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Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress

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Summary

The Navy has been procuring Arleigh Burke (DDG-51) class Aegis destroyers since FY1985. The two DDG-51s requested for procurement in FY2018 are to be the 78th and 79th ships in the class.

DDG-51s procured in FY2013-FY2017 were procured under a multiyear-procurement (MYP) contract. The Navy wants to use another MYP contract to procure DDG-51s in FY2018-FY2022. As part of its proposed FY2018 budget, the Navy is requesting congressional approval for this new MYP contract.

The Navy plans to shift in FY2017 to a new variant of the DDG-51, called the Flight III DDG-51, that is to incorporate a new and more capable radar called the Air and Missile Defense Radar (AMDR).

The Navy estimates the combined procurement cost of the two DDG-51s requested for procurement in FY2018 at \$3,499.1 million. The Navy's proposed FY2018 budget requests:

- \$3,499.1 million in procurement funding to fully fund the procurement of the two DDG-51s requested for FY2018;
- \$90.3 million in EOQ (economic order quantity) advance procurement (AP) funding for up-front batch orders of components for DDG-51s to be procured under the proposed DDG-51 MYP contract for FY2018-FY2022;
- \$51.4 million in cost-to-complete procurement funding to cover cost growth on DDG-51s procured in prior fiscal years;
- \$32.1 million in research and development funding for the AMDR; and
- \$224.0 million in procurement funding to cover costs for building DDG-1000 class destroyers procured in prior fiscal years.

Issues for Congress for FY2018 for the DDG-51 and DDG-1000 destroyer programs include the following:

- whether to approve, reject, or modify the Navy's requests for FY2018 procurement and research and development funding for the DDG-51 and DDG-1000 programs;
- whether to approve the Navy's request for a using new MYP contract for DDG-51s to be procured in FY2018-FY2022;
- whether to provide funding for the procurement in FY2018 of one or two additional DDG-51s (i.e., whether to provide funding for the procurement in FY2018 of a total of three or four DDG-51s);
- continued cost growth in the DDG-1000 program;
- cost, schedule, and technical risk in the Flight III DDG-51 effort; and
- the lack of an announced Navy roadmap for accomplishing three things in the cruiser-destroyer force: restoring ship growth margins; introducing large numbers of ships with integrated electric drive systems or other technologies that could provide ample electrical power for supporting future electrically powered weapons; and introducing technologies for substantially reducing ship operating and support (O&S) costs.

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Introduction

This report presents background information and potential oversight issues for Congress on the Navy's Arleigh Burke (DDG-51) and Zumwalt (DDG-1000) class destroyer programs. The Navy's proposed FY2018 budget requests funding for the procurement of two DDG-51s. Decisions that Congress makes concerning destroyer procurement could substantially affect Navy capabilities and funding requirements, and the U.S. shipbuilding industrial base.

For an overview of the strategic and budgetary context in which the DDG-51, DDG-1000, 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

Large Surface Combatant Force-Level Goal

Goal Increased from 88 to 104

The Navy's previous force-level goal to achieve and maintain a 308-ship fleet included a goal to achieve and maintain a force of 88 large surface combatants (LSCs), meaning cruisers and destroyers. The Navy's new force-level goal to achieve and maintain a 355-ship fleet, released in December 2015, includes a goal to achieve and maintain a force of 104 LSCs.¹

Additional Procurement Needed to Achieve and Maintain 104 Ships

CRS estimates that 23 cruisers and destroyers would need to be added to the Navy's FY2017 30-year shipbuilding plan to achieve a force of 104 LSCs and maintain the force at that level through the end of the 30-year period (i.e., through FY2046), unless the Navy reactivates retired cruisers or extends the service lives of currently active cruisers and destroyers.

CBO estimates that 24 or 25 cruisers and destroyers would need to be added to the Navy's FY2018 30-year shipbuilding plan to achieve a force of 104 LSCs and maintain the force not only through the end of the 30-year period (i.e., through FY2047), but for another 10 years beyond that (i.e., through FY2057), unless the Navy reactivates retired cruisers or extends the service lives of currently active cruisers and destroyers.²

DDG-51 Program

The DDG-51 program was initiated in the late 1970s.³ The DDG-51 (**Figure 1**) is a multi-mission destroyer with an emphasis on air defense (which the Navy refers to as anti-air warfare, or AAW) and blue-water (mid-ocean) operations. DDG-51s, like the Navy's 22 Ticonderoga (CG-47) class

¹ CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .

² CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .

³ The program was initiated with the aim of developing a surface combatant to replace older destroyers and cruisers that were projected to retire in the 1990s. The DDG-51 was conceived as an affordable complement to the Navy's Ticonderoga (CG-47) class Aegis cruisers.

cruisers,⁴ are equipped with the Aegis combat system, an integrated ship combat system named for the mythological shield that defended Zeus. CG-47s and DDG-51s consequently are often referred to as Aegis cruisers and Aegis destroyers, respectively, or collectively as Aegis ships. The Aegis system has been updated several times over the years. Existing DDG-51s (and also some CG-47s) are being modified to receive an additional capability for ballistic missile defense (BMD) operations.⁵

Figure 1. DDG-51 Class Destroyer



Source: Navy file photograph accessed October 18, 2012, at http://www.navy.mil/view_image.asp?id=134605.

The first DDG-51 was procured in FY1985. A total of 77 have been procured through FY2017, including 62 in FY1985-FY2005 and 15 in FY2010-FY2017.⁶ During the period FY2006-FY2009, the Navy procured three Zumwalt (DDG-1000) class destroyers (see discussion below) rather than DDG-51s. The first DDG-51 entered service in 1991, and a total of 62 were in service as of the end of FY2016. DDG-51s are built by General Dynamics' Bath Iron Works (GD/BIW) of Bath, ME, and Huntington Ingalls Industries' Ingalls Shipbuilding (HII/Ingalls) of Pascagoula, MS.

⁴ A total of 27 CG-47s were procured for the Navy between FY1978 and FY1988; the ships entered service between 1983 and 1994. The first five, which were built to an earlier technical standard, were judged by the Navy to be too expensive to modernize and were removed from service in 2004-2005.

⁵ The modification for BMD operations includes, among other things, the addition of a new software program for the Aegis combat system and the arming of the ship with the SM-3, a version of the Navy's Standard Missile that is designed for BMD operations. For more on Navy BMD programs, CRS Report RL33745, *Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress*, by (name redacted) .

⁶ The 15 DDG-51s procured in FY2010-FY2015 include one in FY2010, two in FY2011, one in FY2012, three in FY2013, one in FY2014, two in FY2015, three in FY2016, and two in FY2017.

The DDG-51 design has been modified over time. The first 28 DDG-51s (i.e., DDGs 51 through 78) are called Flight I/II DDG-51s. In FY1994, the Navy shifted to the Flight IIA design, which incorporated a significant design change that included, among other things, the addition of a helicopter hangar.

The Navy plans to shift in FY2017 to a new variant of the DDG-51, called the Flight III DDG-51, that is to incorporate a new and more capable radar called the Air and Missile Defense Radar (AMDR). The Navy testified on May 24, 2017, that it has “a handshake agreement with Huntington Ingalls to introduce the Flight III capability on their FY[20]17 ship.”⁷ The Navy had previously planned for one of the DDG-51s procured in FY2016 to be the first Flight III ship.

As part of its action on the Navy’s FY2013 budget, Congress granted the Navy authority to use a multiyear procurement (MYP) contract for DDG-51s to be procured FY2013-FY2017.⁸ The Navy awarded the contract on June 3, 2013.⁹ The Navy plans to use an engineering change proposal (ECP) to shift from the Flight IIA design to the Flight III design during this MYP contract.

The Navy wants to use another MYP contract to procure DDG-51s in FY2018-FY2022. As part of its proposed FY2018 budget, the Navy is requesting congressional approval for this new MYP contract.

The Navy is implementing a program for modernizing all DDG-51s (and CG-47s) so as to maintain their mission and cost effectiveness out to the end of their projected service lives.¹⁰ Older CRS reports provide additional historical and background information on the DDG-51 program.¹¹

⁷ Transcript of spoken testimony of Allison Stiller, performing the duties of the Assistant Secretary, Navy for Research, Development, and Acquisition, at a May 24, 2017, hearing before the Seapower and Projection Forces subcommittee of the House Armed Services Committee on the seapower and projection forces portion of the Department of the Navy’s proposed FY2018 budget. The Navy’s prepared statement for the hearing states that DDG-51s to be procured in FY2018-FY2022

will incorporate Integrated Air and Missile Defense and provide additional Ballistic Missile Defense (BMD) capacity known as Flight III, which incorporates the Air and Missile Defense Radar (AMDR)....

This radar is planned for inclusion in FY 2017 via an Engineering Change Proposal to the Flight IIA configuration.

(Statement of Allison F. Stiller, Principal Civilian Deputy Assistant Secretary of the Navy for Research, Development and Acquisition (ASN(RD&A)), performing the duties and functions of ASN(RD&A), and Lieutenant General Robert S. Walsh, Deputy Commandant, Combat Development and Integration & Commanding General, Marine Corps Combat Development Command, and Vice Admiral William K. Lescher, Deputy Chief of Naval Operations for Integration of Capabilities and Resources, before the Subcommittee on Seapower and Projection Forces of the House Armed Services Committee on Department of the Navy Seapower and Projection Forces Capabilities, May 24, 2017, p. 7.)

⁸ For more on MYP contracts, 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) .

⁹ “DDG 51 Multiyear Procurement Contract Awarded,” *Navy News Service*, June 3, 2013, accessed July 1, 2013, at http://www.navy.mil/submit/display.asp?story_id=74583. See also Mike McCarthy, “Navy Awards Multi-Year Contracts For Destroyers,” *Defense Daily*, June 4, 2013: 1.

¹⁰ For more on this program, see CRS Report RS22595, *Navy Aegis Cruiser and Destroyer Modernization: Background and Issues for Congress*, by (name redacted) .

¹¹ See CRS Report 94-343, *Navy DDG-51 Destroyer Procurement Rate: Issues and Options for Congress*, by Ronald O’Rourke (April 25, 1994; out of print and available directly from the author), and CRS Report 80-205, *The Navy’s Proposed Arleigh Burke (DDG-51) Class Guided Missile Destroyer Program: A Comparison With An Equal-Cost Force Of Ticonderoga (CG-47) Class Guided Missile Destroyers*, by Ronald O’Rourke (November 21, 1984; out of (continued...))

DDG-1000 Program

The DDG-1000 program was initiated in the early 1990s.¹² The DDG-1000 is a multi-mission destroyer with an emphasis on naval surface fire support (NSFS) and operations in littoral (i.e., near-shore) waters. The DDG-1000 is intended to replace, in a technologically more modern form, the large-caliber naval gun fire capability that the Navy lost when it retired its Iowa-class battleships in the early 1990s,¹³ to improve the Navy's general capabilities for operating in defended littoral waters, and to introduce several new technologies that would be available for use on future Navy ships. The DDG-1000 was also intended to serve as the basis for a planned cruiser called CG(X) that was subsequently canceled.¹⁴

The DDG-1000 is to have a reduced-size crew of 142 sailors (compared to roughly 300 on the Navy's Aegis destroyers and cruisers) so as to reduce its operating and support (O&S) costs. The ship incorporates a significant number of new technologies, including an integrated electric-drive propulsion system¹⁵ and automation technologies enabling its reduced-sized crew.

With an estimated full load displacement of 15,656 tons, the DDG-1000 design is roughly 65% larger than the Navy's current 9,500-ton Aegis cruisers and destroyers, and larger than any Navy destroyer or cruiser since the nuclear-powered cruiser *Long Beach* (CGN-9), which was procured in FY1957.

Navy plans for many years called for ending DDG-51 procurement in FY2005, to be followed by procurement of up to 32 DDG-1000s and some number of CG(X)s. Planned total numbers of DDG-1000s were subsequently reduced. At the end of July 2008, in a major reversal of its destroyer procurement plans, the Navy announced that it wanted to end procurement of DDG-1000s and resume procurement of DDG-51s. In explaining this reversal, the Navy stated that it had reevaluated the future operating environment and determined that its destroyer procurement now needed to emphasize three missions: open-ocean antisubmarine warfare (ASW), countering anti-ship cruise missiles (ASCMs), and countering ballistic missiles. Although the DDG-1000 could perform the first two of these missions and could be modified to perform the third, the Navy concluded that the DDG-51 design could perform these three missions adequately and would be less expensive to procure than the DDG-1000 design.

The Navy's proposal to stop procuring DDG-1000s and resume procuring DDG-51s was presented in the Navy's proposed FY2010 budget, which was submitted to Congress in 2009. Congress, in acting on the Navy's FY2010 budget, approved the idea of ending DDG-1000 procurement and restarting DDG-51 procurement, and procured a third DDG-1000 as the final ship in the class.

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print and available directly from the author).

¹² The program was originally designated DD-21, which meant destroyer for the 21st Century. In November 2001, the program was restructured and renamed DD(X), meaning a destroyer whose design was in development. In April 2006, the program's name was changed again, to DDG-1000, meaning a guided missile destroyer with the hull number 1000.

¹³ The Navy in the 1980s reactivated and modernized four Iowa (BB-61) class battleships that were originally built during World War II. The ships reentered service between 1982 and 1988 and were removed from service between 1990 and 1992.

¹⁴ For more on the CG(X) program, see CRS Report RL34179, *Navy CG(X) Cruiser Program: Background for Congress*, by (name redacted) .

¹⁵ For more on integrated electric-drive technology, see CRS Report RL30622, *Electric-Drive Propulsion for U.S. Navy Ships: Background and Issues for Congress*, by (name redacted) .

In retrospect, the Navy's 2008 reversal in its destroyer procurement plans can be viewed as an early indication of the ending of the post-Cold War era (during which the Navy focused its planning on operating in littoral waters against the land- and sea-based forces of countries such as Iran and North Korea) and the shift in the international security environment to a new situation featuring renewed great power competition (during which the Navy is now focusing its planning more on being able to operate in mid-ocean waters against capable naval forces from near-peer competitors such as China and Russia).¹⁶

The first two DDG-1000s were procured in FY2007 and split-funded (i.e., funded with two-year incremental funding) in FY2007-FY2008; the Navy's FY2018 budget submission estimates their combined procurement cost at \$9,148.8 million. The third DDG-1000 was procured in FY2009 and split-funded in FY2009-FY2010; the Navy's FY2018 budget submission estimates its procurement cost at \$3,733.2 million.

The first DDG-1000 was commissioned into service on October 15, 2016, although its delivery date has been revised in the FY2018 budget submission to May 2018. The delivery dates for the second and third ships in have been revised in the FY2018 budget submission to May 2020 and December 2021, respectively.¹⁷

As shown in **Table 1** below, the estimated combined procurement cost for all three DDG-1000s, as reflected in the Navy's annual budget submission, has grown by \$3,904.1 million, or 43.5%, since the FY2009 budget (i.e., the budget for the fiscal year in which the third DDG-1000 was procured).

Some of the cost growth in the earlier years in the table was caused by the truncation of the DDG-1000 program from seven ships to three, which caused some class-wide procurement-rated costs that had been allocated to the fourth through seventh ships to be reallocated to the three remaining ships.

The Navy states that the cost growth shown through FY2015 in the table reflects, among other things, a series of incremental, year-by-year movements away from an earlier Navy cost estimate for the program, and toward a higher estimate developed by the Cost Assessment and Program Evaluation (CAPE) office within the Office of the Secretary of Defense (OSD). As one consequence of a Nunn-McCurdy cost breach experienced by the DDG-1000 program in 2010 (see "2010 Nunn-McCurdy Breach, Program Restructuring, and Milestone Recertification" in **Appendix**), the Navy was directed to fund the DDG-1000 program to CAPE's higher cost estimate for the period FY2011-FY2015, and to the Navy's cost estimate for FY2016 and beyond. The Navy states that it implemented this directive in a year-by-year fashion with each budget submission from FY2010 through FY2015, moving incrementally closer each year through FY2015 to CAPE's higher estimate. The Navy stated in 2014 that even with the cost growth shown in the table, the DDG-1000 program as of the FY2015 budget submission was still about

¹⁶ For additional discussion, see CRS Report R43838, *A Shift in the International Security Environment: Potential Implications for Defense—Issues for Congress*, by (name redacted) , and CRS Report R44635, *Navy Force Structure: A Bigger Fleet? Background and Issues for Congress*, by (name redacted) , and CRS Report RL33153, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, by (name redacted) .

¹⁷ The revised delivery dates for the three ships reflect Section 121 of the FY2017 National Defense Authorization Act (S. 2943/P.L. 114-328 of December 23, 2016), a provision that establishes standards for determining vessel delivery dates and which also required the Secretary of the Navy to certify that the delivery dates for certain ships, including the three DDG-1000 class destroyers, had been adjusted in accordance with the provision.

3% below the program’s rebaselined starting point for calculating any new Nunn-McCurdy cost breach on the program.¹⁸

Table I. Estimated Combined Procurement Cost of DDG-1000, DDG-1001, and DDG-2002

In millions, rounded to nearest tenth, as shown in annual Navy budget submissions

Budget submission	Estimated combined procurement cost (millions of dollars)	Change from prior year’s budget submission	Cumulative change from FY2009 budget submission
FY09	8,977.1	—	—
FY10	9,372.5	+395.4 (+4.4%)	+395.4 (+4.4%)
FY11	9,993.3	+620.8 (+6.6%)	+1,016.2 (+11.3%)
FY12	11,308.8	+1,315.5 (+13.2%)	+2,331.7 (+26.0%)
FY13	11,470.1	+161.3 (+1.4%)	+2,493.0 (+27.8%)
FY14	11,618.4	+148.3 (+1.3%)	+2,641.3 (+29.4%)
FY15	12,069.4	+451.0 (+3.9%)	+3,092.3 (+34.4%)
FY16	12,288.7	+219.3 (+1.8%)	+3,311.6 (+36.9%)
FY17	12,738.2	+449.5 (+3.7%)	+3,761.1 (+41.9%)
FY18	12,882.0	+143.8 (+1.1%)	+3,904.0 (+43.5%)

Source: Table prepared by CRS based on data in annual Navy budget submissions.

GD/BIW is the builder for all three DDG-1000s, with some portions of each ship being built by HII/Ingalls for delivery to GD/BIW. Raytheon is the prime contractor for the DDG-1000’s combat system (its collection of sensors, computers, related software, displays, and weapon launchers).

For additional background information on the DDG-1000 program, see **Appendix**.

Surface Combatant Construction Industrial Base

All cruisers, destroyers, and frigates procured since FY1985 have been built at General Dynamics’ Bath Iron Works (GD/BIW) shipyard of Bath, ME, and Huntington Ingalls Industries’ Ingalls Shipbuilding (HII/Ingalls) of Pascagoula, MS. Both yards have long histories of building larger surface combatants. Construction of Navy surface combatants in recent years has accounted for virtually all of GD/BIW’s ship-construction work and for a significant share of HII/Ingalls’ ship-construction work. (HII/Ingalls also builds amphibious ships for the Navy.) Navy surface combatants are overhauled, repaired, and modernized at GD/BIW, HII/Ingalls, and other U.S. shipyards.

Lockheed Martin and Raytheon are generally considered the two leading Navy surface combatant radar makers and combat system integrators. Lockheed is the lead contractor for the DDG-51 combat system (the Aegis system), while Raytheon is the lead contractor for the DDG-1000 combat system, the core of which is called the Total Ship Computing Environment Infrastructure (TSCE-I). Lockheed has a share of the DDG-1000 combat system, and Raytheon has a share of

¹⁸ Source: Navy briefing for CRS and the Congressional Budget Office (CBO) on the DDG-1000 program, April 30, 2014.

the DDG-51 combat system. Lockheed, Raytheon, and Northrop competed to be the maker of the AMDR to be carried by the Flight III DDG-51. On October 10, 2013, the Navy announced that it had selected Raytheon to be the maker of the AMDR.

The surface combatant construction industrial base also includes hundreds of additional firms that supply materials and components. The financial health of Navy shipbuilding supplier firms has been a matter of concern in recent years, particularly since some of them are the sole sources for what they make for Navy surface combatants.

FY2018 Funding Request

The Navy estimates the combined procurement cost of the two DDG-51s requested for procurement in FY2018 at \$3,499.1 million. The Navy's proposed FY2018 budget requests:

- \$3,499.1 million in procurement funding to fully fund the procurement of the two DDG-51s requested for FY2018;
- \$90.3 million in EOQ (economic order quantity) advance procurement (AP) funding for up-front batch orders of components for DDG-51s to be procured under the proposed DDG-51 MYP contract for FY2018-FY2022;
- \$51.4 million in cost-to-complete procurement funding to cover cost growth on DDG-51s procured in prior fiscal years;
- \$32.1 million in research and development funding for the AMDR; and
- \$224.0 million in procurement funding to cover costs for building DDG-1000 class destroyers procured in prior fiscal years.

The funding request for the AMDR was contained in Program Element (PE) 0604522N (“Air and Missile defense Radar (AMDR) System”), which is line 129 in the Navy's FY2018 research and development account.

Issues for Congress for FY2018

FY2018 Funding Request

One issue for Congress for FY2018 whether to approve, reject, or modify the Navy's requests for FY2018 procurement and research and development funding for the DDG-51 and DDG-1000 programs. In considering this issue, Congress may consider, among other things, whether the Navy has accurately priced the work it is proposing to fund for FY2018.

Authority for DDG-51 Multiyear Procurement in FY2018-FY2022

Another issue for Congress for FY2018 is whether to approve the Navy's request for a using new MYP contract for DDG-51s to be procured in FY2018-FY2022. As discussed in another CRS report, MYP contracts can reduce the procurement costs of Navy ships by roughly 10%, but can reduce Congress's flexibility for making changes (particularly reductions) to annual procurement rates of ships covered by MYP contracts to respond to changes in strategic or budgetary circumstances.¹⁹

¹⁹ For more on MYP contracts, see CRS Report R41909, *Multiyear Procurement (MYP) and Block Buy Contracting in* (continued...)

Option of Providing Funding for One or Two Additional DDG-51s in FY2018

Another issue for Congress for FY2018 whether to provide funding for the procurement in FY2018 of one or two additional DDG-51s (i.e., whether to provide funding for the procurement in FY2018 of a total of three or four DDG-51s). Supporters could argue that procuring three or four DDG-51s in FY2018, rather than two, could reduce DDG-51 unit procurement costs due to improved production economies of scale and start building toward the 104-ship cruiser-destroyer force called for in the Navy's new 355-ship force-level goal. Skeptics or opponents could argue that providing funding for the procurement of one or two additional DDG-51s in FY2018 could reduce funding for other (and possibly higher-priority) Navy or DOD programs.

Cost Growth in DDG-1000 Program

Another issue for Congress for FY2018, as in previous years, is the continued cost growth in the DDG-1000 program shown in **Table 1**. Potential oversight questions for Congress include the following: What are the causes of this cost growth? Does the Navy expect the cost growth to continue past FY2018? What is the Navy doing to end this cost growth and bring DDG-1000 procurement costs under control?

Cost, Technical, and Schedule Risk in Flight III DDG-51 Effort

Another issue for Congress for FY2018, as in previous years, concerns cost, technical, and schedule risk for the Flight III DDG-51.

March 2017 GAO Report

A March 2017 GAO report assessing selected DOD acquisition programs stated the following in its assessment of the Flight III DDG-51:

The Navy continues Flight III detail design activities, which include extensive changes to the ship's hull, mechanical, and electrical systems to incorporate the SPY-6 radar and restore safety margins to the weight and stability limitations of the ship. To reduce technical risk, the Flight III design includes new electrical and air conditioning systems that are currently in use on other ship classes. The existing DDG 51-class ship design is dense and creates challenges for Flight III design and construction, such as having to rearrange equipment to fit new items and potentially higher construction costs due to inefficiencies caused by working in tight spaces. The Navy began Flight III zone design—three-dimensional modeling of the individual ship units—in October 2015 and plans to complete zone design before starting construction in spring 2018. The Navy's plans are ambitious, considering the amount and complexity of the remaining design work. For example, one shipbuilder was not scheduled to begin zone design on the five zones requiring the most complex changes until December 2016, which may provide insufficient time to discover and address problems.

The Navy planned to modify its existing Flight IIA multiyear procurement contracts to construct the first three Flight III ships. In fiscal year 2016, the Navy received \$1 billion in construction funding to procure an additional ship. The Navy now plans to use this

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

funding to acquire the first Flight III ship under a fixed price incentive engineering change proposal. The Navy is revising its Flight III acquisition strategy, including an updated acquisition program baseline and cost estimate, for an upcoming but unscheduled program review ahead of Flight III construction start.²⁰

Regarding the AMDR specifically, the report stated:

Technology Maturity

AMDR's four critical technologies—digital beamforming, transmit/receive modules, multi-mission scheduling and discrimination software, and distributed receivers/exciters—are nearing maturity. The program is expected to deliver its first radar for installation on the lead DDG 51 Flight III ship in early 2020. To support initial integration between the radar and the combat system, the AMDR contractor developed and delivered SPY-6 simulator and emulator capabilities to help inform the program's knowledge of the radar and Aegis combat system interface performance prior to a 6-month risk reduction test period planned for the second half of fiscal year 2017. Additionally, the contractor built and tested a full-scale, single-face, 14-foot S-band radar array. In June 2016, this production-representative array was delivered and installed at the Navy's Pacific Missile Range Facility in Hawaii for live testing in a more representative environment. This testing is expected to reduce technical risk for the radar and help inform a low-rate initial production decision in September 2017.

The AMDR program's software has been developed in four builds using an approach that includes upfront requirements and architecture analysis for each build, as well as continuous integration of new software and automated testing to ensure functionality and performance. This includes aligning software features to test events to ensure timely software completion and delivery to support dry runs and tests. The first two builds developed basic infrastructure, anti-air warfare, and ballistic missile defense capabilities. The third and fourth provide the full extent of radar capabilities, including debris detection and mitigation and advanced discrimination of missile threats. As of December 2016, the fourth build was 80 percent complete, with completion planned by April 2017—about half a year later than previously planned. The Navy also plans to upgrade the combat system for integration with the SPY-6 radar, which will require significant software development for the interface between the radar and the combat management system. These software builds are expected to be completed in fiscal year 2021.

Design and Production Maturity

In April 2015, the program office completed a critical design review, with 100 percent of design drawings finalized. The design has remained stable as the program moves toward its initial production decision. However, because the decision to begin low-rate initial production will be made prior to demonstrating technology maturity at sea and before combat system integration and test, design stability remains a risk. Any design issues identified through testing the radar at sea and with the combat system will need to be addressed during SPY-6 production. The program office identified four key product characteristics that will be closely monitored during manufacturing. The characteristics are associated with the structural features of the radar and elements of the transmit/receive modules and beamforming technologies.

Other Program Issues

In 2013, DOT&E disapproved AMDR's test and evaluation master plan due to concerns the Navy's proposed testing approach would not provide realistic operational conditions.

²⁰ Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-17-333SP, March 2017, p. 124.

A senior DOT&E official noted the concern that the Navy has not involved DOT&E in efforts to update the test plan and anticipates that, without DOT&E involvement, the plan is likely to remain unapproved by DOT&E when the program reaches its September 2017 production decision.

Program Office Comments

In commenting on a draft of this assessment, the program office stated the SPY-6 testing it completed at the Pacific Missile Range Facility validated the system performance previously measured in testing at the contractor's facility, allowing the program to procure long lead material for the first DDG 51 Flight III in December 2016. Upcoming live testing of several systems is expected to demonstrate the advanced features and unprecedented capability of this radar. The program reports being on track to provide this much-needed capability to the warfighter.²¹

February 2017 CBO Report

A February 2017 Congressional Budget Office (CBO) report on the cost of the Navy's shipbuilding programs stated the following about the Flight III DDG-51:

The Navy's strategy for meeting the combatant commanders' goal of improving ballistic missile defense capabilities so that in the future they exceed those provided by existing DDG-51s—and for replacing 11 Ticonderoga class cruisers when they are retired in the 2020s—is to substantially modify the design of the DDG-51 Flight IIA destroyer to create a Flight III configuration. That modification would incorporate the new Air and Missile Defense Radar (AMDR), now under development, which will be larger and more capable than the radar on current DDG-51s. The effective operation of the AMDR in the new Flight III configuration, however, will require an increase in the ships' capacity to generate electrical power and their ability to cool major systems.

With those improvements incorporated into the design of the Flight III and the associated increases in the ships' displacement, CBO expects that the average cost per ship over the entire production run would be \$1.9 billion in 2016 dollars—about 15 percent more than the Navy's estimate of \$1.7 billion. Costs could be higher or lower than CBO's estimate, however, depending on the eventual cost and complexity of the AMDR and the associated changes to the ship's design to integrate the new radar.²²

December 2016 DOT&E Report

A December 2016 report from DOD's Director of Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2016 stated the following regarding the Flight III DDG-51:

Assessment

- DOT&E's assessment is that, absent an AMDR and Aegis-equipped SDTS [self-defense test ship] the Navy's operational test programs for the AMDR, Aegis Combat System, ESSM [Evolved Sea Sparrow Missile] Block 2, and DDG 51 Flight III destroyer programs cannot be adequate to fully assess their capabilities, in particular those associated with self-defense. They would also not be adequate to test the following Navy-approved DDG 51 Flight III, AMDR, Aegis Combat System, and ESSM Block 2 requirements.

²¹ Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-17-333SP, March 2017, p. 90.

²² Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2017 Shipbuilding Plan*, February 2017, pp. 28-29.

- The AMDR Capability Development Document (CDD) describes AMDR's IAMD mission, which requires AMDR to support simultaneous defense against multiple ballistic missile threats and multiple advanced anti-ship cruise missile (ASCM) threats. The CDD also includes an AMDR minimum track range Key Performance Parameter.

- The DDG 51 Flight III destroyer has a survivability Key Performance Parameter requirement directly tied to meeting a self-defense requirement threshold against ASCMs described in the Navy's Surface Ship Theater Air and Missile Defense Assessment document of July 2008. It clearly states that area defense will not defeat all the threats, thereby demonstrating that area air defense will not completely attrite all ASCM raids and individual ships must be capable of defeating ASCM leakers in the self defense zone.

- The ESSM Block 2 CDD has a requirement to provide self-defense against incoming ASCM threats in clear and jamming environments. The CDD also includes an ESSM Block 2 minimum intercept range Key Performance Parameter.

• Use of manned ships for operational testing with threat-representative ASCM surrogates in the close-in, self-defense battlespace is not possible due to Navy safety restrictions because targets and debris from intercepts pose an unacceptable risk to personnel at ranges where some of the engagements will take place. The November 2013 mishap on USS Chancellorsville (CG 62) involving an ASCM surrogate target resulted in even more stringent safety constraints. - In addition to stand-off ranges, safety restrictions require that ASCM targets not be flown directly at a manned ship, but at some cross range offset, which unacceptably degrades the operational realism of the test.

- Similar range safety restrictions will preclude manned ship testing of five of the seven self-defense ASCM scenarios included in the Navy-approved requirements document for the Aegis Modernization Advanced Capability Build 20 Combat System upgrade and will severely limit the operational realism of the two scenarios that can be flown against a manned ship. Restrictions also preclude testing of the AMDR minimum track range requirement against threat representative ASCM threat surrogates at the land-based AMDR Pacific Missile Range Facility test site.

- To overcome these safety restrictions for the LHA 6, Littoral Combat Ship, DDG 1000, LPD 17, LSD 41/49, and CVN 78 ship classes, the Navy developed an Air Warfare/Ship Self-Defense Enterprise Modeling and Simulation (M&S) test bed, which uses live testing in the close-in battlespace with targets flying realistic threat profiles and manned ship testing for other battlespace regions, as well as soft-kill capabilities to validate and accredit the M&S test bed. The same needs to be done for the DDG 51 Flight III destroyer with its AMDR, as side-by-side comparison between credible live fire test results and M&S test results form the basis for the M&S accreditation. Without an SDTS with AMDR and an Aegis Combat System, there will not be a way to gather all of the operationally realistic live fire test data needed for comparison to accredit the M&S test bed.

• Since Aegis employs ESSMs in the close-in, self-defense battlespace, understanding ESSM's performance is critical to understanding the self-defense capabilities of the DDG 51 Flight III destroyer.

- Past DOT&E annual reports have stated that the ESSM Block 1 operational effectiveness has not been determined. The Navy has not taken action to adequately test the ESSM's operational effectiveness.

- The IOT&E for ESSM Block 2 will be conducted in conjunction with the DDG 51 Flight III destroyer, AMDR, and Aegis Combat System operational testing.

- Specifically, because safety limitations preclude ESSM firing in the close-in self-defense battlespace, there are very little test data available concerning ESSM's performance, as installed on Aegis ships, against supersonic ASCM surrogates.

- Any data available regarding ESSM's performance against supersonic ASCM surrogates are from a Ship Self-Defense System-based combat system configuration, using a completely different guidance mode or one that is supported by a different radar suite.

- The cost of building and operating an Aegis SDTS, estimated to be about \$350 Million, is small when compared to the total cost of the AMDR development/procurement and the eventual cost of the 22 or more DDG 51 Flight III ships that are planned for acquisition (\$55 Billion or higher). Even smaller is the cost of the SDTS compared to the cost of the ships that the DDG 51 Flight III destroyer is expected to protect (approximately \$450 Billion in new ship construction over the next 30 years). If DDG 51 Flight III destroyers are unable to defend themselves, these other ships are placed at substantial risk. Therefore, it is essential that the Navy program fully now to support all the tests, targets, and Aegis combat system equipment needed to conduct realistic self-defense testing using an AMDR and Aegis-equipped SDTS.

- The modification/upgrades being planned for DDG 51 Flight III are significant enough to warrant an assessment of the impact of these changes on ship survivability. The Navy has unofficially indicated the DDG 51 Flight III LFT&E strategy will include Component Shock Qualification, a Total Ship Survivability Trial, and a Full Ship Shock Trial. Other LFT&E program particulars are still under discussion to ensure DDG 51 Flight III adequately addresses survivability requirements against operationally relevant threats and recoverability requirements.

Recommendations

- Status of Previous Recommendations. The Navy has not addressed the following previous recommendations. The Navy should:

1. Program and fully fund an SDTS equipped with the AMDR, ESSM Block 2, and DDG 51 Flight III Aegis Combat System in time to support the DDG 51 Flight III destroyer and ESSM Block 2 IOT&Es.

2. Modify the AMDR, ESSM Block 2, and DDG 51 Flight III TEMP's to include a phase of IOT&E using an SDTS equipped with the AMDR and DDG 51 Flight III Combat System.

3. Modify the AMDR, ESSM Block 2, and DDG 51 Flight III TEMP's to include a credible M&S effort that will enable a full assessment of the AMDR, ESSM Block 2, and DDG 51 Flight III Combat System's self-defense capabilities.

4. Comply with the DEPSECDEF direction to develop and fund a plan, to be approved by DOT&E, to conduct at-sea testing of the self-defense of the DDG 51 Flight III destroyer with the AMDR, ESSM Block 2, and Aegis Combat System.

5. Provide DOT&E the DDG 51 Flight III LFT&E Strategy for approval in coordination with the TTEMP.

- FY16 Recommendations. The Navy should:

1. Comply with the DEPSECDEF direction to work with DOT&E to develop an integrated test strategy for the DDG 51 Flight III, AMDR, Aegis Modernization, ESSM Block 2 programs, and document that strategy into draft TEMP's for those programs to be provided to DOT&E.

2. Program funds in the Future Years Defense Plan to complete all activities and procurements required to conduct adequate operational testing of the DDG 51 Flight III, AMDR, and ESSM Block 2's self-defense capabilities on an Aegis-equipped SDTS scheduled for FY23.

3. Include within the LFT&E Strategy, testing aimed at addressing LFT&E knowledge gaps that can be included in codes/tools designed to assist in determining the platforms' vulnerability and recoverability.²³

Lack of Roadmap for Accomplishing Three Things in Cruiser-Destroyer Force

Another issue for Congress in FY2018, as in previous years, concerns the lack of an announced Navy roadmap for accomplishing three things in the cruiser-destroyer force:

- restoring ship growth margins;
- introducing large numbers of ships with integrated electric drive systems or other technologies that could provide ample electrical power for supporting future electrically powered weapons; and
- introducing technologies (such as those for substantially reducing ship crew size) for substantially reducing ship operating and support (O&S) costs.

The Navy's pre-2008 plan to procure DDG-1000 destroyers and then CG(X) cruisers based on the DDG-1000 hull design represented the Navy's roadmap at the time for restoring growth margins, and for introducing into the cruiser-destroyer force significant numbers of ships with integrated electric drive systems and technologies for substantially reducing ship crew sizes. The ending of the DDG-1000 and CG(X) programs in favor of continued procurement of DDG-51s leaves the Navy without an announced roadmap to do these things, because the Flight III DDG-51 will not feature a fully restored growth margin, will not be equipped with an integrated electric drive system or other technologies that could provide ample electrical power for supporting future electrically powered weapons, and will not incorporate features for substantially reducing ship crew size or for otherwise reducing ship O&S costs substantially below that of Flight IIA DDG-51s. One option for addressing this issue would be to further modify the DDG-51 design. Another would be to initiate a program to design a new cruiser or destroyer class.

Legislative Activity for FY2018

Summary of Congressional Action on FY2018 Funding Request

Table 2 summarizes congressional action on the Navy's FY2018 procurement funding requests for the DDG-51 and DDG-1000 programs, and its research and development funding request for the Air and Missile Defense Radar (AMDR).

²³ Department of Defense, *Director, Operational Test and Evaluation, FY 2016 Annual Report*, December 2016, pp. 232-234. See also pp. xiii, 189-192, 456-457.

Table 2. Congressional Action on FY2018 Funding Request

Millions of dollars, rounded to nearest tenth

	Request	Authorization			Appropriation		
		HASC	SASC	Conf.	HAC	SAC	Conf.
DDG-51 funding							
Procurement funding	3,499.1						
“Regular” advance procurement (AP) funding for DDG-51s to be procured in future years	0						
EOQ (economic order quantity) AP funding for FY18-FY22 DDG-51 MYP	90.3						
Cost to complete for DDG-51s procured in prior years	51.4						
AMDR research and development (PE 0604522N, line 129)	32.1						
DDG-1000 funding							
Procurement funding	224.0						

Source: Table prepared by CRS based on Navy’s FY2018 budget submission.

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

Appendix. Additional Background Information on DDG-1000 Program

This appendix presents additional background information on the DDG-1000 program.

Program Origin

The program known today as the DDG-1000 program was announced on November 1, 2001, when the Navy stated that it was replacing a destroyer-development effort called the DD-21 program, which the Navy had initiated in the mid-1990s, with a new Future Surface Combatant Program aimed at developing and acquiring a family of three new classes of surface combatants:²⁴

- **a destroyer called DD(X)** for the precision long-range strike and naval gunfire mission;
- **a cruiser called CG(X)** for the air defense and ballistic missile mission; and
- **a smaller combatant called the Littoral Combat Ship (LCS)** to counter submarines, small surface attack craft (also called “swarm boats”), and mines in heavily contested littoral (near-shore) areas.²⁵

On April 7, 2006, the Navy announced that it had redesignated the DD(X) program as the DDG-1000 program. The Navy also confirmed in that announcement that the first ship in the class, DDG-1000, is to be named the *Zumwalt*, in honor of Admiral Elmo R. Zumwalt, the Chief of Naval operations from 1970 to 1974. The decision to name the first ship after Zumwalt was made by the Clinton Administration in July 2000, when the program was still called the DD-21 program.²⁶

New Technologies

The DDG-1000 incorporates a significant number of new technologies, including a wave-piercing, tumblehome hull design for reduced detectability,²⁷ a superstructure made partly of large sections of composite (i.e., fiberglass-like) materials rather than steel or aluminum, an integrated electric-drive propulsion system,²⁸ a total-ship computing system for moving information about

²⁴ The DD-21 program was part of a Navy surface combatant acquisition effort begun in the mid-1990s and called the SC-21 (Surface Combatant for the 21st Century) program. The SC-21 program envisaged a new destroyer called DD-21 and a new cruiser called CG-21. When the Navy announced the Future Surface Combatant Program in 2001, development work on the DD-21 had been underway for several years, while the start of development work on the CG-21 was still years in the future. The current DDG-1000 destroyer CG(X) cruiser programs can be viewed as the descendants, respectively, of the DD-21 and CG-21. The acronym SC-21 is still used in the Navy’s research and development account to designate the line item (i.e., program element) that funds development work on both the DDG-1000 and CG(X).

²⁵ For more on the LCS program, see CRS Report RL33741, *Navy Littoral Combat Ship/Frigate (LCS/FF) Program: Background and Issues for Congress*, by (name redacted) .

²⁶ For more on Navy ship names, see CRS Report RS22478, *Navy Ship Names: Background for Congress*, by (name redacted) .

²⁷ A tumblehome hull slopes inward, toward the ship’s centerline, as it rises up from the waterline, in contrast to a conventional flared hull, which slopes outward as it rises up from the waterline.

²⁸ For more on integrated electric-drive technology, see CRS Report RL30622, *Electric-Drive Propulsion for U.S. Navy Ships: Background and Issues for Congress*, by (name redacted) .

the ship, automation technologies enabling its reduced-sized crew, a dual-band radar, a new kind of vertical launch system (VLS) for storing and firing missiles, and two copies of a 155mm gun called the Advanced Gun System (AGS).

The AGS was to fire a new rocket-assisted 155 mm shell, called the Long Range Land Attack Projectile (LRLAP). LRLAP has a range of more than 60 nautical miles. DDG-1000s are designed carry 600 LRLAP rounds (300 for each gun), and to have additional LRLAP rounds brought aboard the ship while the guns are firing, which would create what Navy officials call an “infinite magazine.” In November 2016, however, it was reported that the Navy had decided to stop procuring LRLAP projectiles because the projected unit cost of each projectile had risen to at least \$800,000.²⁹ In December 2016, it was reported that the Navy has decided to instead procure Excalibur guided artillery rounds for use by AGSs on DDG-1000s. The Excalibur rounds reportedly have about half the range of LRLAP rounds and cost roughly \$250,000 each.³⁰

Planned Quantity

When the DD-21 program was initiated, a total of 32 ships was envisaged. In subsequent years, the planned total for the DD(X)/DDG-1000 program was reduced to 16 to 24, then to 7, and finally to 3.

Construction Shipyards

Under a DDG-1000 acquisition strategy approved by the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD AT&L) on February 24, 2004, the first DDG-1000 was to have been built by HII/Ingalls, the second ship was to have been built by GD/BIW, and contracts for building the first six were to have been equally divided between HII/Ingalls³¹ and GD/BIW.

In February 2005, Navy officials announced that they would seek approval from USD AT&L to instead hold a one-time, winner-take-all competition between HII/Ingalls and GD/BIW to build all DDG-1000s. On April 20, 2005, the USD AT&L issued a decision memorandum deferring this proposal, stating in part, “at this time, I consider it premature to change the shipbuilder portion of the acquisition strategy which I approved on February 24, 2004.”

Several Members of Congress also expressed opposition to the Navy’s proposal for a winner-take-all competition. Congress included a provision (§1019) in the Emergency Supplemental Appropriations Act for 2005 (H.R. 1268/P.L. 109-13 of May 11, 2005) prohibiting a winner-take-all competition. The provision effectively required the participation of at least one additional shipyard in the program but did not specify the share of the program that is to go to the additional shipyard.

On May 25, 2005, the Navy announced that, in light of Section 1019 of P.L. 109-13, it wanted to shift to a “dual-lead-ship” acquisition strategy, under which two DDG-1000s would be procured in FY2007, with one to be designed and built by HII/Ingalls and the other by GD/BIW.

²⁹ Christopher P. Cavas, “New Warship’s Big Guns Have No Bullets,” *Defense News*, November 6, 2016; Sam LaGrone, “Navy Planning on Not Buying More LRLAP Rounds for Zumwalt Class,” *USNI News*, November 7, 2016; Ben Guarino, “The Navy Called USS Zumwalt A Warship Batman Would Drive. But at \$800,000 Per Round, Its Ammo Is Too Pricey to Fire,” *Washington Post*, November 8, 2016.

³⁰ Sam LaGrone, “Raytheon Excalibur Round Set to Replace LRLAP on Zumwalts,” *USNI News*, December 13, 2016.

³¹ At the time of the events described in this section, HII was owned by Northrop Grumman and was called Northrop Grumman Shipbuilding (NGSB).

Section 125 of the FY2006 defense authorization act (H.R. 1815/P.L. 109-163) again prohibited the Navy from using a winner-take-all acquisition strategy for procuring its next-generation destroyer. The provision again effectively requires the participation of at least one additional shipyard in the program but does not specify the share of the program that is to go to the additional shipyard.

On November 23, 2005, the USD AT&L granted Milestone B approval for the DDG-1000, permitting the program to enter the System Development and Demonstration (SDD) phase. As part of this decision, the USD AT&L approved the Navy's proposed dual-lead-ship acquisition strategy and a low rate initial production quantity of eight ships (one more than the Navy subsequently planned to procure).

On February 14, 2008, the Navy awarded contract modifications to GD/BIW and HII/Ingalls for the construction of the two lead ships. The awards were modifications to existing contracts that the Navy has with GD/BIW and HII/Ingalls for detailed design and construction of the two lead ships. Under the modified contracts, the line item for the construction of the dual lead ships is treated as a cost plus incentive fee (CPIF) item.

Until July 2007, it was expected that HII/Ingalls would be the final-assembly yard for the first DDG-1000 and that GD/BIW would be the final-assembly yard for the second. On September 25, 2007, the Navy announced that it had decided to build the first DDG-1000 at GD/BIW, and the second at HII/Ingalls.

On January 12, 2009, it was reported that the Navy, HII/Ingalls, and GD/BIW in the fall of 2008 began holding discussions on the idea of having GD/BIW build both the first and second DDG-1000s, in exchange for HII/Ingalls receiving a greater share of the new DDG-51s that would be procured under the Navy's July 2008 proposal to stop DDG-1000 procurement and restart DDG-51 procurement.³²

On April 8, 2009, it was reported that the Navy had reached an agreement with HII/Ingalls and GD/BIW to shift the second DDG-1000 to GD/BIW, and to have GD/BIW build all three ships. HII/Ingalls will continue to make certain parts of the three ships, notably their composite deckhouses. The agreement to have all three DDG-1000s built at GD/BIW was a condition that Secretary of Defense Robert Gates set forth in an April 6, 2009, news conference on the FY2010 defense budget for his support for continuing with the construction of all three DDG-1000s (rather than proposing the cancellation of the second and third).

Procurement Cost Cap

Section 123 of the FY2006 defense authorization act (H.R. 1815/P.L. 109-163 of January 6, 2006) limited the procurement cost of the fifth DDG-1000 to \$2.3 billion, plus adjustments for inflation and other factors. Given the truncation of the DDG-1000 program to three ships, this unit procurement cost cap appears moot.

2010 Nunn-McCurdy Breach, Program Restructuring, and Milestone Recertification

On February 1, 2010, the Navy notified Congress that the DDG-1000 program had experienced a critical cost breach under the Nunn-McCurdy provision. The Nunn-McCurdy provision (10

³² Christopher P. Cavas, "Will Bath Build Second DDG 1000?" *Defense News*, January 12, 2009: 1, 6.

U.S.C. 2433a) requires certain actions to be taken if a major defense acquisition program exceeds (i.e., breaches) certain cost-growth thresholds and is not terminated. Among other things, a program that experiences a cost breach large enough to qualify under the provision as a critical cost breach has its previous acquisition system milestone certification revoked. (In the case of the DDG-1000 program, this was Milestone B.) In addition, for the program to proceed rather than be terminated, DOD must certify certain things, including that the program is essential to national security and that there are no alternatives to the program that will provide acceptable capability to meet the joint military requirement at less cost.³³

The Navy stated in its February 1, 2010, notification letter that the DDG-1000 program's critical cost breach was a mathematical consequence of the program's truncation to three ships.³⁴ Since the DDG-1000 program has roughly \$9.3 billion in research and development costs, truncating the program to three ships increased to roughly \$3.1 billion the average amount of research and development costs that are included in the average acquisition cost (i.e., average research and development cost plus procurement cost) of each DDG-1000. The resulting increase in program acquisition unit cost (PAUC)—one of two measures used under the Nunn-McCurdy provision for measuring cost growth³⁵—was enough to cause a Nunn-McCurdy critical cost breach.

In a June 1, 2010, letter (with attachment) to Congress, Ashton Carter, the DOD acquisition executive (i.e., the Under Secretary of Defense for Acquisition, Technology and Logistics), stated that he had restructured the DDG-1000 program and that he was issuing the certifications required under the Nunn-McCurdy provision for the restructured DDG-1000 program to proceed.³⁶ The letter stated that the restructuring of the DDG-1000 program included the following:

- A change to the DDG-1000's design affecting its primary radar.
- A change in the program's Initial Operational Capability (IOC) from FY2015 to FY2016.
- A revision to the program's testing and evaluation requirements.

Regarding the change to the ship's design affecting its primary radar, the DDG-1000 originally was to have been equipped with a dual-band radar (DBR) consisting of the Raytheon-built X-band SPY-3 multifunction radar (MFR) and the Lockheed-built S-band SPY-4 Volume Search Radar (VSR). (Raytheon is the prime contractor for the overall DBR.) Both parts of the DBR have been in development for the past several years. An attachment to the June 1, 2010, letter stated that, as a result of the program's restructuring, the ship is now to be equipped with "an upgraded multifunction radar [MFR] and no volume search radar [VSR]." The change eliminates the Lockheed-built S-band SPY-4 VSR from the ship's design. The ship might retain a space and

³³ For more on the Nunn-McCurdy provision, see CRS Report R41293, *The Nunn-McCurdy Act: Background, Analysis, and Issues for Congress*, by (name redacted) and (name redacted).

³⁴ Source: Letter to congressional offices dated February 1, 2010, from Robert O. Work, Acting Secretary of the Navy, to Representative Ike Skelton, provided to CRS by Navy Office of Legislative Affairs on February 24, 2010.

³⁵ PAUC is the sum of the program's research and development cost and procurement cost divided by the number of units in the program. The other measure used under the Nunn-McCurdy provision to measure cost growth is average program unit cost (APUC), which is the program's total procurement cost divided by the number of units in the program.

³⁶ Letter dated June 1, 2010, from Ashton Carter, Under Secretary of Defense (Acquisition, Technology and Logistics) to the Honorable Ike Skelton, with attachment. The letter and attachment were posted on InsideDefense.com (subscription required) on June 2, 2010.

weight reservation that would permit the VSR to be backfitted to the ship at a later point. The Navy states that

As part of the Nunn-McCurdy certification process, the Volume Search Radar (VSR) hardware was identified as an acceptable opportunity to reduce cost in the program and thus was removed from the current baseline design....

Modifications will be made to the SPY-3 Multi-Function Radar (MFR) with the focus of meeting ship Key Performance Parameters. The MFR modifications will involve software changes to perform a volume search functionality. Shipboard operators will be able to optimize the SPY-3 MFR for either horizon search or volume search. While optimized for volume search, the horizon search capability is limited. Without the VSR, DDG 1000 is still expected to perform local area air defense....

The removal of the VSR will result in an estimated \$300 million net total cost savings for the three-ship class. These savings will be used to offset the program cost increase as a result of the truncation of the program to three ships. The estimated cost of the MFR software modification to provide the volume search capability will be significantly less than the estimated procurement costs for the VSR.³⁷

Regarding the figure of \$300 million net total cost savings in the above passage, the Navy during 2011 determined that eliminating the SPY-4 VSR from the DDG-1000 increased by \$54 million the cost to integrate the dual-band radar into the Navy's new Gerald R. Ford (CVN-78) class aircraft carriers.³⁸ Subtracting this \$54 million cost from the above \$300 million savings figure would bring the net total cost savings to about \$246 million on a Navy-wide basis.

A July 26, 2010, press report quotes Captain James Syring, the DDG-1000 program manager, as stating: "We don't need the S-band radar to meet our requirements [for the DDG-1000]," and "You can meet [the DDG-1000's operational] requirements with [the] X-band [radar] with software modifications."³⁹

An attachment to the June 1, 2010, letter stated that the PAUC for the DDG-1000 program had increased 86%, triggering the Nunn-McCurdy critical cost breach, and that the truncation of the program to three ships was responsible for 79 of the 86 percentage points of increase. (The attachment stated that the other seven percentage points of increase are from increases in development costs that are primarily due to increased research and development work content for the program.)

Carter also stated in his June 1, 2010, letter that he had directed that the DDG-1000 program be funded, for the period FY2011-FY2015, to the cost estimate for the program provided by the Cost Assessment and Program Evaluation (CAPE) office (which is a part of the Office of the Secretary of Defense [OSD]), and, for FY2016 and beyond, to the Navy's cost estimate for the program. The program was previously funded to the Navy's cost estimate for all years. Since CAPE's cost estimate for the program is higher than the Navy's cost estimate, funding the program to the CAPE estimate for the period FY2011-FY2015 will increase the cost of the program as it appears in the budget for those years. The letter states that DOD "intends to address the [resulting] FY2011 [funding] shortfall [for the DDG-1000 program] through reprogramming actions."

³⁷ Source: Undated Navy information paper on DDG-51 program restructuring provided to CRS and CBO by Navy Office of Legislative Affairs on July 19, 2010.

³⁸ Source: Undated Navy information paper on CVN-78 cost issues, provided by Navy Office of Legislative Affairs to CRS on March 19, 2012.

³⁹ Cid Standifer, "Volume Radar Contracted For DDG-1000 Could Be Shifted To CVN-79," *Inside the Navy*, July 26, 2010.

An attachment to the letter stated that the CAPE in May 2010 estimated the PAUC of the DDG-1000 program (i.e., the sum of the program's research and development costs and procurement costs, divided by the three ships in the program) as \$7.4 billion per ship in then-year dollars (\$22.1 billion in then-year dollars for all three ships), and the program's average procurement unit cost (APUC), which is the program's total procurement cost divided by the three ships in the program, as \$4.3 billion per ship in then-year dollars (\$12.8 billion in then-year dollars for all three ships). The attachment stated that these estimates are at a confidence level of about 50%, meaning that the CAPE believes there is a roughly 50% chance that the program can be completed at or under these cost estimates, and a roughly 50% chance that the program will exceed these cost estimates.

An attachment to the letter directed the Navy to "return for a Defense Acquisition Board (DAB) review in the fall 2010 timeframe when the program is ready to seek approval of the new Milestone B and authorization for production of the DDG-1002 [i.e., the third ship in the program]."

On October 8, 2010, DOD reinstated the DDG-1000 program's Milestone B certification and authorized the Navy to continue production of the first and second DDG-1000s and commence production of the third DDG-1000.⁴⁰

Technical Risk and Test and Evaluation Issues

March 2017 GAO Report

A March 2017 GAO report assessing selected major DOD weapon acquisition programs stated the following of the DDG-1000 program:

Technology Maturity

At start of detail design in 2005, the DDG 1000 program had matured 1 of its current 11 critical technologies—an acquisition approach inconsistent with best practices. The DDG 1000 program has since fully matured 5 of 11 critical technologies. The program states that 5 of the remaining 6 will be demonstrated during post-delivery availability and combat systems activation, extending from the second quarter of fiscal year 2017 to the first quarter of fiscal year 2019. The Navy has since delayed the start of this activity to early 2018. Prior to the May 2016 delivery of the lead ship's hull, mechanical, and electrical systems, the program experienced significant technical issues with the integrated power system, a critical technology which supplies power to the ship's propulsion and electronic systems. Challenges were due, in part, to the Navy's decision not to fully test and validate the performance of the system in a representative environment prior to installation on the ship. Program officials noted that combat systems testing and activation relies on stable power, and will introduce new challenges for the power system beyond those encountered to date. After scheduling combat systems acceptance trials for the lead ship in the third quarter of fiscal year 2017, the Navy has delayed this activity to early 2018.

The program reported land-based testing of modifications to the multifunction radar, to include a volume search capability, is complete. In 2017, testing of the modified multifunction radar will move to a Navy test bed for ship self-defense, before initial operational testing aboard the lead ship. The program also reported that the planned date

⁴⁰ Christopher J. Castelli, "Pentagon Approves Key Milestone For Multibillion-Dollar Destroyer," *Inside the Navy*, November 22, 2010.

for completion of software development for the class was delayed from January 2016 to December 2017 to prioritize cybersecurity enhancements and software corrections related to integration of the ship's power and engineering control systems. The program did not make a low-rate initial production decision on the long-range land-attack projectile in fiscal year 2016 as planned.

Design and Production Maturity

The DDG 1000 design was not stable at lead ship fabrication start in 2009. Since then, the Navy and its contractors stabilized the design, but ongoing development and shipboard testing of technologies may result in design changes. Delivery of the lead ship's hull, mechanical, and electrical systems was 18 months behind schedule due in part to challenges completing electrical work, with the shipbuilder citing resource shortages and workforce turnover. Program officials noted the lead ship will not complete final contract trials, foregoing an opportunity to identify and mitigate technical and design deficiencies prior to completing construction of the remaining two ships.

As of October 2016, construction of the two remaining ships was 91 and 59 percent complete, respectively. Program officials noted the shipbuilder continues to face challenges in completing electrical work and since March 2016, delivery dates for the remaining two ships have each slipped by about two fiscal quarters. With the Navy as lead integrator, program officials noted that timely delivery of government-furnished equipment to the shipbuilder will be critical to achieving cost and schedule baselines for these ships' hulls, under the terms of their fixed-price construction contracts.

Other Program Issues

During the lead ship's transit between its Maine construction site and California home port, the ship's propulsion system experienced two seawater intrusions which required unscheduled repairs.

Program Office Comments

In commenting on a draft of this assessment, program officials stated the program reached a significant milestone with delivery of the first-of-class ship in fiscal year 2016. Program officials noted that DDG 1000 underwent an extensive period of testing including three sets of trials prior to delivery and the ship continued test and activation activities during its transit to San Diego. Officials also noted that during transit, seawater contamination occurred in two propulsion motor bearing lubricating oil sumps and it is not uncommon for first-of-class ships to identify deficiencies and undergo repairs during underway periods following construction. According to program officials, the ship's post-delivery availability will include periods of in-port and at-sea testing and activation of ship systems. Finally the program noted that following combat system activation, the ship will conduct dockside and at-sea trials as well as start operational testing.⁴¹

December 2016 DOT&E Report

A December 2016 report from DOD's Director of Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2016—stated the following regarding the DDG-1000 program:

Assessment

- The threat torpedo surrogates currently available for operational assessment of the Zumwalt-class destroyer have significant limitations in their representation of threat

⁴¹ Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-17-333SP, March 2017, p. 98.

torpedoes. The proposed development of a GTT [general threat torpedo] addresses many of the DOT&E concerns; however, the GTT's capability to support realistic operational testing is dependent upon future Navy decisions to procure sufficient quantity of GTTs.

- All three ships of the Zumwalt class share significant new designs, including the unique wave-piercing tumblehome hull form, as well as the new Integrated Power System, Total Ship Computing Environment (software, equipment, and infrastructure), Integrated Undersea Warfare System, Peripheral Vertical Launching System, the AGS, and the associated automated magazines. These systems and equipment have not been subjected to shock testing on previous ship classes. Moreover, the significant automation and relatively small crew may limit the sailors' ability to conduct repairs needed to enable recovery from shock-induced damage.

- Additional AN/SPY-3 radar development and testing at the Wallops Island test facility has significantly compressed the schedule for self-defense testing of the Zumwalt-class destroyer and the Gerald R. Ford-class nuclear aircraft carrier on SDTS [self-defense test ship]. The completion of this live-fire testing, and the subsequent use of the Probability of Raid Annihilation test bed, is essential to be able to evaluate the self-defense and survivability of the Zumwalt-class destroyer. The Navy must identify how the required ship self-defense testing will be completed prior to deployment of a Zumwalt-class destroyer. This may mean delaying the AN/SPY-3 radar installation on DDG 1002.

- The Navy has requested funding in FY18/19 to execute a reduced scope component shock qualification program, and is going through the process to identify the equipment/systems and shock grade to which these will be qualified.

- Indications are that the number of components undergoing shock qualification will be a reduced set, which will introduce risk for the shock trial. Additionally, by reducing the number of components undergoing shock qualification, the assessment of the vulnerability and recoverability capability of the ship at design levels for underwater threats will be limited. The Navy had indicated in prior years that the component shock testing would be funded and conducted prior to installation of any equipment on the first ship, which is the normal, common-sense approach. However, the Navy diverted that funding to other uses; so, the component shock testing was not done and cannot now be done in the normal sequence.

- Despite these limitations, the shock trials currently scheduled for FY20 must be performed at the traditional severity levels for a surface combatant. These trials will now be the sole source of comprehensive data on the survivability of mission-critical ship systems to shock, and are therefore critical to the success in combat of the ship and her crew.

- The Program Office and the Navy Technical Community encountered problems when attempting to upgrade the survivability M&S [modeling and simulation] tools, which led them to an off-ramp decision to perform the DDG 1000 vulnerability analysis using the existing M&S tools and methods with known shortfalls. The Navy could benefit largely from existing improvements in specific M&S modules by troubleshooting the upgraded M&S modules in a stand-alone mode before integrating them into the over-arching survivability M&S tool that has demonstrated module interface and integration issues. The Navy should also develop a long-term investment strategy to improve the confidence and fidelity levels of its vulnerability and recoverability M&S tools.

- If the Zumwalt-class destroyers are not outfitted with LRLAP because of the high cost of the projectiles, the ships will have no capability to conduct Joint Surface Fire Support missions until replacement projectiles are acquired and the AGS is modified to fire the new projectiles. Thus, Zumwalt-class destroyers' land attack capability will be limited to TLAMs.

- The currently approved version of the TEMP [test and evaluation master plan] does not address significant changes to the Zumwalt-class destroyer baseline, test strategies and delays in the production schedule. The TEMP revision in Navy routing is required to support operational test.

Recommendations

- Status of Previous Recommendations. The Navy should address the following open recommendations from FY15 and earlier:

1. Fund and schedule component shock qualification to support the Zumwalt-class destroyers' requirement to maintain all mission essential functions when exposed to underwater explosion shock loading.
2. Develop and conduct an accreditation plan to assess the acceptability of the Probability of Raid Annihilation test bed to support operational testing of the ship's air defense effectiveness.

- FY16 Recommendations. The Navy should:

1. Complete the revision to the TEMP that accounts for Zumwalt-class destroyer baseline changes and system delivery schedule.
2. Acquire a sufficient quantity of GTTs, when developed, to support testing and fully characterize Zumwalt-class destroyer capability to defeat threat torpedoes during FOT&E.
3. Develop and implement a strategy to address the current limitations with damage predictions in the underwater and air explosion vulnerability assessment tools.
4. Update DOT&E on the details of the component shock qualification program.
5. Develop and implement a strategy to complete self-defense testing of the Zumwalt-class destroyer on the SDTS.⁴²

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⁴² Department of Defense, *Director, Operational Test and Evaluation, FY 2016 Annual Report*, December 2016, pp. 228-229.

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