential impact on funding available for other Navy shipbuilding programs. It has been known for some time that the Columbia-class program, if funded through the Navy's shipbuilding account, could make it considerably more difficult for the Navy to procure other kinds of ships in desired numbers, unless the shipbuilding account were increased to accommodate the additional funding needs of the Columbia-class program.

On September 18, 2013, Admiral Jonathan Greenert, the Chief of Naval Operations, testified that the Columbia-class program "is the top priority program for the Navy."[61] Navy officials since then have reiterated this statement on numerous occasions. The Navy's decision to make the Columbia-class program its top program priority means that the Columbia-class program will be fully funded, and that any resulting pressures on the Navy's shipbuilding account would be borne by other Navy programs, including shipbuilding programs. 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.[62]

Some Options for Addressing the Issue

In addition to making further changes and refinements in the design of the Columbia class, there are other options for reducing the cost of the Columbia-class program or for otherwise reducing the program's potential impact on funding available for other Navy programs (particularly shipbuilding programs), as discussed in the following sections.

Block Buy Contracting (BBC) and Multiyear Procurement (MYP) Contracting

To help reduce ship procurement costs, the Navy in recent years has made extensive use of MYP contracts and block buy contracting (BBC) in its shipbuilding programs. In light of this, the Navy may seek to use a block buy contract for procuring the first several Columbia-class boats, and either BBC or an MYP contract for procuring later boats in the program. As discussed in other CRS reports and testimony, using BBC and MYP can reduce procurement costs in shipbuilding

[61] 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.

[62] Transcript of hearing. (Spoken remarks of Rear Admiral Richard Breckenridge. The other witness at the hearing was Rear Admiral David Johnson.)

programs by roughly 10%, compared to costs under the standard or default DOD approach of annual contracting.[63]

Authorities Granted Under NSBDF

As mentioned earlier (see "Potential Implications of NSBDF on Funding Available for Other Programs"), using the authorities in subsections (f), (g), (h), and (i) of 10 U.S.C. 2218a (the location in the U.S. Code where the NSBDF is codified) 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...."[64] 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 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....

[63] For additional discussion, see CRS Report R41909, *Multiyear Procurement (MYP) and Block Buy Contracting in Defense Acquisition: Background and Issues for Congress*, by (name redacted) and (name redacted) , and CRS Testimony TE10001, *Acquisition Efficiency and the Future Navy Force*, by (name redacted) .

[64] 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.

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 non-nuclear 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.[65]

Partial Batch-Build Approach for Building Columbia-Class Boats

As another possible means for further reducing the procurement cost of the Columbia-class boats, the Navy at one point considered a partial batch-build approach for building the boats. Under this approach, instead of building the boats in serial fashion, portions of several boats would be built together, in batch form, so as to maximize economies of scale in the production of those portions. Under this approach, the boats would still be finished and enter service one at a time, but aspects of their construction would be undertaken in batch fashion rather than serial fashion. Implementing a partial batch-building approach might be facilitated by using existing or proposed authorities in the National Sea-Based Deterrence Fund (see previous section), but fully implementing a partial batch-building approach might require additional authorities.

Altering Procurement Schedule to Make More Use of Incremental Funding

The Navy currently intends to use incremental funding to procure the first two Columbia-class boats, and traditional full funding to procure the final 10 ships in the program.[66] Another option for managing the potential impact of the Columbia-class program on other Navy shipbuilding programs would be to stretch out the schedule for procuring Columbia-class boats so as to create opportunities for using incremental funding to procure some (perhaps most) of the final 10 boats

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[65] 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.

[66] The Navy states that

> To minimize overall impact to other department prorams, the Navy is pursuing an incremental funding profile for the lead OR SSBN over the three year period, FY2021 to FY2023, with resources aligned to a 41% (FY2021), 35% (FY2022), and 24% (FY2023) profile. A similar funding strategy will be pursued for the second OR SSBN ([to be procured in] FY2024) with funding spread over FY2024 and FY2025. Once serial production of the OR SSBN beings [sic: begins] in FY2026, each successive OR SSBN is planned to be fully funded in the year in which Navy intends to contract for the vessel (standard advanced procurement funding profiles notwithstanding).
>
> (U.S. Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal year 2017*, April 2016, p. 10).

in the program.[67] This option would not reduce the total procurement cost of the Columbia-class program—to the contrary, it might increase the program's total procurement cost somewhat by reducing production learning curve benefits in the Columbia-class program.[68] This option could, however, reduce the impact of the Columbia-class program on the amount of funding available for the procurement of other Navy ships in certain individual years. This might reduce the amount of disruption that the Columbia-class program causes to other shipbuilding programs in those years, which in turn might avoid certain disruption-induced cost increases for those other programs. The annual funding requirements for the Columbia-class program might be further spread out by funding some of the final 10 Columbia-class boats with three- or four-year incremental funding.[69]

Table 3 shows the Navy's currently planned schedule for procuring 12 Columbia-class boats and a notional alternative schedule that would start two years earlier and end two years later than the Navy's currently planned schedule.

Table 3. Navy Columbia Class Procurement Schedule and a Notional Alternative Schedule

Fiscal year	Navy's Schedule	Boat might be particularly suitable for 2-, 3-, or 4-year incremental funding	Notional alternative schedule	Boat might be particularly suitable for 2-, 3-, or 4-year incremental funding
2019			1	X
2020				
2021	1	X	1	X
2022				
2023			1	X
2024	1	X		
2025			1	X
2026	1			
2027	1		1	
2028	1		1	
2029	1		1	X
2030	1		1	X
2031	1		1	X
2032	1			
2033	1	X	1	X
2034	1	X		
2035	1	X	1	X
2036				
2037			1	X
Total	**12**		**12**	

Source: Navy's schedule is based on Navy budget submissions. Notional alternative schedule prepared by CRS.

[67] Under split funding, a boat's procurement cost is divided into two parts, or increments. The first increment would be provided in the fiscal year that the boat is procured, and the second would be provided the following fiscal year.

[68] Procuring one Columbia-class boat every two years rather than at the Navy's planned rate of one per year could result in a loss of learning at the shipyard in moving from production of one SSBN to the next.

[69] The Navy, with congressional support, currently uses split funding to procure large-deck amphibious assault ships (i.e., LHAs). The Navy currently is permitted by Congress to use four-year incremental funding for procuring the first three Ford (CVN-78) class carriers (i.e., CVN-78, CVN-79, and CVN-80); the authority was granted in §121 of the FY2007 defense authorization act [H.R. 5122/P.L. 109-364 of October 17, 2006].

Notes: Notional alternative schedule could depend on Navy's ability to carefully husband the use of the nuclear fuel cores on the last two Ohio-class SSBNs, so as to extend the service lives of these two ships by one or two years. Alternatively, Congress could grant the Navy the authority to begin construction on the 11th boat a year before its nominal year of procurement, and the 12th boat two years prior to its nominal year of procurement. Under Navy's schedule, the boat to be procured in FY2033 might be particularly suitable for 4-year incremental funding, and boat to be procured in FY2034 might be particularly suitable for 3- or 4-year incremental funding.

Although the initial ship in the alternative schedule in **Table 3** would be procured in FY2019, it could be executed as it if were funded in FY2021. Subsequent ships in the alternative schedule that are funded earlier than they would be under the Navy's currently planned schedule could also be executed as if they were funded in the year called for under the Navy's schedule. Congress in the past has funded the procurement of ships whose construction was executed as if they had been procured in later fiscal years.[70] The ability to stretch the end of the procurement schedule by two years, to FY2035, could depend on the Navy's ability to carefully husband the use of the nuclear fuel cores on the last two Ohio-class SSBNs, so as to extend the service lives of these two ships by one or two years. Alternatively, Congress could grant the Navy the authority to begin construction on the 11th boat a year before its nominal year of procurement, and the 12th boat two years prior to its nominal year of procurement.

Reducing the Planned Number of Columbia-Class Boats

Some observers over the years 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 eight boats as a cost-reduction measure.[71] Earlier CBO reports have presented options for reducing the SSBN force to 10 boats as a cost-reduction measure.[72] 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 recommends reducing the SSBN force to 7 boats,[73] a September 2010 report from the Cato Institute recommends reducing the SSBN force to 6 boats,[74] and a September 2013 report from a group organized by the Stimson Center recommends reducing the force to 10 boats.[75]

Views on whether a force of fewer than 12 Columbia-class boats would be adequate 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.[76] Reducing the number of SSBNs

[70] Congress funded the procurement of two aircraft carriers (CVNs 72 and 73) in FY1983, and another two (CVNs 74 and 75) in FY1988. Although CVN-73 was funded in FY1983, it was built on a schedule consistent with a carrier funded in FY1985; although CVN-75 was funded in FY1988, it was built on a schedule consistent with a carrier funded in FY1990 or FY1991.

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

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

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

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

[75] *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.)

[76] For further discussion, see CRS Report RL33640, *U.S. Strategic Nuclear Forces: Background, Developments, and Issues*, by (name redacted)

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 (see "Planned Procurement Quantity") 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 FY2019

Summary of Congressional Action on FY2019 Funding Request

Table 4 below summarizes congressional action on the Navy's FY2019 funding request for the Columbia-class program.

Table 4. Congressional Action on FY2019 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.
Research and development (R&D)							
PE0603570N (line 049)/Project 3219	190.1						
PE0603595N (line 054)/Project 3220	514.8						
Subtotal R&D	***704.9***						
Advance procurement (AP)	**3,005.3**						
TOTAL	**3,710.2**						

Source: Navy FY2019 budget submission and committee and conference reports and explanatory statements on FY2019 National Defense Authorization Act and FY2019 DOD 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. **PE0603561N/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.

Legislative Activity for FY2018

Summary of Congressional Action on FY2018 Funding Request

Table 5 below summarizes congressional action on the Navy's FY2018 funding request for the Columbia-class program.

Table 5. Congressional Action on FY2018 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.**
Research and development (R&D)							
PE0603570N (line 049)/Project 3219	265.5	265.5	265.5	265.5	265.5	265.5	265.5
PE0603595N (line 054)/Project 3220	776.2	776.2	776.2	776.2	776.2	801.2	801.2
Subtotal R&D	***1,041.7***	***1,041.7***	***1,041.7***	***1,041.7***	***1,041.7***	***1,066.7***	***1,066.7***
Advance procurement (AP) (SCN account)	**842.9**	**842.9**	**842.9**	**842.9**	**842.9**	**842.9**	**861.9**
TOTAL	**1,884.6**	**1,884.6**	**1,884.6**	**1,884.6**	**1,884.6**	**1,909.6**	**1,928.6**

Source: Navy FY2018 budget submission and committee and conference reports and explanatory statements on FY2018 National Defense Authorization Act and FY2018 DOD 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. **PE0603561N/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.

FY2018 National Defense Authorization Act (H.R. 2810/S. 1519)

House

The House Armed Services Committee, in its report (H.Rept. 115-200 of July 6, 2017) on H.R. 2810, recommended the funding levels for the Columbia-class program shown in the HASC column of **Table 5**.

Section 214 of H.R. 2810 as reported states the following:

> SEC. 214. Critical technologies for Columbia class submarine.
>
> (a) In general.—For purposes of sections 2366b and 2448b(a)(2) of title 10, United States Code, the components identified in subsection (b) are deemed to be critical technologies for the Columbia class ballistic missile submarine construction program.
>
> (b) Critical technologies.—The components identified in this subsection are—
>
> (1) the coordinated stern for the Columbia class ballistic missile submarine;
>
> (2) the electric drive system for the submarine; and
>
> (3) the nuclear reactor for the submarine.

Section 1013 of H.R. 2810 as reported states the following:

> SEC. 1013. Use of National Sea-Based Deterrence Fund for multiyear procurement of certain critical components.
>
> (a) In general.—Subsection (i) of section 2218a of title 10, United States Code, is amended—
>
> (1) by striking "the common missile compartment" each place it appears and inserting "critical components"; and

(2) in paragraph (1), by striking "critical parts, components, systems, and subsystems" and inserting "critical components".

(b) Definition of critical component.—Subsection (k) of such section is amended by adding at the end the following new paragraph:

"(3) The term 'critical component' means any—

"(A) any item that is high volume or high value; or

"(B) any common missile compartment component, shipyard manufactured component, valve, torpedo tube, or Government furnished equipment, including propulsors and strategic weapons system launchers.".

(c) Clerical amendment.—The subsection heading for subsection (i) of such section is amended by striking "of the common missile compartment".

Section 1670 of H.R. 2810 as reported states the following (emphasis added):

SEC. 1670. Sense of Congress on importance of independent nuclear deterrent of United Kingdom.

It is the sense of Congress that—

(1) nuclear deterrence is foundational to the defense and security of the United States and the security of the United States is enhanced by a nuclear-armed ally with common values and security priorities;

(2) the United States sees the nuclear deterrent of the United Kingdom as central to transatlantic security and welcomes the commitment of the United Kingdom to the North Atlantic Treaty Organization (NATO) to continue to spend two percent of gross domestic product on defense;

(3) in the face of increasing threats, the presence of credible nuclear deterrent forces of the United Kingdom is essential to international stability and for NATO;

(4) the commitment of the United Kingdom to sustaining an independent nuclear deterrent, deployed continuously at sea, provides a vital second decision-making point within the deterrent capability of NATO, creating essential uncertainty in the mind of any potential adversary;

(5) **the United States Navy must continue to execute the Columbia-class submarine program on time and within budget to ensure that the sea-based leg of the nuclear triad of the United States is sustained and the program delivers a Common Missile Compartment, the Trident II (D5) Strategic Weapon System, and associated equipment and production capabilities, to support the successful development and deployment of the Dreadnought submarines of the United Kingdom**;

(6) the support that the United Kingdom provides to deployments of strategic ships and aircraft of the United States at specialized facilities enables a vital part of the deterrence posture of the United States as well as mutual deterrence of adversaries and assurance to the allies and partners of the United States; and

(7) the collaboration of the United Kingdom with the United States on the military use of atomic energy ensures a peer in the technology and science of nuclear weapons and provides independent expert peer review of the nuclear programs of the United States, ensuring resilience, and cost effectiveness to the nuclear defense programs of both nations.

H.Rept. 115-200 states the following:

Columbia-class submarine program

> The committee continues to exercise specific oversight on the progress and challenges facing the Navy's Columbia-class acquisition program and the replacement to the Ohio-class ballistic missile submarines, which are scheduled to begin retirement in 2027. The committee notes the Department of Defense and the Navy consider the Columbia-class acquisition among the highest priorities in order to meet sea-based strategic deterrence requirements in the future threat environment through the 2080s. The magnitude of the program's estimated cost, expected to exceed $267.0 billion over its life cycle, as well as the aggressive schedule on which the Navy and its shipbuilders plan to complete the submarine's technology development and design, and start constructing the new class, among other issues, will be subjects of continued interest and concern to the committee.
>
> Therefore, the committee directs the Comptroller General of the United States to assess the Navy's Columbia-class acquisition and submit a report to the congressional defense committees by March 1, 2018, that includes an analysis of the following:
>
> (1) technology development including activities in support of the submarine's nuclear propulsion system;
>
> (2) progress of shipbuilder design products;
>
> (3) program cost estimates;
>
> (4) approved acquisition strategy and use of expanded authorities including cross-program material procurement, early structural fabrication, and advance construction;
>
> (5) industrial base capacity to meet the Navy's plans and requirements; and
>
> (6) construction readiness and feasibility of achieving on-time submarine delivery to meet Navy operational requirements. (Page 21)

H.Rept. 115-200 also states the following:

> *Naval Reactors program*
>
> The Naval Reactors program is responsible for all aspects of naval nuclear propulsion efforts, including reactor plant technology design and development, reactor plant operation and maintenance, and reactor retirement and disposal. The program ensures the safe and reliable operation of reactor plants in nuclear-powered submarines and aircraft carriers. These ships comprise over 40 percent of the Navy's major combatants.
>
> The committee notes that the recent identification of a manufacturing problem with the prototype electric-drive motor for the Columbia-class submarine will result in late delivery of the prototype motor to the test facility. Naval Reactors assures the committee that this delay will not delay delivery of the shipboard motor for the lead ship of the Columbia class. The committee understands that there is no margin left in the Columbia-class schedule and expects Naval Reactors to take strong action to ensure they meet all deliverables to the Navy.
>
> The committee has long been supportive of the Naval Reactors program and believes it is an exceptional example of a nuclear-related government program that is safety-focused, mission-driven, and well-managed. Due to this success, the committee and the Navy will continue to have very high expectations for performance by Naval Reactors. The committee will continue its oversight of Naval Reactors' stewardship of the Navy's nuclear mission. (Page 335)

Senate

The Senate Armed Services Committee, in its report (S.Rept. 115-125 of July 10, 2017) on S. 1519, recommended the funding levels for the Columbia-class program shown in the SASC column of **Table 5**. The report states the following:

Columbia-class submarines

The budget request included $842.9 million in line item 1 of Shipbuilding and Conversion, Navy (SCN), for Columbia-class submarines advance procurement.

The committee notes the cost estimate for the lead ship non-recurring engineering program support increased from the 2014 Life Cycle Cost Estimate to the 2016 Milestone B cost estimate. The committee asked about this increase, but the Navy did not provide a timely answer to the questions. The committee is disappointed by the Navy's performance and expects the Navy to ensure robust, punctual explanations are provided whenever the committee asks for program clarifications.

In addition, the committee directs the Secretary of the Navy to conduct a comprehensive security classification review of the Columbia-class program to ensure all systems and capabilities are properly classified. The Secretary shall submit his findings at the appropriate classification level to the Committees on Armed Services of the Senate and House of Representatives not later December 1, 2017.

Composite technology in submarine construction

The committee notes that the Navy has successfully integrated composite technology into different submarine classes and that composites can reduce procurement costs and lower overall lifecycle costs for certain components and subsystems. For example, a February 2016, Navy report to Congress found a composite technology alternative for Columbia-class bow domes would save the Navy at least $6.6 million and avoid an additional $8.7 million in tooling.

The committee believes the Navy should further explore opportunities to integrate proven composite technology, particularly for Virginia-class submarines, including the bow dome and Virginia Payload Module, and Columbia-class submarines, including the superstructure.

Therefore, not later than November 1, 2017, the Secretary of the Navy shall deliver a report to the Committees on Armed Services of the Senate and House of Representatives on the feasibility and merits of further integrating proven composite technology into Virginia-class and Columbia-class submarines. The report shall:

(1) Identify non-composite systems and components planned for Block V Virginia-class submarines and Columbia-class submarines for which a proven composite alternative is in development or fielded; and

(2) For those systems and components identified in paragraph (1), provide the approximate cost and schedule differences if such composite systems and components were substituted for non-composite systems and components.

Domestic supply of submarine missile launcher tubes

The committee supports the Navy's ongoing efforts to reduce cost and risk in development and production of launcher tubes for both the Virginia Payload Module (VPM) and the Columbia-class program, including the Common Missile Compartment (CMC). In written testimony for a hearing of the Strategic Forces Subcommittee on June 7, 2017, Vice Admiral Terry Benedict, Director of the Navy's Strategic Systems Programs, testified to the importance of the CMC as a critical component for both the U.S. Columbia-class and United Kingdom Dreadnought-class programs, with any delay to the joint CMC effort having the potential to impact the ability of both nations to maintain an effective sea-based deterrent.

Missile tube construction is a critical and fragile subset of the U.S. shipbuilding industrial base that is regenerating after the last Ohio-class ballistic missile submarine was built in the 1990s. The committee is aware of the Navy's work to reduce risk in the restart of launcher system production at the surface test launch facility at the Naval Air Warfare

> Center Weapons Division, China Lake, to demonstrate that the launcher industrial base can replicate the successful performance of the Ohio-class Trident II (D5) launcher system.
>
> The committee urges the Navy to take every appropriate measure to ensure a viable supply of launcher tubes are available through the U.S. industrial base to meet the cost and schedule requirements facing both the Columbia-class program and the Virginia-class guided missile variant through VPM. (Pages 28-29)

S.Rept. 115-125 also states the following:

> **Undersea warfare applied research**
>
> The budget request included $56.1 million in Research, Development, Test, and Evaluation, Navy, PE 62747N, for undersea warfare applied research. The committee notes that the Navy has been researching the capacity of the shipyards that build our nation's nuclear submarine forces to maintain higher production rates for the Virginia-class submarines while also designing and then beginning construction of the first of the Columbia-class submarines in fiscal year 2021.
>
> The committee encourages the Navy to align their efforts with qualified higher education partners focusing on undersea vehicle applications related to several key fabrication and manufacturing process technologies including composites, metals, and electronics. In addition, investments should address the overall affordability challenge faced by current and future submarine and undersea vehicle programs, including fabrication process innovation and the ability to introduce continuous technology improvements at the Navy's existing undersea shipyard industrial base.
>
> The committee directs the Navy to closely coordinate this effort with its industrial base partners to ensure that funded research projects are relevant to specific engineering and manufacturing needs, as well as defined systems capabilities. Partnerships with academia should focus on specific, well-defined short- and long-term submarine and autonomous undersea vehicle research needs and accelerated technology transition, and they should include a strong workforce development component. To bolster this effort, the committee recommends an aggregate increase of $25.0 million in PE 62747N for a total of $81.1 million. (Page 57)

Conference

The conference report (H.Rept. 115-404 of November 9, 2017) on H.R. 2810, recommended the funding levels for the Columbia-class program shown in the authorization conference column of **Table 5**.

Section 231 of the conference version of H.R. 2810 states the following:

> SEC. 231. Columbia-class program accountability matrices.
>
> (a) Submittal of matrices.—Concurrent with the President's annual budget request submitted to Congress under section 1105 of title 31, United States Code, for fiscal year 2019, the Secretary of the Navy shall submit to the congressional defense committees and the Comptroller General of the United States the matrices described in subsection (b) relating to the Columbia-class program.
>
> (b) Matrices described.—The matrices described in this subsection are the following:
>
> (1) DESIGN AND CONSTRUCTION GOALS.—A matrix that identifies, in six-month increments, key milestones, development events, and specific performance goals for the design and construction of the Columbia-class program, which shall be subdivided, at a minimum, according to the following:

(A) Technology-readiness levels of major components and key demonstration events.

(B) Design maturity.

(C) Manufacturing-readiness levels for critical manufacturing operations and key demonstration events.

(D) Manufacturing operations.

(E) Reliability.

(2) COST.—A matrix expressing, in annual increments, the total cost phased over the entire Columbia-class design and construction period of—

(A) the Navy service cost position for the prime contractor's portion of Columbia-class design and construction activities, including the estimated price at completion for each submarine and confidence level of this estimate;

(B) the program manager's estimate for the prime contractor's portion of Columbia-class design and construction activities, including the estimated price and variance at completion for each submarine; and

(C) the prime contractor's estimate for the prime contractor's portion of Columbia-class design and construction activities, including the estimated price and variance at completion for each submarine.

(c) Update of matrices.—

(1) IN GENERAL.—Not later than 180 days after the date on which the Secretary of the Navy submits the matrices required by subsection (a), and concurrent with the submittal of each annual budget request to Congress under section 1105 of title 31, United States Code, beginning with the fiscal year 2020 request, the Secretary of the Navy shall submit to the congressional defense committees and the Comptroller General of the United States updates to the matrices described in subsection (b).

(2) ELEMENTS.—Each update submitted under paragraph (1) shall detail progress made toward the goals identified in the matrix described in subsection (b)(1) and provide updated cost data as prescribed in subsection (b)(2).

(3) TREATMENT OF INITIAL MATRICES AS BASELINE.—The matrices submitted pursuant to subsection (a) shall be treated as the baseline for the full Columbia-class design and construction period for purposes of the updates submitted pursuant to paragraph (1) of this subsection.

(4) REPORT TERMINATION.—The report required under paragraph (1) shall terminate upon delivery of the first Columbia-class submarine.

(d) Assessment by Comptroller General of the United States.—Not later than 90 days after the date on which the Comptroller General of the United States receives an update to a matrix under subsection (c)(1), the Comptroller General shall review such matrix and provide to the congressional defense committees an assessment of such matrix in whatever form that the Comptroller General deems appropriate.

(e) Repeal of report requirement.—Section 131 of the National Defense Authorization Act for Fiscal Year 2016 (129 Stat. 754; Public Law 114–92) is hereby repealed.

(f) Major component defined.—In this section, the term "major component" includes, at a minimum, the integrated power system, nuclear reactor, propulsor and related coordinated stern features, stern area system, and common missile compartment.

Regarding Section 231, H.Rept. 115-404 states the following:

Columbia-class program accountability matrices (sec. 231)

The House bill contained a provision (sec. 214) that would deem certain Columbia-class ballistic missile submarine components as critical technologies.

The Senate amendment contained no similar provision.

The Senate recedes with an amendment that would require submittal and periodic updates of matrices on Columbia-class cost, design and construction goals. The Comptroller General of the United States would be required to review and assess each periodic update. The amendment would also repeal section 131 of the National Defense Authorization Act for Fiscal Year 2016 (Public Law 114–92).[77] (Pages 780-781)

Section 1022 states the following:

SEC. 1022. Use of National Sea-Based Deterrence Fund for multiyear procurement of certain critical components.

(a) In general.—Subsection (i) of section 2218a of title 10, United States Code, is amended—

(1) by striking "the common missile compartment" each place it appears and inserting "critical components"; and

(2) in paragraph (1), by striking "critical parts, components, systems, and subsystems" and inserting "critical components".

(b) Definition of critical component.—Subsection (k) of such section is amended by adding at the end the following new paragraph:

"(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.

[77] Section 131 of P.L. 114-92 states the following:

SEC. 131. REPORTING REQUIREMENT FOR OHIO-CLASS REPLACEMENT SUBMARINE PROGRAM.

If the budget of the President submitted to Congress under section 1105(a) of title 31, United States Code, for a fiscal year includes a request for funds for the Ohio-class replacement submarine program, the Secretary of Defense shall include in the budget justification materials submitted to Congress in support of the Department of Defense budget for such fiscal year a report that includes the following elements regarding such program (described in terms of both fiscal year 2010 dollars and current fiscal year dollars as of the date of the report):

(1) Lead ship end cost (with plans).

(2) Lead ship end cost (less plans).

(3) Lead ship non-recurring engineering cost.

(4) Average follow-on ship cost.

(5) Average operations and sustainment cost per hull per year.

(6) The average follow-on ship affordability target as determined by the Under Secretary of Defense for Acquisition, Technology, and Logistics.

(7) The operations and sustainment cost per hull per year affordability target as determined by the Under Secretary of Defense for Acquisition, Technology, and Logistics.

"(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.".

(c) Clerical amendment.—The subsection heading for subsection (i) of such section is amended by striking "of the common missile compartment".

Regarding Section 1022, H.Rept. 115-404 states the following:

Use of National Sea-Based Deterrence Fund for multiyear procurement of certain critical components (sec. 1022)

The House bill contained a provision (sec. 1013) that would expand the authority of the Secretary of the Navy to enter into a multiyear contract for certain nuclear-powered vessel components to include missile tubes, torpedo tubes, and propulsors.

The Senate amendment contained no similar provision.

The Senate recedes with an amendment that would define "critical components" as the following: a common missile compartment component, a spherical air flask, an air induction diesel exhaust valve, an auxiliary seawater valve, a hovering valve, a missile compensation valve, a main seawater valve, a launch tube, a trash disposal unit, a logistics escape trunk, a torpedo tube, a weapons shipping cradle weldment, a control surface, a launcher component, and a propulsor. (Page 916)

Section 1672 states the following (emphasis added):

SEC. 1672. Sense of Congress on importance of independent nuclear deterrent of United Kingdom.

It is the sense of Congress that—

(1) nuclear deterrence is foundational to the defense and security of the United States and the security of the United States is enhanced by a nuclear-armed ally with common values and security priorities;

(2) the United States sees the nuclear deterrent of the United Kingdom as central to transatlantic security and welcomes the commitment of the United Kingdom to the North Atlantic Treaty Organization (NATO) to continue to spend two percent of gross domestic product on defense;

(3) in the face of increasing threats, the presence of credible nuclear deterrent forces of the United Kingdom is essential to international stability and for NATO;

(4) the commitment of the United Kingdom to sustaining an independent nuclear deterrent, deployed continuously at sea, provides a vital second decision-making point within the deterrent capability of NATO, creating essential uncertainty in the mind of any potential adversary;

(5) the United States Navy must continue to execute the Columbia-class submarine program on time and within budget to ensure that the sea-based leg of the nuclear

> **triad of the United States is sustained and the program delivers a Common Missile Compartment, the Trident II (D5) Strategic Weapon System, and associated equipment and production capabilities, to support the successful development and deployment of the Dreadnought submarines of the United Kingdom;**
>
> (6) the support that the United Kingdom provides to deployments of strategic ships and aircraft of the United States at specialized facilities enables a vital part of the deterrence posture of the United States as well as mutual deterrence of adversaries and assurance to the allies and partners of the United States; and
>
> (7) the collaboration of the United Kingdom with the United States on the military use of atomic energy ensures a peer in the technology and science of nuclear weapons and provides independent expert peer review of the nuclear programs of the United States, ensuring resilience and cost effectiveness to the nuclear defense programs of both nations.

FY2018 DOD Appropriations Act (Division A of H.R. 3219/S. XXXX/Division C of H.R. 1625/P.L. 115-141)

House

H.R. 3219 as reported by the House Appropriations Committee (H.Rept. 115-219 of July 13, 2017) was the FY2018 DOD Appropriations Act. H.R. 3219 as passed by the House is called the Make America Secure Appropriations Act, 2018. H.R. 3219 as passed by the House includes the FY2018 DOD Appropriations Act as Division A and four other appropriations acts as Divisions B through E. The discussion below relates to Division A.

The House Appropriations Committee, in its report (H.Rept. 115-219 of July 13, 2017) on H.R. 3219, recommended the funding levels for the Columbia-class program shown in the HAC column of **Table 5**. The paragraph in H.R. 3219 as reported that makes appropriations for the Shipbuilding and Conversion, Navy (SCN) account includes this proviso:

> *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

On November 21, 2017, the Senate Appropriations Committee released a Chairman's recommendation and explanatory statement for the FY2018 DOD Appropriations Act, referred to here as S. XXXX. The explanatory statement recommended the funding levels shown in the SAC column of **Table 5**. The recommended increase of $25 million for PE0603595N (line 054)/Project 3220 is for "Program increase: Advanced materials propeller program." (Page 169)

The explanatory statement states the following:

> *Submarine Industrial Base.*—The fiscal year 2018 President's budget includes $1,884,500,000 for the Ohio-class replacement program [ORP] and $5,581,500,000 for the Virginia-class program [VA] in Research, Development, Test and Evaluation, Navy; Shipbuilding and Conversion, Navy; and Other Procurement, Navy. The Committee understands that the budget request fully funds the programs' respective cost estimates and recommends full funding. Further, the Committee notes that no special acquisition or

> funding authorities in addition to those previously provided have been requested in the President's budget or are required in fiscal year 2018.
>
> The Committee notes recent major accomplishments in these programs, including the approval of Milestone B for ORP in November 2016 and award of the ORP Integrated Product and Process Development contract in September 2017. Additionally, significant upcoming milestones include the cut-in to production of the Virginia Payload Module [VPM] in fiscal year 2019 and a planned ten-ship multi-year procurement contract award for the Virginia-class program in fiscal year 2018.
>
> The Committee is aware of several issues that could potentially introduce risk to these programs, including: cost and schedule concerns raised by the shipbuilder regarding the Virginia-class Block V multi-year procurement program; capacity constraints at sub-tier vendors impacting critical component deliveries; schedule delays in design completions across the enterprise requiring aggressive remedial schedules; vendor oversight issues; loss of schedule margin in certain prototype manufacturing; and consistent manning shortfalls across all submarine programs. The Committee understands that these issues have not yet negatively affected costs and schedules of the ORP and VA programs. However, the Committee is concerned with the accumulation of challenges and encourages the Secretary of the Navy and the Chief of Naval Operations to remain focused on addressing these issues. The Committee recommends an additional $175,000,000 in Shipbuilding and Conversion, Navy for submarine industrial base expansion in support of Navy efforts to implement action plans to improve readiness assessments of critical suppliers for the ORP and VA shipbuilding enterprise. (Pages 106-107)

Conference

The FY2018 DOD Appropriations Act was enacted as Division C of H.R. 1625/ P.L. 115-141 of March 23, 2018, the Consolidated Appropriations Act, 2018. The explanatory statement for Division C of H.R. 1625 provides the funding levels for the Columbia-class program shown in the appropriation conference column of **Table 5**. The increase of $25.0 million for PE0603595N (line 054)/Project 3220 is for "Program increase—advanced materials propeller program" (PDF page 254 of 391). The increase of $19.0 million for advance procurement (AP) funding is for "Program increase—foundry propeller center facilitization" (PDF page 166 of 391).

The paragraph in Division C of H.R. 1625 / P.L. 115-141 of March 23, 2018, that appropriates funding for the Shipbuilding and Conversion, Navy, appropriation account includes a provision that states:

> ... *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)).[78]

[78] 10 U.S.C. 2218a is the statute establishing the National Sea-Based Deterrence Fund.

Appendix A. Summary of 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.[79] 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

[79] 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.[80] 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.[81] The Navy testified in

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

[81] 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

(continued...)

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."[82]

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.[83]

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."[84] The first new boat is to be delivered by 2028, or about four years later than previously planned.[85]

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[86] 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."[87] 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

(...continued)

> 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* (www.nti.org/gsn), July 30, 2014.

[82] 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.

[83] *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.

[84] *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.

[85] *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.

[86] 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.

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

> exchange with the UK Ministry of Defence under the US/UK 1958 Mutual Defence Agreement. The 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.[88]

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."[89]

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."[90]

[88] 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.

[89] 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.

[90] 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 Early Milestones

This appendix provides background information on the Columbia-class program's 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).[91] 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[92] and approved by DOD's Joint Requirements Oversight Committee (JROC) on June 20, 2008.[93] 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.[94] The Navy established an Columbia-class program office at about this same time.[95]

The AOA reportedly began in the summer or fall of 2008.[96] 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.[97] The AOA concluded that a new-design SSBN was the best option for replacing the Ohio-class SSBNs. (For a June 26, 2013, Navy blog post discussing options that were examined for replacing the Ohio-class SSBNs, see **Appendix E**.)

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[91] 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.)

[92] 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.)

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

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

[95] 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.

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

[97] *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).

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.[98]

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

Appendix D. Earlier Oversight Issue: A Design with 16 vs. 20 SLBM Tubes

This appendix provides background information on an earlier oversight issues regarding the Columbia-class program—the question of whether Columbia-class boats should be equipped with 16 or 20 SLBM launch 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 to toward the Navy's target cost of $4.9 billion in FY2010 dollars.[99] 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 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

[99] 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.)

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.[100]

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.
>
> 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

[100] Source: Transcript of hearing.

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.[101]

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:

Sir, we looked at the ability of the system, again, SSP does not look at specific targets with...

REPRESENTATIVE LARSEN:

Right. Yes, yes, yes.

[101] Source: Transcript of hearing.

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.[102]

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.[103]

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:

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

[102] Source: Transcript of hearing.

[103] Source: Transcript of hearing.

> (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.[104]

[104] 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. June 2013 Navy Blog Post Regarding Ohio Replacement Options

This appendix presents the text of 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. The text is as follows:

> 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:
>
> • 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.[105]

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[105] "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/.