



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

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Summary

The Navy has been procuring Virginia (SSN-774) class nuclear-powered attack submarines (SSNs) at a rate of one per year for the past several years, and a total of 12 boats have been procured through FY2011. The Navy's proposed FY2011 budget increases the procurement rate to two boats per year. The eight boats to be procured in the five-year period FY2009-FY2013 (boats 11 through 18) are being procured under a multiyear procurement (MYP) arrangement.

The Navy's proposed FY2011 budget requests \$3,441.5 million in procurement funding to complete the procurement cost of the 13th and 14th Virginia-class boats. The FY2011 budget estimates the combined procurement cost of these two boats at \$5,344.4 million, and the boats have received a total of \$1,903.0 million in prior-year advance procurement (AP) and Economic Order Quantity (EOQ) funding. The Navy's proposed FY2011 budget also requests \$1,436.8 million in AP funding for Virginia-class boats to be procured in future years, and \$254.4 million in Economic Order Quantity (EOQ) purchases of long-leadtime items for Virginia-class boats to be procured under the FY2009-FY2013 MYP arrangement.

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Introduction

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Background

U.S. Navy Submarines

U.S. Navy submarines fall into three types—nuclear-powered ballistic missile submarines (SSBNs), nuclear-powered cruise missile submarines (SSGNs), and nuclear-powered attack submarines (SSNs).¹

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.² As of the end of FY2008, the Navy included 14 Ohio (SSBN-726) class SSBNs, which are commonly called Trident submarines because they carry Trident SLBMs. Each Trident SSBN can carry 24 Trident SLBMs.

The Navy's four SSGNs, which are a recent addition to the fleet, are former Trident SSBNs that have been converted (i.e., modified) to carry Tomahawk cruise missiles and special operations forces (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

¹ In the designations SSBN, SSGN, and SSN, 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.

² Although this mission is often associated with the Cold War-era nuclear competition between the United States and the Soviet Union, it has continued, with some modifications, in the post-Cold War era. For a discussion of U.S. strategic nuclear weapons policy and force structure, see CRS Report RL31623, *U.S. Nuclear Weapons: Changes in Policy and Force Structure*, by Amy F. Woolf.

submarine missions and are sometimes included in counts of the projected total number of Navy attack submarines. The Navy's SSGNs are discussed in another CRS report.³

The SSNs—the focus of this report—are general-purpose submarines that 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);
- 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 the Soviet submarine force 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.⁴ In the post-Cold War era, although anti-submarine warfare remains a mission, the SSN force has focused more on performing the other missions noted on the list above.

Attack Submarine Force Levels

In February 2006, the Navy proposed achieving and maintaining in coming years a fleet with a total of 313 ships, including 48 SSNs (and 4 SSGNs). For a review of SSN force level goals since the Reagan Administration, see **Appendix A**.

The SSN force included more than 90 boats during most of the 1980s, peaked at 98 boats at the end of FY1987, and then began to decline. The force included 85 to 88 boats during the early 1990s, 79 boats at the end of FY1996, 65 boats at the end of FY1998, 57 boats at the end of FY1999, and 56 boats at the end of FY2000. It has since numbered 53 to 56 boats. The decline in the number of SSNs since the late 1980s has roughly paralleled the decline in the total size of the Navy over the same time period.

The 53 SSNs in service at the end of FY2008 included the following:

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

³ CRS Report RS21007, *Navy Trident Submarine Conversion (SSGN) Program: Background and Issues for Congress*, by Ronald O'Rourke.

⁴ 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).

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 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) are equipped 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 FY2009, 18 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.⁵ 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.⁶

Virginia (SSN-774) Class Program

General

The Virginia-class attack submarine 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,⁷ but incorporates newer technologies. Virginia-class boats currently cost about \$2.6 billion each to procure. The first Virginia-class boat entered service in October 2004.

Past and Projected Procurement Rate

As shown in **Table 1**, 12 Virginia-class boats have been procured through FY2010 at a rate of about one boat per year, and the Navy's proposed FY2011 budget increases the procurement rate two boats per year.

⁵ 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.

⁶ SSN-23 is 100 feet longer than SSN-21 and SSN-22 and has a submerged displacement of 12,158 tons.

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

Table I. Past and Planned Virginia-Class Procurement

FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06
		0						
FY07	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15
				2	2	2	2	2

Source: Prepared by CRS based on U.S. Navy data. The eight boats procured or to be procured in FY2009-FY2013 are being procured under a multiyear procurement (MYP) arrangement.

Multiyear Procurement (MYP)

Under a multiyear procurement (MYP) arrangement requested by the Navy and approved by Congress in FY2008 and FY2009,⁸ a total of eight Virginia-class boats (boats 11 through 18 in the program) are to be procured in the period FY2009-FY2013, in annual quantities of 1, 1, 2, 2, and 2, respectively.

The five Virginia-class boats procured in FY2004-FY2008 were also procured under a multiyear procurement (MYP) arrangement. The four boats procured in FY1998-FY2002 were procured under a somewhat similar arrangement called a block buy. The boat procured in FY2003 fell between the FY1998-FY2002 block buy and the FY2004-FY2008 MYP.

Joint Production Arrangement

Virginia-class boats are built jointly by General Dynamics' Electric Boat Division (GD/EB) of Groton, CT, and Quonset Point, RI, and the Newport News, VA, shipyard that forms part of Northrop Grumman Shipbuilding (NGSB).⁹ Under the arrangement, GD/EB builds certain parts of each boat, Newport News builds certain other parts of each boat, and the yards take turns building the reactor compartments and performing final assembly of the boats. GD/EB is building the reactor compartments and performing final assembly on boats 1, 3, and so on, while Newport News is doing so on boats 2, 4, and so on. The arrangement results 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.

The joint production arrangement is a departure from past 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

⁸ Section 8011 of the compromise version of the FY2009 defense appropriations act (Division C of H.R. 2638/P.L. 110-329 of September 30, 2008) granted authority for using FY2009 funds for an MYP arrangement for the Virginia-class program. Section 122 of the compromise version of the FY2009 defense authorization bill (S. 3001/P.L. 110-417 of October 14, 2008) modified the authority to use an MYP arrangement for Virginia-class boats to be procured in FY2009-FY2013 that was granted to the Secretary of the Navy by Section 121 of FY2008 defense authorization act (H.R. 4986/P.L. 110-181 of January 28, 2008). The modification additionally permits the Secretary to enter into one or more contracts for advance procurement and advance construction of components for the boats procured under the MYP arrangement.

⁹ GD/EB and the Newport News shipyard are the only two shipyards in the country capable of building nuclear-powered ships. GD/EB builds submarines only, while the Newport News shipyard also builds nuclear-powered aircraft carriers and is capable of building other types of surface ships.

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 Newport News 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.

Cost-Reduction Effort

The Navy states that it has achieved a goal of reducing the cost of Virginia-class submarines so that two boats can be procured in FY2012 for combined cost of \$4.0 billion in FY2005 dollars—a goal referred to as “2 for 4 in 12.” Achieving this goal involved removing about \$400 million (in FY2005 dollars) from the cost of each submarine. (The Navy calculates that the unit target cost of \$2.0 billion in FY2005 dollars for each submarine translates into about \$2.6 billion for a boat procured in FY2012, and about \$2.7 billion for a boat procured in FY2013.)

The Navy says that, in constant FY2005 dollars, about \$200 million of the \$400 million in the sought-after cost reductions were 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 will be introduced to Virginia-class boats procured prior to FY2012, but the Navy says the full set of design changes will 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. The Navy says that the goal of reducing shipyard construction time to 60 months is a medium-risk goal, meaning that the Navy believes that there is a moderate (as opposed to low or high) risk that the goal will not be achieved.¹⁰

¹⁰ For more on the Navy’s plan for reducing the procurement cost of the Virginia-class design, see Statement of Ms. Allison Stiller, Deputy Assistant Secretary of the Navy (Ship Programs) and RDML [Rear Admiral] William Hilarides, Program Executive Officer for Submarines, Before the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee [hearing on] Force Structure Requirements and Alternative Funding Strategies for the United States Submarine Fleet, March 8, 2007; Richard R. Burgess, “Sub Force Innovation,” *Seapower*, February 2008: 16-19; Dave Johnson and Dustin Muniz, “More for Less,” *Undersea Warfare*, Winter 2007: 22-23, 28; and William Hilarides, “2 For 4 in 2012, The Virginia-Class Road Ahead,” *U.S. Naval Institute Proceedings*, June 2006: 68-69.

Submarine Construction Industrial Base

General

In addition to GD/EB and Newport News, the submarine construction industrial base includes scores of supplier firms, as well as laboratories and research facilities, in numerous states. About 80% of the total material procured from supplier firms for the construction of submarines (measured in dollars rather than pieces, parts, or purchase orders) comes from single or sole source suppliers. Observers in recent years have expressed concern for the continued survival of many of these firms. For nuclear-propulsion component suppliers, an additional source of stabilizing work is the Navy's nuclear-powered aircraft carrier construction program.¹¹ In terms of work provided to these firms, a carrier nuclear propulsion plant is roughly equivalent to five submarine propulsion plants.

Design and Engineering Portion

Earlier in this decade, some observers expressed concern about the design and engineering portion of the submarine construction industrial base. Much of the design and engineering portion is resident at GD/EB and Newport News. (A small portion is resident at some of the component makers.) With Virginia-class design work winding down and no other submarine-design projects underway, the submarine design and engineering base faced the near-term prospect, for the first time in about 50 years, of having no major submarine-design project on which to work. Navy and industry officials, Members of Congress, and other observers were concerned that unless a major submarine-design project is begun soon, the submarine design and engineering base would begin to atrophy through the departure of experienced personnel. Rebuilding an atrophied submarine design and engineering base, Navy and industry officials believe, could be time-consuming, adding time and cost to the task of the next submarine-design effort, whenever it might begin. Concern about this possibility among some Navy and industry officials was strengthened by the UK's difficulties a few years ago in designing its new Astute-class SSN. The UK submarine design and engineering base atrophied for lack of work, and the subsequent Astute-class design effort experienced considerable delays and cost overruns. Submarine designers and engineers from GD/EB were assigned to the Astute-class project to help the UK overcome these problems.¹²

The issue of maintaining the submarine design and engineering base appears to have been addressed by bringing forward the start of design work on the next-generation SSBN. For further discussion, see **Appendix D**.

¹¹ For more on this program, see CRS Report RS20643, *Navy Ford (CVN-78) Class Aircraft Carrier Program: Background and Issues for Congress*, by Ronald O'Rourke.

¹² See, for example, Andrew Chuter, "U.K. Spending Mounts for U.S. Help on Sub," *Defense News*, September 13, 2005: 4; Richard Scott, "Electric Boat Provides Project Director for Astute Class," *Jane's Navy International*, May 2004: 33; Richard Scott, "Astute Sets Out on the Long Road to Recovery," *Jane's Navy International*, December 2003, pp. 28-30; Richard Scott, "Recovery Plan Shapes Up for Astute Submarines," *Jane's Defence Weekly*, November 19, 2003, p. 26.

Projected SSN Shortfall

Size and Timing of Shortfall

The Navy’s 30-year SSN procurement plan, if implemented, would not be sufficient to maintain a force of 48 SSNs consistently over the long run. As shown in **Table 2**, the Navy projects that the SSN force will fall below 48 boats starting in 2024, reach a minimum of 39 boats in 2030, and remain below 48 boats through 2040. Since the Navy plans to retire the four SSGNs by 2028 without procuring any replacements for them, no SSGNs would be available in 2028 and subsequent years to help compensate for a drop in SSN force level below 48 boats. The projected SSN shortfall has been discussed in CRS reports and testimony since 1995.

Table 2. SSN Force Level, 2011-2040 (Navy Projection)

11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
53	54	55	55	54	51	51	50	51	49	49	48	48	46	45
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
44	43	41	40	39	41	41	42	43	44	45	46	45	45	45

Source: Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY 2011, p. 22.

Navy Study On Options For Mitigating Projected Shortfall

The Navy in 2006 initiated a study on options for mitigating the projected SSN shortfall. The study was completed in early 2007 and briefed to CRS and the Congressional Budget Office (CBO) on May 22, 2007.¹³ 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.¹⁴
- 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.¹⁵
- 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 40.¹⁶

¹³ Navy briefing entitled, “SSN Force Structure, 2020-2033,” presented to CRS and CBO on May 22, 2007.

¹⁴ The requirement for 10.0 deployed SSNs, the Navy stated in the briefing, was the current requirement at the time the study was conducted.

¹⁵ 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.

¹⁶ If shipyard construction time is reduced from 72 months to 60 months, the result would be a one-year acceleration in (continued...)

- 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.¹⁷ The total cost of extending the lives of the 16 boats would be roughly \$500 million in constant FY2005 dollars.¹⁸
- 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—three 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 7-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.

(...continued)

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.

¹⁷ 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.

¹⁸ 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.

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, 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 an SSN from service before the end of its expected service live.¹⁹
- Seven-month deployments might affect retention rates for submarine personnel.

Issues for Congress

Planned Procurement and Projected SSN Shortfall

Navy 30-year shipbuilding plans for FY2009 and prior years showed the SSN force recovering to 48 boats by the early 2030s. The Navy's new FY2011 30-year (FY2011-FY2040) plan shows the SSN remaining below 48 boats through 2040. The change is due to a reduction in planned SSN procurements. As can be seen in **Table 3**, the FY2009 plan included procurement of 53 SSNs over 30 years, while the FY2011 plan includes procurement of 44 SSNs over 30 years. The reduction in SSN procurements in the FY2011 plan may be due in large part to the planned procurement of 12 next-generation SSBNs in FY2019-FY2033. The FY2009 plan did not account for the cost of these 12 SSBNs, while the FY2011 does, apparently causing reductions in planned procurement rates for SSNs and other types of ships during that period.

¹⁹ 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.)

Table 3. SSNs in FY2009 and FY2011 30-Year Shipbuilding Plans

FY	Procurement in FY2009 plan	Procurement in FY2011 plan	Force level in FY2009 plan	Force level in FY2011 plan
2009	1	n/a	53	n/a
2010	1	n/a	52	n/a
2011	2	2	52	53
2012	2	2	53	54
2013	2	2	54	55
2014	2	2	51	55
2015	2	2	51	54
2016	2	2	49	51
2017	2	2	50	51
2018	2	1	49	50
2019	2	2	50	51
2020	2	2	48	49
2021	2	2	48	49
2022	2	2	47	48
2023	2	1	47	48
2024	2	1	46	46
2025	2	1	45	45
2026	2	1	44	44
2027	2	1	43	43
2028	2	1	41	41
2029	1	1	41	40
2030	2	1	42	39
2031	1	1	44	41
2032	2	1	45	41
2033	1	1	47	42
2034	2	1	49	43
2035	1	2	50	44
2036	2	1	52	45
2037	1	2	53	46
2038	2	1	53	45
2039	n/a	2	n/a	45
2040	n/a	1	n/a	45
30-year total	53	44	n/a	n/a

Source: Prepared by CRS using data figures from Navy FY2009 and FY2011 30-year shipbuilding plans. n/a means not applicable.

48-Boat Force-Level Goal

Some observers have argued that the Navy in coming years should seek to maintain a force of more than 48 SSNs, particularly in light of Chinese naval modernization²⁰ and the possibility of a rejuvenated Russian submarine force. Other observers argue that given the kinds of irregular warfare operations in which the United States appears likely to participate in coming years, the United States can afford to reduce the SSN force-level goal to something less than 48 boats. For additional discussion of the 48-boat goal, see **Appendix B**.

Virginia-Class Technology Insertion

Regarding Navy plans for inserting new technology into the Virginia-class design, a March 2010 Government Accountability Office (GAO) report stated:

There are three new technologies that the Navy plans to incorporate on current and future Virginia Class submarines once they mature—advanced electromagnetic signature reduction (AESR), a conformal acoustic velocity sensor wide aperture array (CAVES WAA), and a flexible payload sail. AESR is a software package comprised of two systems that use improved algorithms to continuously monitor and recalibrate the submarine’s signature. The basic algorithms required to support this technology have been proven on other submarines. Navy officials stated they are now developing software and conducting laboratory tests in support of further algorithm development. The Navy has completed and released about 80 percent of the software code for this technology and plans to test it on board a submarine in February 2010. The Navy will begin permanent AESR installations with SSN 782. It also plans to install the software on earlier ships when they are modernized.

CAVES WAA is a sensor array that is designed to detect the vibrations and acoustic signatures of targets. The Navy has stated that CAVES WAA could save approximately \$4 million per submarine. The Navy is analyzing two options for CAVES WAA production—ceramic accelerometers, a mature but more costly technology, or fiber-optic accelerometers, a less expensive but immature technology. According to program officials, the Navy completed testing panels incorporating both types of sensors in December 2008 and plans additional at sea testing in 2010. The Navy is also considering another option, using a more mature conformal array technology manufactured for the United Kingdom’s Royal Navy. The Navy is evaluating whether or not this technology is a viable candidate for installation on Virginia-class submarines.

The flexible payload sail would replace the sail atop the main body of the submarine. Due to recent changes in communications requirements, the Navy is reevaluating the design of the sail and is not certain when this technology will be ready for installation.²¹

²⁰ For further discussion, see CRS Report RL33153, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, by Ronald O’Rourke.

²¹ Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-10-388SP, March 2010, p. 134.

Potential Options for Congress

Potential options for Congress in FY2011 include approving or modifying the Navy's FY2011 funding request for the Virginia-class program and directing the Navy to provide an update on options for mitigating the projected attack submarine shortfall.

Legislative Activity For FY2011

FY2011 Funding Request

The Navy's proposed FY2011 budget requests \$3,441.5 million in procurement funding to complete the procurement cost of the 13th and 14th Virginia-class boats. The FY2011 budget estimates the combined procurement cost of these two boats at \$5,344.4 million, and the boats have received a total of \$1,903.0 million in prior-year advance procurement (AP) and Economic Order Quantity (EOQ) funding. The Navy's proposed FY2011 budget also requests \$1,436.8 million in AP funding for Virginia-class boats to be procured in future years, and \$254.4 million in Economic Order Quantity (EOQ) purchases of long-leadtime items for Virginia-class boats to be procured under the FY2009-FY2013 MYP arrangement.

FY2011 Defense Authorization Bill (H.R. 5136/S. 3454)

House

The House Armed Services Committee, in its report (H.Rept. 111-491 of May 21, 2010) on the FY2011 defense authorization bill (H.R. 5136), recommends approval of the Navy's FY2011 request for procurement and advance procurement funding for the Virginia-class program (page 73). The report states the following in the section discussing the Navy's FY2011 funding request for its research and development account:

Development of hybrid multi-functional composites for submarine structures

The budget request contained \$608.6 million in PE 63561N²² for advanced submarine systems development, but contained no funding for the development of hybrid multi-functional composites for submarine structures.

The committee notes the excellent results of the Virginia-class submarine program of composite technology in the areas of the wide aperture array and main ballast tank vent gratings. The committee understands the use of composites is beneficial in life-cycle maintenance costs, as well as weight savings, which are always a key element of submarine design. The committee understands that emerging technologies using hybrid composite structures have the potential to continue to reduce weight with increased strength for many submarine applications.

²² Line items in DOD research and development accounts are called program elements (PEs).

The committee recommends an increase of \$4.0 million in PE 63561N for continued development of hybrid multi-functional composite technology. (Page 157)

Senate

The FY2011 defense authorization bill (S. 3454), as reported by the Senate Armed Services Committee (S.Rept. 111-201 of June 4, 2010), recommends approval of the Navy's request for FY2011 procurement and advance procurement funding for the Virginia-class program (see page 677 of the printed bill).

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.²³ 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 2012.²⁴

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.²⁵ 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."²⁶ 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

²³ 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.

²⁴ 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.

²⁵ Secretary of Defense Les Aspin, U.S. Department of Defense, *Report on the Bottom-Up Review*, October 1993, pp. 55-57.

²⁶ 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.”²⁷

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 Department of Defense (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.”²⁸

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.²⁹

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.³⁰

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.³¹

In February 2006, the Navy proposed to maintain in coming years a fleet of 313 ships, including 48 SSNs.

²⁷ Department of Navy point paper dated February 7, 2000. Reprinted in *Inside the Navy*, February 14, 2000, p. 5.

²⁸ U.S. Department of Defense, *Quadrennial Defense Review*, September 2001, p. 23.

²⁹ 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.

³⁰ 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.

³¹ 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. Views Regarding 48-Boat SSN Force-Level Goal

This appendix summarizes the Navy's view and an alternative view regarding the appropriateness of the Navy's 48-boat SSN force-level goal.

Navy View³²

In support of its position that 48 is the correct number of SSNs to meet future needs, the Navy in 2006 argued the following:

- The figure of 48 SSNs was derived from a number of force-level studies that converged on a figure of about 48 boats, making this figure an analytical “sweet spot.”
- A force of 48 boats is a moderate-risk (i.e., acceptable-risk) force, as opposed to the low-risk force called for in the 1999 JCS study.
- A force of 48 boats will be sufficient in coming years to maintain about 10 forward-deployed SSNs on a day-to-day basis—the same number of forward-deployed boats that the Navy has previously maintained with a force of more than 50 SSNs. The Navy will be able to maintain 10 forward-deployed SSNs in coming years with only 48 boats because the force in coming years will include an increased number of newer SSNs that require less maintenance over their lives and consequently are available for operation a greater percentage of the time.
- U.S. regional military commanders would prefer a day-to-day forward-deployed total of about 18 SSNs, but total of 10 will be sufficient to meet their most important needs.
- All 10 of the forward-deployed SSNs are needed for day-to-day missions such as intelligence, surveillance and reconnaissance (ISR), while about 7.5 of these submarines are also needed to ensure that an adequate number of SSNs are in position for the opening phases of potential conflicts in various locations.

On the issue of meeting U.S. regional military commanders' requirements for day-to-day forward-deployed SSNs, the Navy states:

Each Combatant Commander (COCOM) requests assets to execute required missions utilizing the Global Force Management Process. Broad categories of mission types are used to make requests including National and Fleet ISR, Exercise and Training (supporting US tactical development), Exercise and Operations (supporting US engagement strategy), Carrier Strike Group (CSG) /Expeditionary Strike Group (ESG) tasking, OPLAN (war plans) support, and Other. As assignment of Critical, High Priority, Priority or Routine is assigned to each of the requested missions. The theater allocation request process prior to 2004 did not include a priority breakdown. In general, ISR missions have been assigned as Critical or

³² This section is based on Navy testimony to the Projection Forces subcommittee of the House Armed Services Committee on March 28, 2006, and to the Seapower subcommittee of the Senate Armed Services Committee on March 29, and April 6, 2006.

High Priority requirements. Other mission areas have been assigned from High Priority to Routine, based on the relative importance to the theater commander. No allocation is currently requested to support OPLAN or Other mission areas.

Each COCOM has authority to use its allocated SSNs as required to meet current national and theater priorities. The CJCS [Chairman Joint Chiefs of Staff] allocation order to the Submarine Force strictly directs an allotted number of SSN days of presence be provided, capable of meeting each theaters' [sic] taskings. The breakdown of mission priorities into Critical, High Priority, Priority and Routine is predominantly a construct to demonstrate how a COCOM could meet their priorities, given a specific level of SSN presence. It serves as an aid to the CJCS in apportioning limited SSN presence to the various theaters.

The number of SSNs allocated against Critical Missions enabled COCOMs to meet all requirements in 2004 and 2005, and 99% of the requirements in 2006. For High Priority missions, sufficient SSNs were allocated to meet 25%, 50% and 34% of requirements in 2004, 2005, and 2006 respectively. Overall, the number of SSNs forward deployed was sufficient to cover 66%, 61% and 54% of Combatant Commanders' requested SSN mission taskings in 2004, 2005, and 2006 respectively.³³

Alternative View

Some observers believe that more than 48 SSNs will be needed to meet future needs. One such observer—retired Vice Admiral Albert Konetzni, Jr., a former commander of the U.S. Pacific Fleet submarine force—argued the following in 2006:³⁴

- The Navy's SSN force-level analyses called for a force of 48 to 60 SSNs. In this context, a force of 48 SSNs looks more like a sour spot than a sweet spot.
- The Navy's SSN force-level analyses reflect "reverse engineering," in which an SSN force-level number is selected at the outset for affordability reasons, and assumptions used in the force-level study are then adjusted to produce that figure.
- The 1999 JCS study on SSN requirements remains valid today.
- All of the U.S. regional military commanders' requirements for day-to-day forward-deployed SSNs, and not just the 60% or so of those requirements that are being met, are critical.
- In light of the potential size of China's submarine force in 2020, a force of 48 SSNs in that year will be insufficient.³⁵

³³ Source: Written response by Vice Admiral Charles L. Munns, Commander Naval Submarine Forces, to a question posed by Representative Rob Simmons at a March 28, 2006, hearing before the Projection Forces Subcommittee of the House Armed Services Committee on submarine force structure. Munns' written response was provided to CRS on July 5, 2006, by the office of Representative Simmons and is used here with the permission of that office.

³⁴ These points are based on Konetzni's testimony to the Projection Forces subcommittee of the House Armed Services Committee on March 28, 2006.

³⁵ For more on China's submarine force, and China's naval modernization effort in general, see CRS Report RL33153, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, by Ronald O'Rourke.

Appendix C. Options for Funding SSNs

This appendix presents information on some alternatives for funding SSNs that was originally incorporated into this report during discussions in earlier years on potential options for Virginia-class procurement.

Alternative Funding Methods

Alternative methods of funding the procurement of SSNs include but are not necessarily limited to the following:

- **two years of advance procurement funding followed by full funding**—the traditional approach, under which there are two years of advance procurement 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 advance procurement funding followed by full funding**—one year of advance procurement 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 advance procurement funding (single-year full funding)**—full funding of the SSN in the year of procurement, with no advance procurement 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.³⁶

Navy testimony to Congress in early 2007, when Congress was considering the FY2008 budget, suggested that two years of advance procurement funding are required to fund the procurement of an SSN, and consequently that additional SSNs could not be procured until FY2010 at the earliest.³⁷ 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 advance procurement funding (which is used primarily for financing long-leadtime nuclear propulsion components), Congress can procure an SSN without prior-year advance procurement funding, or

³⁶ For additional discussion of these funding approaches, see CRS Report RL32776, *Navy Ship Procurement: Alternative Funding Approaches—Background and Options for Congress*, by Ronald O’Rourke.

³⁷ 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.

with only one year of advance procurement funding. Consequently, Congress currently has 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 advance procurement 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 advance procurement payment for CVN-74. Congress, in acting on the FY1988 budget, decided to accelerate the procurement of both ships to 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.³⁸

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 advance procurement funding or no advance procurement 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.

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.

Procuring SSNs in a 2-1-2 Pattern

Some potential approaches for procuring additional boats in FY2009-FY2011 could result in a pattern of procuring two boats in a given year, followed by one boat the following year, and two boats the year after that—a 2-1-2 pattern. Navy testimony to Congress in early 2007 and early 2008 suggested that if the procurement rate were increased in a given year to two boats, it would not be best, from an industrial-base point of view, to decrease the rate to a single boat the following year, and then increase it again to two boats the next year, because of the workforce fluctuations such a profile would produce.³⁹

³⁸ 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' authority to appropriate funds for the purpose.

³⁹ See, for example, the spoken remarks of Secretary of the Navy Donald Winter at hearings before the House Armed Services Committee on March 1, 2007, and March 6, 2008, and spoken remarks by other Navy officials at a March 29, 2007, hearing before the Senate Armed Services Committee and at a March 14, 2008, hearing before the Seapower and (continued...)

This statement may overstate the production-efficiency disadvantages of a 2-1-2 pattern. If two boats were procured in a given year, followed by one boat the next year—a total of three boats in 24 months—the schedule for producing the three boats could be phased so that, for a given stage in the production process, the production rate would be one boat every eight months. A production rate of one boat every 8 months might actually help the industrial base make the transition from the current schedule of one boat every 12 months (one boat per year) to one boat every 6 months (two boats per year). Viewed this way, a 2-1-2 pattern might actually lead to some benefits in production efficiency on the way to a steady rate of two boats per year. The Navy's own 30-year (FY2009-FY2038) SSN procurement plan calls for procuring SSNs in a 1-2-1-2 pattern in FY2029-FY2038.

(...continued)

Expeditionary Forces subcommittee of the House Armed Services Committee.

Appendix D. Maintaining Submarine Design and Engineering Base

Navy and industry officials earlier in this decade appeared to agree that preserving the submarine design and engineering base over the next several years would require funding substantial submarine design and engineering work in the near term. The Navy plans to address the issue by accelerating into the near term the start of design work on the next-generation SSBN.

The Navy asked RAND to study the question of sustaining the submarine design and engineering base. The RAND study, which was published in 2007, states that, based on RAND's analysis,

we reach the following recommendations:

—Seriously consider starting the design of the next submarine class by 2009, to run 20 years, taking into account the substantial advantages and disadvantages involved.

If the 20-year-design alternative survives further evaluation, the issue of a gap in submarine design is resolved, and no further actions need be taken. If that alternative is judged too risky, we recommend the following:

—Thoroughly and critically evaluate the degree to which options such as the spiral development of the Virginia class or design without construction will be able to substitute for new-submarine design in allowing design professionals to retain their skills.

If options to sustain design personnel in excess of demand are judged on balance to offer clear advantages over letting the workforce erode, then the Navy should take the following actions:

—Request sufficient funding to sustain excess design workforces at the shipyards large enough to permit substantial savings in time and money later.

—Taking into account trends affecting the evolution of critical skills, continue efforts to determine which shipyard skills need action to preserve them within the sustained design core.

—Conduct a comprehensive analysis of vendors to the shipyards to determine which require intervention to preserve critical skills.

—Invest \$30 million to \$35 million annually in the NSWC's Carderock Division submarine design workforce in excess of reimbursable demand to sustain skills that might otherwise be lost.⁴⁰

⁴⁰ John F. Schank, et al, *Sustaining U.S. Submarine Design Capabilities*, RAND, Santa Monica (CA), 2007. pp. xxvii-xxviii. (Prepublication copy posted on the Internet by RAND, accessed on May 9, 2007, at http://www.rand.org/pubs/monographs/2007/RAND_MG608.pdf.)

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