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

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March 10, 2016

Congressional Research Service
7-....
www.crs.gov
RL32109

CRS REPORT
Prepared for Members and
Committees of Congress

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. The second of the two ships 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;
- 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 program;
- issues raised in a January 2016 report from DOD's Director of Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2015; 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 FY2014. 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. The 74th DDG-51 (i.e., DDG-124—the second of the two DDG-51s procured in FY2016) is the

(...continued)

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.

first of a new Flight III version of the DDG-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 the Navy's now-canceled CG(X) cruiser.[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 system[13] and automation technologies enabling its reduced-sized crew.

With an estimated full load displacement of 15,482 tons, the DDG-1000 design is roughly 63% 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 Ronald O'Rourke.

[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 **Appendix B**.

[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 Ronald O'Rourke.

destroyer or cruiser since the nuclear-powered cruiser *Long Beach* (CGN-9), which was procured in FY1957.

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.

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).

Table 1. 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 A**), 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 has been implementing 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.[14]

All three ships in the DDG-1000 program are to be built at GD/BIW, 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). The Navy awarded GD/BIW the contract for the construction of the second and third DDG-1000s on September 15, 2011.[15]

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

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, other private-sector U.S. shipyards, and government-operated naval shipyards (NSYs).

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

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

[15] See, for example, Mike McCarthy, "Navy Awards Contract for DDG-1000s," *Defense Daily*, September 16, 2011: 3-4.

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

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 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?

Flight III DDG-51: Cost, Technical, and Schedule Risk

Another issue for Congress concerns cost, technical, and schedule risk for the Flight III DDG-51.

October 2015 CBO Report

An October 2015 Congressional Budget Office (CBO) report on the cost of the Navy's shipbuilding programs stated:

> The Navy's strategy for meeting the combatant commanders' goal that future ballistic missile defense capabilities 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, creating a Flight III configuration. That change 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 changes and 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 2015 dollars, or 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 in the ship's design to integrate the new radar.[16]

March 2015 GAO Report

A March 2015 Government Accountability Office (GAO) report assessing selected DOD acquisition programs stated the following in its assessment of the DDG-51 program:

> The Navy is undertaking Flight III detail design activities in fiscal 2015 concurrent with AMDR development—a strategy that could disrupt detail design activities as AMDR attributes become more defined. The Navy identifies AMDR integration as posing technical, cost, and schedule risks to the Flight III program. In addition to AMDR, Flight III changes include upgrades to the ships' cooling and electrical systems and other configuration changes intended to increase weight and stability margins. The Navy reports that a prototype of the cooling system is in operation at the vendor's factory and is undergoing environmental qualification testing. However, the Navy identifies cost and schedule risks to the Flight III program associated with these cooling upgrades. The electrical system upgrades include changes to the distribution system to add and modify switchgear and transformers based on the system installed on LHA 6.
>
> The Navy plans to use engineering change proposals to the existing Flight IIA multiyear procurement contracts to construct the first three Flight III ships rather than establish new contracts for detail design and construction. The Navy has allotted 17 months to mature the Flight III detail design ahead of the planned solicitation for these proposals and plans to award construction of the first Flight III ship in fiscal 2016, with two follow-on ships in fiscal 2017. To support this, per DOD policy the Navy sought congressional approval in 2014 to transfer funds and begin detail design in the fourth quarter of fiscal 2014. However, this request was denied, postponing detail design start by several months. In

[16] Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2016 Shipbuilding Plan*, October 2015, p. 27.

September 2014, the Navy notified Congress that a delayed detail design start may prompt it to delay the introduction of AMDR until fiscal 2017.[17]

Regarding the AMDR specifically, the report stated:

> **Technology and Design Maturity**
>
> All four of AMDR's critical technologies—digital-beam-forming; transmit-receive modules; software; and digital receivers/exciters—are approaching full maturity, and program officials state that AMDR is on pace to meet DDG 51 Flight III's schedule requirements. In 2015, the contractor is expected to complete an engineering development model consisting of a single full-sized 14 foot radar array—as opposed to the final four array configuration planned for installation on DDG 51 Flight III—and begin testing in the contractor's indoor facilities. Following the critical design review, scheduled for April 2015, the program plans to install the array in the Navy's land-based radar test facility in Hawaii for further testing in a more representative environment. However, the Navy has no plans to test AMDR in a realistic (at-sea) environment prior to installation on the lead DDG 51 Flight III ship. Though the Navy is taking some risk reduction measures, there are only 15 months planned to install and test the AMDR prototype prior to making a production decision. Delays may cause compounding effects on testing of upgrades to the Aegis combat system since the Navy plans to use the AMDR engineering development model in combat system integration and testing.
>
> In August 2014, AMDR completed its final preliminary design review, which assessed both hardware and software. The total number of design drawings required for AMDR has not yet been determined and will be finalized at the program's critical design review. However, AMDR officials are confident that the robust technology in the prototype represents the physical dimensions, weight, and power requirements to support DDG 51 Flight III integration. The AMDR program office provided an initial interface control document listing AMDR specifications to the DDG 51 Flight III program office. Ensuring correct AMDR design parameters is important since the available space, weight, power, and cooling for DDG 51 Flight III is constrained, and design efforts for the ship will begin before AMDR is fully matured.
>
> The AMDR radar suite controller requires significant software development, with 1.2 million lines of code and four planned builds. The program also plans to apply an open systems approach to available commercial hardware to decrease development risk and cost. The program office identified that the first of four planned builds is complete, has passed the Navy's formal qualification testing and will enter developmental testing next summer. Each subsequent build will add more functionality and complexity. AMDR will eventually need to interface with the Aegis combat management system found on DDG 51 destroyers. This interface will be developed in later software builds for fielding in 2020, and the Navy plans on conducting early combat system integration and risk reduction testing prior to making a production decision.
>
> **Other Program Issues**
>
> AMDR still lacks a Test and Evaluation Master Plan approved by DOD's Director, Operational Test and Evaluation (DOT&E), as required by DOD policy. DOT&E expressed concerns with the lack of a robust live-fire test plan involving AMDR and the Navy's self-defense test ship. According to program officials, their current test plan's models will provide sufficient data to support validation and accreditation and thus verify system performance.

[17] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-15-342SP, March 2015, p. 138.

Program Office Comments

According to the Navy, AMDR is on track to deliver a capability 30 times greater than the radar it will replace. To mitigate development risk and deliver AMDR's software at the earliest possible delivery date, the contractor is implementing software development approaches to improve productivity, in coordination with robust testing, modeling, and live flight test simulations. Further, an AMDR hardware facility—including a fully functioning portion of AMDR's processing equipment and a software integration lab—is operating at the contractor's facility to support iterative testing ahead of, and then in support of, production of the engineering development model. In December 2014, a hardware specific critical design review was successfully completed demonstrating that technical performance measures are in compliance with requirements and the hardware design is sufficiently mature to complete detailed design, and will proceed to engineering development model array production.[18]

Flight III DDG-51: Issues Raised in January 2016 DOT&E Report

Another issue for Congress concerns issues raised in a January 2016 report from DOD's Director of Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2015. Regarding the Flight III DDG-51 program, the report stated:

Assessment

• DOT&E's position continues to be that 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 are not adequate to fully assess their self-defense capabilities. They are also not 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 [integrated air and missile defense] 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 the USS Chancellorsville (CG 62) involving an ASCM surrogate target resulted in even more stringent safety constraints.

[18] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-15-342SP, March 2015, p. 64.

- In addition to stand-off ranges (on the order of 1.5 to 5 nautical miles for subsonic and supersonic surrogates, respectively), 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 eight of the nine ASCM scenarios contained in the Navy-approved requirements document for the Aegis Modernization Advanced Capability Build 16 Combat System upgrade. 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 a Self-Defense Test Ship (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 (plus) DDG 51 Flight III ships that are planned for acquisition ($55+ Billion). 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.

• The modification/upgrades being planned for the 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 four previous recommendations. The Navy should:

1. Program and 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 Test and Evaluation Master Plans to include a phase of IOT&E using an SDTS equipped with the AMDR and DDG 1 Flight III Combat System.

3. Modify the AMDR, ESSM Block 2, and DDG 51 Flight III Test and Evaluation Master Plans 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.

• FY15 Recommendations. The Navy should:

1. Provide program funding for an Aegis-equipped self‑defense test ship to support adequate operational testing of the AMDR, Aegis Combat System, ESSM Block 2, and DDG 51 Flight III Destroyer programs as soon as possible so as not to disrupt the ESSM Block 2 development schedule.

2. Provide DOT&E the DDG 51 Flight III LFT&E Strategy for approval prior to the end of FY16 in coordination with the Test and Evaluation Master Plan.[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

[19] Department of Defense, *Director, Operational Test and Evaluation, FY 2015 Annual Report*, January 2016, pp. 194-195.

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 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

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

Source: Table prepared by CRS based on Navy's FY2017 budget submission and committee and conference reports.

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 A. 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 Ronald O'Rourke.

[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 Ronald O'Rourke.

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 is to fire a new rocket-assisted 155mm shell, called the Long Range Land Attack Projectile (LRLAP), to ranges of more than 60 nautical miles. The DDG-1000 can carry 600 LRLAP rounds (300 for each gun), and additional rounds can be brought aboard the ship while the guns are firing, creating what Navy officials call an "infinite magazine."

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/Ingalls[25] 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.

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

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

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.[26]

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/Iingalls 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 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

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

security and that there are no alternatives to the program that will provide acceptable capability to meet the joint military requirement at less cost.[27]

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.[28] 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 growth[29]—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.[30] 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 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

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

[28] 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.

[29] 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.

[30] 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.

> 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.[31]

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.[32] 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."[33]

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."

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%,

[31] 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.

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

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

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.[34]

Under Secretary of Defense Ashton Carter's June 1, 2010, letter and attachment restructuring the DDG-1000 program and DOD's decision on October 8, 2010, to reinstate the DDG-1000 program's Milestone B certification raise the following potential oversight questions for Congress:

- Why did DOD decide, as part of its restructuring of the DDG-1000 program, to change the primary radar on the DDG-1000?
- What are the potential risks to the DDG-1000 program of changing its primary radar at this stage in the program (i.e., with the first ship under construction, and preliminary construction activities underway on the second ship)?
- How will the upgraded MFR differ in cost, capabilities, and technical risks from the baseline MFR included in the original DDG-1000 design?
- What is the net impact on the capabilities of the DDG-1000 of the change to the DDG-1000's primary radar (i.e., of removing the VSR and upgrading the MFR)?
- Given change to the DDG-1000's primary radar and the May 2010 CAPE estimates of the program's program acquisition unit cost (PAUC) and average program unit cost (APUC), is the DDG-1000 program still cost effective?
- What impact on cost, schedule, or technical risk, if any, will the removal of the VSR from the DDG-1000 design have on the Navy's plan to install the dual-band radar (DBR), including the VSR, on the Ford (CVN-78) class aircraft carriers CVN-78 and CVN-79?[35]

March 2014 GAO Report

A March 2014 GAO report assessing selected major DOD weapon acquisition programs stated the following of the DDG-1000 program:

> **Technology Maturity**
>
> The DDG-1000 program has made progress in developing its critical technologies. However, only 3 of 11 are mature and the remaining 8 will not be demonstrated in a realistic environment until after installation on the lead ship. Guided flight tests of the gun system's long-range land-attack projectile were successfully completed in October

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

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

2013. After significant cost growth and development challenges, all six software releases for the total ship computing environment have been completed and certified to support lead ship activation and delivery and a software spiral update is under contract timed to support initial operating capability. Following a critical Nunn-McCurdy unit-cost breach in 2010, DOD restructured the program and removed the volume search radar from the ship's design. A modified multifunction radar is expected to begin land based testing in 2014, followed by at- sea testing in 2015.

Design and Production Maturity

The DDG 1000 design is largely mature. According to the program manager and ship builder, as of October 2013, production and test efforts for the first two ships were 88 and 70 percent complete, respectively. While few design changes have resulted from lead ship construction, shipbuilders have experienced challenges with the manufacture and integration of the composite deckhouse for the first and second ships, resulting in rework and schedule delays particularly on the first ship. The Navy has emphasized a joint inspection process whereby the prime contractors and the Navy validate product quality and completeness prior to integration with the hull. After assessing alternatives and conducting a competition, the Navy decided to build the third ship's deckhouse and hangar with steel as a cost saving measure as the program manager noted that the Navy has better cost insights into the long-term maintenance of steel compared to composite materials.

Other Program Issues

Delivery of the lead ship (hull, mechanical and electrical systems) may slip past the currently scheduled date of September 2014 and the Navy is in the process of assessing the delivery date. If delivery slips past October 2014, the program will breach its acquisition program baseline schedule requirements. According to the Navy, the delay is the result of difficulties in completing the ship's electrical systems, which is impacting test and activation events.

The program has awarded all major contracts for the three ships in the DDG 1000 class among four prime contractors. As the integrator, the Navy is responsible for ensuring on-time delivery of products and bears the costs of schedule delays that affect another contractor. Bath Iron Works is now producing the hull for all three ships. In August 2013, the Navy awarded a fixed price contract to Bath Iron Works for a steel deckhouse, hangar, and aft peripheral vertical launching system for the third ship. According to the program manager, the shipbuilder negotiated a 5- and 10-month delivery delay for the second and third ship, respectively.

Program officials also reported that the program absorbed sequestration reductions of $70 million in fiscal year 2013 by delaying testing and the award of contracts for mission-related equipment. The program is also incorporating technical configuration changes resulting from the configuration steering board and Nunn-McCurdy annual cost review aimed at maintaining capability and minimizing costs. For example, the program manager told us the program assessed alternatives to the close in gun system and chose a legacy system that met requirements with about half the weight and cost.

Program Office Comments

In commenting on a draft of this assessment the Navy noted that the DDG 1000 lead ship was successfully launched in October 2013, a christening is scheduled for April 2014, and activation activities continue. For the second ship, keel laying and hangar erection have occurred, hull integration is underway, and deckhouse delivery is scheduled for spring 2014. The Navy noted that significant integration efforts between four prime

contractors continue with a focus on cost reduction and schedule performance. The Navy also provided technical comments, which were incorporated where deemed appropriate.[36]

[36] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-14-340SP, March 2014, p. 60.

Appendix B. Additional Background Information on CG(X) Cruiser Program

Background Information on CG(X) Program

The CG(X) cruiser program was announced by the Navy on November 1, 2001.[37] The Navy wanted to procure as many as 19 CG(X)s as replacements for its 22 CG-47s, which are projected to reach the end of their 35-year service lives between 2021 and 2029. The CG-47s are multi-mission ships with an emphasis on AAW and (for some CG-47s) BMD, and the Navy similarly wanted the CG(X) to be a multi-mission ship with an emphasis on AAW and BMD. The CG(X) was to carry the Air and Missile Defense Radar (AMDR), a new radar that was to be considerably larger and more powerful than the SPY-1 radar carried on the Navy's Aegis ships. Some press reports suggested that a nuclear-powered version of the CG(X) might have had a full load displacement of more than 20,000 tons and a unit procurement cost of $5 billion or more.[38]

The Navy's FY2009 budget called for procuring the first CG(X) in FY2011. Beginning in late 2008, however, it was reported that the Navy had decided to defer the procurement of the first CG(X) by several years, to about FY2017.[39] Consistent with these press reports, on April 6, 2009,

[37] The Navy on that date announced that that it was launching a Future Surface Combatant Program aimed at acquiring a family of next-generation surface combatants. This new family of surface combatants, the Navy stated, would include three new classes of ships:

- a destroyer called the DD(X)—later redesignated DDG-1000—for the precision long-range strike and naval gunfire mission,
- a cruiser called the CG(X) for the AAW and BMD mission, and
- a smaller combatant called the Littoral Combat Ship (LCS) to counter submarines, small surface attack craft, and mines in heavily contested littoral (near-shore) areas.

The Future Surface Combatant Program replaced an earlier Navy surface combatant acquisition effort, begun in the mid-1990s, called the Surface Combatant for the 21st Century (SC-21) program. The SC-21 program encompassed a planned destroyer called DD-21 and a planned 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, but the start of development work on the CG-21 was still years in the future. The DD(X) program, now called the DDG-1000 or Zumwalt-class program, is essentially a restructured continuation of the DD-21 program. The CG(X) might be considered the successor, in planning terms, of the CG-21. After November 1, 2001, the acronym SC-21 continued for a time to be used in the Navy's research and development account to designate a line item (i.e., program element) that funded development work on the DDG-1000 and CG(X).

[38] For a discussion of nuclear power for Navy surface ships other than aircraft carriers, see CRS Report RL33946, *Navy Nuclear-Powered Surface Ships: Background, Issues, and Options for Congress*, by Ronald O'Rourke.

[39] Zachary M. Peterson, "Navy Awards Technology Company $128 Million Contract For CG(X) Work," *Inside the Navy*, October 27, 2008. Another press report (Katherine McIntire Peters, "Navy's Top Officer Sees Lessons in Shipbuilding Program Failures," *GovernmentExecutive.com*, September 24, 2008) quoted Admiral Gary Roughead, the Chief of Naval Operations, as saying: "What we will be able to do is take the technology from the DDG-1000, the capability and capacity that [will be achieved] as we build more DDG-51s, and [bring those] together around 2017 in a replacement ship for our cruisers." (Material in brackets in the press report.) Another press report (Zachary M. Peterson, "Part One of Overdue CG(X) AOA Sent to OSD, Second Part Coming Soon," *Inside the Navy*, September 29, 2008) quoted Vice Admiral Barry McCullough, the Deputy Chief of Naval Operations for Integration of Capabilities and Resources, as saying that the Navy did not budget for a CG(X) hull in its proposal for the Navy's budget under the FY2010-FY2015 Future Years Defense Plan (FYDP) to be submitted to Congress in early 2009.

An earlier report (Christopher P. Cavas, "DDG 1000 Destroyer Program Facing Major Cuts," *DefenseNews.com*, July 14, 2008) stated that the CG(X) would be delayed until FY2015 or later. See also Geoff Fein, "Navy Likely To Change CG(X)'s Procurement Schedule, Official Says," *Defense Daily*, June 24, 2008; Rebekah Gordon, "Navy Agrees CG(X) By FY-11 Won't Happen But Reveals Little Else," *Inside the Navy*, June 30, 2008.

Secretary of Defense Robert Gates announced—as part of a series of recommendations for the then-forthcoming FY2010 defense budget—a recommendation to "delay the CG-X next generation cruiser program to revisit both the requirements and acquisition strategy" for the program.[40] The Navy's proposed FY2010 budget deferred procurement of the first CG(X) beyond FY2015.

Cancellation of CG(X) Program

The Navy's FY2011 budget proposed terminating the CG(X) program as unaffordable. The Navy's desire to cancel the CG(X) and instead procure Flight III DDG-51s apparently took shape during 2009: at a June 16, 2009, hearing before the Seapower Subcommittee of the Senate Armed Services Committee, the Navy testified that it was conducting a study on destroyer procurement options for FY2012 and beyond that was examining design options based on either the DDG-51 or DDG-1000 hull form.[41] A January 2009 memorandum from the Department of Defense acquisition executive had called for such a study.[42] In September and November 2009, it was reported that the Navy's study was examining how future requirements for AAW and BMD operations might be met by a DDG-51 or DDG-1000 hull equipped with a new radar.[43] On December 7, 2009, it was reported that the Navy wanted to cancel its planned CG(X) cruiser and instead procure an improved version of the DDG-51.[44] In addition to being concerned about the projected high cost and immature technologies of the CG(X),[45] the Navy reportedly had concluded that it does not need a surface combatant with a version of the AMDR as large and capable as the one envisaged for the CG(X) to adequately perform projected AAW and BMD missions, because the Navy will be able to augment data collected by surface combatant radars with data collected by space-based sensors. The Navy reportedly concluded that using data collected by other sensors would permit projected AAW and BMD missions to be performed adequately with a radar smaller enough to be fitted onto the DDG-51.[46] Reports suggested that the

[40] Source: Opening remarks of Secretary of Defense Robert Gates at an April 6, 2009, news conference on DOD recommendations for the then-forthcoming FY2010 defense budget.

[41] Source: Transcript of spoken remarks of Vice Admiral Bernard McCullough at a June 16, 2009, hearing on Navy force structure shipbuilding before the Seapower subcommittee of the Senate Armed Services Committee.

[42] A January 26, 2009, memorandum for the record from John Young, the then-DOD acquisition executive, stated that "The Navy proposed and OSD [the Office of the Secretary of Defense] agreed with modification to truncate the DDG-1000 Program to three ships in the FY 2010 budget submission." The memo proposed procuring one DDG-51 in FY2010 and two more FY2011, followed by the procurement in FY2012-FY2015 (in annual quantities of 1, 2, 1, 2) of a ship called the Future Surface Combatant (FSC) that could be based on either the DDG-51 design or the DDG-1000 design. The memorandum stated that the FSC might be equipped with a new type of radar, but the memorandum did not otherwise specify the FSC's capabilities. The memorandum stated that further analysis would support a decision on whether to base the FSC on the DDG-51 design or the DDG-1000 design. (Memorandum for the record dated January 26, 2009, from John Young, Under Secretary of Defense [Acquisition, Technology and Logistics], entitled "DDG 1000 Program Way Ahead," posted on InsideDefense.com [subscription required].)

[43] Zachary M. Peterson, "Navy Slated To Wrap Up Future Destroyer Hull And Radar Study," *Inside the Navy*, September 7, 2009. Christopher P. Cavas, "Next-Generation U.S. Warship Could Be Taking Shape," *Defense News*, November 2, 2009: 18, 20.

[44] Christopher J. Castelli, "Draft Shipbuilding Report Reveals Navy Is Killing CG(X) Cruiser Program," *Inside the Navy*, December 7, 2009.

[45] Christopher J. Castelli, "Draft Shipbuilding Report Reveals Navy Is Killing CG(X) Cruiser Program," *Inside the Navy*, December 7, 2009.

[46] Amy Butler, "STSS Prompts Shift in CG(X) Plans," *Aerospace Daily & Defense Report*, December 11, 2009: 1-2.

new smaller radar would be a scaled-down version of the AMDR originally intended for the CG(X).[47]

The Navy's February 2010 report on its FY2011 30-year (FY2011-FY2040) shipbuilding plan, submitted to Congress in conjunction with the FY2011 budget, states that the 30-year plan:

> Solidifies the DoN's [Department of the Navy's] long-term plans for Large Surface Combatants by truncating the DDG 1000 program, restarting the DDG 51 production line, and continuing the Advanced Missile Defense Radar (AMDR) development efforts. Over the past year, the Navy has conducted a study that concludes a DDG 51 hull form with an AMDR suite is the most cost-effective solution to fleet air and missile defense requirements over the near to mid-term....
>
> The Navy, in consultation with OSD, conducted a Radar/Hull Study for future destroyers. The objective of the study was to provide a recommendation for the total ship system solution required to provide Integrated Air and Missile Defense (IAMD) (simultaneous ballistic missile and anti-air warfare (AAW) defense) capability while balancing affordability with capacity. As a result of the study, the Navy is proceeding with the Air and Missile Defense Radar (AMDR) program....
>
> As discussed above, the DDG 51 production line has been restarted. While all of these new-start guided missile destroyers will be delivered with some BMD capability, those procured in FY 2016 and beyond will be purpose-built with BMD as a primary mission. While there is work to be done in determining its final design, it is envisioned that this DDG 51 class variant will have upgrades to radar and computing performance with the appropriate power generation capacity and cooling required by these enhancements. These upgraded DDG 51 class ships will be modifications of the current guided missile destroyer design that combine the best emerging technologies aimed at further increasing capabilities in the IAMD arena and providing a more effective bridge between today's capability and that originally planned for the CG(X). The ships reflected in this program have been priced based on continuation of the existing DDG 51 re-start program. Having recently completed the Hull and Radar Study, the Department is embarking on the requirements definition process for these AMDR destroyers and will adjust the pricing for these ships in future reports should that prove necessary.[48]

In testimony to the House and Senate Armed Services Committees on February 24 and 25, 2010, respectively, Admiral Gary Roughead, the Chief of Naval Operations, stated:

> Integrated Air and Missile Defense (IAMD) incorporates all aspects of air defense against ballistic, anti-ship, and overland cruise missiles. IAMD is vital to the protection of our force, and it is an integral part of our core capability to deter aggression through conventional means....
>
> To address the rapid proliferation of ballistic and anti-ship missiles and deep-water submarine threats, as well as increase the capacity of our multipurpose surface ships, we restarted production of our DDG 51 Arleigh Burke Class destroyers (Flight IIA series). These ships will be the first constructed with IAMD, providing much-needed Ballistic Missile Defense (BMD) capacity to the Fleet, and they will incorporate the hull, mechanical, and electrical alterations associated with our mature DDG modernization

[47] Cid Standifer, "NAVSEA Plans To Solicit Contracts For Air And Missile Defense Radar," *Inside the Navy*, December 28, 2009; "Navy Issues RFP For Phase II of Air And Missile Defense Radar Effort," *Defense Daily*, December 24, 2009: 4.

[48] U.S. Navy, *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY 2011*, February 2010, pp. 12, 13, 19. The first reprinted paragraph, taken from page 12, also occurs on page 3 as part of the executive summary.

> program. We will spiral DDG 51 production to incorporate future integrated air and missile defense capabilities....
>
> The Navy, in consultation with the Office of the Secretary of Defense, conducted a Radar/Hull Study for future surface combatants that analyzed the total ship system solution necessary to meet our IAMD requirements while balancing affordability and capacity in our surface Fleet. The study concluded that Navy should integrate the Air and Missile Defense Radar program S Band radar (AMDR-S), SPY-3 (X Band radar), and Aegis Advanced Capability Build (ACB) combat system into a DDG 51 hull. While our Radar/Hull Study indicated that both DDG 51 and DDG 1000 were able to support our preferred radar systems, leveraging the DDG 51 hull was the most affordable option. Accordingly, our FY 2011 budget cancels the next generation cruiser program due to projected high cost and risk in technology and design of this ship. I request your support as we invest in spiraling the capabilities of our DDG 51 Class from our Flight IIA Arleigh Burke ships to Flight III ships, which will be our future IAMD-capable surface combatant. We will procure the first Flight III ship in FY 2016.[49]

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[49] Statement of Admiral Gary Roughead, Chief of Naval Operations, before the House Armed Services Committee on 24 February, 2010, pp. 10-11; and Statement of Admiral Gary Roughead, Chief of Naval Operations, before the Senate Armed Services Committee on 25 February 2010, pp. 10-11.