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Navy Virginia (SSN-774) Class Attack Submarine Procurement: Background and Issues for Congress

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Specialist in Naval Affairs

October 4, 2017

Congressional Research Service

7-....

www.crs.gov

RL32418

Summary

The Navy has been procuring Virginia (SSN-774) class nuclear-powered attack submarines since FY1998. The two Virginia-class boats requested for procurement in FY2018 are to be the 27th and 28th boats in the class. The 10 Virginia-class boats programmed for procurement in FY2014-FY2018 (two per year for five years) are being procured under a multiyear-procurement (MYP) contract.

The Navy estimates the combined procurement cost of the two Virginia-class boats requested for procurement in FY2018 at \$5,532.7 million, or an average of \$2,766.4 million each. The boats have received a total of \$1,647.0 million in prior-year “regular” advance procurement (AP) funding and \$580.4 million in prior-year Economic Order Quantity (EOQ) AP funding. The Navy’s proposed FY2018 budget requests the remaining \$3,305.3 million needed to complete the boats’ estimated combined procurement cost. The Navy’s proposed FY2018 budget also requests \$1,920.6 million in AP funding for Virginia-class boats to be procured in future fiscal years, bringing the total FY2018 funding request for the program (excluding outfitting and post-delivery costs) to \$5,225.9 million.

The Navy plans to build one of the two Virginia-class boats scheduled to be procured in FY2019, and all Virginia-class boats procured in FY2020 and subsequent years, with an additional mid-body section, called the Virginia Payload Module (VPM), that contains four large-diameter, vertical launch tubes that the boats would use to store and fire additional Tomahawk cruise missiles or other payloads, such as large-diameter unmanned underwater vehicles (UUVs). The Navy’s proposed FY2018 budget requests \$72.9 million in research and development funding for the Virginia Payload Module (VPM).

The Navy’s previous force-level goal was to achieve and maintain a 308-ship fleet, including 48 SSNs. The Navy’s new force-level goal, released in December 2015, is to achieve and maintain a 355-ship fleet, including 66 SSNs. The Navy’s FY2017 30-year shipbuilding plan was developed in association with the previous 308-ship force-level goal, and consequently does not include enough SSNs to achieve and maintain a force of 66 SSNs. CRS estimates that 19 SSNs would need to be added to the FY2017 30-year shipbuilding plan to achieve and maintain a 66-boat SSN force. The Congressional Budget Office (CBO) estimates that 16 to 19 would need to be added to the FY2017 30-year shipbuilding plan to achieve and maintain a 66-boat SSN force. Taking into account the capacity of the submarine construction industrial base and the Navy’s current plan to also build Columbia (SSBN-826) class ballistic missile submarines in coming years, CRS and CBO estimate that the earliest a 66-boat SSN force could be achieved might be the mid- to late 2030s.

From FY2025 to FY2036, the number of SSNs is projected to experience a dip or valley, reaching a minimum of 41 boats (i.e., 25 boats, or about 38%, less than the 66-boat force-level goal) in FY2029. This projected valley is a consequence of having procured a relatively small number of SSNs during the 1990s, in the early years of the post-Cold War era. Some observers are concerned that this projected valley in SSN force levels could lead to a period of heightened operational strain for the SSN force, and perhaps a period of weakened conventional deterrence against potential adversaries. The projected SSN valley was first identified by CRS in 1995 and has been discussed in CRS reports and testimony every year since then. The Navy has been exploring options for mitigating the projected valley. Procuring additional Virginia-class boats in the near term is one of those options. In that connection, the Navy has expressed interest in procuring an additional Virginia-class boat in FY2021. Congress also has the option of funding the procurement of one or more additional Virginia-class boats in FY2018-FY2020.

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Introduction

This report provides background information and issues for Congress on the Virginia-class nuclear-powered attack submarine (SSN) program. The Navy's proposed FY2018 budget requests \$5,225.9 million in procurement and advance procurement (AP) funding for the program. Decisions that Congress makes on procurement of Virginia-class boats could substantially affect U.S. Navy capabilities and funding requirements, and the U.S. shipbuilding industrial base.

The Navy's Columbia (SSBN-826) class ballistic missile submarine program, previously known as the Ohio Replacement or SSBN(X) program, is discussed in another CRS report.¹

For an overview of the strategic and budgetary context in which the Virginia-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) .

Background

U.S. Navy Submarines²

The U.S. Navy operates three types of submarines—nuclear-powered ballistic missile submarines (SSBNs),³ nuclear-powered cruise missile and special operations forces (SOF) submarines (SSGNs),⁴ and nuclear-powered attack submarines (SSNs). The SSNs are general-purpose submarines that can (when appropriately equipped and armed) perform a variety of peacetime and wartime missions, including the following:

- covert intelligence, surveillance, and reconnaissance (ISR), much of it done for national-level (as opposed to purely Navy) purposes;
- covert insertion and recovery of SOF (on a smaller scale than possible with the SSGNs);

¹ See CRS Report R41129, *Navy Columbia Class (Ohio Replacement) Ballistic Missile Submarine (SSBN[X]) Program: Background and Issues for Congress*, by (name redacted) .

² In U.S. Navy submarine designations, SS stands for submarine, N stands for nuclear-powered, B stands for ballistic missile, and G stands for guided missile (such as a cruise missile). Submarines can be powered by either nuclear reactors or non-nuclear power sources such as diesel engines or fuel cells. All U.S. Navy submarines are nuclear-powered. 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 The SSBNs' basic mission is to remain hidden at sea with their nuclear-armed submarine-launched ballistic missiles (SLBMs) and thereby deter a strategic nuclear attack on the United States. The Navy's SSBNs are discussed in CRS Report R41129, *Navy Columbia Class (Ohio Replacement) Ballistic Missile Submarine (SSBN[X]) Program: Background and Issues for Congress*, by (name redacted) , and CRS Report RL31623, *U.S. Nuclear Weapons: Changes in Policy and Force Structure*, by (name redacted)

⁴ The Navy's four SSGNs are former Trident SSBNs that have been converted (i.e., modified) to carry Tomahawk cruise missiles and SOF rather than SLBMs. Although the SSGNs differ somewhat from SSNs in terms of mission orientation (with the SSGNs being strongly oriented toward Tomahawk strikes and SOF support, while the SSNs are more general-purpose in orientation), SSGNs can perform other submarine missions and are sometimes included in counts of the projected total number of Navy attack submarines. The Navy's SSGNs are discussed in CRS Report RS21007, *Navy Trident Submarine Conversion (SSGN) Program: Background and Issues for Congress*, by (name redacted) .

- covert strikes against land targets with the Tomahawk cruise missiles (again on a smaller scale than possible with the SSGNs);
- covert offensive and defensive mine warfare;
- anti-submarine warfare (ASW); and
- anti-surface ship warfare.

During the Cold War, ASW against Soviet submarines was the primary stated mission of U.S. SSNs, although covert ISR and covert SOF insertion/recovery operations were reportedly important on a day-to-day basis as well.⁵ In the post-Cold War era, although anti-submarine warfare remained a mission, the SSN force focused more on performing the other missions noted on the list above. In light of the recent shift in the strategic environment from the post-Cold War era to a new situation featuring renewed great power competition that some observers conclude has occurred, ASW against Russian and Chinese submarines may once again become a more prominent mission for U.S. Navy SSNs.⁶

U.S. Attack Submarine Force Levels

Force-Level Goal

The Navy's previous force-level goal was to achieve and maintain a 308-ship fleet, including 48 SSNs. The Navy's new force-level goal, released in December 2015, is to achieve and maintain a 355-ship fleet, including 66 SSNs.⁷ For a review of SSN force level goals since the Reagan Administration, see **Appendix A**.

Force Level at End of FY2016

The SSN force included more than 90 boats during most of the 1980s, when plans called for achieving a 600-ship Navy including 100 SSNs. The number of SSNs peaked at 98 boats at the end of FY1987 and has declined since then in a manner that has roughly paralleled the decline in the total size of the Navy over the same time period. The 52 SSNs in service at the end of FY2016 included the following:

- 36 Los Angeles (SSN-688) class boats;
- 3 Seawolf (SSN-21) class boats; and
- 13 Virginia (SSN-774) class boats.

Los Angeles- and Seawolf-Class Boats

A total of 62 Los Angeles-class submarines, commonly called 688s, were procured between FY1970 and FY1990 and entered service between 1976 and 1996. They are equipped with four

⁵ For an account of certain U.S. submarine surveillance and intelligence-collection operations during the Cold War, see Sherry Sontag and Christopher Drew with Annette Lawrence Drew, *Blind Man's Bluff* (New York: Public Affairs, 1998).

⁶ For further discussion of this shift in the strategic environment and how it has led to, among other things, an increased emphasis in discussions of U.S. defense policy on submarines and ASW, see CRS Report R43838, *A Shift in the International Security Environment: Potential Implications for Defense—Issues for Congress*, by (name redacted) .

⁷ For additional information on Navy force-level goals, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .

21-inch diameter torpedo tubes and can carry a total of 26 torpedoes or Tomahawk cruise missiles in their torpedo tubes and internal magazines. The final 31 boats in the class (SSN-719 and higher) were built with an additional 12 vertical launch system (VLS) tubes in their bows for carrying and launching another 12 Tomahawk cruise missiles. The final 23 boats in the class (SSN-751 and higher) incorporate further improvements and are referred to as Improved Los Angeles class boats or 688Is. As of the end of FY2016, 26 of the 62 boats in the class had been retired.

The Seawolf class was originally intended to include about 30 boats, but Seawolf-class procurement was stopped after three boats as a result of the end of the Cold War and associated changes in military requirements. The three Seawolf-class submarines are the *Seawolf* (SSN-21), the *Connecticut* (SSN-22), and the *Jimmy Carter* (SSN-23). SSN-21 and SSN-22 were procured in FY1989 and FY1991 and entered service in 1997 and 1998, respectively. SSN-23 was originally procured in FY1992. Its procurement was suspended in 1992 and then reinstated in FY1996. It entered service in 2005. Seawolf-class submarines are larger than Los Angeles-class boats or previous U.S. Navy SSNs.⁸ They are equipped with eight 30-inch-diameter torpedo tubes and can carry a total of 50 torpedoes or cruise missiles. SSN-23 was built to a lengthened configuration compared to the other two ships in the class.⁹

Virginia (SSN-774) Class Program

General

The Virginia-class attack submarine (see **Figure 1**) was designed to be less expensive and better optimized for post-Cold War submarine missions than the Seawolf-class design. The Virginia-class design is slightly larger than the Los Angeles-class design,¹⁰ but incorporates newer technologies. Virginia-class boats currently cost about \$2.7 billion each to procure. The first Virginia-class boat entered service in October 2004.

Past and Projected Annual Procurement Quantities

Table 1 shows annual numbers of Virginia-class boats procured from FY1998 (the lead boat) through FY2017, and numbers scheduled for procurement under the FY2018-FY2022 Future Years Defense Plan (FYDP).

Table 1. Annual Numbers of Virginia-Class Boats Procured or Projected for Procurement

FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10
1	1	0	1	1	1	1	1	1	1	1	1	1
FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	
2	2	2	2	2	2	2	2	2	2	2	2	

Source: Table prepared by CRS based on U.S. Navy data.

⁸ Los Angeles-class boats have a beam (i.e., diameter) of 33 feet and a submerged displacement of about 7,150 tons. Seawolf-class boats have a beam of 40 feet. SSN-21 and SSN-22 have a submerged displacement of about 9,150 tons.

⁹ SSN-23 is 100 feet longer than SSN-21 and SSN-22 and has a submerged displacement of 12,158 tons.

¹⁰ Virginia-class boats have a beam of 34 feet and a submerged displacement of 7,800 tons.

Figure I. Virginia-Class Attack Submarine



Source: U.S. Navy file photo accessed by CRS on January 11, 2011, at http://www.navy.mil/search/display.asp?story_id=55715.

Multiyear Procurement (MYP)

The 10 Virginia-class boats shown in **Table 1** for the period FY2014-FY2018 (referred to as the Block IV boats) are being procured under a multiyear procurement (MYP) contract¹¹ that was approved by Congress as part of its action on the FY2013 budget, and awarded by the Navy on April 28, 2014. The eight Virginia-class boats procured in FY2009-FY2013 (the Block III boats) were procured under a previous MYP contract, and the five Virginia-class boats procured in FY2004-FY2008 (the Block II boats) were procured under a still-earlier MYP contract. The four boats procured in FY1998-FY2002 (the Block I boats) were procured under a block buy contract, which is an arrangement somewhat similar to an MYP contract.¹² The boat procured in FY2003 fell between the FY1998-FY2002 block buy contract and the FY2004-FY2008 MYP arrangement, and was contracted for separately.

The Navy, as part of its FY2018 budget submission, may request approval for a new MYP contract for Virginia-class boats to be procured in FY2019-FY2023 (referred to as the Block V boats). Although this MYP contract would begin in FY2019—the budget for which Congress will consider in 2018—the Navy in the past has asked for authority for submarine MYP contracts one

¹¹ For a discussion of MYP contracting, 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) .

¹² For a discussion of block buy contracting, 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) .

year prior to the first year of the requested contract period to provide the Navy more time to negotiate the details of the MYP contract.

Joint Production Arrangement

Overview

Virginia-class boats are built jointly by 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 arrangement for jointly building Virginia-class boats was proposed to Congress by GD/EB, HII/NNS, and the Navy, and agreed to by Congress in 1997, at the outset of Virginia-class procurement.¹³ A primary aim of the arrangement is to minimize the cost of building Virginia-class boats at a relatively low annual rate in two shipyards (rather than entirely in a single shipyard) while preserving key submarine-construction skills at both shipyards.

Under the arrangement, GD/EB builds certain parts of each boat, HII/NNS builds certain other parts of each boat, and the yards have taken turns building the reactor compartments and performing final assembly of the boats. GD/EB has built the reactor compartments and performing final assembly on boats 1, 3, and so on, while HII/NNS has done so on boats 2, 4, and so on. The arrangement has resulted in a roughly 50-50 division of Virginia-class profits between the two yards and preserves both yards' ability to build submarine reactor compartments (a key capability for a submarine-construction yard) and perform submarine final-assembly work.¹⁴

Navy's Proposed Submarine Unified Build Strategy (SUBS)

The Navy, under a plan it calls the Submarine Unified Build Strategy (SUBS), is proposing to build Columbia-class ballistic missile submarines 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 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;

¹³ See Section 121 of the FY1998 National Defense Authorization Act (H.R. 1119/P.L. 105-85 of November 18, 1997).

¹⁴ The joint production arrangement is a departure from prior U.S. submarine construction practices, under which complete submarines were built in individual yards. The joint production arrangement is the product of a debate over the Virginia-class acquisition strategy within Congress, and between Congress and DOD, that occurred in 1995-1997 (i.e., during the markup of the FY1996-FY1998 defense budgets). The goal of the arrangement is to keep both GD/EB and HII/NNS involved in building nuclear-powered submarines, and thereby maintain two U.S. shipyards capable of building nuclear-powered submarines, while minimizing the cost penalties of using two yards rather than one to build a submarine design that is being procured at a relatively low annual rate. The joint production agreement cannot be changed without the agreement of both GD/EB and HII/NNS.

- GD/EB is to build certain parts of each Columbia-class boat—parts that are more or less analogous to the parts that GD/EB builds for each Virginia-class attack submarine;
- HII/NNS is to build certain other parts of each Columbia-class boat—parts that are more or less analogous to the parts that HII/NNS builds for each Virginia-class attack submarine;
- GD/EB is to perform the final assembly on all 12 Columbia-class boats;
- as a result of the three previous points, the Navy estimates that GD/EB would receive an estimated 77%-78% of the shipyard work building Columbia-class boats, and HII/NNS would receive 22%-23%;
- GD/EB is to continue as prime contractor for the Virginia-class program, but to help balance out projected submarine-construction workloads at GD/EB and HII/NNS, the division of work between the two yards for building Virginia-class boats is to be adjusted so that HII/NNS would perform the final assembly on a greater number of Virginia-class boats than it would have under a continuation of the current Virginia-class division of work (in which final assemblies are divided more or less evenly between the two shipyards); as a consequence, HII/NNS would receive a greater share of the total work in building Virginia-class boats than it would have under a continuation of the current division of work.¹⁵

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 [Ohio replacement, i.e., Columbia-class] 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.¹⁶

¹⁵ See Richard B. Burgess, "Submarine Admirals: 'Unified Build Strategy' Seeks Affordability for Future Sub Fleet," *Seapower*, July 8, 2016; 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.

¹⁶ Statement of the Honorable Sean J. Stackley, Assistant Secretary of the Navy (Research, Development and (continued...)

Cost-Reduction Effort

The Navy states that it achieved a goal of reducing the procurement cost of Virginia-class submarines so that two boats could be procured in FY2012 for a combined cost of \$4.0 billion in constant FY2005 dollars—a goal referred to as “2 for 4 in 12.” Achieving this goal involved removing about \$400 million (in constant FY2005 dollars) from the cost of each submarine. (The Navy calculated that the unit target cost of \$2.0 billion in constant FY2005 dollars for each submarine translated into about \$2.6 billion for a boat procured in FY2012.)¹⁷

Schedule and Cost Performance on Deliveries

As noted in CRS testimony in 2014,¹⁸ the Virginia (SSN-774) class attack program has been cited frequently in recent years as an example of a successful acquisition program. The program received a David Packard Excellence in Acquisition Award from DOD in 2008. Although the program experienced cost growth in its early years that was due in part to annual procurement rates that were lower than initially envisaged and challenges in restarting submarine production at Newport News Shipbuilding,¹⁹ the lead ship in the program was delivered within four months of the target date that had been established about a decade earlier, and ships in recent years have been delivered largely on cost and ahead of schedule. As a recent exception to that record, a March 13, 2017, press report states:

The luster is off a bit for the Virginia-class submarine building program, long considered a model US Navy construction effort that routinely brings down the building time and cost for each successive sub. One submarine has just missed its contract delivery date — pushed back even more when sea trials were halted to return to port — and shipbuilders are working harder to keep construction on schedule....

(...continued)

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.

¹⁷ The Navy says that, in constant FY2005 dollars, about \$200 million of the \$400 million in the sought-after cost reductions was accomplished simply through the improved economies of scale (e.g., better spreading of shipyard fixed costs and improved learning rates) of producing two submarines per year rather than one per year. The remaining \$200 million in sought-after cost reductions, the Navy says, was accomplished through changes in the ship’s design (which will contribute roughly \$100 million toward the cost-reduction goal) and changes in the shipyard production process (which will contribute the remaining \$100 million or so toward the goal). Some of the design changes are being introduced to Virginia-class boats procured prior to FY2012, but the Navy said the full set of design changes would not be ready for implementation until the FY2012 procurement.

Changes in the shipyard production process are aimed in large part at reducing the total shipyard construction time of a Virginia-class submarine from 72 months to 60 months. (If the ship spends less total time in the shipyard being built, its construction cost will incorporate a smaller amount of shipyard fixed overhead costs.) The principal change involved in reducing shipyard construction time to 60 months involves increasing the size of the modules that form each submarine, so that each submarine can be built out of a smaller number of modules. For detailed discussions of the Virginia-class cost-reduction effort, see David C. Johnson et al., “Managing Change on Complex Programs: VIRGINIA Class Cost Reduction,” *Naval Engineers Journal*, No. 4, 2009: 79-94; and John D. Butler, “The Sweet Smell of Acquisition Success,” *U.S. Naval Institute Proceedings*, June 2011: 22-28.

¹⁸ See Statement of Statement of Ronald O’Rourke, Specialist in naval Affairs, Congressional Research Service, before the House Armed Services Committee on Case Studies in DOD Acquisition: Finding What Works, June 24, 2014, p. 4.

¹⁹ See Statement of Ronald O’Rourke, Specialist in National Defense, Congressional Research Service, before the House Armed Services Committee Subcommittee on Seapower and Expeditionary Forces Hearing on Submarine Force Structure and Acquisition Policy, March 8, 2007, Table 10 on pp. 14-15.

Problems seem to stem from two primary factors: the move in 2011 to double the submarine construction rate from one to two per year has strained shipyards and the industrial base that supplies parts for the subs; and the Navy has successively reduced contractual building times as shipbuilders grew more experienced with building the submarines, cutting back on earlier, highly-trumpeted opportunities to beat deadlines.

The situation seemingly came to a head March 2 shortly after the submarine Washington began its initial sea trials off the Virginia coast. The submarine, fitting out at Huntington Ingalls Newport News Shipbuilding, has been falling behind schedule for some time, missing a targeted summer 2016 delivery date and a scheduled Jan. 7 commissioning ceremony. More delays ensued in January when, according to the Navy, a problem was found with the hatch seating surface in the large lockout trunk access hatch, requiring a notice to Congress that the ship would miss its Feb. 28 contract delivery date and a rescheduled March 25 commissioning date.

It's not the first time a Virginia-class submarine has missed a contract delivery date. The first two subs were late, and in late 2007 the North Carolina, the third Virginia, was delivered by Newport News seven weeks late because of welding issues. But since then, every submarine delivered by Newport News and Virginia class prime contractor General Dynamics Electric Boat has been delivered by the contract date or more often, earlier, causing something of a competition between the two yards.

Rear Adm. Michael Jabaley, program executive officer for submarines at Naval Sea Systems Command, was aboard the Washington for the sea trials but would not specify the exact problem that caused officials to take the highly unusual move of cutting short the sea trials.

Initial sea trials, he said March 9, are "a focused, two-and-a-half-day period where you certify the full capability of the ship from a propulsion, from a safety and recovery standpoint." If an issue comes up that impacts the ability to continue trials, he said, "you're coming back in. And that's what we did."

"We're working through this particular issue, and the delivery and commissioning date for the Washington is under review as a result," he added. "But my estimation is that we'll come through it relatively quickly."

But even with the sub's late delivery, Jabaley remains hopeful that by the end of the completion cycle — including post-delivery tests and a nearly six-month-long post shakedown availability overhaul — the planned date by which the completed, ready-for-operations submarine is turned over to commanders will still be met.

"Washington will deliver very close to schedule," Jabaley said, "and at delivery to the type commander she will be as early or earlier than almost any other submarine we've delivered in terms of getting her to the type commander as an operational asset."

So far, the Navy said, costs are not rising.

"The last nine Virginia submarines, (New Hampshire SSN 778 through Illinois SSN 786) have all been delivered under target cost and within Navy budget," Jabaley said. "Current projections are that all remaining Block III submarines (Washington SSN 787 through Delaware SSN 791) will also deliver under target cost and within Navy budget."...

The 2011 ramp-up from one to two submarines ordered each year strained the shipbuilders and the submarine industrial base. Electric Boat and Newport News, who share equally in building each sub, had to hire more workers, injecting a level of inexperience into their work forces with a consequent rise in the amount of work needing to be redone. Some parts suppliers have struggled to keep up with increased demand, and late deliveries and quality problems have become more frequent.

“Both shipbuilders hired additional people to account for the increase to two submarines per year,” Jabaley said. “As a result, obviously when you bring in an influx of new people your level of experience goes down.

“There is always a certain amount of rework in any manufacturing endeavor, and submarine construction is no different,” he said. “It is something we monitor closely. We knew there would be what we call the green labor effect as we went up to two per year. But we have in general satisfactorily come through that.”

The building schedule has also been significantly reduced since the first four Block I Virginias were contracted for an 84-month building period, reduced to 74 months for the six Block IIs. The eight Block III subs — those currently under construction — are set for a 66-month building times, and Block IVs will be reduced further to 62 and then 60 months.

The first three Block IIIs were delivered by the contract date, Jabaley noted, but the streak was broken with Washington. Sources noted concerns that Colorado, the next submarine to be delivered from Electric Boat, is challenged to meet her Aug. 31 delivery date, but Jabaley expressed confidence the program would work through its problems, declaring that, “at this point, Colorado is on schedule and we’re working very hard for her and subsequent ships — Indiana’s the one after her — to meet their contract delivery dates.”

The late delivery of the Washington is “not indicative of a systemic problem,” Jabaley said. “What this is is a recognition that we have challenged the shipbuilders.

“The Virginia class continues to be a high-performing program with each successive submarine delivering with improved quality, less deferred work, and reduced acquisition cost.”²⁰

Virginia Payload Module (VPM)

The Navy plans to build one of the two Virginia-class boats scheduled to be procured in FY2019, and all Virginia-class boats procured in FY2020 and subsequent years, with an additional mid-body section, called the Virginia Payload Module (VPM). The VPM, with a reported length of 83 feet, 9.75 inches,²¹ contains four large-diameter, vertical launch tubes that would be used to store and fire additional Tomahawk cruise missiles or other payloads, such as large-diameter unmanned underwater vehicles (UUVs).²²

The four additional launch tubes in the VPM could carry a total of 28 additional Tomahawk cruise missiles (7 per tube),²³ which would increase the total number of torpedo-sized weapons (such as Tomahawks) carried by the Virginia class design from about 37 to about 65—an increase of about 76%.²⁴

²⁰ Christopher P. Cavas, “US Navy Submarine Program Loses Some of Its Shine,” *Defense News*, March 13, 2017.

²¹ Source: Jason Sherman and Lee Hudson, “Navy on Track to Beat VPM Cost Targets, Forge First Tube Prototype in October,” *Inside the Navy*, September 26, 2016, discussing a July 29, 2016, Navy report to Congress on the VPM project.

²² For an illustration of the VPM, see http://www.gdeb.com/news/advertising/images/VPM_ad/VPM.pdf, which was accessed by CRS on March 1, 2012.

²³ Michael J. Conner, “Investing in the Undersea Future,” *U.S. Naval Institute Proceedings*, June 2011: 16-20.

²⁴ A Virginia-class SSN can carry about 25 Tomahawks or other torpedo-sized weapons in its four horizontal torpedo tubes and associated torpedo room, and an additional 12 Tomahawk cruise missiles in its bow-mounted vertical launch tubes, for a total of about 37 torpedo-sized weapons. Another 28 Tomahawks in four mid-body vertical tubes would increase that total by about 76%.

In constant FY2010 dollars, the Navy in January 2015 estimated the nonrecurring engineering (i.e., design) cost of the VPM as \$725 million, the production cost for the first VPM-equipped boat as \$409 million, and the production cost for subsequent VPM-equipped boats as \$305 million. Using DOD's deflator for procurement costs other than pay fuel and medical, the figure of \$305 million in constant FY2010 dollars equated to about \$340 million in FY2017 dollars. Given the current Virginia-class unit procurement cost of about \$2.7 billion, an additional cost of \$340 million would represent an increase of roughly 13% in unit procurement cost.

A September 23, 2016, press report stated that the Navy, in a July 29, 2016, report to Congress on the VPM project, now estimates that VPM costs will come in below nonbinding cost targets that were established by the Joint Requirements Oversight Council (JROC) in December 2013:

The non-recurring engineering costs [of the VPM project], in fiscal year 2010 dollars, are forecast to be \$725 million, below the \$800 million threshold and \$750 million objective. The VPM cost for the lead boat to receive the new tubes is estimated to be \$409 million, below the \$475 million threshold and \$425 objective, according to the report. And the VPM price tag for follow-on submarines is slated to be \$305 million, below the \$350 million threshold and \$325 million objective cost, the report states.²⁵

Building Virginia-class boats with the VPM would compensate for a sharp loss in submarine force weapon-carrying capacity that will occur with the retirement in FY2026-FY2028 of the Navy's four Ohio-class cruise missile/special operations forces support submarines (SSGNs).²⁶ Each SSGN is equipped with 24 large-diameter vertical launch tubes, of which 22 can be used to carry up to 7 Tomahawks each, for a maximum of 154 vertically launched Tomahawks per boat, or 616 vertically launched Tomahawks for the four boats. Twenty-two Virginia-class boats built with VPMs could carry 616 Tomahawks in their VPMs.

A November 18, 2015, press report states:

The Virginia-class submarine program is finalizing the Virginia Payload Module design and will start prototyping soon to reduce risk and cost as much as possible ahead of the 2019 construction start, according to a Navy report to Congress.

According to the "Virginia Class Submarine Cost Containment Strategy for Block V Virginia Payload Module Design" report, dated Aug. 31 but not received by the Senate until mid-October, the Navy says late Fiscal Year 2015 and early FY 2016 is a "critical" time period for the program....

The Naval Sea Systems Command's (NAVSEA) engineering directorate will update cost estimates soon based on the final concept design, but so far the program has been successful in sticking to its cost goals. The program had a threshold requirement of \$994 million and an objective requirement of \$931 million in non-recurring engineering costs, and as of January 2015 the program estimated it would end up spending \$936 million. The first VPM module is required to cost \$633 million with an objective cost of \$567 million, and the most recent estimate puts the lead ship VPM at \$563 million. Follow-on VPMs would be required to cost \$567 million each with an objective cost of \$527 million, and the January estimate puts them at an even lower \$508 million.²⁷

²⁵ Source: Jason Sherman and Lee Hudson, "Navy on Track to Beat VPM Cost Targets, Forge First Tube Prototype in October," *Inside the Navy*, September 26, 2016.

²⁶ Michael J. Conner, "Investing in the Undersea Future," *U.S. Naval Institute Proceedings*, June 2011: 16-20.

²⁷ Megan Eckstein, "Navy Finalizing Virginia Payload Module Design, Will Begin Prototyping To Reduce Risk," *USNI News*, November 18, 2015.

The joint explanatory statement for the FY2014 Department of Defense (DOD) Appropriations Act (Division C of H.R. 3547/P.L. 113-76 of January 17, 2014) required the Navy to submit biannual reports to the congressional defense committees describing the actions the Navy is taking to minimize costs for the VPM.²⁸ The first such report, dated July 2014, is reprinted in **Appendix C**.²⁹

FY2018 Funding Request

The Navy estimates the combined procurement cost of the two Virginia-class boats requested for procurement in FY2018 at \$5,532.7 million, or an average of \$2,766.4 million each. The boats have received a total of \$1,647.0 million in prior-year “regular” advance procurement (AP) funding and \$580.4 million in prior-year Economic Order Quantity (EOQ) AP funding. The Navy’s proposed FY2018 budget requests the remaining \$3,305.3 million needed to complete the boats’ estimated combined procurement cost. The Navy’s proposed FY2018 budget also requests \$1,920.6 million in AP funding for Virginia-class boats to be procured in future fiscal years, bringing the total FY2018 funding request for the program (excluding outfitting and post-delivery costs) to \$5,225.9 million.

The Navy’s proposed FY2018 budget also requests \$72.9 million in research and development funding for the Virginia Payload Module (VPM). The funding is contained in Program Element (PE) 0604580N, entitled Virginia Payload Module (VPM), which is line 134 in the Navy’s FY2018 research and development account.

Submarine Construction Industrial Base

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.³⁰ In terms of work provided to these firms, a carrier nuclear propulsion plant is roughly equivalent to five submarine propulsion plants. 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.

Projected SSN Force Levels

Relative to 66-Boat Force Level Goal

Table 2 shows the Navy’s projection of the number of SSNs over time if the Navy’s FY2017 30-year shipbuilding plan were fully implemented. The FY2017 30-year shipbuilding plan was developed in association with the previous 308-ship force-level goal (which included a 48-boat force-level goal for SSNs). Consequently, as can be seen in the table, the FY2017 30-year shipbuilding plan does not include enough SSNs to achieve and maintain a force of 66 SSNs.

²⁸ See PDF page 239 of 351 of the joint explanatory statement for Division C of H.R. 3547.

²⁹ For an article discussing the navy’s report, see Lee Hudson, “Stackley Outlines Virginia Payload Module Cost Strategy For Congress,” *Inside the Navy*, November 3, 2014.

³⁰ 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) .

Table 2. Projected SSN Force Levels

As shown in Navy’s FY2017 30-Year (FY2017-FY2046) Shipbuilding Plan

Fiscal year	Annual procurement quantity	Projected number of SSNs	Force level relative to new 66-boat goal		Force level relative to previous 48-boat goal	
			Number of ships	Percent	Number of ships	Percent
17	2	52	-14	-21%		
18	2	53	-13	-20%		
19	2	52	-14	-21%		
20	2	52	-14	-21%		
21	1	51	-15	-23%		
22	2	48	-18	-27%		
23	2	49	-17	-26%		
24	1	48	-18	-27%		
25	2	47	-19	-29%	1	-2%
26	1	45	-21	-32%	3	-6%
27	1	44	-22	-33%	4	-8%
28	1	42	-24	-36%	6	-13%
29	1	41	-25	-38%	7	-15%
30	1	42	-24	-36%	6	-13%
31	1	43	-23	-35%	5	-10%
32	1	43	-23	-35%	5	-10%
33	1	44	-22	-33%	4	-8%
34	1	45	-21	-32%	3	-6%
35	1	46	-20	-30%	2	-4%
36	2	47	-19	-29%	1	-2%
37	2	48	-18	-27%		
38	2	47	-19	-29%	1	-2%
39	2	47	-19	-29%	1	-2%
40	1	47	-19	-29%	1	-2%
41	2	47	-19	-29%	1	-2%
42	1	49	-17	-26%		
43	2	49	-17	-26%		
44	1	50	-16	-24%		
45	2	50	-16	-24%		
46	1	51	-15	-23%		

Source: Table prepared by CRS based on Navy’s FY2017 30-year shipbuilding plan. Percent figures rounded to nearest percent.

Projected Valley from FY2025 to FY2036

As also shown in **Table 2**, the number of SSNs is projected to experience a dip or valley in FY2025-FY2036, reaching a minimum of 41 boats (i.e., 25 boats, or about 38%, less than the 66-boat force-level goal) in FY2029. This projected valley is a consequence of having procured a relatively small number of SSNs during the 1990s, in the early years of the post-Cold War era. Some observers are concerned that this projected valley in SSN force levels could lead to a period of heightened operational strain for the SSN force, and perhaps also a period of weakened conventional deterrence against potential adversaries. The projected SSN valley was first identified by CRS in 1995 and has been discussed in CRS reports and testimony every year since then.

Issues for Congress

FY2018 Funding

One issue for Congress is whether to approve, reject, or modify the Navy's FY2018 procurement, advance procurement (AP), and research and development funding requests for the Virginia-class program. In considering this issue, Congress may consider several factors, including the amount of work the Navy is proposing to fund for the program in FY2018 (discussed further in the sections below about achieving a 66-boat SSN force and mitigating the projected valley in SSN force levels), and whether the Navy has accurately priced the work it is proposing to do in FY2018.

Impact of CR on Execution of FY2018 Funding

Another potential issue for Congress concerns the impact of using a continuing resolution (CR) to fund DOD for the first few months of FY2018.³¹ Division D of the Continuing Appropriations Act, 2018 and Supplemental Appropriations for Disaster Relief Requirements Act, 2017 (H.R. 601/P.L. 115-56 of September 8, 2017) is the Continuing Appropriations Act, 2018, a CR that funds government operations through December 8, 2017. Consistent with CRs that have funded DOD operations for parts of prior fiscal years, DOD funding under this CR is based on funding levels in the previous year's DOD appropriations act—in this case, the FY2017 DOD Appropriations Act (Division C of the Consolidated Appropriations Act, 2017 [H.R. 244/P.L. 115-31 of May 5, 2017]). Also consistent with CRs that have funded DOD operations for parts of prior fiscal years, this CR prohibits new starts, year-to-year quantity increases, and the initiation of multiyear procurements utilizing advance procurement funding for economic order quantity (EOQ) procurement unless specifically appropriated later. Division D of H.R. 601/P.L. 115-56 of September 8, 2017, does not include any anomalies for Department of the Navy acquisition programs.³²

A Navy point paper on the potential effects of a CR on FY2018 Department of the Navy programs states in part (emphasis added):

The following contracts are scheduled to be awarded in Q1 FY18 [the first quarter of FY2018] and would be impacted by a 3 month CR without legislative relief. OMB has already said they are not accepting any requests for legislative relief. Accordingly, these programs will be delayed.

- Columbia Class AP \$843M (Oct 2017)
- **VA Class submarine AP [work funded with advance procurement funding] \$1,921M (Oct 2017)**
- CMV-22 (Nov 2017)
- JLTV (Dec 2017)

³¹ For an overview discussion of the impact of the CR on FY2018 DOD acquisition programs, including Navy shipbuilding programs, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) . See also CRS In Focus IF10734, *FY2018 Defense Spending Under an Interim Continuing Resolution*, by (name redacted) .

³² Anomalies are special provisions within a CR that exempt individual programs or groups of programs from the general provisions of the CR.

- KC-130J (Dec 2017)
- Trident Missile subsystems (Nov 2017)
- RAM (Dec 2017)
- Griffin (Dec 2017)
- ESSM (Dec 2017)
- Hellfire Missiles (Dec 2017)³³

An August 3, 2017, table of CR impacts to FY2018 DOD programs that was reportedly sent by DOD to the Office of Management and Budget (OMB) in August 2017 states that the CR will impact the execution of:

- about \$68.4 million in Virginia-class advance procurement (AP) funding (within a total of about \$1,920.6 million of such funding), starting on October 1, 2017; and
- about \$117.3 million in Virginia-class procurement funding (within a total of about \$3,305.3 million of such funding), starting on March 1, 2018.³⁴

Achieving a 66-Boat SSN Force

Another issue for Congress concerns the Navy's new 66-boat force-level goal for SSNs, which has prompted discussions about how many SSNs would need to be added to the Navy's 30-year shipbuilding plan to achieve a 66-boat force, how quickly a 66-boat force could be achieved, how easily the submarine construction industrial base could take on the additional work, and how much it would cost to achieve and maintain a force of 66 SSNs.

Number of Additional Boats Needed in 30-Year Shipbuilding Plan

CRS estimates that achieving a 66-boat SSN force would require adding 19 SSNs to the FY2017 30-year shipbuilding plan. CBO estimates that achieving a 66-boat SSN force would require adding 16 to 19 SSNs to the FY2017 30-year shipbuilding plan.³⁵

As one possible approach for adding 16 to 19 SSNs to the 30-year shipbuilding plan, 12 Virginia-class boats could be added by inserting a second Virginia-class boat in each of the 12 years (FY2021, FY2024, and FY2026-FY2035) when the Navy also plans to procure a Columbia-class ballistic missile submarine. In other words, the production rate for Virginia- and Columbia-class

³³ Navy point paper entitled "FY 2018 Continuing Resolution (CR) Impacts and Anomalies," provided to CRS and CBO by Navy Office of Legislative Affairs on September 12, 2017.

³⁴ Table entitled "Production Increases," dated August 3, 2017, posted September 11, 2017, at InsideDefense.com (subscription required). InsideDefense.com states the following about the table: "In August 2017, the Defense Department sent the White House Office of Management and Budget a detailed list of acquisition program priorities it had hoped to fund at the beginning of fiscal year 2018 in the event Congress passed a stopgap budget measure restricting spending levels and prohibiting new programs. Includes the list of prioritized weapon production increases, a list of approximately 75 significant new-start programs that would be unable to begin in the event of a continuing resolution as well as a 'list of anomalies OMB submitted for the FY-18 CR' provided by a DOD spokesman to Inside Defense." ("DOD's Consolidated Anomaly List for OMB," *InsideDefense.com*, September 11, 2017.)

³⁵ For additional discussion of CRS and CBO estimates of the numbers of ships of various types that would need to be added to the FY2017 30-year shipbuilding plan to achieve and maintain the Navy's desired 355-ship fleet, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .

boats, respectively, in these 12 years would be changed from the currently planned rate 1+1 to a new rate of 2+1. The other four to seven Virginia-class boats that would be needed to get to a total of 16 to 19 additional Virginia-class boats would then be added in years where the FY2017 30-year shipbuilding plan currently calls for a Virginia- and Columbia-class procurement rate of 2+0, so as to convert those four to seven years into years with a 3+0 rate.

Navy officials, beginning in 2016, have expressed interest in procuring an additional Virginia-class boat in FY2021, so as to convert that year from 1+1 to 2+1. Congress also has the option of funding the procurement of additional Virginia-class boats in FY2018-FY2020. This option is discussed further below, in the section discussing options for mitigating the projected SSN force level valley.

Time Needed to Achieve a 66-Boat Force

CRS and CBO estimate that increasing the SSN procurement rate along the lines described above would permit the SSN force to reach a total of 66 boats by the mid- to late 2030s. Given the capacity of the submarine construction industrial base (see next section), CRS and CBO estimate that this might be the earliest that a 66-boat SSN force could be achieved.

Ability of Industrial Base to Achieve Higher Production Rates

Overview

Increasing the combined Virginia- and Columbia-class submarine production to include 16 to 19 years with 2+1 and 3+0 rates of production would require additional tooling at the submarine construction shipyards (GD/EB and HII/NNS) and at supplier firms, and the hiring and training of additional production and supervisory workers at the shipyards and supplier firms. Implementing these actions—particularly the hiring and training of new workers—would take some time. As a result, the submarine production rate could not be substantially increased overnight—it would need to ramp up to higher levels over time. Any additional Virginia-class boats funded in FY2018-FY2020 would likely execute on a delayed schedule, making them look more like boats funded in later fiscal years. Congress in the past, however, has funded the procurement of nuclear-powered ships (specifically, aircraft carriers) that were not expected to begin construction right away. (For additional discussion, see **Appendix B**.)

Increasing the submarine construction rate along the lines discussed above would pose substantial industrial base management challenges for the Navy and industry. In assessing the ability of the Navy and industry to meet these challenges, it can be noted that procurement of Los Angeles class SSNs and Ohio-class ballistic missile submarines reached rates of 3+1 and 4+1 during the Cold War years of FY1984-FY1988. It can also be noted, however, Virginia-class SSNs (particularly those equipped with the VPM) and Columbia-class ballistic missile submarines are larger and in some respects built to higher performance standards than Los Angeles-class SSNs and Ohio-class ballistic missile submarines, respectively. In addition, certain elements of the submarine construction industrial base (particularly the supplier base) were reduced in capacity in the years following the end of the Cold War, when submarine procurement rates fell for a time to an average of less than one boat per year. The Navy and industry are now studying the challenges associated with increasing Virginia- and Columbia-class production to rates such as 2+1 and 3+0.

September 2017 Press Report

A September 11, 2017, press report states:

The two attack submarine manufacturers can support a three Virginia-class boat per year build rate in the years the Navy is not buying a ballistic missile submarine as long as the service supports industry in both planning and investment.

Kenneth Perry, vice president for program integration at General Dynamics Electric Boat, told *Inside the Navy* Aug. 30 in Newport, RI, the company has sent the Navy an outline of what it will take for EB to build three Virginia-class attack submarines per year.

This would include investments not only in EB's facilities but also in growing a skilled workforce, he said.³⁶

July 2017 Navy Report to Congress

A July 2017 Navy report to Congress on the submarine industrial base and the viability of producing additional attack submarines beyond those shown in the FY2017 shipbuilding plan during the period FY2017-FY2030 states:

The VIRGINIA Class Submarine (VCS) program is healthy and maintaining a construction rate of two SSNs per year. The Navy is committed to maintaining this rate as long as feasible within budgetary constraints.

The Navy assess that procurement of additional attack submarines beyond those in the FY 2017 shipbuilding plan is viable, and would have a positive effect on the overall submarine industrial base cost and workload profiles. In particular, the procurement of VCS [Virginia-class submarines] with the Virginia Payload Module (VPM) at a steady cadence of two per year during the procurement years of the COLUMBIA Class SSBN is achievable, and would provide benefit to [the] Navy's attack submarine force inventory. Maintaining a two per year VCS procurement cadence will result in the procurement of seven additional SSNs over the FY 2017 – FY 2030 timeframe. This ramp up in production will require increased management and investment, jointly managed by both the Navy and the shipbuilders, to ensure all aspects of the nuclear shipbuilding enterprise are prepared. The key areas of concern are shipbuilder facilities, work force readiness (manpower ramp up), and supplier/vendor industrial base health.

As increased VCS procurements will present facilities, manpower, and vendor base challenges additional to those already presented by the baseline FY 2017 shipbuilding plan, the Navy is working closely with the shipbuilders to ensure that these issues can be managed successfully and without negatively impacting the COLUMBIA Class program. A table construction plan and adequate funding lead time are critical to stabilize the vendor base health, and will also be needed to allow for facilities and manpower ramp ups at the shipyards to meet the increased workload volume. Maintaining a steady VCS procurement cadence would result in added labor and economic order quantity (EOQ) efficiencies, optimization of production facilities, and elimination of costly production surges and gaps, reducing VCS costs across the respective block buys.

The Navy continues to work with Congress to ensure authorities are in place to maximize acquisition efficiency and cost savings opportunities. In particular, near-term Congressional support in the form of multi-year procurements (MYP), EOQ, and buying across shipbuilding programs will be required in order to provide adequate lead time for industrial base preparations. During the years of COLUMBIA procurement, additional shipbuilding funding will be required in order to procure additional attack submarines without negatively impacting other Navy ship procurement programs.

³⁶ Lee Hudson, "Industry Can Support Three Attack Submarine Per Year Build Rate," *Inside the Navy*, September 11, 2017.

The Navy is committed to working closely with Congress and industry to provide continued stability, acquisition efficiency, and cost savings opportunities to best support the production of additional attack submarines beyond the Navy's current shipbuilding plan.³⁷

Cost to Achieve and Maintain 66-Boat SSN Force

Overview

As discussed earlier, Virginia-class boats currently cost about \$2.7 billion each to procure. The Navy estimates in its FY2018 budget submission that VPM-equipped Virginia-class boats will cost about \$3.2 billion each to procure. Increasing the annual submarine production rate could reduce unit procurement costs for both Virginia- and Columbia-class boats by a few or several percent due to increased spreading of fixed overhead costs at shipyards and supplier firms.

As the SSN force increases in size beyond levels projected under the FY2017 30-year shipbuilding plan, there would be additional operation and support (O&S) expenses for the SSN force. A 2016 CBO report estimates that each Navy attack submarine incurs, in constant FY2017 dollars, an average of \$70 million in direct annual O&S costs, \$40 million in indirect annual O&S costs, and \$30 million in overhead-related annual costs.³⁸ (These figures, being O&S cost figures, include personnel-related costs, most notably pay and benefits for the crews of the additional SSNs.)

June 2017 Navy Information Paper

A June 2017 Navy information paper on additional near-term funding needed to procure 13 rather than 10 Virginia-class submarines during the period FY2019-FY23 states:

QUESTION:

How much EOQ [economic order quantity purchasing] (including AP [advance procurement]) would be required for procuring more than 10 VCS [Virginia-class submarines] (e.g. 13 boats based on 3 [additional] boats [added in] in FY[20]20, FY[20]22 and FY[20]23)?

RESPONSE:

The Navy's analysis for increasing VCS production to three per year in the years without COLUMBIA[-class SSBN] construction is shown in Tables 1 and 2. The analysis showed that the most efficient option to increase the build rate for VCSs would be in FY[20]22 as it is the most suitable ramp up for the shipbuilders and their suppliers.

The government will need to commit to building additional VCSs by fall 2017 to support vendor equipment manufacturing decisions. This would allow adequate time for the shipbuilders, their vendor base, and the Nuclear [propulsion] Industrial Base (NIB) to be prepared for this enhanced production rate. Two year Advance Procurement (AP) would be required to support the three additional submarines (i.e., FYs [20]20, [20]22, and [20]23).

³⁷ U.S. navy, Report to Congress [on] The Submarine Industrial Base and the Viability of Producing Additional Attack Submarines Beyond the Fiscal Year 2017 Shipbuilding Plan in the 2017-2030 Timeframe, July 2017, Executive Summary (p. ii). The report was posted at *USNI News* on July 18, 2017. See also Megan Eckstein, "Navy Report: Submarine Industrial Base Can Maintain 2-Attack Boat Construction Rate, Bolstering Lawmakers' Plans," *USNI News*, July 18, 2017.

³⁸ Congressional Budget Office, *The U.S. Military's Force Structure: A Primer*, July 2016, p. 59.

Table 1: VCS Investment Estimate for Production Increase to 3 per Year (FYs 20/22/23) in TY18\$			
	FY18	FY19-23 (Delta to PB18)	TOTAL
FY18 AP2 (nuclear/non-nuclear)	\$698M		
FY18 EOQ	\$1,080M		
AP/EOQ/FF (FY19-23 Delta to PB18)		\$8,815M	
TOTAL	\$1,778M	\$8,815M	\$10,593M

Note: Assumes all inserted SSNs are VPM hulls and under a Multi-Year Procurement Contract.

Table 1 above reflects the funding required for the construction of three VCSs per year in FY[20]20, FY[20]22, and FY[20]23 (i.e., a 13-ship VCS Block V). In FY18, two year AP funding (\$698M [million]) is required to support the construction of one additional nuclear propulsion plant (~\$550M) as well as additional contractor furnished Long Lead Time Material (LLTM) (~\$148M). Also necessary is FY18 EOQ funding to enable the non-nuclear industrial vendor base to ramp up its production efforts through multi-year contracts. With FY18 EOQ, the government and its vendors will contract for the necessary materials earlier and in larger quantities to achieve a lower unit price. This will also allow production to be performed over a longer time period to more optimally accommodate the greater material demand. It is important to note that a 13 ship Block V will result in longer construction spans requiring close coordination with the shipbuilders and the overall industrial base.

Table 2: VCS Investment Estimate for Production Increase to 3 per Year (FYs 22/23) in TY18\$			
	FY18	FY19-23 (Delta to PB18)	TOTAL
FY18 EOQ	\$720M		
AP/EOQ/FF (FY19-23 Delta to PB18)		\$5,622M	
TOTAL	\$720M	\$5,622M	\$6,342M

Note: Assumes all inserted SSNs are VPM hulls and under a Multi-Year Procurement Contract.

Table 2 reflects the funding required for a third VCS in FY22 and FY23 (i.e., a 12-ship VCS Block V). It includes the necessary FY18 EOQ, which will enable an optimal ramp up for VCSs in those years. Additionally, in order to add two VCSs, AP and Full Funding would be required for the shipbuilders, their vendor base, and the NIB in FY19-23 as indicated.

For both *Table 1* and *Table 2*, the EOQ requirement to support a greater than ten-ship VCS Block V does not impact COLUMBIA Class construction plans. Also, the direct costs of additional facilities for increased VCS production are not included in the tables. The overall estimated costs and impact to the Navy budget (e.g., if FORD Class construction plans were to change) would need to be assessed to provide a total estimated cost of increased production.³⁹

³⁹ Navy information paper on Virginia-class EOQ required for 13 hulls in Block V, June 14, 2017, provided to CRS by Navy Office of Legislative Affairs on July 13, 2017.

Mitigating Projected SSN Force-Level Valley

Overview

Another potential issue for Congress concerns the potential implications for the SSN force and for U.S. security of the projected valley in SSN force levels. Regarding potential implications for U.S. security, it can be noted, for example, that China has taken note of the valley. The November 2014 edition of a Chinese military journal, for example, includes an article with a passage that translates as follows:

... in 2028, the [U.S. Navy] force of nuclear attack submarines will fall from the current number of 55 down to 41 boats. Some are concerned about whether this force level can meet the requirements of the Asia-Pacific rebalance.”⁴⁰

The Navy has been exploring options for mitigating the projected valley since at least 2006. (For additional background information on a study initiated by the Navy in 2006 on options for mitigating the valley, see **Appendix D**.) Notional options for mitigating the valley include (but are not necessarily limited to) the following:

- shifting planned maintenance periods on SSNs where possible from the valley years to years before or after the valley years, so as to maximize the fraction of the SSN force that is available for operation during the valley years;
- extending the service lives of a few of the youngest Los Angeles (SSN-688) class SSNs from the currently planned notional figure of 33 years to 36 or 37 years, so that those boats can continue serving further into the valley years;
- performing a nuclear refueling on a few of the youngest Los Angeles (SSN-688) class boats, for the purpose of permitting those boats to operate for a few more years, so as to help fill in the valley;
- procuring additional Virginia-class boats in the near term, meaning early enough so that they could enter service prior to or during the valley years.

Extending a Few SSN-688 Service Lives to Age 36 or 37

The option of extending the service lives of a few of the youngest Los Angeles-class SSNs, if feasible, might be facilitated by rationing their operations and taking particularly good care of those boats. As of late 2016, three SSN-688 class boats—*Bremerton* (SSN-698), *Jacksonville* (SSN-699), and *Dallas* (SSN-700)—remained in operation at about age 36, and one of them (*Bremerton*) was scheduled to remain in operation until FY2019, at which point it would be age 37. Since the youngest SSN-688 class boats are currently scheduled to serve to remain in service as late as FY2029—the bottom year of the valley—extending their lives to 36 or 37 years could help fill in part of the valley.

Refueling a Few SSN-688s

Refueling a few of the youngest SSN-688s, if feasible, it would be very (some might say extremely) expensive in terms of dollars spent for each additional year of operation. Supporters might argue that it might nevertheless be cost effective if it helps strengthen conventional

⁴⁰ Lyle Goldstein, “Evolution of Chinese Power Projection Capabilities,” presentation to Center for a New American Security (CNAS) roundtable discussion, September 29, 2016, slide 7 of 41.

deterrence by filling part of the valley and thereby makes less likely a conflict that could be vastly more expensive.

Procuring Additional Virginia-Class Boats in Near Term

Regarding the option of procuring additional Virginia-class boats in the near term, the Navy has expressed interest in procuring an additional Virginia-class boat in FY2021. Congress also has the option of funding the procurement of one or more additional Virginia-class boats in FY2018-FY2020.

An SSN procured in FY2018 would normally receive advance procurement (AP) funding in FY2016 and FY2017 to procure its long lead time components (principally, its nuclear propulsion equipment), and an SSN procured in FY2019 similarly would normally receive AP funding in FY2017 and FY2018. Congress, as part of its action in marking up the Navy's FY2016 and FY2017 budgets, did not provide AP funding for the procurement of additional Virginia-class boats in FY2018 and FY2019. Even so, Congress has the option of funding the procurement of one or more additional Virginia-class boats in FY2018 and FY2019. Such boats would have a longer interval between their recorded year of procurement and the year they enter service, but they would otherwise be built in the same general way as a Virginia-class boat funded with two years of AP funding. Congress in the past has funded the procurement of nuclear-powered ships for which no prior-year AP funding had been provided. (For additional discussion, see **Appendix B**.) Congress also has the option of funding the procurement of an additional Virginia-class boat in FY2020, for which AP funding could be provided in the normal manner in FY2018 and FY2019.

Regarding the option of procuring an additional Virginia-class boat in FY2021, at an April 6, 2016, hearing on Navy shipbuilding programs before the Seapower subcommittee of the Senate Armed Services Committee, the following exchange occurred:

SENATOR KELLY AYOTTE (continuing):

I wanted to follow up, Admiral Mulloy on—you were talking about the requirements overall for the size of our fleet. Well, one of the issues that I'm concerned about, as we look at all the threats that we're facing and all the challenges that were certainly outlined well by Senator King is the Navy's requirement for the attack submarine fleet was actually established, as I understand it, in I think it was around 2006.

And given all the things that have changed since 2006 and the challenges that we face and in particular, obviously, that in the Asia Pacific region, is the Navy going to undertake establishing a new requirement for the attack submarine fleet as well? We already know that 50 percent to 60 percent of our combatant commander's request[s] [f]or the attack submarine is not being met.

VICE ADMIRAL JOSEPH P. MULLOY, USN, DEPUTY CHIEF OF NAVAL OPERATIONS FOR INTEGRATION OF CAPABILITIES AND RESOURCES:

Yes, ma'am. As part of that four (ph)-structure assessment [sic: Force Structure Assessment], there's actually nine analysis [sic: analyses:] of carriers, large service combatants [and other ship types] and one of those is SSNs and SSBNs as well and clearly, the [SSN] number is 48, it has been since the 2006 study.

Unfortunately, and we're probably above it right now, but based upon the decommissioning rate of the Virginia Class—[correction:] of the 688 (ph) Class submarines, we built them at four or five a year with the tremendous support of Congress back in the '80s. We will go down to a number of 41 [SSNs] in 2009 [sic: 2029] and we'll stable it [sic: stay] at 48 for over 10 more years.

So, it's important to get—actually, that multiyear [contact], [and] one item that we've been asked by the host [sic: House] Arms Services Committee and we're looking at now in next year's budget is, there's—in FY21, we got to one Virginia because we started [procuring] the first Ohio Replacement [boat in FY2021].

AYOTTE:

You're reading my mind. We love this.

MULLOY:

That is clearly—that is—clearly, we are now looking at what are the disadvantages [sic] that would come from the authorization of more of those ships in the multiyear. Could we get further savings out of the hulls [sic: hulls?] that—that we'll ask them and we'll have to come back next year?

But clearly, the first submarine that fills in that activities (ph) is buying the [FY]'21 submarine. Mr. Stackley had commissioned a group and he'll probably talk—they'll talk more about it, the Submarine Bill Unified Strategy that looked at Virginia Class, Virginia payload, and Ohio Replacement. And we think we'd be able to do that.

AYOTTE:

Well, Secretary Stackley, I certainly love your comment on that of what Admiral Mulloy just said because this is also something that has been raised by both the Chief and the Vice Chief have expressed a real interest in not going down to one Virginia Class submarine in 2021 and our ability to keep it at two. Even with two, you know, we have a gap. But with one, it's just—it's not sensible.

SEAN J. STACKLEY, ASSISTANT SECRETARY OF THE NAVY RESEARCH, DEVELOPMENT, AND ACQUISITION:

Yes, ma'am. We've been building two [Virginia class] submarines a year since 2011 and this year is actually the first year. [that] We start delivering at two per year.

So, we've got stability in a [production] line. Admiral Mulloy referred to the Submarine Unified Build Strategy. [FY]'21 is a challenge year because of the Ohio Replacement [lead ship]. We spent a lot of time this past year working with industry taking a look at how can we best build the Ohio Replacement program so that we can leverage the best of our two submarine builders, Electric Boat and Newport News.

And as we work through that, what we're uncovering is opportunity and capacity across the two builders. So, one of the challenges was capacity and imposing a potential risk on the Ohio Replacement. We think we have the capacity to address that.

The second challenge is design associated with the Ohio Replacement [program]. We have that on track today. A third challenge then becomes cost. And so, as we look at building the Virginia multiyear and as we look at driving down cost frankly in the Ohio Replacement program, we're finding more opportunities.

So, we're working—this is a top priority in our [FY]2018 budget build, to be able to come back and fill in that [second] [FY]2021 [Virginia-class] submarine because of all the decisions going forward to mitigate the [SSN] shortfall that Admiral Mulloy described. That vote [sic: boat, i.e., a second Virginia-class boat in FY2021] is the first and best mitigation effort that we can have.

So, it's a priority. We think we have tools available to address it as opposed to just bring it back to large bill and a lot of risk associated with it and we look forward to continue to work with you all in the course of this year and with next year's budget to do so.

AYOTTE:

Well, I think that's excellent and I look forward to working with you both on that issue.⁴¹

Press Reports

A March 8, 2016, press report discussed options the Navy is currently considering for mitigating the projected SSN valley, including the option of finding a way to procure a second Virginia-class boat in FY2021. The press report stated:

A spike in demand for the Navy's attack submarines, just ahead of a spate of decommissionings and a dip in new SSN construction, is leading the Navy to look at some previously unthinkable measures to mitigate the upcoming shortfall in the fleet.

Those measures include extending the life of some legacy boats and increasing submarine production despite the cost and workforce strain the Ohio Replacement [i.e., Columbia-class] Program will put on the Navy and industry....

Even though the Navy's Fiscal Year 2017 budget request released in early February called for just one attack submarine to be built in 2021 – a deviation from the current two-a-year build rate to accommodate the construction of the first Ohio Replacement Program ballistic missile submarine – just two weeks later officials floated the idea of trying to find money to buy back that second attack sub....

Seeing this situation approaching, the Navy devised a three-pronged approach in the mid-2000s to try to mitigate the upcoming strain on the attack sub fleet.

First, the Navy would consider extending the life of the Los Angeles-class boats – something almost unheard of with the carefully managed nuclear-powered subs. Schedules, and therefore nuclear fuel consumption, for these boats are rigidly managed throughout the life of the sub, and conventional wisdom dictates that a sub's service life cannot be lengthened.

However, [Rear Admiral Michael] Jabaley [Program Executive Officer for Submarines] said, the Navy has found some exceptions to the rule. A couple years before each Los Angeles-class sub hits the end of its life, the Navy has begun an engineering analysis process. First, will there be enough nuclear fuel to support a six-month deployment tacked on to the end of the boat's life? If yes, proceed to the next question: will the submarine still be structurally sound enough to support submerging and operating for an additional six months? Jabaley said the Navy would not pay for additional work to extend the life of the boats, but if the answer to both questions happens to be yes then the Navy will deploy the Los-Angeles class boat once more, providing a bit of extra overseas presence to fill combatant commander needs, before retiring the boat.

Second, Jabaley said the Navy began lengthening some Los Angeles-class deployments – also considered taboo.

“By deploying for eight months instead of six, you're using incrementally more fuel than you would otherwise in a normal operating cycle, so that can actually be counterproductive to the ability to extend that same submarine when you get to the end of life,” Jabaley said, explaining that submarines consume nuclear fuel more rapidly during overseas deployments than during in-port training or maintenance availabilities.

⁴¹ Transcript of hearing. See also Kris Osborn, “Navy Admiral: We CAN Build More Virginia-Class Attack Submarine[s] Faster—2-per Year in the 2020s,” *Scout Warrior*, August 26, 2016.

“It requires a very close management of fuel usage so we’re sure that the submarine has the ability to operate to the end of its life, and if you have more fuel remaining then you can consider the extension.”

Despite the complications it presented, Jabaley said the lengthened deployments were worth the extra overseas presence they provided as well.

Third in the mitigation strategy, the Navy would try to build the new Virginia-class submarines faster. Whereas the first Virginia-class boats took about 84 months to build, General Dynamics Electric Boat and Newport News Shipbuilding now can deliver a sub to the fleet in about 61 months.

“We have a goal to get down to 55 months, the shipbuilders have a plan they call ‘Drive for 55,’” Jabaley said. That plan revolves around “productivity improvements, changes to the manufacturing and assembly plan to be able to deliver a submarine in as short a time as 55 months.” The faster the industrial base can deliver each submarine, the faster those boats can get through training and get out to sea.

“That was all well and good in 2006: we had a problem, we knew we were facing it,” Jabaley said.

“But things have changed since then. In particular, the resurgence of Russia and the ascendance of China, both of which are producing numerous submarines, and in particular in Russia’s part, extremely capable submarines. So we’re facing challenges of both quantity and quality from our competitors....

Though attack submarine requirements can be hard to talk about publicly due to classification, the combatant commanders have, as Jabaley said, “started to proclaim quite clearly that they are not getting enough submarines on deployment.” During FY 2017 budget hearings, both U.S. Pacific Command commander Adm. Harry Harris and U.S. European Command commander Gen. Philip Breedlove made clear to lawmakers they are only getting about 60 percent of the submarines they request, and they need more to keep up with evolving Russian and Chinese threats.

“All of that put together has made the urgency even greater,” Jabaley said....

or Navy acquisition chief Sean Stackley, the entire situation presents challenges and opportunities. The challenge is maintaining the efficient two-a-year Virginia construction rate, while also moving into the larger Block V configuration in 2019 which includes a Virginia Payload Module section, while also keeping the Ohio Replacement Program on track – while grappling with other Navy shipbuilding needs, and while adhering to spending caps from Congress.

The opportunity, he explained March 3 at the American Society of Naval Engineers’ annual ASNE Day, is leveraging authorities given by Congress in the 2015 and 2016 National Defense Authorization Act to get creative. Not only did Congress give incremental funding and advanced construction authority for the Ohio Replacement Program to help keep costs down, lawmakers also passed a key provision “that allows us to look across programs, across years in terms of procuring material to buy it as efficiently as possible and drive cost down,” Stackley said.

“Quietly in the background we’ve been working with industry to figure out, given this significant amount of submarine workload coming, how can we best accomplish it in terms of not just efficiency but looking at facility investments that have to be made at our two boatyards, EB and Newport News,” Stackley said.

“We laid that all out, and in doing that we identified where we have risk and also where we have opportunity – opportunity in terms of capacity and also opportunity in terms of driving down cost.”

“What we see is opportunity, and if we don’t nail that opportunity down, if we let 2021 pass, we are not going to get that boat back in the future and it just deepens the valley we’re looking at,” he concluded.

Jabaley explained that the 2021 submarine is the most important for shaping the submarine shortfall. The shortfall would begin in 2025 or 2026, depending on the success of the effort to extend the life of the Los Angeles boats. A Virginia-class boat procured in 2021 would deliver in 2026, possibly staving off the start of the shortfall another year. Then, that boat would decrease the depth of the shortfall each year, slightly decreasing the impact felt by the fleet. And it would negate the one-sub shortfall expected in the last year of the trough, in 2036, and from 2038 to 2041.

Put another way, Jabaley said there is currently a 51 SSN-year shortfall over 17 years. The addition of the second 2021 boat—and its subsequent effects—could reduce the attack boat shortfall to 35.

Stackley tasked Jabaley and the rest of PEO Subs with making it happen, and he made clear last week how serious he was about buying back the second boat in 2021.

“That’s frankly our requirement this year inside our shipbuilding program to figure out how to get there because that is our asymmetrical advantage: we own the undersea domain, we cannot give it up and 2021 is our next big opportunity to deepen, frankly, deepen our hold on that,” Stackley said....

The first thing to figure out was if industry could handle the workload, and Jabaley said “we are convinced that it can.”...

With industry on board and ready for the workload, the next question is how to pay for the second 2021 attack sub.

First, “there are some savings just by adding it in,” Jabaley said, due to the savings that buying more units creates throughout the supply chain.

Second, as the Navy analyzes the Block V contract – it owes the Secretary of Defense a cost estimate for the addition of the Virginia Payload Module – “we’re aggressively looking for ways we can reduce cost, so the Virginia program has their work to do in lowering cost.”

And lastly, as Stackley alluded to in his comments about the contracting authorities provided in the NDAA, there are savings to be had if the Navy can find creative ways to move away from stovepiped contracting for each ship class and look more holistically at its overall shipbuilding needs.

“I need to bring [the Virginia class and Ohio Replacement Program] together, and I need to employ innovative contracting and acquisition strategies to find synergy and cost savings,” Jabaley said.”⁴²

A July 16, 2016, press report stated:

The US Navy is stretching the lives of some of its submarines, if only by a year or two.

In the latest version of the 30-year fleet shipbuilding plan, submitted to Congress July 9, the Navy juggled the schedule for ships it plans to dispose of in the next five years. The number of ships planned for inactivation in 2017 dropped from 10 to six, and four submarines gained a modest lease on life....

⁴² Megan Eckstein, “Navy Finds Urgency In Staving Off A Sub Shortfall Decades In The Making,” *USNI News*, March 8, 2016. See also Kris Osborn, “Navy Wants More Attack Submarines Faster,” *Scout*, February 26, 2016.

In the latest iteration of the inactivation plan, two submarines previously scheduled to leave service in 2017 have been extended—the Jacksonville [SSN-699] to 2018, and the Bremerton [SSN-698] to 2019. Two submarines planned to leave the fleet in 2019 have also been stretched out—the Louisville [SSN-724] to 2020, and the Providence [SSN-719] to 2021....

The Navy frequently adjusts inactivation dates based on a variety of factors, including operational need and budgetary constraints and, in the case of nuclear-powered ships, the amount of fuel remaining in the reactors. The four submarines being extended give back about six years of operating time, allowing for the possibility that at least one additional deployment could be gained from each extension.⁴³

Navy Plans for Building VPM-Equipped Virginia-Class Boats

Another issue for Congress is whether to approve, modify, or reject the Navy’s plans for building VPM-equipped Virginia-class boats. As discussed earlier (see “Virginia Payload Module (VPM)”), the Navy plans to build one of the two Virginia-class boats procured in FY2019, and all Virginia-class boats procured in FY2020 and subsequent years, with the Virginia Payload Module (VPM). In assessing the Navy’s plans for procuring VPM-equipped Virginia-class boats, Congress may consider various factors, including the cost and operational value of the VPM, the impact on the submarine construction industrial base and the Virginia-class construction effort of building Virginia-class boats with VPMs, and the potential impact, in a situation of constrained defense funding, on other Navy or DOD programs of funding VPMs for Virginia-class boats.

Three Virginia-Class Boats Built with Defective Parts

Another issue for Congress concerns three Virginia-class boats that were discovered to have been built with defective parts, and the operational and cost implications of this situation. A March 28, 2016, press report states:

In early 2015 engineers on a brand-new submarine made a troubling find: A pipe joint near the innermost chamber of its nuclear-powered engine showed signs of tampering.

The defective elbow pipe, used to funnel steam from the reactor to the sub’s propulsion turbines and generators, showed evidence of jury-rigged welding that could’ve been designed to make it appear satisfactory. But the part was already installed, the sub already commissioned.

These defective parts, each probably valued on the order of \$10,000 or less, have kept the \$2.7 billion attack submarine Minnesota languishing in an overhaul for two years, while engineers attempt to cut out and replace a difficult to reach part near the nuclear reactor. Meanwhile, Navy engineers are scouring aircraft carriers and other submarines for problems and criminal investigators are gathering evidence.

The unauthorized parts are impacting three new Virginia-class attack submarines, likely extending the post-shakedown overhauls for the other two subs and adding greatly to the final tab at a time these fearsome vessels are needed around the globe to defend carrier groups and strike America’s adversaries. It’s also trapped its crew in limbo as repair deadlines come and go, while other subs must take their place.

The Minnesota, the 10th Virginia-class attack boat, was delivered 11 months ahead of schedule. But it has been in the shipyards at Electric Boat in Groton, Connecticut for two years—more than twice as long as a normal post-shakedown availability. It still has

⁴³ Christopher P. Cavas, “US Navy Stretches Submarine Fleet in Latest Fleet Plan,” *Defense News*, July 16, 2016.

months to go. The plankowner crew has spent only a handful of days at sea since joining the fleet and experts say they're likely to forfeit their whole deployment cycle, forcing fleet bosses to make tough decisions about whether to extend deployments or withhold forces from missions overseas.

News of the lousy parts first emerged in August, a month after the Minnesota was to have finished its overhaul. Since then, a Justice Department-led investigation is examining the quality control issues that led the shoddy part to be installed in the \$2.7-billion sub.

The same shoddy elbow joints were installed aboard attack subs North Dakota and John Warner, forcing the Navy to spend millions of dollars and many more months to repair them. If these pipes ruptured, they would leak steam and force the submarine to take emergency measures that would impair its combat effectiveness....

At the center of the debacle is pipe-maker Nuflo Inc., a Jacksonville, Florida-based manufacturer that is the focus of the investigation into quality control issues, according to two Navy sources familiar with the inquiry. The investigation has delayed the repairs so that agents can recover evidence, sources said....

Making matters worse are concerns that the flawed pipe fittings may extend well beyond the three identified attack submarines. In a statement, NAVSEA, which oversees ship construction and maintenance, said it has sent inspectors across the fleet to test Nuflo-made fittings on other ships.

“As part of an ongoing investigation into a quality control issue with a supplier, General Dynamics Electric Boat and Huntington Ingalls Incorporated, Newport News, determined that fittings supplied by the vendor in question required additional testing and repair due to incorrect test documentation, incorrect testing, or unauthorized and undocumented weld repairs performed on these fittings,” a NAVSEA spokeswoman said in the statement. “The fittings, which are used in various piping applications aboard new construction submarines, are also installed on other ships. Therefore, out of an abundance of caution, the Navy, in coordination with its industry partners, has been performing additional inspections and surveys throughout the fleet to fully bound the issue.”

The full scope of the problem remains unclear. NAVSEA declined to comment on whether any other shoddy parts had been found on other ships, citing the ongoing investigation....

Spokespeople for the Navy and NAVSEA declined to provide an estimated cost for Minnesota’s extra year in the shipyards or to say how much it will likely cost to fix the John Warner and North Dakota. The Navy spokesman acknowledged that maintenance delays affect what ships are sent on deployment, but declined to go into any specifics about how other crews were affected.

“Generally speaking, delays in maintenance periods will impact the overall operational availability of the submarine force,” Lt. Cmdr. Tim Hawkins said. “Leaders regularly review operational schedules and adjust them based on force availability and presence requirements. Attack submarines, which are always in high demand, will continue to be deployed when and where they are needed most.”

No subs have been recalled from deployment for related repairs, NAVSEA said. But the parts must be replaced within a few years of its commissioning to reduce the risk that the joint will leak or even burst in a combat scenario.

If the pipe joint were to rupture, it would not cause a radioactive incident. But it could effectively render the submarine unable to operate for weeks or months until fixed. The crew of the attack submarine Jefferson City discovered a water leak in the propulsion plant; finding and fixing that kept the sub stuck in Guam for five months in 2014....

What's not clear is how long the repairs of John Warner and North Dakota will take, how many other ships have these deficient fittings, and what the total cost will be in terms of money and lost operational time.

The Navy refuses to comment while the investigation grinds on.⁴⁴

A May 24, 2016, press report states:

Shipbuilders are fixing the biggest problem on one of the Pentagon's top priorities, the Navy's nuclear submarine fleet. As Defense Secretary Ashton Carter toured the Groton shipyard and talked up the importance of submarines, Electric Boat officials told reporters they're fixing faulty welds in the nuclear-powered propulsion plants of three Virginia-class attack subs. As a result, the long-delayed USS Minnesota will finally leave the shipyard Friday.

"We've pretty much identified all of the issues that arose as a result of that vendor," one Electric Boat official said referring to pipe-maker Nuflo. Other officials were more cautious, since they're still waiting on the results of some inspections. Electric Boat spokesman Tim Boulay said on the record that: "We are continuing to perform inspections and take appropriate actions to resolve the issues....A great deal of progress has been made."

Secretary Carter expressed his confidence in the Navy and the shipyards during his visit. "It was a propulsion system weld issue," the former physicist acknowledged when I asked him at a brief pierside press conference. "The effect of it is, yes, to delay the delivery of one of the new [Virginia-class] boats, and that obviously creates an operational impact that we have to fill and we're going to fill as we promptly rectify the underlying problem" (i.e. the welds)....

After placing the blame squarely on a subcontractor, the Electric Boat officials told us the question as to who will pay for the problem — the subcontractor, the shipyards, or the government — remains unsettled. The priority, they said, was to get it fixed fast and assign blame later. All Virginia-class contracts to date explicitly say the government will bear the cost for all damages over \$2 million, [a] Hill staffer said, although there's a provision in the House draft of the National Defense Authorization Act to change that for future boats.

The first sub to display the welding defect, the USS Minnesota, will finally leave the Groton yard this Friday. The welds are also being fixed on the future USS Colorado, in whose shadow Carter spoke today, and on a third sub being built at EB's partner yard, Newport News Shipbuilding in Virginia.⁴⁵

A June 4, 2016, press report states:

The new attack submarine Minnesota finally returned to the fleet in late May, fully repaired from a mysterious problem that bedeviled the sub and stretched its overhaul to two years.

Minnesota was commissioned in September 2013 and, after a shakedown cruise, it was slated to spend less than a year in its post-shakedown availability at Electric Boat in Groton, Connecticut, and join the fleet in February 2015. Then came a baffling series of setbacks.

In early 2015, engineers discovered a shoddy part installed close to the nuclear reactor. Exposure limits near the reactor and an ensuing federal investigation stretched the

⁴⁴ David Larer, "Secret Weld: How Shoddy Parts Disabled A \$2.7 Billion Submarine," *Navy Times*, March 28, 2016.

⁴⁵ Sydney J. Freedberg Jr., "Welding Problems Fixed For Virginia Subs; Carter Tours Electric Boat," *Breaking Defense*, May 24, 2016.

overhaul to 27 months at a time while the fleet needed more attack boats, like the state-of-the-art Minnesota, to carry out missions around the world. That limbo finally ended on May 27, when the Minnesota completed its PSA and docked at Naval Submarine Base New London....

The cause of Minnesota's long yards stay was a relatively cheap part installed into the system that funnels steam out of the reactor. The 10-inch pipe elbow, used to guide steam pipes around corners, showed signs of having "undocumented and unauthorized weld repairs," according to a statement from Naval Sea Systems Command.

Upon further investigation, the Navy discovered these parts had been welded into the Virginia-class attack submarines John Warner and North Dakota as well. Minnesota only had the one part installed, John Warner has three and North Dakota has six.

The issue with the part in Minnesota is that it was installed in a hard to access section of the reactor and required ripping out fittings that were designed to never be replaced — Virginia-class submarines are designed never to need refueling.

Furthermore, a federal investigation into the fiasco further hampered the repair and maintenance efforts; the progress of that inquiry remains unclear.

The North Dakota and John Warner have entered their PSAs and are not seeing the kinds of extensive delays endured by Minnesota's crew, NAVSEA said in a statement.

"USS North Dakota's Post-Shakedown Availability is planned to complete in September 2016," NAVSEA spokeswoman Colleen O'Rourke⁴⁶ said in an email. "The submarine completed a successful deployment in 2015 between its delivery and PSA start. USS John Warner's PSA is planned to complete in August 2016 and is tracking to be the shortest duration PSA to date for a Virginia-class submarine."

According to a Defense Department contract in March, John Warner's availability is going to cost about \$30 million; an August contract for North Dakota priced its availability in \$22 million.

NAVSEA did not provide a final cost estimate for the Minnesota's PSA by press time Friday.⁴⁷

Potential oversight questions for Congress include the following:

- How did this problem of defective parts occur in the Virginia-class program, which has been in production since FY1998? Was there a breakdown in the following of procedures, and if so, what was the nature of the breakdown, and why did it happen?
- How much time and money will it cost to fix the affected ships? How much of this cost will be borne by the government, and how much by private industry?
- What is the operational impact of affected ships being unavailable for deployment due to the need to fix problems with these defective parts?
- When does the Navy anticipate completing its investigation into the matter?
- What steps has the Navy taken, or what steps does it plan to take, to ensure that this does not happen again in the Virginia-class program or other Navy shipbuilding programs?

⁴⁶ Colleen O'Rourke is not related to Ronald O'Rourke.

⁴⁷ David Larer, "Attack Sub Minnesota Rejoins Fleet After Parts Fiasco," *Navy Times*, June 4, 2016.

Reported Problem with Hull Coating

Another issue for Congress concerns a reported problem with the hull coating used on Virginia-class boats. A March 6, 2017, press report stated:

In 2010, when rubberlike quieting material started to peel off the hulls of newer Virginia-class submarines, the Navy said it was fine-tuning a fix for a problem occurring on the first few ships made.

Seven years later, the Navy still appears to be seeking a cure.

When the \$2 billion USS Mississippi recently returned to Pearl Harbor, its "Mold-In-Place/Special Hull Treatment" looked ragged and was missing chunks on at least one side of the hull. The sub was commissioned in 2012....

The Naval Sea Systems Command in Washington skirted questions about what happened to the Mississippi and how much of a problem the debonding remains for Virginia-class attack boats.

Asked what caused the damage, the command in an email cited the "wear and tear from the harsh environment in which the submarine operates," but would not say when or why it occurred.

The Honolulu Star-Advertiser also asked how much of a problem debonding remains across the Virginia-class fleet, given past problems with the hull treatment that is applied in sections.

"Navy and industry continue to find efficiencies and improvements in the construction and maintenance of Virginia-class submarines," the command said in the emailed response. "An integrated process team was assembled to address conditions such as those reflected in the (USS Mississippi) photograph, and improvements to materials, processes and testing were subsequently identified, evaluated and implemented. The Navy is continually assessing and developing more effective solutions."

Bryan Clark, a senior fellow at the Center for Strategic and Budgetary Assessments and a former Navy submariner, said the amount of acoustic coating missing on the Mississippi "could create enough flow noise to be a sound problem at even relatively slow speeds. Also, there is enough tile missing that it could reduce the coating's ability to absorb sonar energy and make the submarine easier to find with active sonar."

Clark said it isn't clear from the photo if the tiles came off due to debonding, meaning a loss of adhesion, "or if they got stripped off from something rubbing against the submarine. Nets and cables adrift at sea can do this."

Cmdr. Corey Barker, a spokesman for the Pacific Fleet Submarine Force, said that in terms of possible abrasion, he was "not aware of anything of that nature" happening....

The USS Hawaii, Texas and North Carolina, all now based at Pearl Harbor and among the first Virginia subs to be built, were part of a group of about six of the vessels identified in 2010 as having a problem with the mold-in-place urethane coating.

"We've been made aware of the issues, we're making improvements in the process, and we're seeing results already," the Associated Press quoted Alan Baribeau, a Naval Sea Systems Command spokesman, saying at the time.

The website Next Navy posted photos from 2013, however, showing the submarines Minnesota and Missouri with some coating coming off....

Naval analyst and author Norman Polmar, who served as a consultant to three secretaries of the Navy, said it's a glue issue with the acoustic material.

"Remember, (the coating sheets) are external to a submarine, which is going from surface pressure down to, let's say, 1,000 feet occasionally," Polmar said. "In addition, the temperature changes radically."

The glue has to "take the constant changes in pressure, constant changes in temperature, and it ain't an easy thing to do," he said. Additionally, submarines periodically brush against floating debris, against a pier, or "rarely, but sometimes, against another submarine."

The Pearl Harbor Naval Shipyard said in 2015 that it was working on special hull treatment restoration on the USS Hawaii. Naval Sea Systems Command did not disclose when the Mississippi will receive repairs or the estimated cost.

Clark, with the Center for Strategic and Budgetary Assessments, said the Navy always has had difficulty keeping anechoic coatings on submarine hulls. Since the sound energy from sonar hits the whole submarine, a few missing tiles will not significantly affect the return, he said.

But he said the Navy will have to continue to improve the acoustic coating's resilience with other countries starting to use more active variable-depth sonars on ships and helicopters that can be positioned to more effectively look for submarines.⁴⁸

Issues Raised in December 2016 DOT&E Report

Another oversight issue for Congress concerns Virginia-class program issues raised in a December 2016 report from DOD's Director, Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2016. The report stated the following in its section on the Virginia-class program:

Assessment

- The September 2015 DOT&E classified Early Fielding Report details the impact of the new major components of the system with respect to the intended mission during the early deployment. The report concluded the following:
 - The changes to the Virginia class Block III submarine do not appear to improve or degrade the system's ability to conduct submarine missions.
 - The LAB [large aperture bow] array demonstrates the potential to perform as an adequate replacement for the legacy spherical array.
 - Although the technical parameters are similar, the system presented a series of display artifacts, which could affect performance. The Navy issued software fixes to mitigate the effects; however, the software remains to be operationally tested.
 - The sonar LWWAA experienced a hardware fault which limited the ability to assess effectiveness of the system.
 - Developmental testing of the system indicates that system software reliability meets the Navy's thresholds. Hardware reliability was not able to be evaluated because of the limited time available to testers for the evaluation. The LAB array outboard signal processing equipment has exhibited some early failures. The Navy issued fleet guidance for monitoring system performance and continues to investigate potential causes.
- The cybersecurity assessment of the Virginia class Block III submarine remains ongoing and will be reported in FY17.

⁴⁸ William Cole, "Navy Subs Still Show Issue with Stealth Coating," *Military.com*, March 6, 2017.

Recommendations

• Status of Previous Recommendations. The following are recommendations that remain from FY15. The Navy should:

1. Test against a diesel submarine threat surrogate in order to evaluate Virginia’s capability, detectability, and survivability against modern diesel-electric submarines.
2. Conduct an FOT&E to examine Virginia’s susceptibility to airborne anti-submarine warfare threats such as Maritime Patrol Aircraft and helicopters.
3. Coordinate the Virginia, Acoustic Rapid Commercial Off-the-Shelf Insertion (A-RCI), and AN/BYG-1 Test and Evaluation Master Plans to facilitate testing efficiencies.
4. Complete the verification, validation, and accreditation of the Transient Shock Analysis method used for Virginia class Block III items.
5. Repeat the FOT&E event to determine Virginia’s susceptibility to low-frequency active sonar and the submarine’s ability to conduct anti-surface ship warfare in a low-frequency active environment. This testing should include a Los Angeles class submarine operating in the same environment to enable comparison with the Virginia class submarine.
6. Investigate and implement methods to aid the Special Operation Forces in identifying the submarine during operations in conditions of low visibility.
7. Address the three classified recommendations listed in the September 2015 Block III Virginia class Early Fielding Report.

• FY16 Recommendations. None.⁴⁹

Legislative Activity for FY2018

Congressional Action on FY2018 Funding Request

Table 3 summarizes congressional action on the Navy’s FY2018 funding request for the Virginia-class program.

Table 3. Congressional Action on FY2018 Funding
(Millions of dollars, rounded to nearest tenth)

	Request	Authorization			Appropriation		
		HASC	SASC	Conf.	HAC	SAC	Conf.
Virginia class procurement	3,305.3	3,305.3	3,305.3		3,305.3		
Virginia class advance procurement (AP)	1,920.6	2,863.6	3,093.6		1,920.6		
Virginia Payload Module (VPM) research and development (PE 0604580N, line 134)	72.9	72.9	72.9		72.9		

Source: Table prepared by CRS based on Navy’s FY2018 budget submission and committee reports on FY2018 National Defense Authorization Act and FY2018 DOD Appropriations Act.

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

⁴⁹ Department of Defense, Director, Operational Test & Evaluation, *FY2016 Annual Report*, December 2016, p. 323.

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, recommends the funding levels for the Virginia-class program shown in the HASC column of **Table 3**.

Section 124 of H.R. 2810 as reported states:

SEC. 124. Multiyear procurement authority for Virginia class submarine program.

(a) Authority for multiyear procurement.—Subject to section 2306b of title 10, United States Code, the Secretary of the Navy may enter into one or more multiyear contracts, beginning with the fiscal year 2019 program year, for the procurement of up to 13 Virginia class submarines at a rate of not more than 3 submarines per year during the covered period.

(b) Baseline estimate.—Before entering into any contract for the procurement of a Virginia class submarine under subsection (a), the Secretary of Navy shall determine a baseline estimate for the submarine in accordance with section 2435 of title 10, United States Code.

(c) Limitation.—The Secretary of the Navy may not enter into a contract for the procurement of a Virginia class submarine under subsection (a) if the contract would increase the cost of the submarine by more than 10 percent above the baseline estimate for the submarine determined under subsection (b).

(d) Authority for advance procurement.—The Secretary may enter into one or more contracts, beginning in fiscal year 2018, for advance procurement—

(1) associated with the vessels for which authorization to enter into a multiyear procurement contract is provided under subsection (a); and

(2) for other equipment and subsystems associated with the Virginia class submarine program.

(e) Condition for out-year contract payments.—A contract entered into under subsection (a) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year after fiscal year 2018 is subject to the availability of appropriations or funds for that purpose for such later fiscal year.

(f) Definitions.—In this section:

(1) COVERED PERIOD.—The term “covered period” means the 5-year period beginning with the fiscal year 2019 program year and ending with the fiscal year 2023 program year.

(2) VIRGINIA CLASS SUBMARINE.—The term “Virginia class submarine” means a block V configured Virginia class submarine.

Section 1257 of H.R. 2810 as reported states:

SEC. 1257. Sense of Congress on enhancing maritime capabilities.

Congress notes the 2016 Force Structure Assessment (FSA) that increased the requirement for fast attack submarine (SSN) from 48 to 66 and supports an acquisition plan that enhances maritime capabilities that address this requirement.

H.Rept. 115-200 states:

Academic partnerships for undersea technology

The budget request contained \$57.8 million in PE 63680N [in the Navy’s research and development account] for the manufacturing technology program.

The Navy has been studying the capacity of U.S. shipyards to maintain higher production rates for the Virginia-class submarine, while at the same time designing and then beginning construction of the first Columbia-class ballistic missile submarine in 2021. Although this is a feasible option aligned with the administration’s stated strategic objectives, this scenario may present numerous schedule and affordability issues.

The committee is aware that opportunity may exist for the Navy to leverage existing relationships with higher education partners in the Manufacturing Technology (MANTECH) program to decrease the risk the proposed concurrency at the shipyards may pose for the cost and schedule of the programs. Specifically, the committee believes greater leverage of existing partnerships within MANTECH that are focused on undersea vehicle applications relating to several key fabrication and manufacturing processes technologies, including composites, metals, and electronics, may be beneficial.

Therefore, the committee recommends \$67.8 million, an increase of \$10.0 million, in PE 63680N to develop increased manufacturing capability through academic and industrial partnerships to better support the needs of the submarine and undersea fleet. (Pages 55-56)

Senate

The Senate Armed Services Committee, in its report (S.Rept. 115-125 of July 10, 2017) on S. 1519, recommends the funding levels for the Virginia-class program shown in the SASC column of **Table 3**.

Section 121 of S. 1519 as reported states:

SEC. 121. Multiyear procurement authority for Virginia class submarine program.

(a) Authority for multiyear procurement.—Subject to section 2306b of title 10, United States Code, the Secretary of the Navy may enter into one or more multiyear contracts, beginning with the fiscal year 2019 program year, for the procurement of up to 13 Virginia class submarines.

(b) Authority for advance procurement.—The Secretary of the Navy may enter into one or more contracts, beginning in fiscal year 2018, for advance procurement associated with the Virginia Class submarines for which authorization to enter into a multiyear procurement contract is provided under subsection (a), and for equipment or subsystems associated with the Virginia Class submarine program, including procurement of—

(1) long lead time material; or

(2) material or equipment in economic order quantities when cost savings are achievable.

(c) Condition for out-year contract payments.—A contract entered into under subsection (a) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year after fiscal year 2019 is subject to the availability of appropriations or funds for that purpose for such fiscal year.

(d) Limitation on termination liability.—A contract for construction of Virginia Class submarines entered into in accordance with subsection (a) shall include a clause that limits the liability of the United States to the contractor for any termination of the contract. The maximum liability of the United States under the clause shall be the amount appropriated for the submarines covered by the contract regardless of the amount obligated under the contract.

Regarding Section 121, S.Rept. 115-125 states:

Multiyear procurement authority for Virginia class submarine program (sec. 121)

The committee recommends a provision that would authorize the Secretary of the Navy to procure up to 13 Virginia-class submarines under one or more multiyear contracts subject to section 2306b of title 10, United States Code. The Secretary would also be authorized to enter into one or more contracts for advance procurement associated with such vessels and equipment beginning in fiscal year 2018. These authorities would be subject to the availability of appropriations or funds.

The committee notes this would be the fourth multiyear contract for the Virginia-class program. The Navy estimates that the previous three multiyear procurement contracts (fiscal years 2003–2008, 2009–2013, and 2014–2018) achieved savings of greater than 10 percent, as compared to annual procurements. For the fourth contract for fiscal years 2019–2023, the Navy is estimating savings of 14 percent, or in excess of \$5.0 billion, for the multiyear procurement of 10 ships as compared to annual procurement contracts.

The committee believes that should additional funds become available for Virginia-class submarines, above what is planned in the fiscal year 2018 future years defense program, the Navy should obtain the benefits and savings of this authority for up to 13 submarines. (Page 7)

S.Rept. 115-125 also states:

Virginia-class submarine advance procurement

The budget request included \$1.9 billion in line item 5 of Shipbuilding and Conversion, Navy (SCN), for Virginia-class submarine advance procurement.

The committee notes that \$750.0 million in additional economic order quantity funding for the Block V Virginia-class submarines that begin procurement in fiscal year 2019 would enable greater cost savings across the program.

The committee recommends an additional \$450.0 million for the Secretary of the Navy to use for (1) procurement of a third Virginia-class submarine in fiscal year 2020; or (2) to expand second and third tier contractors in the submarine industrial base to support planned increased production requirements, which may include economic order quantity procurement for existing programs.

If the Secretary pursues option (2), the Secretary shall notify the congressional defense committees within 30 days of obligating funds for such purpose of the: obligation date, contractor name or names, location, description of the shortfall to be addressed, actions to be undertaken, desired end state, usable end items to be procured, period of performance, dollar amount, projected associated savings including business case analysis if applicable, contract name, and contract number.

The committee believes that utilizing economic order quantity procurement, procuring an additional submarine, and expanding the capabilities of the supplier base should lead to greater cost savings and improved efficiency as production increases to meet the Columbia-class schedule and higher requirement for attack submarines in the Navy's latest Force Structure Assessment. The committee also notes Virginia-class submarines will benefit from savings associated with missile tube continuous production and economic order quantity authorities. Accordingly, the committee recommends a decrease of \$27.0 million due to the associated savings.

Therefore, the committee recommends a net increase of \$1.2 billion. (Pages 15-16)

S.Rept. 115-125 also states:

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:

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)

FY2018 DOD Appropriations Act (Division A of H.R. 3219)

House Committee Report

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 Virginia-class program shown in the HAC column of **Table 3**.

Section 8010 of H.R. 3219 as reported provides multiyear procurement authority for, *inter alia*, SSN Virginia Class Submarine and Government-furnished equipment.

H.Rept. 115-219 states:

VIRGINIA CLASS SUBMARINE ADVANCE PROCUREMENT

The Committee remains supportive of the procurement of two Virginia class submarines each fiscal year and fully funds the budget request for the program in fiscal year 2018. However, the Committee notes that the budget request for advance procurement funding for the Virginia class submarine program continues to grow each fiscal year, while the budget justification materials provide very few corresponding details. The Committee directs the Secretary of the Navy to provide a report to the congressional defense committees not later than 30 days after the enactment of this Act that details the items being procured with advance procurement funding for the Virginia class submarine program. The report shall include the items being procured, the cost of each item, and the lead time associated with each item. Furthermore, the Committee directs the Secretary of the Navy to provide this level of detail with the submission of the fiscal year 2019 and subsequent budget requests. (Page 162)

House Floor Consideration

On July 27, 2017, as part of its consideration of H.R. 3219, the House agreed to by voice vote H.Amdt. 258, which included, *inter alia*, amendment 36 as printed in H.Rept. 115-261 of July 26, 2017, on H.Res. 478, providing for the further consideration of H.R. 3219. Amendment 36, as summarized in H.Rept. 115-261, "amends Section 8010 to provide multiyear authority for up to 13 Virginia class submarines."

Appendix A. Past SSN Force-Level Goals

This appendix summarizes attack submarine force-level goals since the Reagan Administration (1981-1989).

The Reagan-era plan for a 600-ship Navy included an objective of achieving and maintaining a force of 100 SSNs.

The George H. W. Bush Administration's proposed Base Force plan of 1991-1992 originally called for a Navy of more than 400 ships, including 80 SSNs.⁵⁰ In 1992, however, the SSN goal was reduced to about 55 boats as a result of a 1992 Joint Staff force-level requirement study (updated in 1993) that called for a force of 51 to 67 SSNs, including 10 to 12 with Seawolf-level acoustic quieting, by the year 2012.⁵¹

The Clinton Administration, as part of its 1993 Bottom-Up Review (BUR) of U.S. defense policy, established a goal of maintaining a Navy of about 346 ships, including 45 to 55 SSNs.⁵² The Clinton Administration's 1997 QDR supported a requirement for a Navy of about 305 ships and established a tentative SSN force-level goal of 50 boats, "contingent on a reevaluation of peacetime operational requirements."⁵³ The Clinton Administration later amended the SSN figure to 55 boats (and therefore a total of about 310 ships).

The reevaluation called for in the 1997 QDR was carried out as part of a Joint Chiefs of Staff (JCS) study on future requirements for SSNs that was completed in December 1999. The study had three main conclusions:

- "that a force structure below 55 SSNs in the 2015 [time frame] and 62 [SSNs] in the 2025 time frame would leave the CINC's [the regional military commanders-in-chief] with insufficient capability to respond to urgent crucial demands without gapping other requirements of higher national interest. Additionally, this force structure [55 SSNs in 2015 and 62 in 2025] would be sufficient to meet the modeled war fighting requirements";
- "that to counter the technologically pacing threat would require 18 Virginia class SSNs in the 2015 time frame"; and

⁵⁰ For the 80-SSN figure, see Statement of Vice Admiral Roger F. Bacon, U.S. Navy, Assistant Chief of Naval Operations (Undersea Warfare) in U.S. Congress, House Armed Services Committee, Subcommittee on Seapower and Strategic and Critical Materials, *Submarine Programs*, March 20, 1991, pp. 10-11, or Statement of Rear Admiral Raymond G. Jones, Jr., U.S. Navy, Deputy Assistant Chief of Naval Operations (Undersea Warfare), in U.S. Congress, Senate Armed Services Committee, Subcommittee on Projection Forces and Regional Defense, *Submarine Programs*, June 7, 1991, pp. 10-11.

⁵¹ See Richard W. Mies, "Remarks to the NSL Annual Symposium," *Submarine Review*, July 1997, p. 35; "Navy Sub Community Pushes for More Subs than Bottom-Up Review Allowed," *Inside the Navy*, November 7, 1994, pp. 1, 8-9; *Attack Submarines in the Post-Cold War Era: The Issues Facing Policymakers*, op. cit., p. 14; Robert Holzer, "Pentagon Urges Navy to Reduce Attack Sub Fleet to 50," *Defense News*, March 15-21, 1993, p. 10; Barbara Nagy, "Size of Sub Force Next Policy Battle," *New London Day*, July 20, 1992, pp. A1, A8.

⁵² Secretary of Defense Les Aspin, U.S. Department of Defense, *Report on the Bottom-Up Review*, October 1993, pp. 55-57.

⁵³ Secretary of Defense William S. Cohen, U.S. Department of Defense, *Report of the Quadrennial Defense Review*, May 1997, pp. 29, 30, 47.

- “that 68 SSNs in the 2015 [time frame] and 76 [SSNs] in the 2025 time frame would meet all of the CINCs’ and national intelligence community’s highest operational and collection requirements.”⁵⁴

The conclusions of the 1999 JCS study were mentioned in discussions of required SSN force levels, but the figures of 68 and 76 submarines were not translated into official DOD force-level goals.

The George W. Bush Administration’s report on the 2001 QDR revalidated the amended requirement from the 1997 QDR for a fleet of about 310 ships, including 55 SSNs. In revalidating this and other U.S. military force-structure goals, the report cautioned that as DOD’s “transformation effort matures—and as it produces significantly higher output of military value from each element of the force—DOD will explore additional opportunities to restructure and reorganize the Armed Forces.”⁵⁵

DOD and the Navy conducted studies on undersea warfare requirements in 2003-2004. One of the Navy studies—an internal Navy study done in 2004—reportedly recommended reducing the attack submarine force level requirement to as few as 37 boats. The study reportedly recommended homeporting a total of nine attack submarines at Guam and using satellites and unmanned underwater vehicles (UUVs) to perform ISR missions now performed by attack submarines.⁵⁶

In March 2005, the Navy submitted to Congress a report projecting Navy force levels out to FY2035. The report presented two alternatives for FY2035—a 260-ship fleet including 37 SSNs and 4 SSGNs, and a 325-ship fleet including 41 SSNs and 4 SSGNs.⁵⁷

In May 2005, it was reported that a newly completed DOD study on attack submarine requirements called for maintaining a force of 45 to 50 boats.⁵⁸

In February 2006, the Navy proposed to maintain in coming years a fleet of 313 ships, including 48 SSNs. Although the Navy’s ship force-level goals have changed repeatedly in subsequent years, the figure of 48 SSNs remained unchanged until December 2015, when the Navy released a force-level objective for achieving and maintaining a force of 355 ships, including 66 SSNs.

⁵⁴ Department of Navy point paper dated February 7, 2000. Reprinted in *Inside the Navy*, February 14, 2000, p. 5.

⁵⁵ U.S. Department of Defense, *Quadrennial Defense Review*, September 2001, p. 23.

⁵⁶ Bryan Bender, “Navy Eyes Cutting Submarine Force,” *Boston Globe*, May 12, 2004, p. 1; Lolita C. Baldor, “Study Recommends Cutting Submarine Fleet,” *NavyTimes.com*, May 13, 2004.

⁵⁷ U.S. Department of the Navy, *An Interim Report to Congress on Annual Long-Range Plan for the Construction of Naval Vessels for FY 2006*. The report was delivered to the House and Senate Armed Services and Appropriations Committees on March 23, 2005.

⁵⁸ Robert A. Hamilton, “Delegation Calls Report on Sub Needs Encouraging,” *The Day (New London, CT)*, May 27, 2005; Jesse Hamilton, “Delegation to Get Details on Sub Report,” *Hartford (CT) Courant*, May 26, 2005.

Appendix B. Options for Funding SSNs

This appendix presents information on some alternative profiles for funding the procurement of SSNs. These alternatives include but are not necessarily limited to the following:

- **two years of advance procurement (AP) funding followed by full funding**—the traditional approach, under which there are two years of AP funding for the SSN’s long-leadtime components, followed by the remainder of the boat’s procurement funding in the year of procurement;
- **one year of AP funding followed by full funding**—one year of AP funding for the SSN’s long-leadtime components, followed by the remainder of the boat’s procurement funding in the year of procurement;
- **full funding with no AP funding (single-year full funding, aka point-blank full funding)**—full funding of the SSN in the year of procurement, with no AP funding in prior years;
- **incremental funding**—partial funding of the SSN in the year of procurement, followed by one or more years of additional funding increments needed to complete the procurement cost of the ship; and
- **advance appropriations**—a form of full funding that can be viewed as a legislatively locked in form of incremental funding.⁵⁹

Navy testimony to Congress in early 2007, when Congress was considering the FY2008 budget, suggested that two years of AP funding are required to fund the procurement of an SSN, and consequently that additional SSNs could not be procured until FY2010 at the earliest.⁶⁰ This testimony understated Congress’s options regarding the procurement of additional SSNs in the near term. Although SSNs are normally procured with two years of AP funding (which is used primarily for financing long-leadtime nuclear propulsion components), Congress can procure an SSN without prior-year AP funding, or with only one year of AP funding. Consequently, Congress at that time had the option of procuring an additional SSN in FY2009 and/or FY2010.

Single-year full funding has been used in the past by Congress to procure nuclear-powered ships for which no prior-year AP funding had been provided. Specifically, Congress used single-year full funding in FY1980 to procure the nuclear-powered aircraft carrier CVN-71, and again in FY1988 to procure the CVNs 74 and 75. In the case of the FY1988 procurement, under the Administration’s proposed FY1988 budget, CVNs 74 and 75 were to be procured in FY1990 and FY1993, respectively, and the FY1988 budget was to make the initial AP payment for CVN-74. Congress, in acting on the FY1988 budget, decided to accelerate the procurement of both ships to

⁵⁹ For additional discussion of these funding approaches, see CRS Report RL32776, *Navy Ship Procurement: Alternative Funding Approaches—Background and Options for Congress*, by (name redacted) .

⁶⁰ For example, at a March 1, 2007, hearing before the House Armed Services Committee on the FY2008 Department of the Navy budget request, Representative Taylor asked which additional ships the Navy might want to procure in FY2008, should additional funding be made available for that purpose. In response, Secretary of the Navy Donald Winter stated in part: “The Virginia-class submarines require us to start with a two-year advanced procurement, to be able to provide for the nuclear power plant that supports them. So we would need to start two years in advance. What that says is, if we were able to start in ‘08 with advanced procurement, we could accelerate, potentially, the two a year to 2010.” (Source: Transcript of hearing.) Navy officials made similar statements before the same subcommittee on March 8, 2007, and before the Senate Armed Services Committee on March 29, 2007.

FY1988, and fully funded the two ships that year at a combined cost of \$6.325 billion. The ships entered service in 1995 and 1998, respectively.⁶¹

The existence in both FY1980 and FY1988 of a spare set of Nimitz-class reactor components was not what made it possible for Congress to fund CVNs 71, 74, and 75 with single-year full funding; it simply permitted the ships to be built more quickly. What made it possible for Congress to fund the carriers with single-year full funding was Congress's constitutional authority to appropriate funding for that purpose.

Procuring an SSN with one year of AP funding or no AP funding would not materially change the way the SSN would be built—the process would still encompass about two years of advance work on long-leadtime components, and an additional six years or so of construction work on the ship itself. The outlay rate for the SSN could be slower, as outlays for construction of the ship itself would begin one or two years later than normal, and the interval between the recorded year of full funding and the year that the ship enters service would be longer than normal.

Congress in the past has procured certain ships in the knowledge that those ships would not begin construction for some time and consequently would take longer to enter service than a ship of that kind would normally require. When Congress procured two nuclear-powered aircraft carriers (CVNs 72 and 73) in FY1983, and another two (CVNs 74 and 75) in FY1988, it did so in both cases in the knowledge that the second ship in each case would not begin construction until some time after the first.

⁶¹ In both FY1988 and FY1980, the Navy had a spare set of Nimitz (CVN-68) class nuclear propulsion components in inventory. The existence of a spare set of components permitted the carriers to be built more quickly than would have otherwise been the case, but it is not what made the single-year full funding of these carriers possible. What made it possible was Congress's authority to appropriate funds for the purpose.

Appendix C. July 2014 Navy Report to Congress on Virginia Payload Module (VPM)

The joint explanatory statement for the FY2014 DOD Appropriations Act (Division C of H.R. 3547/P.L. 113-76 of January 17, 2014) requires the Navy to submit biannual reports to the congressional defense committees describing the actions the Navy is taking to minimize costs for the VPM.⁶² This appendix reprints the first of these reports, which is dated July 2014.⁶³

⁶² See PDF page 239 of 351 of the joint explanatory statement for Division C of H.R. 3547.

⁶³ The report was posted at *InsideDefense.com* (subscription required) on November 13, 2014.

REPORT TO CONGRESS

VIRGINIA (SSN774) ATTACK CLASS SUBMARINE

Cost Containment Strategy
for the
Block V VIRGINIA Payload Module (VPM) Design

July 2014



IN COMPLIANCE WITH THE JOINT EXPLANATORY STATEMENT ACCOMPANYING
THE
CONSOLIDATED APPROPRIATIONS ACT, 2014

PREPARED BY
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The estimated cost of this report or study for the
Department of Defense is approximately \$10,000 for the 2014 Fiscal Year.
This includes \$0 in expenses and \$10,000 in DoD labor.
Generated on 2014Jul24 RefID: D-1DF2309

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- 4.1 **Implementation of IPPD in conjunction with execution of existing build plan**
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- 4.3 **Design completion**
- 4.4 **Risk mitigation**
- 4.5 **Cost reporting**

5.0 Conclusion

Reporting Requirement

Division C of the Joint Explanatory Statement accompanying the Consolidated Appropriations Act, 2014 (Public Law 113-76), directs the Secretary of the Navy to create a separate budget line item to enable additional congressional oversight and increase transparency into the costs of the VIRGINIA Payload Module (VPM). Furthermore, Congress directed the Secretary to submit a bi-annual report to the congressional defense committees describing the actions the Navy is taking to minimize costs. The agreement fences \$20 million until the first bi-annual report is provided to the congressional defense committees.

Executive Summary

In the mid-2020s, the Navy's four guided missile submarines (SSGNs) will begin to decommission. These SSGNs provide the Navy and the Nation with unmatched undersea conventional strike capability and capacity, with each SSGN carrying up to 154 Tomahawk land attack cruise missiles. The Navy's current fleet of attack submarines (SSNs) can carry 12 Tomahawks each. The loss of the SSGNs will result in an over 60 percent drop in undersea strike capacity.

The Department of Defense's Office of Cost and Program Evaluation (CAPE) conducted a review of the potential undersea strike alternatives to determine the optimal materiel solution to recapitalize the SSGNs' strike capacity. CAPE certified to the Office of the Under Secretary of Defense (Acquisition, Technology and Logistics) (AT&L) that the Navy studies in conjunction with CAPE's independent review and the Naval Sea Systems Command's (NAVSEA) Cost Engineering and Industrial Analysis's (05C) cost estimate met the requirements of an Analysis of Alternatives (AoA), and CAPE did not recommend performing an AoA for undersea strike. The review determined that the VIRGINIA Payload Module (VPM), a hull insert with four large-diameter tubes inserted aft of the sail, each tube capable of carrying seven Tomahawks, represented the best materiel solution to mitigate the loss of undersea strike capacity given near-term budget constraints. To minimize cost, schedule, and technical risks, VPM will reuse operationally proven systems and will not require the development of any new technology. For example, the missile tubes that will be used in VPM are nearly identical to the multiple all-up-round canister (MAC) tubes that are currently deployed on the SSGNs.

In December 2013, the Joint Requirement Oversight Council (JROC) approved the Capability Development Document (CDD) establishing the requirements and Key Performance Parameters (KPPs) for VPM. The CDD set clear KPPs for cost, schedule, and strike capacity. By placing cost on equal footing as capability, the CDD ensures the Navy will leverage its best practices and lessons learned from previous submarine research and development, acquisition, and modernization efforts to deliver the required capability within the strict cost targets.

Alteration to the design of any weapon system in full rate production has the potential to introduce justifiable concern associated with the possible erosion of program cost performance and production. The Navy recognizes these risks as they apply to implementation of VPM during Block V construction and intends to employ a full range of management techniques to mitigate them, commencing early in the design phase. The Navy has a proven record of developing and executing similarly scaled efforts such as the Block III design for affordability effort including the redesigned bow. These techniques are well established and embedded in the current submarine acquisition community culture, developed during "NSSN" [the New Attack Submarine Program – the precursor to the VIRGINIA Class] program inception and evolved through the successful VIRGINIA Class Block IV construction contract award.

The Navy's disciplined engineering and acquisition management approach for VPM, in conjunction with treating cost and capability as equally important requirements, will minimize the potential for cost performance degradation and program disruption. The key actions the Navy is taking to minimize costs are: continue proven management techniques used from program inception through Block IV award; implementation of Integrated Product and Process Development (IPPD) in conjunction with execution of existing build plans; ensure stable requirements; high design completion at construction start; risk mitigation; and cost reporting.

1. Background

The VIRGINIA Class Submarine Program was the first major defense program to implement the tenets of the October 1994 Under Secretary of Defense for Acquisition and Technology memorandum, “Implementation of Integrated Product and Process Development (IPPD) in DoD Acquisition Programs.” The VIRGINIA Class program has continuously implemented the use of Commercial Off-the-Shelf (COTS) components, open systems standards, acquisition streamlining, total ownership cost (TOC) driven decision making, Lean 6 Sigma assessments of all processes, and recent should cost/will cost and Better Buying Power initiatives to improve the program as it has matured.

1.1 Block I – IPPD Design/Build Genesis (SSNs 774–777)

From inception, the VIRGINIA Class Submarine Program was strikingly different from past fast attack programs, in part due to advances in technology, but mostly due to revolutionary changes in the design/build, business, and acquisition processes. The Navy, General Dynamics Electric Boat (GDEB) and their major subcontractor, Huntington Ingalls Industries – Newport News Shipbuilding (HII-NNS), embraced the IPPD concept and established multi-disciplined teams to collaboratively design and build the submarine. Inherent in the definition of IPPD, both products and processes derived benefit from structured and hierarchical integration of the cross-functional teams. The IPPD approach holistically linked operational performance, construction techniques, test methods, and life-cycle supportability into an up-front “single-pass” design effort. IPPD enabled the shipbuilder to expand the use of modular construction and off-hull module assembly techniques beyond that of previous submarine programs and erect the entire submarine from 10 major sections. While the IPPD approach was exceedingly effective, the introduction of a new, sophisticated Computer Aided Three-dimensional Interactive Application (CATIA) also greatly enhanced the design/build process and programmatic business efficiency. The CATIA software design tool replaced traditional drawings and hand crafted wooden models with 3-D manipulative color graphics dispersed to Integrated Product Team members to facilitate timely and efficient, visual design collaboration. CATIA also established the single shipbuilding construction and procurement database, linking design with production and business operations. CATIA also provided a higher fidelity design release forecast which in turn supported the establishment of a more accurate budget baseline from which to conduct cost analysis.

1.2 Block II – Continuous Improvement via Capital Expenditure (SSNs 778–783)

As the program began construction on the Block II submarines, the Navy set about to improve construction efficiencies beginning with USS *New Hampshire* (SSN 778), the first submarine in the Block II contract. Recognizing construction span time reduction held the most immediate promise for lowering cost and accelerating delivery of the warships, focus was directed at determining what could be done to improve industrial efficiency without compromise to quality or performance. Teaming for success, the Navy and shipbuilders agreed that facility investment was needed, and a strategy to incorporate an innovative Capital Expenditure (CAPEX) incentive clause was devised and incorporated in the Block II contract. Of the 10 Block II CAPEX funded projects, the transportation system upgrades provided the most visible evidence of reduced span time by allowing a shift from the Block I 10 module build plan to a plan entailing only four “super” modules to undergo final assembly at the delivery shipyard. Block II CAPEX projects have produced a seven to one return on investment.

1.3 Block III – Design for Affordability (DFA) (SSNs 784–791)

The VIRGINIA Class cost reduction program began in earnest in late 2005, when the Chief of Naval Operations (CNO) issued a challenge to the VIRGINIA Class Program to reduce the acquisition cost of each submarine to \$2 billion (in FY 2005 dollars) by 2012 as a condition of increasing the procurement rate from one to two submarines per year. This challenge represented a 20 percent decrease in unit cost. The CNO issued the challenge to support the acquisition of VIRGINIA Class submarines within the Navy shipbuilding budget, and make the necessary increase in attack submarine production to support national force levels. At the time, cutting 20 percent of the unit cost of a submarine with a mature design in serial production, without removing capability, was an unprecedented task.

General Dynamics Electric Boat and the Navy developed an integrated cost reduction strategy focusing on three areas – Design for Affordability (DFA), construction performance, and acquisition/procurement strategy. Implementation of all three elements resulted in a savings of \$400 million per ship and a reduction in construction span by 30 percent (from 84 to 60 months). In recognition of these collaborative achievements, the VIRGINIA Class Program received the 2008 David Packard Excellence in Acquisition Award for “embracing the principles of acquisition reform since its initiation,” and for having significantly reduced total program costs.

1.4 Block IV – Reduced Total Ownership Cost (RTOC) (SSNs 792–801)

Having optimized the construction process via targeted capital investment and DFA, the program concentrated on creating more operational value from each submarine by increasing the time between major maintenance availabilities. The goal was to alter the established life cycle maintenance plan from 72-month operating cycles, with 14 deployments and four major depot availabilities, to 96-month operating cycles, with 15 deployments and only three major depot availabilities. The challenge once again was to identify which design changes offered the highest Reduction of Total Ownership Cost (RTOC) return on investment from a limited design budget – assessing maintenance drivers and factors that determine the aggregate operating cycle. By eliminating one depot availability per hull, the program will avoid approximately \$120 million (FY 2010 dollars) in Operating and Support costs per submarine. By enabling an additional deployment from each subsequent Block IV and beyond hull, an operational availability equivalent to one submarine will be realized following delivery of SSN 805.

2.0 Block V –VPM Concept Origination

The VPM concept was introduced to address the eventual loss of submarine guided missile (SSGN) strike capabilities in the mid-2020s when the Navy’s four SSGNs retire, reducing Navy-wide undersea strike volume by almost two-thirds. The SSGNs’ retirement also coincides with a historically low attack class submarine force structure.

In a 2013 review of undersea strike alternatives conducted by CAPE, VPM was identified to be the optimal materiel solution to recapitalize undersea strike without substantially changing a mature and stable submarine design. CAPE certified to AT&L that the review met the requirements of an AoA, and an AoA was not required. VIRGINIA Class submarines with VPM would retain all existing mission capability, while providing approximately 94 percent of the current undersea strike volume.

In December 2013, the JROC approved the CDD establishing the requirements and KPPs for VPM. The CDD sets clear KPPs for strike capacity, schedule, and cost. The strike KPP increases the missile capacity from 12 to 40. For schedule, the VPM's Initial Operating Capability (IOC) threshold and objective dates are no later than 2nd quarter FY 2028 and no later than 4th quarter FY 2026, respectively.

The cost KPP includes criteria for design, lead ship, and follow ship thresholds and objectives requiring a disciplined approach to balance capabilities within the established cost parameters. Based on the NAVSEA 05C current estimate, the VPM cost estimate is below the CDD's cost objectives.

Cost - CY10\$ (\$M)				Cost - TYS (\$M)			
	Threshold	Objective	Current Est.		Threshold	Objective	Current Est.
NRE:	800	750	744	NRE:	994	931	924
Lead Ship:	475	425	423	Lead Ship:	633	567	564
Follow on Ships	350	325	318	Follow on Ships	567	527	515

Note: CDD Cost values are for 20 VPM modules and start of construction in FY19

The Navy/Industry team is focused on controlling VPM program costs, while minimizing baseline ship impacts, and maintaining the established VIRGINIA Class build plan cadence. As a result of the VIRGINIA Class modular design, inherent design features make the insertion of a hull section less of an impact on the build plan. The VPM design is modeled after other successful VIRGINIA Class programs, which have lowered costs through a proven cost reduction framework.

3.0 FY 2014 VPM Design Funding and Cost Control Management Requirements

The Consolidated Appropriations Act, 2014 (Public Law 113-76) appropriated \$59.1 million for the development of VPM. Division C of the Joint Explanatory Statement accompanying the Consolidated Appropriations Act, 2014, directed the creation of a separate budget line item to enable additional congressional oversight and increase transparency into the costs of the VPM. The Navy established *Navy PE: 0604580N VIRGINIA Payload Module (VPM)* to fulfill this requirement. The Joint Explanatory Statement also stipulated the withholding of \$20 million in funding until the first submission of a bi-annual report to the congressional defense committees describing the actions the Navy plans to take to minimize costs. The following sections of this report are intended to fulfill this requirement.

4.0 Cost Containment Strategy for the Block V VPM Design

The strategy to design and seamlessly insert VPM into the construction sequence within the established budget is to employ the full spectrum of proven management techniques used from program inception through Block IV contract award. Specifically:

- Incorporate key tenets of the USD(AT&L) Better Buying Power 2.0 approach to defense acquisition such as affordability targets and innovative contract incentives.
- Apply overarching IPPD practices and implement design/build teams (Block I and III lessons learned).

- Identify capital investment opportunities with high return on investment potential (Block II and III lessons learned).
- Develop design focused on affordability (Block III lessons learned) and life cycle maintenance costs (Block IV lessons learned).
- Explore and establish ship and component level acquisition strategies to yield a higher confidence/lower cost construction cost (Block III and IV lessons learned).
- Utilize an incentive structure that specifically details required cost reductions in design, construction, and operations and support.

These techniques have guided the VIRGINIA Class Program and will be used throughout the VPM effort.

4.1 Implementation of IPPD in conjunction with execution of existing build plan

The IPPD approach that was utilized as part of the successful Block III bow redesign effort provided the program with the experience and the strategy that can be leveraged for VPM during ongoing production. This will ensure the VPM design is strategically coordinated with construction and will not disrupt the established four-module build plan or construction cadence. This, in turn, requires an increase in the Advance Procurement funding profile for Block V to enable the completion of VPM during the fabrication and assembly phase at the same time as the other module components. A detailed Integrated Master Schedule (IMS) and Module Build Plan will be completed in December 2014, providing the comprehensive IPPD roadmap to minimize baseline ship impacts and maintain the established VIRGINIA Class construction cadence. In addition, the design team will evaluate capital investment opportunities to lower construction costs.

4.2 Stable requirements

The CDD sets clear KPPs for cost, strike capacity, and schedule based on stable requirements. These KPPs promote stability in the Program, providing the Navy and Shipbuilders with fixed, tangible, and measurable objectives. By placing cost on equal footing as capability, the CDD ensures the Navy will leverage its best practices and lessons learned from previous submarine research and development, acquisition, and modernization efforts to deliver the required capability within the strict cost targets. The ship specification process will further define the requirements in strict accordance with the KPPs.

4.3 Design completion

The current VPM design concept does not require the development of any new technology to satisfy the CDD requirements. By relying on proven operational systems, the Navy avoids the unnecessary risk new technology poses. Similarly, “like” systems and components already utilized or proven elsewhere in the submarine enterprise will be leveraged, scaled, or reused to an extensive degree. The most obvious example of this strategy pertains to replication of the tubes and scaling of the launch control electronics from the bow of the Block III design. The collective sum of the re-use strategy tied to the VIRGINIA Payload Tubes (VPTs), Submarine Warfare Federated Tactical System (SWFTS) combat system, Ship Service Hydraulic Plant, Electronic Auxiliary Fresh Water Plant, and other Hull, Mechanical and Electrical subsystems results in a high Technology Readiness Level (TRL) for the VPM effort. This equates to an achievable goal of having the VPM design 80 percent complete prior to

construction start, adding confidence to completing the design within budget and minimizing construction costs.

4.4 Risk mitigation

The VPM cost reduction program will employ a low-risk technical approach, with a goal of having the VPM design 80 percent complete prior to construction start. This will ensure that design errors do not create issues during the construction phase, thereby avoiding unforeseen costs later in the program. With no new technology and significant design and component reuse, the VPM design has a high TRL, thus low risk to the shipbuilder. The program will continue to evaluate and mitigate construction and design risk. For example, the program will benefit when the land based VPT test site is completed at Naval Undersea Warfare Center (NUWC) Newport this fall. Manufactured at Quonset Point and installed by Electric Boat, this collaborative Navy/shipbuilder test facility will support early electronic testing to mitigate VPM risk, and lower shipbuilding construction risk.

The shipbuilding industrial base is well positioned to simultaneously design both VPM and OHIO Replacement as the completion of the VIRGINIA Block III and Moored Training Ship design efforts allow for sufficient General Dynamics Electric Boat (GDEB) resources to support both designs.

The VIRGINIA Program is collaborating with the OHIO Replacement Program to ensure commonality among select ship components and design features which will benefit the acquisition and life-cycle costs for both programs. Where possible, the programs will utilize common equipment designs such as Ship Control System hardware, and Command, Control, Communications, and Intelligence (C3I) systems. The two programs will utilize best manufacturing processes and practices to ensure cost savings across both classes.

4.5 Cost reporting

The VPM program will continue to use the established best practices that enabled previous cost reduction. The program has an effective and established metrics/performance measurement system to manage cost, schedule and risk. A key and essential factor governing effectiveness is the accuracy of the underlying work scope comprising the budget baseline being tracked. The CATIA design application has remained in use since Block I and provides this essential fidelity. Cost analysis data, combined shipbuilder and Navy estimates at completion (EACs), formal risk management program outputs, and quarterly design reviews will all be utilized to assess the VPM program health. To promote specific transparency into cost, as directed, a separate Research, Development, Test and Evaluation (RDT&E) Program Element (PE: 0604580N) was developed for VPM funding. This new PE is reflected in the 2015 budget submission to Congress and ensures VPM costs are separate and distinct from the program's overall RDT&E budget. Consistent with the program's history of monitoring cost, cost estimates for VPM design will be reviewed quarterly and refined by the VPM design team and the program has developed action plans (based on estimates of cost-at-completion) to track cost reporting.

5.0 Conclusion

This report provides a baseline understanding of VPM and the cost reduction and containment strategies employed by the Navy throughout the VIRGINIA Class Program to include the early efforts on VPM.

Subsequent bi-annual reports will provide additional specific metrics for VPM as its acquisition, design, and construction strategies are developed and refined. Products such as design curves, manning ramp-up plans, design drawings, and progress on ship specifications will be provided with future reports as they become available.

Appendix D. 2006 Navy Study on Options for Mitigating Projected Valley in SSN Force Level

This appendix presents background information on a study initiated by the Navy in 2006 for mitigating the valley in the SSN force levels projected for the 2020s and 2030s. The study was completed in early 2007 and briefed to CRS and CBO on May 22, 2007.⁶⁴ At the time of the study, the SSN force was projected to bottom out at 40 boats and then recover to 48 boats by the early 2030s. Principal points in the Navy study (which cite SSN force-level projections as understood at that time) include the following:

- The day-to-day requirement for deployed SSNs is 10.0, meaning that, on average, a total of 10 SSNs are to be deployed on a day-to-day basis.⁶⁵
- The peak projected wartime demand is about 35 SSNs deployed within a certain amount of time. This figure includes both the 10.0 SSNs that are to be deployed on a day-to-day basis and 25 additional SSNs surged from the United States within a certain amount of time.⁶⁶
- Reducing Virginia-class shipyard construction time to 60 months—something that the Navy already plans to do as part of its strategy for meeting the Virginia-class cost-reduction goal (see earlier discussion on cost-reduction goal)—will increase the size of the SSN force by two boats, so that the force would bottom out at 42 boats rather than 40.⁶⁷
- If, in addition to reducing Virginia-class shipyard construction time to 60 months, the Navy also lengthens the service lives of 16 existing SSNs by periods ranging from 3 months to 24 months (with many falling in the range of 9 to 15 months), this would increase the size of the SSN force by another two boats, so that the force would bottom out at 44 boats rather than 40 boats.⁶⁸ The total cost of

⁶⁴ Navy briefing entitled, “SSN Force Structure, 2020-2033,” presented to CRS and CBO on May 22, 2007.

⁶⁵ The requirement for 10.0 deployed SSNs, the Navy stated in the briefing, was the current requirement at the time the study was conducted.

⁶⁶ The peak projected wartime demand of about 35 SSNs deployed within a certain amount of time, the Navy stated, is an internal Navy figure that reflects several studies of potential wartime requirements for SSNs. The Navy stated that these other studies calculated various figures for the number of SSNs that would be required, and that the figure of 35 SSNs deployed within a certain amount of time was chosen because it was representative of the results of these other studies.

⁶⁷ If shipyard construction time is reduced from 72 months to 60 months, the result would be a one-year acceleration in the delivery of all boats procured on or after a certain date. In a program in which boats are being procured at a rate of two per year, accelerating by one year the deliveries of all boats procured on or after a certain date will produce a one-time benefit of a single year in which four boats will be delivered to the Navy, rather than two. In the case of the Virginia-class program, this year might be around 2017. As mentioned earlier in the discussion of the Virginia-class cost-reduction goal, the Navy believes that the goal of reducing Virginia-class shipyard construction time is a medium-risk goal. If it turns out that shipyard construction time is reduced to 66 months rather than 60 months (i.e., is reduced by 6 months rather than 12 months), the size of the SSN force would increase by one boat rather than two, and the force would bottom out at 41 boats rather than 42.

⁶⁸ The Navy study identified 19 existing SSNs whose service lives currently appear to be extendable by periods of 1 to 24 months. The previous option of reducing Virginia-class shipyard construction time to 60 months, the Navy concluded, would make moot the option of extending the service lives of the three oldest boats in this group of 19, leaving 16 whose service lives would be considered for extension.

extending the lives of the 16 boats would be roughly \$500 million in constant FY2005 dollars.⁶⁹

- The resulting force that bottoms out at 44 boats could meet the 10.0 requirement for day-to-day deployed SSNs throughout the 2020-2033 period if, as an additional option, about 40 SSN deployments occurring in the eight-year period 2025-2032 were lengthened from six months to seven months. These 40 or so lengthened deployments would represent about one-quarter of all the SSN deployments that would take place during the eight-year period.
- The resulting force that bottoms out at 44 boats could not meet the peak projected wartime demand of about 35 SSNs deployed within a certain amount of time. The force could generate a total deployment of 32 SSNs within the time in question—3 boats (or about 8.6%) less than the 35-boat figure. Lengthening SSN deployments from six months to seven months would not improve the force's ability to meet the peak projected wartime demand of about 35 SSNs deployed within a certain amount of time.
- To meet the 35-boat figure, an additional four SSNs beyond those planned by the Navy would need to be procured. Procuring four additional SSNs would permit the resulting 48-boat force to surge an additional three SSNs within the time in question, so that the force could meet the peak projected wartime demand of about 35 SSNs deployed within a certain amount of time.
- Procuring one to four additional SSNs could also reduce the number of seven-month deployments that would be required to meet the 10.0 requirement for day-to-day deployed SSNs during the period 2025-2032. Procuring one additional SSN would reduce the number of seven-month deployments during this period to about 29; procuring two additional SSNs would reduce it to about 17, procuring three additional SSNs would reduce it to about 7, and procuring four additional SSNs would reduce it to 2.

The Navy added a number of caveats to these results, including but not limited to the following:

- The requirement for 10.0 SSNs deployed on a day-to-day basis is a current requirement that could change in the future.
- The peak projected wartime demand of about 35 SSNs deployed within a certain amount of time is an internal Navy figure that reflects recent analyses of potential future wartime requirements for SSNs. Subsequent analyses of this issue could result in a different figure.
- The identification of 19 SSNs as candidates for service life extension reflects current evaluations of the material condition of these boats and projected use rates for their nuclear fuel cores. If the material condition of these boats years from now turns out to be worse than the Navy currently projects, some of them might no longer be suitable for service life extension. In addition, if world conditions over the next several years require these submarines to use up their nuclear fuel cores more quickly than the Navy now projects, then the amounts of time that their service lives might be extended could be reduced partially, to zero,

⁶⁹ The Navy stated that the rough, order-of-magnitude (ROM) cost of extending the lives of 19 SSNs would be \$595 million in constant FY2005 dollars, and that the cost of extending the lives of 16 SSNs would be roughly proportional.

- or to less than zero (i.e., the service lives of the boats, rather than being extended, might need to be shortened).
- The analysis does not take into account potential rare events, such as accidents, that might force the removal of an SSN from service before the end of its expected service life.⁷⁰
 - Seven-month deployments might affect retention rates for submarine personnel.

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⁷⁰ In January 2005, the Los Angeles-class SSN *San Francisco* (SSN-711) was significantly damaged in a collision with an undersea mountain near Guam. The ship was repaired in part by transplanting onto it the bow section of the deactivated sister ship *Honolulu* (SSN-718). (See, for example, Associated Press, “Damaged Submarine To Get Nose Transplant,” *Seattle Post-Intelligencer*, June 26, 2006.) Prior to the decision to repair the *San Francisco*, the Navy considered the option of removing it from service. (See, for example, William H. McMichael, “Sub May Not Be Worth Saving, Analyst Says,” *Navy Times*, February 28, 2005; Gene Park, “Sub Repair Bill: \$11M,” *Pacific Sunday News (Guam)*, May 8, 2005.)

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