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

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Summary

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 procured DDG-51s from FY1985 through FY2005, and resumed procuring them in FY2010. The three DDG-51s requested for procurement in FY2019 are to be the 80th, 81st, and 82nd ships in the class. The Navy procured three DDG-1000s in FY2007-FY2009 and plans no further procurement of DDG-1000s.

The 13 DDG-51s planned for procurement in FY2018-FY2022 are to be procured under a multiyear procurement (MYP) contract that Congress approved as part of its action on the Navy's FY2018 budget. DDG-51s procured in FY2017 and subsequent years are being built to a new design, called the Flight III DDG-51 design, that incorporates a new and more capable radar called the Air and Missile Defense Radar (AMDR) or SPY-6 radar.

The Navy estimates the combined procurement cost of the three DDG-51s requested for procurement in FY2019 at $5,292.7 million, or an average of $1,764.2 million each. The ships are to receive $39.4 million in prior-year (FY2018) Economic Order Quantity (EOQ) advance procurement (AP) funding (i.e., funding for up-front batch orders of components of DDG-51s to be procured under the FY2018-FY2022 MYP contract). The Navy's proposed FY2019 budget requests the following:

- the remaining $5,253.3 million in procurement funding needed to complete the estimated procurement cost for the three DDG-51s requested for FY2019;
- $391.9 million in additional EOQ AP funding for DDG-51s to be procured under the FY2018-FY2022 MYP contract;
- $54.0 million in cost-to-complete procurement funding to cover cost increases on DDG-51s procured in prior fiscal years; and
- $271.0 million in procurement funding to cover cost increases on Zumwalt (DDG-1000) class destroyers.

Issues for Congress for FY2019 for the DDG-51 and DDG-1000 destroyer programs include the following:

- whether to approve, reject, or modify the Navy's FY2019 funding requests for the DDG-51 and DDG-1000 programs;
- whether to provide funding for the procurement of an additional DDG-51 (for a total procurement of four DDG-51s rather than three) in FY2019;
- continued cost growth in the DDG-1000 program;
- the Navy's intended shift in mission orientation for the DDG-1000s;
- 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 FY2019 budget requests funding for the procurement of three DDG-51s. Decisions that Congress makes concerning destroyer procurement could substantially affect Navy capabilities and funding requirements, and the U.S. shipbuilding industrial base.

For an overview of the strategic and budgetary context in which the DDG-51, DDG-1000, and other Navy shipbuilding programs may be considered, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .[1]

Background

Navy's Force of Large Surface Combatants (LSCs)

LSC Definition

Decades ago, the Navy's cruisers were considerably larger and more capable than its destroyers. In the years after World War II, however, the Navy's cruiser designs in general became smaller while its destroyer designs in general became larger. As a result, since the 1980s there has been substantial overlap in size and capability of Navy cruisers and destroyers. (The Navy's new Zumwalt [DDG-1000] class destroyers, in fact, are considerably larger than the Navy's cruisers.) In part for this reason, the Navy now refers to its cruisers and destroyers collectively as *large surface combatants (LSCs)*, and distinguishes these ships from the Navy's *small surface combatants (SSCs)*, the term the Navy now uses to refer collectively to its frigates, Littoral Combat Ships (LCSs), mine warfare ships, and patrol craft. The Navy's annual 30-year shipbuilding plan, for example, groups the Navy's surface combatants into LSCs and SSCs.[2]

LSC Force-Level Goal

In December 2016, the Navy released a goal to achieve and maintain a Navy of 355 ships, including 104 LSCs. The 104-ship LSC force-level goal represented an increase of 16 ships over the 88-ship LSC force-level goal that was included in the Navy's previous plan for achieving and maintaining a 308-ship fleet. The 16 additional LSCs included in the 355-ship force-level goal account for about a third of the 47 ships that were added to the 308-ship force-level goal to create the 355-ship force-level goal.[3]

LSC Force at End of FY2017

At the end of FY2017, the Navy's force of LSCs totaled 87 ships, including:

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[1] See also CRS Report R43838, *A Shift in the International Security Environment: Potential Implications for Defense—Issues for Congress*, by (name redacted) , and CRS Report R44891, *U.S. Role in the World: Background and Issues for Congress*, by (name redacted) and (name redacted) .

[2] The Navy sometimes also uses the term *Cru-Des* (an abbreviation of cruiser-destroyer, pronounced "crew-dez") to refer collectively to its cruisers and destroyers.

[3] For more on the current 355-ship force-level goal and the previous 308-ship force-level goal, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .

- 22 Ticonderoga (CG-47) class cruisers;[4]
- 64 Arleigh Burke (DDG-51) class destroyers; and
- 1 Zumwalt (DDG-1000) class destroyer.

Additional Procurement for Achieving LSC Force-Level Goal

Additional Procurement Needed to Achieve 104-Ship Force

The Navy's FY2017 30-year (FY2017-FY2046) shipbuilding plan, which was intended to support the Navy's previous 308-ship force-level goal (and within that, the 88-ship goal for LSCs), included the procurement of 66 LSCs. The Navy projected that under the FY2017 30-year plan, the Navy would have maintained a force of 86 or more LSCs throughout most of the 30-year period before declining to 80 ships over the final five years of the plan.

CRS estimated in 2017 that 23 LSCs would need to be added to the FY2017 30-year shipbuilding plan (making for a total procurement during the 30-year period of 89 LSCs rather than 66) to achieve a force of 104 LSCs (as called for in the Navy's 355-ship force-level goal) and maintain the LSC force at that level through the end of the 30-year period (i.e., through FY2046)—unless the Navy reactivates retired cruisers and/or extends the service lives of currently active cruisers and destroyers, in which case the needed number of additional LSCs might be something less than 23.

The Congressional Budget Office (CBO) similarly estimated in 2017 that 24 or 25 LSCs would need to be added to the FY2017 30-year shipbuilding plan (making for a total procurement during the 30-year period of 90 or 91 LSCs) to achieve a force of 104 LSCs and maintain the force not only through the end of the 30-year period (i.e., through FY2047), but for another 10 years beyond that (i.e., through FY2057)—unless the Navy reactivates retired cruisers and/or extends the service lives of currently active cruisers and destroyers, in which case the needed number of additional LSCs might be something less than 24 or 25.[5]

Additional Procurement Included in FY2019 30-year Shipbuilding Plan

The Navy's FY2019 30-year (FY2019-FY2048) shipbuilding plan, which is intended to support the Navy's 355-ship force-level goal, includes the procurement of 76 LSCs—10 more than the 66 that were included in the Navy's FY2017 30-year shipbuilding plan, and 13 to 15 less than the 89 to 91 LSCs that CRS and CBO estimated in 2017 would needed to achieve and maintain a 104-ship LSC force on a sustained basis (see previous section). The Navy's FY2019 budget submission also proposes service life extensions for six CG-47 class cruisers.

Consistent with the CRS and CBO estimates from 2017, the Navy projects that the FY2019 30-year shipbuilding plan would not maintain a 104-ship LSC force during most of the 30-year period. More specifically, the Navy projects that under the FY2019 30-year plan, the LSC force would grow to a peak of 104 ships in FY2024, then decline to a minimum of 88 ships in FY2035,

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

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

grow to a secondary peak of 96 ships in FY2040 and FY2041, and then drop to a total of 91 or 92 ships in the final years of the plan.[6]

DDG-51 Program

Overview

The DDG-51 program was initiated in the late 1970s.[7] 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.

Figure 1. DDG-51 Class Destroyer

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

DDG-51s, like the Navy's 22 Ticonderoga (CG-47) class cruisers, 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

[6] For the Navy's year-by-year projection of the number of LSCs under the FY2019 30-year shipbuilding plan, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name r edacted) .

[7] 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. For an early discussion of the DDG-51 program, see Alva M. Bowen and Ronald O'Rourke, "DDG-51 and the Future Surface Navy," *U.S. Naval Institute Proceedings*, May 1985: 176-189.

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.[8]

The first DDG-51 was procured in FY1985 and entered service in 1991. A total of 79 have been procured through FY2018, including 62 in FY1985-FY2005 and 17 in FY2010-FY2018.[9] (During the period FY2006-FY2009, the Navy procured three Zumwalt [DDG-1000] class destroyers [see discussion below] rather than DDG-51s.) With a total of 79 ships funded through FY2018, the DDG-51 program is, in terms of number of hulls, one of the largest Navy shipbuilding programs since World War II. As noted earlier, as of the end of FY2017, a total of 64 DDG-51s were in service.

Design Changes

The DDG-51 design has been modified over time:

- The first 28 DDG-51s (i.e., DDGs 51 through 78) are called Flight I/II DDG-51s.
- In FY1994, the Navy shifted DDG-51 procurement to the Flight IIA DDG-51 design, which incorporated a significant design change that included, among other things, the addition of a helicopter hangar. A total of 47 Flight IIA DDG-51s (i.e., DDG-79 through DDG-124, plus DDG-127)[10] were procured through FY2016.
- In FY2017, the Navy shifted DDG-51 procurement to the Flight III DDG-51 design, which incorporates a new and more capable radar called the Air and Missile Defense Radar (AMDR) or SPY-6 radar and associated changes to the ship's electrical power and cooling systems. DDG-51s procured in FY2017 and subsequent years (i.e., DDGs 125 and higher, except for DDG-127 noted above) are to be Flight III DDG-51s.

Multiyear Procurement (MYP)

As part of its action on the Navy's FY2018 budget, Congress granted the Navy authority to use a multiyear procurement (MYP) contract for the 13 DDG-51s planned for procurement in FY2018-FY2022. This is the fourth MYP contract for the DDG-51 program—previous DDG-51 MYP contracts covered DDG-51s procured in FY2013-FY2017, FY2002-FY2005, and FY1998-FY2001.

Additional DDG-51s in FY2019 Five-Year Plan

The Navy's FY2018 five-year (FY2018-FY2022) shipbuilding plan included a total of 10 DDG-51s at a rate of two per year. The Navy's FY2019 five-year (FY2019-FY2023) shipbuilding plan includes a total of 14 DDG-51s—3 DDG-51s per year, except for 2 in FY2020. The Navy says that the 14 DDG-51s included in the FY2019 five-year shipbuilding plan are 4 more than the 10

[8] 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) .

[9] The 17 DDG-51s procured in FY2010-FY2018 include one in FY2010, two in FY2011, one in FY2012, three in FY2013, one in FY2014, two in FY2015, three in FY2016, two in FY2017, and two in FY2018.

[10] The hull-number discontinuity regarding DDG-127 is an administrative consequence of the ship having been funded as a Congressional addition to the Navy's proposed FY2016 shipbuilding request.

DDG-51s that were included in the period FY2019-FY2023 under the Navy's FY2018 budget submission. (The FY2023 column was not visible to Congress in the Navy's FY2018 budget submission.) The 4 additional DDG-51s in the period FY2019-FY2023 account for more than one-third of the 11 ships that the Navy says were added to the FY2019 five-year shipbuilding plan compared to the period FY2019-FY2023 under the Navy's FY2018 budget submission.

Shipbuilders, Combat System Lead, and Radar Makers

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. Lockheed is the lead contractor for the Aegis system installed on all DDG-51s. The SPY-1 radar—the primary radar for the Aegis system on Flight I/II and Flight IIA DDG-51s—is made by Lockheed. The AMDR—the primary radar for the Aegis system on Flight III DDG-51s—is made by Raytheon.

Modernization of Existing DDG-51s

The Navy is modernizing its existing DDG-51s (and its CG-47s) so as to maintain their mission and cost-effectiveness out to the end of their projected service lives.[11]

Older CRS reports provide additional historical and background information on the DDG-51 program.[12]

DDG-1000 Program

Overview

The DDG-1000 program was initiated in the early 1990s.[13] The DDG-1000 is a multi-mission destroyer with an originally intended emphasis on naval surface fire support (NSFS) and operations in littoral (i.e., near-shore) waters. (NSFS is the use of naval guns to provide fire support for friendly forces operating ashore). The DDG-1000 was originally 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,[14] 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.[15]

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

[12] 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).

[13] 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.

[14] 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.

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

The DDG-1000 is to have a reduced-size crew of 175 sailors (147 to operate the ship, plus a 28-person aviation detachment), 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[16] and automation technologies enabling its reduced-sized crew.

With an estimated full load displacement of 15,612 tons, the DDG-1000 design is roughly 64% larger than the Navy's current 9,500-ton Aegis cruisers and destroyers, and larger than any Navy destroyer or cruiser since the nuclear-powered cruiser *Long Beach* (CGN-9), which was procured in FY1957.

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 FY2019 budget submission estimates their combined procurement cost at $9,242.3 million. The third DDG-1000 was procured in FY2009 and split-funded in FY2009-FY2010; the Navy's FY2019 budget submission estimates its procurement cost at $3,789.9 million.

The first DDG-1000 was commissioned into service on October 15, 2016, although its delivery date was revised in the Navy's FY2018 budget submission to May 2018, and revised further in the Navy's FY2019 budget submission to December 2018, creating an unusual situation in which a ship was commissioned into service more than two years prior to its delivery date. The delivery dates for the second and third ships were revised in the Navy's FY2018 budget submission to May 2020 and December 2021, respectively, and were revised further in the Navy's FY2019 budget submission to September 2020 and September 2022, respectively.[17]

Shipbuilders and Combat System Prime Contractor

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).

Reduction in Procurement to Three Ships

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. In subsequent years, the planned total number of DDG-1000s was reduced to 16 to 24, then to 7, and finally to 3.

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, which came after two DDG-1000s had been procured, the Navy stated that it had reevaluated the future operating environment and determined that its destroyer

[16] 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) .

[17] The revised delivery dates for the three ships reflect Section 121 of the FY2017 National Defense Authorization Act (S. 2943/P.L. 114-328 of December 23, 2016), a provision that establishes standards for determining vessel delivery dates and which also required the Secretary of the Navy to certify that the delivery dates for certain ships, including the three DDG-1000s, had been adjusted in accordance with the provision. The Navy's original plan for the DDG-1000 program was to install certain elements of each DDG-1000's combat system after delivering the ship and commissioning it into service. Section 121 of P.L. 114-328 in effect requires the Navy to defer the delivery date of a DDG-1000 until those elements of the combat system are installed. By the time P.L. 114-328 was enacted, DDG-1000, per the Navy's original plan, had already been commissioned into service without those elements of its combat system.

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).[18]

Change in Mission Orientation

As noted earlier, the DDG-1000 is a multi-mission destroyer with an originally intended emphasis on naval surface fire support (NSFS) and operations in littoral (i.e., near-shore) waters. Consistent with that mission orientation, the ship was designed with two new-design 155mm guns called Advanced Gun Systems (AGSs). The AGSs were to fire a new 155mm, gun-launched, rocket-assisted guided projectile called the Long-Range Land-Attack Projectile (LRLAP, pronounced LUR-lap). 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 called 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.[19] The Navy began exploring options for procuring a less expensive (and less capable) replacement munition for the AGSs.

The Navy to date has not announced a replacement munition for the AGSs.[20] In the meantime, it was reported in December 2017 that, due to shifts in the international security environment and resulting shifts in Navy mission needs, the mission orientation of the DDG-1000s will be shifted from an emphasis on NSFS to an emphasis surface strike, meaning the use of missiles to attack surface ships and perhaps also land targets.[21]

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[18] 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 RL33153, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, by (name redacted) .

[19] 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.

[20] See Sam LaGrone, "No New Round Planned For Zumwalt Destroyer Gun System; Navy Monitoring Industry," *USNI News*, January 11, 2018; Richard Abott, "Navy Still Has No Plans For DDG-1000 Gun Ammo," *Defense Daily*, January 12, 2018: 1-2.

[21] Megan Eckstein, "New Requirements for DDG-1000 Focus on Surface Strike," *USNI News*, December 4, 2017. See also Richard Abott, "Navy Will Focus Zumwalt On Offensive Surface Strike," *Defense Daily*, December 5, 2017.

Under this new plan, the mix of missiles carried in the 80 vertical launch system (VLS) tubes of each DDG-1000 may now feature a stronger emphasis on anti-ship and land-attack cruise missiles missiles. The two AGSs on each DDG-1000 will, for the time being at least, remain for the most part dormant, pending a final decision on whether to procure a replacement munition for the AGSs (which would require modifying the AGSs and their below-deck munition-handling equipment, since both were designed specifically for LRLAP), or instead pursue another option, such as removing the AGSs and their below-deck equipment and replacing them with additional VLS tubes.

A February 15, 2018, press report states:

> The Navy has a new vision for what its enormous high-tech destroyers will do: Killing enemy warships at extended ranges.
>
> The Navy is asking Congress to fund a conversion of its 600-foot stealth destroyers from primarily a land attack ship to an anti-surface, offensive strike platform, according to budget documents released Feb. 12.
>
> The service's 2019 budget request includes a request for $89.7 million to transform its Zumwalt-class destroyers by integrating Raytheon's long-range SM-6 missile, which can dual hat as both an anti-air and anti-surface missile, as well as its Maritime Strike variant of the Tomahawk missile.
>
> Converting DDG-1000 into a hunter-killer is a win for the surface warfare community's years-long drive to beef up the force's offensive capabilities. It also answers the bell for U.S. Pacific Command, which has been pushing for the Navy to add longer range weapons to offset the increasing threat from Chinese long-range missile technology....
>
> The decision to switch the requirements from a land-attack platform to an anti-surface platform came in November following a review of the requirements, according to the documents.
>
> "After a comprehensive review of Zumwalt class requirements, Navy decided in November 2017 to refocus the primary mission of the Zumwalt Class Destroyers from Land Attack to Offensive Surface Strike," the documents read. "The funding requested in [FY19] will facilitate this change in mission and add lethal, offensive fires against targets afloat and ashore."[22]

Increase in Estimated Procurement Cost

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 $4,055.1 million, or 45.1%, since the FY2009 budget (i.e., the budget for the fiscal year in which the third DDG-1000 was procured).

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

The Navy states that the cost growth shown through FY2015 in the table reflects, among other things, a series of incremental, year-by-year movements away from an earlier Navy cost estimate for the program, and toward a higher estimate developed by the Cost Assessment and Program

[22] David B. Larter, "The Navy's Stealth Destroyers to Get New Weapons and a New Mission: Killing Ships," *Defense News*, February 15, 2018. Material in brackets as in original.

Evaluation (CAPE) office within the Office of the Secretary of Defense (OSD). As one consequence of a Nunn-McCurdy cost breach experienced by the DDG-1000 program in 2010 (see "2010 Nunn-McCurdy Breach, Program Restructuring, and Milestone Recertification" in **Appendix**), the Navy was directed to fund the DDG-1000 program to CAPE's higher cost estimate for the period FY2011-FY2015, and to the Navy's cost estimate for FY2016 and beyond. The Navy states that it implemented this directive in a year-by-year fashion with each budget submission from FY2010 through FY2015, moving incrementally closer each year through FY2015 to CAPE's higher estimate. The Navy stated in 2014 that even with the cost growth shown in the table, the DDG-1000 program as of the FY2015 budget submission was still about 3% *below* the program's rebaselined starting point for calculating any new Nunn-McCurdy cost breach on the program.[23]

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

Budget submission	Estimated combined procurement cost (millions of dollars)	Change from prior year's budget submission	Cumulative change from FY2009 budget submission
FY09	8,977.1	—	—
FY10	9,372.5	+395.4 (+4.4%)	+395.4 (+4.4%)
FY11	9,993.3	+620.8 (+6.6%)	+1,016.2 (+11.3%)
FY12	11,308.8	+1,315.5 (+13.2%)	+2,331.7 (+26.0%)
FY13	11,470.1	+161.3 (+1.4%)	+2,493.0 (+27.8%)
FY14	11,618.4	+148.3 (+1.3%)	+2,641.3 (+29.4%)
FY15	12,069.4	+451.0 (+3.9%)	+3,092.3 (+34.4%)
FY16	12,288.7	+219.3 (+1.8%)	+3,311.6 (+36.9%)
FY17	12,738.2	+449.5 (+3.7%)	+3,761.1 (+41.9%)
FY18	12,882.0	+143.8 (+1.1%)	+3,904.0 (+43.5%)
FY19	13,032.2	+150.2 (+1.2%)	+4,055.1 (+45.1%)

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

The Navy states that the cost growth shown in the FY2019 budget submission (about $150 million from the figure in the FY2018 budget submission) is not due to any problem with shipyard construction performance, but instead reflects costs for design changes resulting from both learning from the construction of the first ship and the shift in the ships' mission orientation from an emphasis on NSFS to an emphasis on surface strike.[24]

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

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

[24] Source: March 16, 2018, Navy briefing on FY2019 budget submission for DDG-1000 program for CRS and CBO,

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 and cutters for the Coast Guard.) 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. Several Navy-operated laboratories and other facilities support the Aegis system and other aspects of the DDG-51 and DDG-1000 programs.

FY2019 Funding Request

The Navy estimates the combined procurement cost of the three DDG-51s requested for procurement in FY2019 at $5,292.7 million, or an average of $1,764.2 million each. The ships are to receive $39.4 million in prior-year (FY2018) Economic Order Quantity (EOQ) advance procurement (AP) funding (i.e., funding for up-front batch orders of components of DDG-51s to be procured under the FY2018-FY2022 MYP contract). The Navy's proposed FY2019 budget requests the following:

- the remaining $5,253.3 million in procurement funding needed to complete the estimated procurement cost for the three DDG-51s requested for FY2019;
- $391.9 million in additional EOQ AP funding for DDG-51s to be procured under the FY2018-FY2022 MYP contract;
- $54.0 million in cost-to-complete procurement funding to cover cost increases on DDG-51s procured in prior fiscal years; and
- $271.0 million in procurement funding to cover cost increases on Zumwalt (DDG-1000) class destroyers.

Issues for Congress for FY2019

FY2019 Funding Request

One issue for Congress for FY2019 is whether to approve, reject, or modify the Navy's FY2019 funding requests for the DDG-51 and DDG-1000 programs. In considering this issue, Congress

may consider, among other things, whether the Navy has accurately priced the work it is proposing to fund for FY2019.

Funding an Additional DDG-51 in FY2019

Another issue for Congress for FY2019 is whether to provide funding for the procurement of an additional DDG-51 (for a total procurement of four DDG-51s in FY2019 rather than three). Supporters could argue that a fourth ship could help make a start toward procuring the 13 to 15 additional DDG-51s that CRS and CBO estimate would need to be added to the Navy's FY2019 30-year shipbuilding plan to achieve and maintain the Navy's 104-ship large surface combatant force-level goal. (See "Additional Procurement for Achieving LSC Force-Level Goal.") Skeptics or opponents could argue that in a situation of finite defense funding, procuring an additional DDG-51 could reduce funding for other Navy or Department of Defense (DOD) programs, or that there are other, higher-priority Navy or DOD programs to which the funding needed to procure an additional DDG-51 could be applied.

Cost Growth in DDG-1000 Program

Another oversight issue for Congress for FY2019, as in previous years, is the continued cost growth in the DDG-1000 program shown in **Table 1**. Potential oversight questions for Congress include the following: Does the Navy expect the cost growth to continue past FY2019? What is the Navy doing to end this cost growth?

Change in DDG-1000 Mission Orientation

Another potential oversight issue for Congress for FY2019 concerns the Navy's plan to shift the mission orientation of the DDG-1000s from an emphasis on NSFS to an emphasis surface strike. Potential oversight questions for Congress include the following:

- What is the Navy's analytical basis for shifting the ships' mission orientation?
- What are the potential costs of implementing this shift? How much of these costs are in the Navy's FY2019 budget submission?
- How cost-effective will it be to operate and support DDG-1000s as ships with an emphasis on surface strike?
- When does the Navy plan to decide on whether to procure a replacement munition for the ships' AGSs, or instead pursue another option, such as removing the AGSs and their below-deck equipment and installing additional VLS tubes? What would be the cost of the latter option, and how many additional VLS tubes could be installed?
- If the ships will operate with their AGSs for the most part dormant, to what degree will that reduce the return on investment (ROI) involved in developing, procuring, operating, and sporting the DDG-1000s?

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

Another oversight issue for Congress for FY2019, as in previous years, concerns cost, technical, and schedule risk for the Flight III DDG-51.

January 2018 DOT&E Report

A January 2018 report from DOD's Director of Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2017—stated the following regarding the Flight III DDG-51:

> **Assessment**
>
> • 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 Seasparrow Missile] Block 2, and DDG 51 Flight III destroyer programs will not 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 [Integrated Air and Missile Defense] mission, which requires AMDR to support simultaneous defense against multiple ballistic missile threats and multiple advanced ASCM [anti-ship cruise missile] threats. The CDD also includes an AMDR minimum track range requirement as part of the IAMD Key Performance Parameter.
>
> - The DDG 51 Flight III destroyer has a survivability Key Performance Parameter 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.
>
> - 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 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 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. Safety 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 on the SDTS 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 Navy should do the same 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 Navy intends to conduct phases of the ESSM Block 2 IOT&E [initial operational test and evaluation] 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 few test data available concerning ESSM's performance 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 a different radar suite supports.

• The cost of building and operating an Aegis SDTS is estimated to be about $350 Million, compared to the estimated $14 Billion cost of the AMDR development/procurement and the estimated $45 Billion cost of the additional 22 or more DDG 51 Flight III ships that are planned for acquisition. Additionally, the cost of the ships that the DDG 51 Flight III destroyer is expected to protect is approximately $450 Billion in new ship construction over the next 30 years. Failure to adequately test the self-defense capability of DDG 51 Flight III destroyers means their survivability and that of a significant number other of ships the DDG-51 Flight III destroyers are intended to defend will be unknown. It is essential that the Navy program now fund the tests, targets, and Aegis Combat System equipment needed to conduct realistic self-defense testing using an AMDR- and Aegis-equipped SDTS.

• The modifications planned for DDG 51 Flight III are substantial enough to justify an assessment of ship survivability. To assess the effects of those modifications on ship survivability, the DDG 51 Flight III LFT&E strategy should include at least component shock qualification tests, a Total Ship Survivability Trial, a shock trial, and a plan to validate simulation tools used in the survivability assessment. The Navy has not yet developed an LFT&E Strategy for the program.

Recommendations

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

1. Program for 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 Test and Evaluation Master Plans (TEMPs) 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 TEMPs 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 [Deputy Secretary of Defense] 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 review and approval in coordination with the TEMP.

6. 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, and ESSM Block 2 programs, and document that strategy into draft TEMPs for those programs to be provided to DOT&E.

• FY17 Recommendation.

1. The Navy should program funds in the Future Years Defense Plan to complete all activities and procurement required to conduct adequate operational testing in FY24 of the DDG 51 Flight III, AMDR, and ESSM Block 2's self-defense capabilities on an Aegis-equipped SDTS.[25]

The report also stated:

Equipping a Self-Defense Test Ship for Aegis Combat System, Air and Missile Defense Radar, and Evolved Seasparrow Missile Block 2 Operational Testing

The close-in ship self-defense battlespace is complex and presents a number of challenges. For example, this environment requires:

• Weapon scheduling with very little time for engagement

• The combat system and its sensors to deal with debris fields generated by successful engagements of individual ASCMs within a multi-ASCM raid

• Rapid multi-salvo kill assessments for multiple targets

• Transitions between Evolved Seasparrow Missile (ESSM) guidance modes

• Conducting ballistic missile defense and area air-defense missions (i.e., integrated air and missile defense) while simultaneously conducting ship self-defense

• Contending with stream raids of multiple ASCMs attacking along the same bearing, in which directors illuminate multiple targets (especially true for maneuvering threats)

• Designating targets for destruction by the Close-In Weapons System (CIWS)

Multiple hard-kill weapon systems operate close-in, including the Standard Missile 2, the ESSM, and the CIWS. Soft-kill systems such as the Nulka MK 53 decoy launching system also operate close-in. The short timelines required to conduct successful ship self-defense place great stress on combat system logic, combat system element synchronization, combat system integration, and end-to-end performance.

Navy range safety restrictions prohibit close-in testing on a manned ship because targets and debris from successful intercepts will pose an unacceptable risk to the ship and personnel at the ranges where these self-defense engagements take place. These restrictions were imposed following a February 1983 incident on USS Antrim (FFG 20), which was struck with a subsonic BQM-74 aerial target during a test of its self-defense weapon systems, killing a civilian instructor. The first unmanned, remotely controlled self-defense test ship (SDTS) – ex-USS Stoddard – was put into service that same year. A similar incident occurred in November 2013, when two sailors were injured when an aerial target struck USS Chancellorsville (CG 62) during a test of its combat system. The Chancellorsville incident underscores the inherent dangers of testing with manned ships in the close-in battlespace.

[25] Department of Defense, *Director, Operational Test and Evaluation, FY 2017 Annual Report*, January 2018, pp. 174-175.

The investigation into the Chancellorsville incident caused the Navy to rethink how it will employ subsonic and supersonic aerial targets near manned ships. The Navy has always considered supersonic ASCM targets high risk to safety and will not permit flying them directly at a manned ship. The Navy has invested in a seagoing, unmanned, remotely-controlled test asset (the SDTS) and is using it to overcome these safety restrictions. The Navy is accrediting a high-fidelity M&S capability – utilizing data from the SDTS as well as data from manned ship testing – so that a full assessment of the self-defense capabilities of non-Aegis ships can be completely and affordably conducted. The Navy recognizes that the SDTS is integral to the test programs for certain weapons systems (the Ship Self-Defense System, Rolling Airframe Missile Block 2, and ESSM Block 1) and ship classes (LPD 17, LHA 6, Littoral Combat Ship, LSD 41/49, DDG 1000, and CVN 78). However, it has not made a similar investment in an SDTS equipped with an Aegis Combat System, Air and Missile Defense Radar (AMDR), and ESSM Block 2 for adequate operational testing of the DDG 51 Flight III destroyer self-defense capabilities. The current SDTS lacks appropriate sensors and other combat system elements to test these capabilities.

On September 10, 2014, DOT&E submitted a classified memorandum to USD(AT&L) with a review of the Design of Experiments study by the Navy Program Executive Office for Integrated Warfare Systems. The Navy study attempted to provide technical justification to show that an Aegis-equipped SDTS was not required to adequately assess the self-defense capability of the DDG 51 Flight III class destroyers. DOT&E found that the study presented a number of flawed justifications and failed to make a cogent argument for not using an Aegis-equipped SDTS for operational testing.

On December 10, 2014, the Deputy Secretary of Defense (DEPSECDEF) issued a memorandum directing the Director of Cost Assessment and Program Evaluation (CAPE) to identify viable at-sea operational testing options that meet DOT&E adequacy requirements and to recommend a course of action (with cost estimates, risks, and benefits) to satisfy testing of the AMDR, Aegis Combat System, and ESSM Block 2 in support of the DDG 51 Flight III destroyer program. The CAPE study evaluated four options to deliver an at-sea test platform adequate for self-defense operational testing. Each option required funding beginning in FY18 to support operational testing of these systems in FY22.

On February 10, 2016, the DEPSECDEF directed the Navy to adjust funds within existing resources to procure long lead items to begin procurement of an SDTS equipped with the Aegis Combat System and AMDR. He further directed the Navy to work with DOT&E to develop an integrated test strategy for the DDG 51 Flight III, AMDR, Aegis Modernization, and ESSM Block 2 programs. The DEPSECDEF required the Navy to document that strategy in draft TEMPs for those programs and submit them to DOT&E by July 29, 2016. The Navy has not complied with the direction to provide an integrated test strategy or TEMPs for those programs. Despite initially budgeting for long lead AMDR components, the Navy did not program funding in the Future Years Defense Plan to complete other activities and equipment required to modify the SDTS to support adequate operational testing of the self-defense capabilities of the DDG 51 Flight III, AMDR, and ESSM Block 2 in FY23 as planned. The Navy subsequently removed funding for the long-lead AMDR components.

On November 21, 2016, the DEPSECDEF directed the Navy to fully fund the Aegis SDTS and aerial targets required for testing the DDG 51 Flight III, AMDR, and ESSM Block 2 programs. The Navy initially complied with the direction but subsequently removed all funding for the Aegis SDTS and aerial targets.

On May 4, 2017, the DEPSECDEF directed the Navy to reinstate funding for the Aegis SDTS and associated test firings in compliance with the November 21, 2016, guidance. DOT&E continues to recommend equipping an SDTS with capabilities to support Aegis

> Combat System, AMDR, and ESSM Block 2 OT&E to test ship self-defense systems' performance in the final seconds of the close-in battle and to acquire sufficient data to validate ship self-defense performance M&S.[26]

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.[27]

Regarding the AMDR specifically, the report stated the following:

> **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.

[26] Department of Defense, *Director, Operational Test and Evaluation, FY 2017 Annual Report*, January 2018, pp. 328-329.

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

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

Design and Production Maturity

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

Other Program Issues

In 2013, DOT&E disapproved AMDR's test and evaluation master plan due to concerns the Navy's proposed testing approach would not provide realistic operational conditions. 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.[28]

February 2017 CBO Report

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

> The Navy's strategy for meeting the combatant commanders' goal of improving ballistic missile defense capabilities so that in the future they exceed those provided by existing DDG-51s—and for replacing 11 Ticonderoga class cruisers when they are retired in the

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

> 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.[29]

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

Another issue for Congress for FY2019, as in previous years, concerns the lack of an announced Navy roadmap for accomplishing three things in the cruiser-destroyer force:

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

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

Legislative Activity for FY2019

Summary of Congressional Action on FY2019 Funding Request

Table 2 summarizes congressional action on the Navy's FY2019 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).

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

Table 2. Congressional Action on FY2019 Funding Request

Millions of dollars, rounded to nearest tenth

		Authorization			Appropriation		
	Request	HASC	SASC	Conf.	HAC	SAC	Conf.
DDG-51 funding							
Procurement funding	5,253.3						
Economic Order Quantity (EOQ) Advance procurement (AP) funding	391.9						
Cost to complete funding for DDG-51s procured in prior years	54.0						
DDG-1000 funding							
Procurement funding	271.1						

Source: Table prepared by CRS based on Navy's FY2019 budget submission, committee and conference reports, and explanatory statements on FY2019 National Defense Authorization Act and FY2019 DOD Appropriations Act.

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.

Legislative Activity for FY2018

Summary of Congressional Action on FY2018 Funding Request

Table 3 summarizes congressional action on the Navy's FY2018 procurement funding requests for the DDG-51 and DDG-1000 programs, and its research and development funding request for the Air and Missile Defense Radar (AMDR).

Table 3. Congressional Action on FY2018 Funding Request

Millions of dollars, rounded to nearest tenth

		Authorization			Appropriation		
	Request	HASC	SASC	Conf.	HAC	SAC	Conf.
DDG-51 funding							
Procurement funding	3,499.1	5,395.9	5,058.1	5,283.1	3,499.1	3,329.1	3,357.1
Advance procurement (AP) funding	90.3	45.0	390.3	340.3	90.3	90.3	90.3
Cost to complete funding for DDG-51s procured in prior years	51.4	51.4	51.4	51.4	51.4	51.4	51.4
AMDR research and development (PE 0604522N, line 129)	32.1	32.1	32.1	32.1	32.1	32.1	32.1
DDG-1000 funding							
Procurement funding	224.0	224.0	174.0	174.0	165.0	224.0	217.0

Source: Table prepared by CRS based on Navy's FY2018 budget submission, committee and conference reports, and explanatory statements on FY2018 National Defense Authorization Act and FY20-18 DOD Appropriations Act.

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.

FY2018 National Defense Authorization Act (H.R. 2810/S. 1519/P.L. 115-91)

House Committee Report

The House Armed Services Committee, in its report (H.Rept. 115-200 of July 6, 2017) on H.R. 2810, recommended the funding levels for the DDG-51 and DDG-1000 programs shown in the HASC column of **Table 3**. The recommended increase of $1,896.8 million in procurement funding for the DDG-51 program includes $1,862.8 million for the procurement of an additional DDG-51, and $34 million for procurement of ship signal-exploitation equipment. (Page 419)

Section 125 of H.R. 2810 as reported states the following:

> SEC. 125. Multiyear procurement authority for Arleigh Burke class destroyers and associated systems.
>
> (a) Authority for multiyear procurement.—Subject to section 2306b of title 10, United States Code, the Secretary of the Navy may enter into one or more multiyear contracts, beginning with the fiscal year 2018 program year, for the procurement of—
>
> (1) up to 15 Arleigh Burke class Flight III guided missile destroyers at a rate of not more than three such destroyers per year during the covered period; and
>
> (2) the Aegis weapon systems, AN/SPY–6(v) air and missile defense radar systems, MK 41 vertical launching systems, and commercial broadband satellite systems associated with such vessels.
>
> (b) Baseline estimate.—Before entering into any contract for the procurement of an Arleigh Burke class destroyer under subsection (a), the Secretary of Navy shall determine a baseline estimate for the destroyer in accordance with section 2435 of title 10, United States Code.
>
> (c) Limitation.—The Secretary of the Navy may not enter into a contract for the procurement of a Arleigh Burke class destroyer or any major subprogram under subsection (a) if the contract would increase the cost of the destroyer by more than 10 percent above the baseline estimate for the destroyer determined under subsection (b).
>
> (d) Authority for advance procurement.—The Secretary may enter into one or more contracts, beginning in fiscal year 2018, for advance procurement associated with the vessels and systems for which authorization to enter into a multiyear procurement contract is provided under subsection (a).
>
> (e) Condition for out-year contract payments.—A contract entered into under subsection (a) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year after fiscal year 2018 is subject to the availability of appropriations or funds for that purpose for such later fiscal year.
>
> (f) Covered period defined.—The term "covered period" means the 5-year period beginning with the fiscal year 2018 program year and ending with the fiscal year 2022 program year.

Section 126 of H.R. 2810 as reported states the following:

> SEC. 126. Limitation on availability of funds for Arleigh Burke class destroyer.
>
> (a) Limitation.—None of the funds authorized to be appropriated by this Act or otherwise made available for fiscal year 2017 for procurement, that are unobligated as of the date of the enactment of this Act, may be obligated or expended to procure an Arleigh Burke

> class destroyer (DDG–51) unless not fewer than two covered destroyers include an AN/SPY–6(V) air and missile defense radar system.
>
> (b) Waiver.—The Secretary of the Navy may waive the limitation in subsection (a) if the Secretary determines that the cost or schedule risk associated with the integration of the AN/SPY–6(V) air and missile defense radar is unacceptable or incongruous with a business case that relies on stable design, technology maturity, and realistic cost and schedule estimates.
>
> (c) Covered destroyer defined.—In this section, the term "covered destroyer" means an Arleigh Burke class destroyer (DDG–51) for which funds were authorized to be appropriated by the National Defense Authorization Act for Fiscal Year 2016 (Public Law 114–92) or the National Defense Authorization Act for Fiscal Year 2017 (Public Law 114–328).

Regarding Section 126, H.Rept. 115-200 states the following:

> Section 126—Limitation on Availability of Funds for Arleigh Burke Class Destroyer
>
> This section would limit the obligation of certain funds to procure new air and missile defense radars for Arleigh Burke class destroyers unless the radars are AN/SPY–6(V) radar modular assembly (RMA) based. This section would authorize the Secretary of the Navy to a waive the limit if the Secretary determines that the cost or schedule risk associated with the integration of the AN/SPY–6(V) radar is unacceptable or incongruous with an appropriate business case.
>
> The committee recognizes that the Under Secretary of Defense for Acquisition, Technology, and Logistics, in his report to Congress required by the committee report (S. Rept. 114–49) accompanying the National Defense Authorization Act for Fiscal Year 2016 (Public Law 114–92), noted that the Navy's current radar program of record, AN/SPY–6(V) Air and Missile Defense Radar, was designed to be fully scalable and modular to support a variety of shipboard radar applications on a variety of platforms and that the radar modular assembly conforms to the Department of Defense's Better Buying Power initiative by leveraging open systems, common logistics, and software baselines, and by securing government data rights to both the hardware and software to affect affordability.
>
> The committee applauds the Navy's successful efforts to leverage RMA-based applications of AN/SPY–6(V) technologies as part of the Enterprise Air Surveillance Radar (EASR) program that provides critical capabilities for America-class amphibious assault ships, amphibious transport docks, and aircraft carrier-class combatants.
>
> The committee believes these efforts demonstrate the feasibility of integrating RMA-based solutions to existing ship designs. The committee believes that all future DDG–51 radar new construction procurements should remain consistent with the Navy's current destroyer modernization plan and leverage the AN/SPY–6(V) radar modular assembly architecture to minimize operation and sustainment costs, reduce training and logistical requirements, and maintain affordability through economies of scale with other programs like EASR. (Pages 39-40)

House Floor Action

On July 13, 2017, as part of its consideration of H.R. 2810, the House agreed to by voice vote H.Amdt. 188, an en bloc amendment that included, inter alia, amendment 19 as printed in H.Rept. 115-217 of July 13 (legislative day, July 12), 2017, on H.Res. 440, providing for the further consideration of H.R. 2810. As summarized in H.Rept. 115-217, amendment 19

> Amends section 126 to exclude FY16 DDG–51s from [the] bill provision's retroactive (or retroactive Flight 3) requirement and make it clear the Navy should bear contractual burden for majority of risk on initial FY17 DDG–51 Flight 3 ship construction.

Senate

The Senate Armed Services Committee, in its report (S.Rept. 115-125 of July 10, 2017) on S. 1519, recommended the funding levels for the DDG-51 and DDG-1000 programs shown in the SASC column of **Table 3**. The recommended net increase of $1,559 million in DDG-51 procurement funding includes an increase of $1,750 million for procuring an additional DDG-51, an increase of $34 million for "UFR: SSEE Inc F for DDG" (meaning an item on the Navy's FY2018 unfunded requirements list for Increment F of ship signal-exploitation equipment), and a reduction of $225 million reflecting the availability of prior-year funding. The recommended increase of $300 million in DDG-51 advance procurement (AP) funding is for additional economic order quantity purchases for the FY2018-FY2022 DFDGG-51 MYP contract. The recommended reduction of $50 million in DDG-1000 procurement funding is for "unjustified cost growth." (Page 402)

Section 122 of S. 1519 as reported states the following:

> SEC. 122. Arleigh Burke class destroyers.
>
> (a) Authority for multiyear procurement.—
>
> (1) IN GENERAL.—Subject to section 2306b of title 10, United States Code, the Secretary of the Navy may enter into one or more multiyear contracts, beginning not earlier than the fourth quarter of fiscal year 2018, for the procurement of up to 15 Arleigh Burke class Flight III guided missile destroyers.
>
> (2) AUTHORITY FOR ADVANCE PROCUREMENT.—The Secretary of the Navy may enter into one or more contracts, beginning in fiscal year 2018, for advance procurement associated with the destroyers for which authorization to enter into a multiyear procurement contract is provided under paragraph (1), and for systems and subsystems associated with such destroyers in economic order quantities when cost savings are achievable.
>
> (3) CONDITION FOR OUT-YEAR CONTRACT PAYMENTS.—A contract entered into under paragraph (1) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year after fiscal year 2018 is subject to the availability of appropriations or funds for that purpose for such fiscal year.
>
> (b) Modification to procurement of additional arleigh burke class destroyer.—Section 125(a)(1) of the National Defense Authorization Act for Fiscal Year 2016 (Public Law 114–92) is amended by striking "to be procured either" and inserting "to be procured using a fixed-price contract either".

Regarding Section 122, S.Rept. 115-125 states the following:

> **Arleigh Burke class destroyers (sec. 122)**
>
> The committee recommends a provision that would authorize the Secretary of the Navy to procure up to 15 Arleigh Burke-class Flight III guided missile destroyers under one or more multiyear contracts subject to section 2306b of title 10, United States Code, beginning no earlier than the fourth quarter of fiscal year 2018. This authority would be subject to the availability of appropriations or funds. The committee also recommends modifying the authority to procure an additional Arleigh Burke-class destroyer provided in section 125(a)(1) of the National Defense Authorization Act for Fiscal Year 2016 (Public Law 114–92).

> The committee notes this would be the fourth multiyear contract for the Arleigh Burke-class program. The Navy estimates that each of the previous three multiyear procurement contracts (fiscal years 1998–2001, 2002–2005, and 2013–2017) achieved savings of greater than $1.0 billion, as compared to annual procurements. For the fourth contract for fiscal years 2018–2022, the Navy is estimating savings of 9.3 percent, or in excess of $1.8 billion, for the multiyear procurement of 10 ships as compared to annual procurement contracts.
>
> The committee believes that should additional funds become available for Arleigh Burke-class Flight III guided missile destroyers, above what is planned in the fiscal year 2018 future years defense program, the Navy should obtain the benefits and savings of this authority for up to 15 ships.
>
> In authorizing procurement of an additional Arleigh Burke-class destroyer in section 125(a)(1) of the National Defense Authorization Act for Fiscal Year 2016 (Public Law 114–92), the committee's intent was and continues to be use of a fixed-price contract with a fair and reasonable cost as determined by the Navy service acquisition executive, which is consistent with the contracts for Arleigh Burke-class destroyers awarded in fiscal years 2011–2017 and planned for fiscal year 2018. (Pages 7-8)

Regarding the recommended increase in DDG-51 procurement funding, S.Rept. 115-125 states the following:

> **Arleigh Burke-class destroyers**
>
> The budget request included $3.5 billion in line item 9 of Shipbuilding and Conversion, Navy (SCN), for Arleigh Burke-class destroyers (DDG–51).
>
> The committee notes that the fiscal year 2016 budget request included funding for two Flight IIA DDG–51 ships and a Flight III engineering change proposal (ECP) to be applied to one of these two ships. The National Defense Authorization Act for Fiscal Year 2016 (Public Law 114–92) and Department of Defense Appropriations Act for Fiscal Year 2016 (Public Law 114–113) supported the budget request.
>
> The committee further notes that the Navy funded the two requested fiscal year 2016 Flight IIA DDG–51 ships on March 29, 2016. However, the committee is unaware of a plan to award the fiscal year 2016 Flight III ECP.
>
> The committee therefore recommends a decrease of $225.0 million for this program, because the fiscal year 2016 Flight III ECP funds can be applied to fiscal year 2018 Arleigh Burke-class destroyer requirements.
>
> The committee also recommends an increase of $1.8 billion for one additional Flight III Arleigh Burke-class destroyer.
>
> Accordingly, the committee recommends a net increase of $1.6 billion. (Pages 16-17)

Regarding the recommended increase in DDG-51 advance procurement (AP) funding, S.Rept. 115-125 states the following:

> **Arleigh Burke-class destroyer advance procurement**
>
> The budget request included $90.3 million in line item 10 of Shipbuilding and Conversion, Navy (SCN), for Arleigh Burke-class destroyer advance procurement.
>
> The committee believes that utilizing economic order quantity procurement across the proposed fiscal year 2018 to 2022 multiyear procurement contract should lead to greater cost savings and improved efficiency.
>
> Therefore, the committee recommends an increase of $300.0 million. (Page 17)

Regarding the recommended reduction in DDG-1000 program procurement funding, S.Rept. 115-125 states the following:

> **DDG–1000**
>
> The budget request included $224.0 million in line item 8 of Shipbuilding and Conversion, Navy (SCN), for the DDG–1000 program. Following a Nunn-McCurdy cost breach in 2010, the committee understands the Navy was directed to fund the DDG–1000 program to the higher cost estimate for fiscal years 2011 through 2015 provided by the Director of the Office of Cost Assessment and Program Evaluation, and to the Navy's cost estimate for fiscal year 2016 and beyond.
>
> While recognizing this cost estimating adjustment increased procurement costs, the committee is concerned by continued significant cost growth in this program across the fiscal year 2016 to 2020 period. In the fiscal year 2016, 2017, and 2018 budget requests, the Navy estimated $572.9 million, $914.3 million, and $1.1 billion, respectively, remaining in procurement costs across the three-ship program. The committee notes the program unit cost has risen above $6.4 billion and urges the Secretary of the Navy to take further measures to regain cost control.
>
> Therefore, the committee recommends a decrease of $50.0 million for this program. (Page 16)

S.Rept. 115-125 also states the following:

> **Navy large surface combatants**
>
> The committee notes that the Navy's 2016 Force Structure Assessment (FSA) sets a requirement for 355 ships in the battle force. While the current fleet includes 87 large surface combatants, the committee understands that the FSA calls for 104 large surface combatants. The committee believes that the Navy should maintain the two proven shipbuilding sources of large surface combatants. The committee emphasizes that the acquisition strategy for the next multiyear procurement contract should help sustain the dual-source large surface combatant shipbuilding base. (Page 36)

S.Rept. 115-125 also states the following:

> **DDG–1000**
>
> The budget request included $140.5 million in PE 24202N [in the Navy's research and development account] for the DDG–1000 program. [Note: This line item is not shown in **Table 3**.]
>
> The committee notes the budget request for this program element contains $121.2 million in cost growth in fiscal year 2018 and $222.3 million in cost growth over the fiscal year 2018 to 2020 period, as compared to the fiscal year 2017 budget request. The committee urges the Secretary of the Navy to take further measures to regain cost control.
>
> Therefore, the committee recommends a decrease of $50.0 million in PE 24202N for the DDG–1000 program for a total of $90.5 million.

Conference

The conference report (H.Rept. 115-404 of November 9, 2017) on H.R. 2810/P.L. 115-91 of December 12, 2018, recommended the funding levels for the DDG-51 and DDG-1000 programs shown in the authorization conference column of **Table 3**. The recommended increase of $1,784 million for DDG-51 procurement funding includes an increase of $1,750 million for an additional DDG-51 destroyer, and an increase of $34 million for ship signal exploitation equipment. The recommended increase of $250 million for DDG-51 advance procurement (AP) funding is for economic order quantity (EOQ) purchases for a FY2018-FY2022 DDG-51 multiyear

procurement (MYP) contract. The recommended reduction of $50 million for DDG-1000 procurement funding is for "Unjustified cost growth." (Page 1136)

Section 123 of the conference version of H.R. 2810 states:

> SEC. 123. Multiyear procurement authority for Arleigh Burke class destroyers.
>
> (a) Authority for multiyear procurement.—Subject to section 2306b of title 10, United States Code, the Secretary of the Navy may enter into one or more multiyear contracts for the procurement of up to 15 Arleigh Burke class Flight III guided missile destroyers.
>
> (b) Authority for advance procurement.—The Secretary of the Navy may enter into one or more contracts, beginning in fiscal year 2018, for advance procurement associated with the destroyers for which authorization to enter into a multiyear procurement contract is provided under subsection (a), and for systems and subsystems associated with such destroyers in economic order quantities when cost savings are achievable.
>
> (c) Condition for out-year contract payments.—A contract entered into under subsection (a) shall provide that any obligation of the United States to make a payment under the contract for a fiscal year after fiscal year 2018 is subject to the availability of appropriations or funds for that purpose for such later fiscal year.
>
> (d) Limitation.—The Secretary of the Navy may not modify a contract entered into under subsection (a) if the modification would increase the target price of the destroyer by more than 10 percent above the target price specified in the original contract awarded for the destroyer under subsection (a).

Regarding Section 123, H.Rept. 115-404 states:

> *Multiyear procurement authority for Arleigh Burke class destroyers (sec. 123)*
>
> The House bill contained a provision (sec. 125) that would authorize the Secretary of the Navy to enter into one or more multiyear contracts for Arleigh Burke-class destroyers and associated systems, in accordance with section 2306b of title 10, United States Code. The provision would also include a limitation on funds associated with section 2435 of title 10, United States Code.
>
> The Senate amendment contained a similar provision (sec. 122).
>
> The House recedes with an amendment that would remove requirements related to contract award timing and the additional Arleigh Burke-class destroyer provided in section 125(a)(1) of the National Defense Authorization Act for Fiscal Year 2016 (Public Law 114–92). The amendment would also prohibit contract modifications resulting in an increase of more than 10 percent to the original target price of a destroyer awarded under the authority provided by this section.
>
> The conferees note this would be the fourth multiyear contract for the Arleigh Burke-class program. The Navy estimates that each of the previous three multiyear procurement contracts (fiscal years 1998–2001, 2002–2005, and 2013–2017) achieved savings of greater than $1.0 billion, as compared to annual procurements. For the fourth contract for fiscal years 2018–2022, the Navy is estimating savings of 9.3 percent, or in excess of $1.8 billion, for the multiyear procurement of 10 ships as compared to annual procurement contracts. (Page 766)

Section 1051(k)(1) repeals a requirement established by Section 123(d) of the FY2006 National Defense Authorization Act (H.R. 1815/P.L. 109-163 of January 6, 2006) for providing a written notice of a change in the cost cap established by Section 123(a) for the fifth ship in the DDG-1000 destroyer program. (Procurement of DDG-1000s was subsequently ended after the procurement of the third ship.)

FY2018 DOD Appropriations Act (Division A of H.R. 3219/S. XXXX/Division C of H.R. 1625/P.L. 115-141)

House Committee Report

H.R. 3219 as reported by the House Appropriations Committee (H.Rept. 115-219 of July 13, 2017) was the FY2018 DOD Appropriations Act. H.R. 3219 as passed by the House is called the Make America Secure Appropriations Act, 2018. H.R. 3219 as passed by the House includes the FY2018 DOD Appropriations Act as Division A and four other appropriations acts as Divisions B through E. The discussion below relates to Division A.

The House Appropriations Committee, in its report (H.Rept. 115-219 of July 13, 2017) on H.R. 3219, recommended the funding levels for the DDG-51 and DDG-1000 programs shown in the HAC column of **Table 3**. The recommended reduction of $58.992 million in DDG-1000 procurement funding includes a reduction of $14 million for "total ship computing environment cost growth" and a reduction of $44.992 million for "VLS [vertical launch system] MK57 [Mark 57] 4-cell modules cost growth." (Page 161)

Section 8010 of H.R. 3219 provides MYP authority for, inter alia, "up to 10 DDG-51 Arleigh Burke class Flight III guided missile destroyers, the MK 41 Vertical Launching Systems, and associated Government-furnished systems and subsystems."

H.Rept. 115-219 states the following:

> DDG–51 DESTROYER
>
> The Committee understands that the two DDG–51 destroyers included in the recommendation for fiscal year 2018 are of the Flight III configuration. However, the Committee reiterates the position, as stated previously in the Consolidated Appropriations Act, 2017, that the Secretary of the Navy should award and complete the additional DDG–51 ship that was fully funded by Congress in fiscal years 2016 and 2017, as an additional DDG–51 Flight IIA ship and that this should be awarded expeditiously. (Page 162)

House Floor Action

On July 27, 2017, as part of its consideration of H.R. 3219, the House agreed to by voice vote an en bloc amendment that includes, inter alia, amendment 37 as printed in H.Rept. 115-261 of July 26, 2017, on H.Res. 478, providing for the further consideration of H.R. 3219. Amendment 37 Strikes the numerical limitation of "up to 10" for the DDG-51 MYP in Section 8010 of H.R. 3219 as reported (see above).

Senate

On November 21, 2017, the Senate Appropriations Committee released a Chairman's recommendation and explanatory statement for the FY2018 DOD Appropriations Act, referred to here as S. XXXX. The explanatory statement recommended the funding levels shown in SAC column of **Table 3**. The recommended reduction of $170 million DDG-51 procurement funding is for "Restoring acquisition accountability: AMDR previously funded." (Page 106)

Section 8010 of S. XXXX provides MYP authority for, inter alia,

> up to 10 DDG–51 Arleigh Burke class Flight III guided missile destroyers, the MK41 Vertical Launching Systems, and associated Government-furnished systems and subsystems.... *Provided further*, That the multiyear procurement authority for the DDG–

> 51 program provided for by this section shall be subject to the certification requirement in section 2306b(i)(1) of title 10, United States Code, with the cost analysis in connection with such certification to be current as of the date of such certification and to be submitted to Congress at the same time as the budget of the President for fiscal year 2019 is submitted to Congress under section 1105 of title 31, United States Code."

Regarding the MYP authority provided in Section 8010, the explanatory statement states:

> *DDG 51 Destroyer.*—The fiscal year 2018 budget request includes $3,499,079,000 for the procurement of two DDG–51 Arleigh Burke class Flight III guided missile destroyers. The Committee supports the Department of the Navy's plans to procure additional DDG-51s, including the request for Multi Year Procurement Authority of up to ten DDGs from fiscal year 2018 to fiscal year 2022 at a cost of $17,865,433,000, a cost avoidance of $1,833,209,000 compared to annual pricing. However, the Committee notes that subsequent to the delivery of the fiscal year 2018 budget request, two DDG–51 Flight III ships have gone under contract. The Committee also notes that the Government Accountability Office [GAO] has expressed concerns about the Navy's limited detail design knowledge to support the current Flight III procurement strategy in GAO report 16–613. Therefore, the Committee directs the Director, Cost Assessment and Program Evaluation, to provide with the fiscal year 2019 budget submission an updated Independent Cost Estimate for the DDG–51 Multi Year Procurement program. This report is also addressed in section 8010 of this bill.
>
> Further, the Secretary of the Navy shall report to the congressional defense committees no later than February 28, 2018, on the multiyear acquisition strategy to include a contracting plan that addresses workload balance, stability and viability for both shipbuilders. (Page 107)

Conference

The FY2018 DOD Appropriations Act was enacted as Division C of H.R. 1625/P.L. 115-141 of March 23, 2018, the Consolidated Appropriations Act, 2018. The explanatory statement for Division C of H.R. 1625 provides the funding levels for the DDG-51 and DDG-1000 programs shown in the appropriation conference column of **Table 3**. The reduction of $142 million for DDG-51 procurement is for "AMDR previously funded;" the reduction of $7.0 million for DDG-1000 procurement is for "Total ship computing environment cost growth" (PDF page 168 of 391).

Section 8010 of Division C of H.R. 1625/P.L. 115-141 provides authority for multiyear procurement (MYP) contracts, including, inter alia, "DDG-51 Arleigh Burke class Flight III guided missile destroyers, the MK41 Vertical Launching Systems, and associated Government-furnished systems and subsystems."

The explanatory statement states:

> DDG-51 DESTROYER
>
> The agreement provides $3,357,079,000 for the procurement of two DDG-51 Arleigh Burke class Flight III guided missile destroyers. The Director of Cost Assessment and Program Evaluation is directed to provide an updated independent cost estimate for the DDG-51 multi-year procurement program to the congressional defense committees not later than 90 days after the enactment of this Act. (pdf page 165 of 391)

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:[30]

- **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.[31]

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.[32]

New Technologies

The DDG-1000 incorporates a significant number of new technologies, including a wave-piercing, tumblehome hull design for reduced detectability,[33] 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,[34] a total-ship computing system for moving information about

[30] 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).

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

[32] For more on Navy ship names, see CRS Report RS22478, *Navy Ship Names: Background for Congress*, by (name r edacted) .

[33] 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.

[34] 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 new 155mm gun called the Advanced Gun System (AGS).

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[35] and GD/BIW.

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

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

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

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,

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

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.[36]

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 security and that there are no alternatives to the program that will provide acceptable capability to meet the joint military requirement at less cost.[37]

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.[38] 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

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

[37] 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) .

[38] 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.

acquisition unit cost (PAUC)—one of two measures used under the Nunn-McCurdy provision for measuring cost growth[39]—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.[40] 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 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.[41]

[39] 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.

[40] 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.

[41] 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.

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.[42] 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."[43]

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%, 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]."

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

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

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.[44]

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 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.

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

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.[45]

December 2016 DOT&E Report

The January 2018 report from DOD's Director of Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2017[46]—mentions the DDG-1000 program several times in passing in sections focused on other Navy programs, but does not contain a section focused on the DDG-1000 program itself.

The December 2016 report from DOD's Director of Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2016—did contain a section focused on the DDG-1000 program, which stated the following:

Assessment

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

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

[46] Department of Defense, *Director, Operational Test and Evaluation, FY 2017 Annual Report*, January 2018, 356 pp.

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.[47]

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