

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 FY2017 are to be the 75th and 76th ships in the class. The 10 DDG-51s programmed for procurement in FY2013-FY2017 (in annual quantities of 3-1-2-2-2) are being procured under a multiyear-procurement (MYP) contract. One of the DDG-51s funded in FY2016 is to be the first of a new DDG-51 design variation called the Flight III design, which is to incorporate a new and more capable radar called the Air and Missile Defense Radar (AMDR).

As part of its action on the Navy's FY2016 budget, Congress provided \$1 billion in unrequested procurement funding to help pay for a DDG-51 that would be in addition to those being procured under the 10-ship MYP contract for FY2013-FY2017. The Navy, in its budget submission, notes this additional \$1 billion in funding for the DDG-51 program, but does not show the additional DDG-51 in its shipbuilding plan. The \$433 million in procurement funding that would be needed to complete the cost of this additional DDG-51 is, however, included as the second item on the Navy's FY2017 unfunded requirements list (i.e., the list of FY2017 programs that the Navy desires, but for which it did not have sufficient funding in FY2017).

The Navy estimates the combined procurement cost of the two DDG-51s requested for procurement in FY2017 at \$3,393.9 million. The ships have received a total of \$182.6 million in prior-year advance procurement (AP) funding. The Navy's proposed FY2017 budget requests the remaining \$3,211.3 million needed to complete the ships' estimated combined procurement cost. The Navy's proposed FY2017 budget also requests \$16.0 million in so-called cost-to-complete procurement funding to cover cost growth on DDG-51s procured in FY2011. The Navy's proposed FY2017 budget also requests \$271.8 million in procurement funding to complete construction of Zumwalt (DDG-1000) class destroyers procured in prior years, and \$144.4 million in research and development funding for development work on the AMDR.

Potential FY2017 issues for Congress concerning destroyer procurement include the following:

- whether to approve, reject, or modify the Navy's FY2017 procurement funding requests for the DDG-51 and DDG-1000 programs, and the Navy's FY2017 research and development funding request for the AMDR program—an issue that includes whether to provide some or all of the \$433 million in procurement funding needed to complete the funding for the additional DDG-51 that was partially funded with \$1 billion in FY2016;
- whether to provide the Navy with authority for entering into an MYP contract for DDG-51s to be procured in FY2018-FY2022;
- 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 FY2017 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.

Background

Strategic and Budgetary Context

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) .

DDG-51 Program

The DDG-51 program was initiated in the late 1970s.¹ 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 cruisers,² 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.³

The first DDG-51 was procured in FY1985. A total of 74 have been procured through FY2016, including 62 in FY1985-FY2005 and 12 in FY2010-FY2016.⁴ During the period FY2006-FY2009, the Navy procured three Zumwalt (DDG-1000) class destroyers (see discussion below) rather than DDG-51s.⁵ The first DDG-51 entered service in 1991, and a total of 62 were in service

¹ 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.

² 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.

³ 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) .

⁴ The ten DDG-51s procured in FY2010-FY2015 include one in FY2010, two in FY2011, one in FY2012, three in FY2013, one in FY2014, and two in FY2015.

⁵ The Navy had planned to end DDG-51 procurement permanently in FY2005 and procure Zumwalt (DDG-1000) class destroyers thereafter. In July 2008, however, the Navy announced that it had changed its mind—that it wanted to halt procurement of DDG-1000s and resume procuring DDG-51s. The Navy announced this change in its plans at a July 31, 2008, hearing before the Seapower and Expeditionary Forces subcommittee of the House Armed Services Committee. In explaining their proposed change in plans, Navy officials cited a reassessment of threats that Navy forces are likely to face in coming years. As a result of this reassessment, Navy officials stated, the service decided that destroyer (continued...)

as of the end of FY2015. 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.

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 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. The next 45 DDG-51s (i.e., DDGs 79 through 123) are referred to as Flight IIA DDG-51s. The Flight IIA design, first procured in FY1994, implemented a significant design change that included, among other things, the addition of a helicopter hangar. One of the DDG-51s funded in FY2016 is to be the first of a new Flight III version of the DDG-

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procurement over the next several years should emphasize three mission capabilities—area-defense AAW, BMD, and open-ocean ASW. Navy officials also stated that they want to maximize the number of destroyers that can be procured over the next several years within budget constraints. Navy officials stated that DDG-51s can provide the area-defense AAW, BMD, and open-ocean ASW capabilities that the Navy wants to emphasize, and that while the DDG-1000 design could also be configured to provide these capabilities, the Navy could procure more DDG-51s than reconfigured DDG-1000s over the next several years for the same total amount of funding. In addition, the Navy by 2008-2009 no longer appeared committed to the idea of reusing the DDG-1000 hull as the basis for the Navy's planned CG(X) cruiser. If the Navy had remained committed to that idea, it might have served as a reason for continuing DDG-1000 procurement.

The Navy's FY2010 budget, submitted in May 2009, reflected the Navy's July 2008 change in plans: the budget proposed truncating DDG-1000 procurement to the three ships that had been procured in FY2007 and FY2009, and resuming procurement of Flight IIA DDG-51s. Congress, as part of its action on the FY2010 defense budget, supported the proposal: The FY2010 budget funded the procurement of one DDG-51, provided advance procurement funding for two DDG-51s the Navy wants to procure in FY2011, completed the procurement funding for the third DDG-1000 (which was authorized but only partially funded in FY2009), and provided no funding for procuring additional DDG-1000s.

51 design that is to feature a new and more capable radar called the Air and Missile Defense Radar (AMDR).

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-FY2017.⁶ The Navy awarded the contract on June 3, 2013.⁷ 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 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.⁸ Older CRS reports provide additional historical and background information on the DDG-51 program.⁹

DDG-1000 Program

The DDG-1000 program was initiated in the early 1990s.¹⁰ 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,¹¹ 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.¹²

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 system¹³ 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

⁶ 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) .

⁷ "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.

⁸ For more on this program, see CRS Report RS22595, *Navy Aegis Cruiser and Destroyer Modernization: Background and Issues for Congress*, by (name redacted) .

⁹ 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 print and available directly from the author).

¹⁰ 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.

¹¹ 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.

¹² For more on the CG(X) program, see CRS Report RL34179, *Navy CG(X) Cruiser Program: Background for Congress*, by (name redacted) .

¹³ 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) .

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.

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).¹⁴

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 FY2017 budget submission estimates their combined procurement cost at \$9,072.0 million. The third DDG-1000 was procured in FY2009 and split-funded in FY2009-FY2010; the Navy's FY2017 budget submission estimates its procurement cost at \$3,666.2 million.

The first DDG-1000 was commissioned into service on October 15, 2016. The second and third ships in the class are scheduled for delivery to the Navy in March 2017 and August 2019, respectively.

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 \$3,761.1 million, or 41.9%, since the FY2009 budget (i.e., the budget for the fiscal year in which the third DDG-1000 was procured).

¹⁴ 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) .

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

	Estimated combined procurement cost (millions of dollars)	Change from prior year's budget submission	Cumulative change from FY2009 budget submission
FY2009 budget	8,977.1	—	—
FY2010 budget	9,372.5	+395.4 (+4.4%)	+395.4 (+4.4%)
FY2011 budget	9,993.3	+620.8 (+6.6%)	+1,016.2 (+11.3%)
FY2012 budget	11,308.8	+1,315.5 (+13.2%)	+2,331.7 (+26.0%)
FY2013 budget	11,470.1	+161.3 (+1.4%)	+2,493.0 (+27.8%)
FY2014 budget	11,618.4	+148.3 (+1.3%)	+2,641.3 (+29.4%)
FY2015 budget	12,069.4	+451.0 (+3.9%)	+3,092.3 (+34.4%)
FY2016 budget	12,288.7	+219.3 (+1.8%)	+3,311.6 (+36.9%)
FY2017 budget	12,738.2	+449.5 (+3.7%)	+3,761.1 (+41.9%)

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

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 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 since 2010, 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 3% *below* the program’s rebaselined starting point for calculating any new Nunn-McCurdy cost breach on the program.¹⁵

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**.

¹⁵ Source: Navy briefing for CRS and the Congressional Budget Office (CBO) on the DDG-1000 program, April 30, 2014.

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 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.

FY2017 Funding Request

The Navy estimates the combined procurement cost of the two DDG-51s requested for procurement in FY2017 at \$3,393.9 million. The ships have received a total of \$182.6 million in prior-year advance procurement (AP) funding. The Navy's proposed FY2017 budget requests the remaining \$3,211.3 million needed to complete the ships' estimated combined procurement cost. The Navy's proposed FY2017 budget also requests \$16.0 million in so-called cost-to-complete procurement funding to cover cost growth on DDG-51s procured in FY2011. The Navy's proposed FY2017 budget also requests \$271.8 million in procurement funding to complete construction of Zumwalt (DDG-1000) class destroyers procured in prior years, and \$144.4 million in research and development funding for development work on the AMDR. The funding request for the AMDR is contained in Program Element (PE) 0604522N ("Air and Missile defense Radar (AMDR) System"), which is line 123 in the Navy's FY2017 research and development account.

Issues for Congress

FY2017 Funding Request

Overview

One issue for Congress is whether to approve, reject, or modify the Navy's FY2017 procurement funding requests for the DDG-51 and DDG-1000 programs, and the Navy's FY2017 research and development funding request for the AMDR program. In assessing this question, Congress may

consider various factors, including whether the Navy has accurately estimated the cost of the work to be done.

\$433 Million for Additional DDG-51

Another issue for Congress is whether to provide some or all of the \$433 million in procurement funding needed to complete the funding for the additional DDG-51 that was partially funded with the additional \$1 billion provided in FY2016. As mentioned earlier, the \$433 million needed to complete funding for the additional DDG-51 is the second item on the Navy's FY2017 unfunded requirements list (URL). In assessing whether to provide some or all of the \$433 million, Congress may consider various factors, including the role this ship would play in fulfilling the terms of a 2002 memorandum of understanding (MOU) among the Navy, GD/BIW, and what is now HII/Ingalls concerning the allocation of DDG-51s and LPD-17 class amphibious ships, the industrial-base impact of procuring an additional DDG-51, the operational value of an additional DDG-51, and the potential impact, in a situation of constraints on defense funding, on other Navy or DOD programs of providing this funding for the DDG-51 program.

Authority for DDG-51 Multiyear Procurement in FY2018-FY2022

Another issue for Congress is whether to provide, as part of Congress's action on the Navy's FY2017 budget, authority for entering into an MYP contract for DDG-51s to be procured in FY2018-FY2022. The Navy has not requested such authority as part of its FY2017 budget submission; the Navy plans to request the authority next year, as part of its FY2018 budget submission. The practice in the Navy's surface ship community (and other parts of DOD) has been to request MYP authority coincident with what would be the first fiscal year of the MYP contract. The practice in the Navy's submarine community, however, has been to request MYP authority one year in advance of what would be the first year of the MYP contract, because the submarine community has found it useful, in terms of negotiating the terms of the contract, to start the negotiating process a year ahead of the planned start of the contract itself.

Cost Growth in DDG-1000 Program

Another issue for Congress 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 FY2017? 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 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 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.¹⁶

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

¹⁶ Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-17-333SP, March 2017, p. 124.

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. 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.¹⁷

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-5:

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.¹⁸

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

¹⁸ Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2017 Shipbuilding Plan*, February 2017, pp. 28-29.

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.

- 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 TEMPLs 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.¹⁹

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

Another issue for Congress 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.

¹⁹ 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.

Legislative Activity for FY2017

Summary of Congressional Action on FY2017 Funding Request

Table 2 summarizes congressional action on the Navy's FY2017 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).

Table 2. Congressional Action on FY2017 Funding Request

Millions of dollars, rounded to nearest tenth

	Request	Authorization			Appropriation		
		HASC	SASC	Conf.	HAC	SAC	Conf.
DDG-51 procurement	3,211.3	3,644.3	3,261.1	3,261.1	3,644.3	3,614.8	3,614.8
DDG-51 cost to complete	16.0	16.0	16.0	16.0	16.0	16.0	16.0
DDG-1000 procurement	271.8	271.8	271.8	271.8	271.8	271.8	271.8
AMDR research and development (PE 0604522N, line 123)	144.4	144.4	144.4	144.4	144.4	144.4	144.4

Source: Table prepared by CRS based on Navy's FY2017 budget submission, committee reports, authorization conference report, and appropriation conference explanatory statement.

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.

FY2017 National Defense Authorization Act (H.R. 4909/S. 2943/P.L. 114-328)

House

The House Armed Services Committee, in its report (H.Rept. 114-537 of May 4, 2016) on H.R. 4909 of the 114th Congress, recommends the funding levels shown in the HASC column of **Table 2**.

H.Rept. 114-537 states:

Arleigh Burke-class destroyer

The budget request included \$3.21 billion for two Arleigh Burke-class destroyers.

The committee notes that the Consolidated Appropriations Act, 2016 (Public Law 114-113) included \$1.00 billion for a third Arleigh Burke-class destroyer in fiscal year 2016 but these funds are insufficient to procure the entire ship. The committee also notes that the Chief of Naval Operations included \$433.0 million on his fiscal year 2017 unfunded requirements list in order to fully fund the balance of this Arleigh Burke-class destroyer.

Therefore, the committee recommends \$3.64 billion, an increase of \$433.0 million, for procurement of an additional Arleigh Burke-class destroyer. (Page 20)

Senate

The Senate Armed Services Committee, in its report (S.Rept. 114-255 of May 18, 2016) on S. 2943 of the 114th Congress, recommends the funding levels shown in the SASC column of **Table 2**.

Section 123 of S. 2943 as reported states:

SEC. 123. Certification on ship deliveries.

(a) In general.—The delivery of the USS JOHN F. KENNEDY (CVN-79), the USS ZUMWALT (DDG-1000), and any other new construction ship that employs a multiple phase delivery scheme shall be deemed to occur at the completion of the final phase of construction.

(b) Certification requirement.—Not later than January 1, 2017, the Secretary of the Navy shall certify that ship delivery dates have been adjusted in accordance with subsection (a). The certification shall include the ship hull numbers and delivery date adjustments. The adjustments shall be reflected in the budget of the President submitted under section 1105(a) of title 31, United States Code, as well as Department of Defense Selected Acquisition Reports.

Regarding Section 123, S.Rept. 114-255 states:

Certification on ship deliveries (sec. 123)

The committee recommends a provision that would require the Secretary of the Navy to deem ship delivery to occur at the completion of the final phase of construction. The Secretary would be required to submit a certification to the congressional defense committees not later than January 1, 2017 that certifies ship delivery dates have been adjusted, including the ship hull numbers and delivery date adjustments. The adjustments would be reflected in the budget of the President submitted under section 1105(a) of title 31, United States Code, as well as Department of Defense Selected Acquisition Reports.

The committee notes that justification materials, which accompanied the President's fiscal year 2016 and 2017 budgets, as well as Department of Defense Selected Acquisition Reports for the CVN-78 class aircraft carrier program, list the delivery date of USS John F. Kennedy (CVN-79) as June 2022. However, the Navy plans to deliver this ship in two phases. Phase I delivery, scheduled to complete in June 2022, will deliver the ship with full propulsion capability, aircraft launch and recovery systems, and safe to sail navigation systems. Phase II delivery, scheduled to complete in September 2024, will add the remaining electronics and ordnance equipment, including the Ship Self-Defense System, weapons systems, and Enterprise Air Search Radar. The committee believes CVN-79 delivery should be deemed to occur at the end of Phase II delivery.

Similarly, the committee understands all three ships in the Zumwalt-class will employ a dual delivery approach with hull, mechanical, and electrical (HM&E) systems delivery at the shipbuilder in Maine and combat systems activation in California. In the case of USS Zumwalt (DDG-1000), HM&E delivery is scheduled for 2016 and combat systems activation is scheduled for 2018. The committee notes the President's fiscal year 2017 budget lists April 2016 as the delivery date. The committee believes Zumwalt-class delivery should be deemed to occur at the completion of the dual delivery approach, following combat systems activation.

The committee is concerned the variance in the Navy's definition of ship delivery may obscure oversight of the program's schedule, including whether or not a project has breached its threshold delivery date. The committee is also concerned Navy ships are being delivered in various degrees of completion and then, after a period of availabilities

and shakedowns, possibly several years later, the ship is delivered to the fleet for operations. CVN-79 and the Zumwalt-class programs illustrate this practice.

Therefore, the committee also directs the Comptroller General of the United States to submit a report, not later than March 1, 2017, that includes analysis and recommendations regarding the Navy's process for fully delivering ships from the time the Navy takes custody of the vessel until the vessels are fully complete and ready for operations. This review should examine the Navy's cost and schedule milestones throughout this process and how these milestones are reported to decision makers and oversight agencies. The review should also propose a common definition and criteria for Navy ship deliveries, including the associated dates. (Pages 9-10)

S.Rept. 114-255 also states:

Arleigh Burke-class destroyers

The budget request included \$3.2 billion in line item 9 of Shipbuilding and Conversion, Navy for procurement of Arleigh Burkeclass destroyers (DDG-51). The committee notes an additional destroyer was provided for in the National Defense Authorization Act for Fiscal Year 2016 (Public Law 114-92), which included incremental funding authority, and the Department of Defense Appropriations Act for Fiscal Year 2016 (Public Law 114-113), which included \$1.0 billion in funding. The committee further notes an additional \$433.0 million is required to fully fund this additional destroyer. Therefore, the committee recommends an increase of \$49.8 million to this program to provide the next increment of funding for the additional fiscal year 2016 Arleigh Burke-class destroyer. (Page 24)

S.Rept. 114-255 also states:

DDG-51 destroyer production gap

The committee is concerned a production gap may occur between the current DDG-51 multi-year procurement contract, which concludes with the procurement of two ships in fiscal year 2017, and the follow-on contract scheduled to begin in fiscal year 2018. The committee notes a previous production gap in this program resulted in increased costs for both construction shipyards, as well as the broader vendor base. The committee urges the Secretary of the Navy to prevent a DDG-51 production gap to the maximum extent practicable.

Therefore, the committee directs the Secretary of the Navy to submit a report to the Committees on Armed Services of the Senate and House of Representatives with the fiscal year 2018 budget request that provides a plan to prevent a DDG-51 production gap or, should the Secretary be unable to prevent a gap, provide mitigation options. (Page 32)

Conference

The conference report (H.Rept. 114-840 of November 30, 2016) on S. 2943/P.L. 114-328 of December 23, 2016, recommends the funding levels shown in the authorization conference column of **Table 2**. The recommended increase of \$49.8 million for DDG-51 procurement is for "Fund additional FY16 destroyer." (Page 1351)

FY2017 DOD Appropriations Act (H.R. 5293/S. 3000/H.R. 244/P.L. 115-31)

House

The House Appropriations Committee, in its report (H.Rept. 114-577 of May 19, 2016) on H.R. 5293 of the 114th Congress, recommends the funding levels shown in the HAC column of **Table 2**.

Senate

The Senate Appropriations Committee, in its report (S.Rept. 114-263 of May 26, 2016) on S. 3000 of the 114th Congress, recommends the funding levels shown in the SAC column of **Table 2**. The net increase of \$403.5 million recommended for DDG-51 procurement includes an increase of \$433 million to complete funding for the procurement of the additional DDG-51 that was partially funded in FY2016, and a decrease of \$29.5 million for “Budget document disparity: Change orders reduction from two ships requested for fiscal year 2017.” (Page 98)

Conference

The final version of the FY2017 DOD appropriations act is Division C of H.R. 244/P.L. 115-31 of May 5, 2017, the Consolidated Appropriations Act, 2017. The explanatory statement for Division C of H.R. 244/P.L. 115-31 provides the funding levels shown in the explanatory statement column of **Table 2**. The net increase of \$403.5 million for DDG-51 procurement includes an increase of \$433 million for “Program increase—only for DDG-51 Flight IIA ship partially funded in fiscal year 2016,” and a reduction of \$29.5 million for “Change orders reduction from two ships requested for fiscal year 2017.” (PDF page 152 of 372) The explanatory statement states:

DDG-51 FLIGHT IIA DESTROYERS

The Navy currently is procuring DDG-51 Flight IIA destroyers under a fiscal year 2013 to fiscal year 2017 multi-year procurement shipbuilding contract awarded in June 2013, as authorized by section 8010 of P.L. 113-6. Additionally, the Navy is addressing increasing ballistic and cruise missile threats through the development and acquisition of an Air and Missile Defense Radar, which is planned for integration on the DDG-51 class of ships through an engineering change proposal, resulting in a new Flight III configuration. However, a recent Government Accountability Office report (GAO 16-613) details concerns regarding a lack of sufficient acquisition and limited detail design knowledge to support the Navy's current Flight III procurement strategy. Further concerns remain regarding the full costs of DDG-51 Flight III destroyers. Therefore, the Secretary of the Navy should award and complete the additional DDG-51 ship, fully funded in fiscal years 2016 and 2017, as an additional DDG-51 Flight IIA ship. The Secretary of the Navy is directed to expeditiously award this ship construction contract. (PDF page 149 of 372)

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:²⁰

- **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.²¹

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.²²

New Technologies

The DDG-1000 incorporates a significant number of new technologies, including a wave-piercing, tumblehome hull design for reduced detectability,²³ 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,²⁴ a total-ship computing system for moving information about

²⁰ 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).

²¹ For more on the LCS program, see CRS Report RL33741, *Navy Littoral Combat Ship (LCS)/Frigate Program: Background and Issues for Congress*, by (name redacted) .

²² For more on Navy ship names, see CRS Report RS22478, *Navy Ship Names: Background for Congress*, by (name redacted) .

²³ 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.

²⁴ 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 \$800,000.²⁵ 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.²⁶

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/Ingalls²⁷ 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 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.

²⁵ 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.

²⁶ Sam LaGrone, “Raytheon Excalibur Round Set to Replace LRLAP on Zumwalts,” *USNI News*, December 13, 2016.

²⁷ 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.²⁸

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

²⁸ 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.²⁹

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.³⁰ 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 growth³¹—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.³² 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

²⁹ 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).

³⁰ 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.

³¹ 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.

³² 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.³³

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.³⁴ 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."³⁵

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."

³³ 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.

³⁴ Source: Undated Navy information paper on CVN-78 cost issues, provided by Navy Office of Legislative Affairs to CRS on March 19, 2012.

³⁵ 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-1000.³⁶

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

³⁶ 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.³⁷

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

³⁷ 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.³⁸

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³⁸ Department of Defense, *Director, Operational Test and Evaluation, FY 2016 Annual Report*, December 2016, pp. 228-229.

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