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

Updated March 2, 2020

Congressional Research Service
https://crsreports.congress.gov
RL32109

CRS REPORT
Prepared for Members and
Committees of Congress

Summary

The Navy began procuring Arleigh Burke (DDG-51) class destroyers, also known as Aegis destroyers, in FY1985, and a total of 85 have been procured through FY2020, including three in FY2020. The Navy's proposed FY2021 budget requests funding for the procurement of two more DDG-51s, which would be the 86th and 87th ships in the class.

DDG-51s are being procured in FY2018-FY2022 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 revised design, called the Flight III 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 two DDG-51s requested for procurement in FY2020 at $3,836.9 million, or an average of $1,918.5 million each. The ships have received $796.6 million in prior-year 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 FY2021 budget requests the remaining $3,040.3 million in procurement funding needed to complete the estimated procurement cost of the two DDG-51s, as well as $29.3 million in EOQ funding for DDG-51s to be procured under the MYP contract, and $9.6 million in cost-to-complete procurement funding to cover cost growth on DDG-51s procured in prior fiscal years, bringing the total amount of procurement funding requested for the DDG-51 program for FY2021 to $3,079.2 million, excluding outfitting and post-delivery costs.

The Navy wants to procure the first ship of a new class of large surface combatants in FY2028. Under the Navy's plan, FY2027 would be the final year of DDG-51 procurement.

Issues for Congress for FY2021 for the DDG-51 program include the following:

- whether to approve, reject, or modify the Navy's FY2021 funding request for the DDG-51 program;
- a projected reduction under the Navy's FY2021 budget submission in the number of DDG-51s to be procured in FY2023-FY2025, compared to previous Navy plans for DDG-51 procurement in those fiscal years, and how this relates, if at all, to a possible change in the surface force architecture that Navy leaders have been talking about since 2019; and
- cost, schedule, and technical risk in the Flight III DDG-51 effort.

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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 FY2021 budget requests funding for the procurement of two DDG-51s. Decisions that Congress makes concerning destroyer procurement could substantially affect Navy capabilities and funding requirements, and the U.S. shipbuilding industrial base.

For an overview of the strategic and budgetary context in which the DDG-51, DDG-1000, and other Navy shipbuilding programs may be considered, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by Ronald O'Rourke.[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 Levels

In December 2016, the Navy released a goal to achieve and maintain a Navy of 355 ships, including 104 LSCs. At the end of FY2019, the Navy's force of LSCs totaled 89 ships, including 22 Ticonderoga (CG-47) class cruisers[3] and 67 Arleigh Burke (DDG-51) class destroyers. Under the Navy's FY2020 30-year (FY2020-FY2049) shipbuilding plan, the Navy is to achieve a force of 104 large surface combatants by FY2029.[4]

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[1] See also CRS Report R43838, *Renewed Great Power Competition: Implications for Defense—Issues for Congress*, by Ronald O'Rourke, and CRS Report R44891, *U.S. Role in the World: Background and Issues for Congress*, by Ronald O'Rourke and Michael Moodie.

[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] 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.

[4] For additional information, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by Ronald O'Rourke.

DDG-51 Program

Overview

The DDG-51 program was initiated in the late 1970s,[5] and the first DDG-51 was procured in FY1985. The DDG-51 program is one of the longest-running shipbuilding programs in Navy history, and the DDG-51 class, in terms of number of hulls, is one of the Navy's largest classes of ships since World War II.

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 several times over the years. Many DDG-51s (and also some CG-47s) have a capability for conducting ballistic missile defense (BMD) operations.[6]

[5] 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.

[6] 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

As mentioned above, the first DDG-51 was procured in FY1985. It entered service in 1991. A total of 85 DDG-51s have been procured through FY2020, including 62 in FY1985-FY2005 and 23 in FY2010-FY2020. (In FY2007-FY2009, during the time when the Navy was not procuring DDG-51s, the Navy instead procured three Zumwalt (DDG-1000) class destroyers, which are discussed below.)

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 certain changes, including the addition of a helicopter hangar. A total of 47 Flight IIA DDG-51s (i.e., DDG-79 through DDG-124, plus DDG-127)[7] 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, as well as associated changes to the ship's electrical power and cooling systems. 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 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.

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 AMDR—the primary radar for the Aegis system on Flight III DDG-51s—is made by Raytheon.

Modernization and Service Life Extension

The Navy is modernizing its existing DDG-51s (and some of its CG-47s) so as to maintain their mission and cost-effectiveness out to the end of their projected service lives. In April 2018, the Navy announced that it wants to extend the service lives of all DDG-51s to 45 years—an increase of 5 or 10 years over previous plans to operate DDG-51s to age 35 or 40. Doing this, the Navy said, would permit the Navy to achieve a total of 355 ships by 2034, or about 20 years earlier than under the FY2019 budget submission, although the resulting 355-ship fleet of the 2030s would have more destroyers and fewer ships of other kinds (including attack submarines and aircraft carriers) than called for in the 355-ship force-level goal.

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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 Ronald O'Rourke.

[7] 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.

Older CRS reports provide additional historical and background information on the DDG-51 program.[8]

DDG-1000 Program

In FY2007-FY2009, during the time when the Navy was not procuring DDG-51s, the Navy instead procured three Zumwalt (DDG-1000) class destroyers. The Navy plans no further procurement of DDG-1000s. The Navy's proposed FY2021 budget requests $78.2 million in procurement funding to help complete the total procurement cost of the three DDG-1000 class ships.

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). 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.[9] The Navy to date has not announced a replacement munition for the AGSs.[10]

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 on surface strike, meaning the use of missiles to attack surface ships and perhaps also land targets.[11] 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.

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

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[8] 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 to congressional clients 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 to congressional clients directly from the author).

[9] 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.

[10] 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.

[11] 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; David B. Larter, "The Navy's Stealth Destroyers to Get New Weapons and a New Mission: Killing Ships," *Defense News*, February 15, 2018.

Surface Combatant Construction Industrial Base

All cruisers, destroyers, and frigates procured since FY1985 have been built at GD/BIW and HII/Ingalls. 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.

FY2021 Funding Request

The Navy estimates the combined procurement cost of the two DDG-51s requested for procurement in FY2020 at $3,836.9 million, or an average of $1,918.5 million each. The ships have received $796.6 million in prior-year 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 FY2021 budget requests the remaining $3,040.3 million in procurement funding needed to complete the estimated procurement cost of the two DDG-51s, as well as $29.3 million in EOQ funding for DDG-51s to be procured under the MYP contract, and $9.6 million in cost-to-complete procurement funding to cover cost growth on DDG-51s procured in prior fiscal years, bringing the total amount of procurement funding requested for the DDG-51 program for FY2021 to $3,079.2 million, excluding outfitting and post-delivery costs.

The Navy's proposed FY2021 budget also requests $78.2 million in procurement funding to help complete the total procurement cost of the three DDG-1000 class ships.

Issues for Congress

FY2021 Funding Request

One issue for Congress for FY2021 is whether to approve, reject, or modify the Navy's FY2021 funding request for the DDG-51 program. In considering this issue, Congress may consider, among other things, whether the Navy has accurately priced the work it is proposing to do in the DDG-51 program in FY2021.

Projected DDG-51 Procurement Rate in FY2023-FY2025

Overview

Another issue for Congress is a projected reduction under the Navy's FY2021 budget submission in the number of DDG-51s to be procured in FY2023-FY2025, compared to previous Navy plans for DDG-51 procurement in those fiscal years, and how this relates, if at all, to a possible change in the surface force architecture that Navy leaders have been talking about since 2019.

Table 1 shows projected procurement rates for DDG-51s and a next-generation LSC called the Future LSC under the Navy's FY2020 and FY2021 budget submissions. As can be seen in the table, for the periods FY2023-FY2025, the Navy's FY2021 budget submission projects the procurement of four surface combatants (all DDG-51s), while the Navy's FY2020 budget submission had projected the procurement of nine surface combatants (eight DDG-51s plus the first Future LSC).

Table 1. DDG-51 and Future LSC Procurement, FY2021-FY2025

Under Navy's FY2020 and FY2021 budget submissions

	FY21	FY22	FY23	FY24	FY25	Total FY21-FY25
FY2020 budget						
DDG-51	2	2	3	3	2	12
Future LSC	0	0	0	0	1	1
Total	**2**	**2**	**3**	**3**	**3**	**13**
FY2021 budget						
DDG-51	2	2	1	2	1	8
Future LSC	0	0	0	0	0	0
Total	**2**	**2**	**1**	**2**	**1**	**8**

Source: Table prepared by CRS based on Navy's FY2020 and FY2021 budget submissions.

Navy officials have stated that under the Navy's FY2021 budget submission, the procurement of the first Future LSC has been deferred from FY2025 to FY2028, in part to provide more time for the maturation of new technologies that the Navy envisions incorporating into that ship. The reduction under the Navy's FY2021 budget submission in the number of DDG-51s projected for procurement in FY2023-FY2025, meanwhile, may reflect a potential change in the surface force architecture that Navy leaders have been talking about since 2019. This change is discussed further in the next section

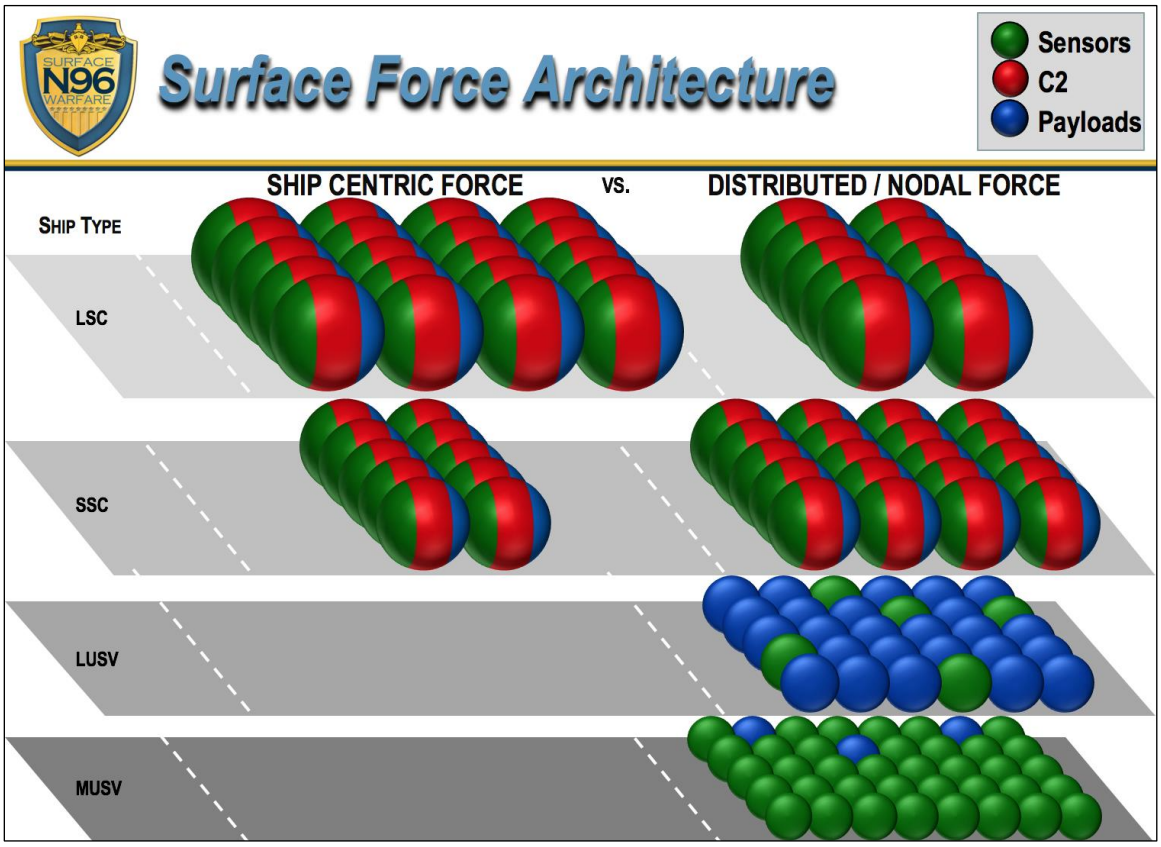
Potential Change in Surface Force Architecture

The Navy's current force-level goal of 355 ships, including 104 large surface combatants (i.e., cruisers and destroyers), is the result of a Force Structure Analysis (FSA) that the Navy conducted in 2016. The Navy conducts a new or updated FSA every few years, and it is currently conducting a new FSA that is scheduled to be completed by the end of 2019. Navy officials have suggested that the Navy in coming years may shift to a new surface force architecture that will include a smaller proportion of large surface combatants, a larger proportion of small surface combatants, and a third tier of numerous unmanned surface vehicles (USVs). Some observers believe the results of the new FSA may reflect this potential new surface force architecture.

Figure 2 shows a Navy briefing slide depicting the potential new surface force architecture, with each sphere representing a manned ship or USV. Consistent with **Figure 2**, the Navy's current 355-ship goal calls for a Navy with twice as many large surface combatants (104) as small surface combatants (52). **Figure 2** suggests that the potential new surface force architecture could lead to the obverse—a planned force mix that calls for twice as many small surface combatants than large surface combatants—along with the new third tier of USVs.[12]

Figure 2. Navy Briefing Slide on Surface Force Architecture

Each sphere represents a ship or a USV



Source: Illustration accompanying Megan Eckstein, "Sea Hunter Unmanned Ship Continues Autonomy Testing as NAVSEA Moves Forward with Draft RFP," *USNI News*, April 29, 2019. The illustration was also included as Slide 2 in a Navy briefing entitled "Designing & Building the Surface Fleet: Unmanned and Small Combatants," by Rear Admiral Casey Moton at a June 20, 2019, conference of the American Society of Naval Engineers (ASNE).

Notes: Each sphere represents a ship or a USV. LSC means large surface combatant (i.e., cruiser or destroyer); SSC means small surface combatant (i.e., frigate or Littoral Combat Ship); LUSV means large USV; MUSV means medium USV. Spheres with multiple colors (the LSCs and SSCs) are ships equipped with a combination of sensors (green), command and control (C2) equipment (red), and payloads (including weapons) (blue). Spheres with single colors (the USVs) are equipped with either payloads (blue) or sensors (green).

A January 15, 2019, press report states

[12] For additional discussion of this possible change in surface force architecture, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by Ronald O'Rourke.

> The Navy plans to spend this year taking the first few steps into a markedly different future, which, if it comes to pass, will upend how the fleet has fought since the Cold War. And it all starts with something that might seem counterintuitive: It's looking to get smaller.
>
> "Today, I have a requirement for 104 large surface combatants in the force structure assessment; [and] I have [a requirement for] 52 small surface combatants," said Surface Warfare Director Rear Adm. Ronald Boxall. "That's a little upside down. Should I push out here and have more small platforms? I think the future fleet architecture study has intimated 'yes,' and our war gaming shows there is value in that."[13]

An April 8, 2019, press report states that Navy discussions about the future surface fleet include

> the upcoming construction and fielding of the [FFG(X)] frigate, which [Vice Admiral Bill Merz, the deputy chief of naval operations for warfare systems] said is surpassing expectations already in terms of the lethality that industry can put into a small combatant.
>
> "The FSA may actually help us on, how many (destroyers) do we really need to modernize, because I think the FSA is going to give a lot of credit to the frigate—if I had a crystal ball and had to predict what the FSA was going to do, it's going to probably recommend more small surface combatants, meaning the frigate … and then how much fewer large surface combatants can we mix?" Merz said.
>
> An issue the Navy has to work through is balancing a need to have enough ships and be capable enough today, while also making decisions that will help the Navy get out of the top-heavy surface fleet and into a better balance as soon as is feasible.
>
> "You may see the evolution over time where frigates start replacing destroyers, the Large Surface Combatant [a future cruiser/destroyer-type ship] starts replacing destroyers, and in the end, as the destroyers blend away you're going to get this healthier mix of small and large surface combatants," he said—though the new FSA may shed more light on what that balance will look like and when it could be achieved.[14]

Potential Oversight Questions

Potential oversight questions for Congress include the following:

- To what degree, if any, does the reduction in the projected number of DDG-51s to be procured in FY2023-FY2025 reflect the potential change in surface force architecture that Navy leaders have been talking about?
- In terms of potential shipyard workloads and employment levels, how might a reduction in DDG-51 procurement in FY2023-FY2025 be offset by procurement of Navy FFG(X) frigates,[15] Navy amphibious ships,[16] Coast Guard National Security Cutters (NSCs), and Coast Guard Offshore Patrol Cutters (OPCs)?[17] To what degree, if at all, are Navy and Coast Guard officials assessing the collective

[13] David B. Larter, "US Navy Moves Toward Unleashing Killer Robot Shps on the World's Oceans," Defense News, January 15, 2019.

[14] Megan Eckstein, "Navy Sees No Easy Answer to Balance Future Surface Fleet," *USNI News*, April 8, 2019. Ellipsis as in original.

[15] For more on the FFG(X) program, see CRS Report R44972, *Navy Frigate (FFG[X]) Program: Background and Issues for Congress*, by Ronald O'Rourke.

[16] For more on Navy amphibious ship programs, see CRS Report R43543, *Navy LPD-17 Flight II and LHA Amphibious Ship Programs: Background and Issues for Congress*, by Ronald O'Rourke.

[17] For more on the NSC and OPC programs, see CRS Report R42567, *Coast Guard Cutter Procurement: Background and Issues for Congress*, by Ronald O'Rourke.

potential impacts on the shipbuilding industrial base of developments regarding procurement of DDG-51s, FFG(X)s, amphibious ships, NSCs, and OPCs?

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

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

October 2019 CBO Report

An October 2019 Congressional Budget Office (CBO) report on the cost of the Navy's shipbuilding programs stated the following about the Flight III DDG-51:

> To meet combatant commanders' goal of improving future ballistic missile defense capabilities beyond those provided by existing DDG-51s—and to replace 15 Ticonderoga class cruisers when they are retired in the 2020s—the Navy is substantially modifying the design of the DDG-51 Flight IIA destroyer to create a Flight III configuration. That modification will incorporate the new Air and Missile Defense Radar (AMDR) or SPY-6, which will be larger and, recent testing indicates, nearly 100 times more powerful than the radar on current DDG-51s. For the AMDR to operate effectively in the new Flight III configuration, however, the ships must have a greater capacity to generate electrical power and cool major systems.
>
> With those improvements incorporated into the design of the Flight III and the associated increases in the ships' displacement, CBO estimates that the average cost per ship over the entire production run would be $1.8 billion—about 7 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. Completion of the first Flight III ship is several years away.[18]

May 2019 GAO Report

A May 2019 Government Accountability Office (GAO) report assessing selected DOD acquisition programs stated the following in its assessment of the Flight III DDG-51:

> **Current Status**
>
> The Navy and the shipbuilders completed Flight III detail design activities in December 2017. As compared to Flight IIA, the Flight III design included considerable changes to the ship's hull, mechanical, and electrical systems to incorporate the AMDR program's SPY-6 radar, and changes to restore ship weight and stability safety margins. To reduce technical risk, the Navy plans to field all but one—the SPY-6 radar—of the program's four mature critical technologies on other ship classes before integration with Flight III. In 2018, however, the Navy identified software-related deficiencies affecting SPY-6 that delayed delivery of a radar array for power and integration testing with the Aegis combat system by at least 1 year. Despite these delays, the Navy plans to complete testing, install the radar on the ship, and activate the combat system for shipboard testing by January 2022.
>
> The Navy expects to complete a draft test and evaluation master plan for Flight III by early 2022. The Navy and the Director, Operational Test and Evaluation continue to disagree on whether the use of a self-defense test ship equipped with Aegis and the SPY-6 radar is necessary to validate performance during operational test and evaluation….

[18] Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2020 Shipbuilding Plan*, October 2019, p. 24.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office said that it has delivered 67 DDG 51 class ships since its inception in 1985 and the class remains in serial production at both new construction shipyards.[19]

Regarding the AMDR specifically, the report stated the following:

Technology Maturity and Design Stability

The program office reported that AMDR's four critical technologies are mature—although we disagree—and that the system design is stable. Since our 2018 assessment, the program office has further demonstrated the radar system's performance and capabilities through live testing and simulation. However, based on industry best practices, the program cannot fully demonstrate all critical technologies until the Navy tests them in their realistic, at-sea environment with the Aegis combat system. According to the AMDR program schedule, such testing will occur in 2023 during operational testing with a DDG 51 Flight III ship. Until the Navy completes this testing, the program's design stability remains at risk for disruption. Specifically, any performance deficiencies the Navy discovers during at-sea testing could require it to revise existing design drawings to remedy issues.

As part of developmental testing, the program office tested a full-scale, single-face radar array at the Navy's Pacific Missile Range Facility (PMRF) beginning in September 2016. The program office successfully completed several live ballistic missile defense, anti-air, and anti-surface warfare tests. However, in March 2018, the array failed a ballistic missile test because of a defective software update that caused the array to stop tracking a live target. Officials said a software update corrected the issue and they verified the array's performance through a successful retest in January 2019. Officials said the single-face array, originally scheduled to support Aegis combat system equipment testing, will undergo additional testing at PMRF through 2019. As a result, the Navy has revised the acquisition schedule and will instead divert the delivery of a new array to support land-based Aegis combat system equipment testing sometime in 2019.

The program has completed software development to support core radar capabilities and will continue to develop radar updates to support system improvements, cybersecurity, and combat system integration through 2021. In parallel to the radar's software development, significant software development remains to integrate AMDR with the Aegis combat system. Program officials said this software development must complete before both systems can be fully integrated and tested. While the Navy plans to test the radar and initial Aegis combat system software at a land-based site, the Navy will not test the radar and final Aegis combat system until both are installed on the lead ship. Any issues identified after the systems are installed on the lead ship could require retrofits to the radar or ship.

Production Readiness

Nearly 18 months after entering production, the program has not demonstrated that all of its critical manufacturing processes are in statistical control. The program reported that it exercised a contract option for the fourth low-rate initial production unit in April 2018 and was authorized to procure five additional low-rate production units in February 2019. However, in August 2018, the contractor reported early cost growth and schedule variance for the first three low-rate production units because of increased material costs and other production delays. Officials said the delays are partly due to a problem with a digital receiver component, which the contractor is testing. As a result, contractor delivery of the first production radar is at risk of delay from December 2019 to April 2020.

[19] Government Accountability Office, *Weapon Systems Annual Assessment[:] Limited Use of Knowledge-Based Practices Continues to Undercut DOD's Investments*, GAO-19-336SP, May 2019, p. 131.

The AMDR program office plans to procure more than two-thirds of its 22 total radars prior to completing operational testing. The Navy deliberately planned for AMDR to begin production prior to the start of Aegis upgrade software development to allow time for key radar technologies to mature and for the design to stabilize. However, this concurrency means any deficiencies identified during combat system integration or operational testing may lead to retrofitting after production is underway or complete for many of the radars. Any required retrofitting is likely to increase program costs or delay radar deliveries.

Other Program Issues

DOD's Director, Operational Test and Evaluation (DOT&E) has yet to approve the AMDR Test and Evaluation Master Plan. DOT&E stated that the proposed test approach for the AMDR and DDG 51 Flight III programs does not provide realistic operational conditions without the use of an AMDR- and Aegis-equipped unmanned self-defense test ship. Because the Navy has elected not to request funds for a test ship, DOT&E and the Navy are revising the DDG 51 Flight III operational test strategy to include AMDR operational requirements and an updated simulation strategy. DOT&E cautioned, however, that DDG 51 Flight III's self-defense and survivability capabilities will not be fully known until the program completes operational testing.

Program Office Comments and GAO Response

We provided a draft of this assessment to the program office for review and comment. In its comments, the program office disagreed with our assessment of the program's technology maturity, stating that combat system testing is not required to demonstrate mature radar technologies since the technologies have been tested and proven at the land-based PMRF site. We disagree. The PMRF site does not provide a realistic, at-sea environment to test the fit and function of the radar and combat system on a ship.[20]

Legislative Activity for FY2021

Summary of Congressional Action on FY2021 Funding Request

Table 2 summarizes congressional action on the Navy's FY2021 procurement funding requests for the DDG-51 and DDG-1000 programs.

Table 2. Congressional Action on FY2021 Funding Request

Millions of dollars, rounded to nearest tenth

		Authorization			Appropriation		
	Request	HASC	SASC	Conf.	HAC	SAC	Conf.
DDG-51 procurement	3,040.3						
DDG-51 EOQ advance procurement (AP)	29.3						
DDG-51 cost to complete	9.6						
DDG-1000 procurement	78.2						

Source: Table prepared by CRS based on Navy's FY2021 budget submission, committee and conference reports, and explanatory statements on FY2021 National Defense Authorization Act and FY2021 DOD Appropriations Act.

[20] Government Accountability Office, *Weapon Systems Annual Assessment[:] Limited Use of Knowledge-Based Practices Continues to Undercut DOD's Investments*, GAO-19-336SP, May 2019, p. 100.

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

Appendix. Additional Background Information on DDG-1000 Program

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

Overview

The DDG-1000 program was initiated in the early 1990s.[21] The DDG-1000 (**Figure A-1**) 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.)

Figure A-1. DDG-1000 Class Destroyer

Source: U.S. Navy photo 151207-N-ZZ999-435, posted December 8, 2015, with a caption that reads in part: "The future USS Zumwalt (DDG 1000) is underway for the first time conducting at-sea tests and trials in the Atlantic Ocean Dec. 7, 2015."

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,[22] to improve the Navy's general capabilities for operating in defended littoral

[21] 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.

[22] 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.

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.[23]

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[24] 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.[25]

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:[26]

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[23] For more on the CG(X) program, see CRS Report RL34179, *Navy CG(X) Cruiser Program: Background for Congress*, by Ronald O'Rourke.

[24] For more on integrated electric-drive technology, see CRS Report RL30622, *Electric-Drive Propulsion for U.S. Navy Ships: Background and Issues for Congress*, by Ronald O'Rourke.

[25] 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.

[26] 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-

- **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.[27]

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.[28]

New Technologies

The DDG-1000 incorporates a significant number of new technologies, including a wave-piercing, tumblehome hull design for reduced detectability,[29] 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,[30] a total-ship computing system for moving information about 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).

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).

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[31] and GD/BIW.

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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).

[27] For more on the LCS program, see CRS Report RL33741, *Navy Littoral Combat Ship (LCS) Program: Background and Issues for Congress*, by Ronald O'Rourke.

[28] For more on Navy ship names, see CRS Report RS22478, *Navy Ship Names: Background for Congress*, by Ronald O'Rourke.

[29] 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.

[30] For more on integrated electric-drive technology, see CRS Report RL30622, *Electric-Drive Propulsion for U.S. Navy Ships: Background and Issues for Congress*, by Ronald O'Rourke.

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

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, 2007, the Navy announced that it had decided to build the first DDG-1000 at GD/BIW, and the second at HII/Ingalls.

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

On April 8, 2009, it was reported that the Navy had reached an agreement with HII/Ingalls and GD/BIW to shift the second DDG-1000 to GD/BIW, and to have GD/BIW build all three ships. HII/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

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

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).

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 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).[33]

Increase in Estimated Procurement Cost

As shown in **Table A-1** below, the estimated combined procurement cost for all three DDG-1000s, as reflected in the Navy's annual budget submission, has grown by $4,298.5 million, or 47.9%, since the FY2009 budget (i.e., the budget for the fiscal year in which the third DDG-1000 was procured).

[33] For additional discussion, see CRS Report R43838, *Renewed Great Power Competition: Implications for Defense—Issues for Congress*, by Ronald O'Rourke, and CRS Report RL33153, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, by Ronald O'Rourke.

Table A-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%)
FY20	13,195.5	+163.3 (+1.3%)	+4,218.4 (+47.0%)
FY21	13,275.6	+80.1 (+ 0.6%)	+4,298.5 (+47.9%)

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

Some of the cost growth in the earlier years in the table was caused by the truncation of the DDG-1000 program from seven ships to three, which caused some class-wide procurement-rated costs that had been allocated to the fourth through seventh ships 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 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 discussion below), 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.[34]

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

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.[35]

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.[36] Since the DDG-1000 program has roughly $9.3 billion in research and development costs, truncating the program to three ships increased to roughly $3.1 billion the average amount of research and development costs that are included in the average acquisition cost (i.e., average research and development cost plus procurement cost) of each DDG-1000. The resulting increase in program acquisition unit cost (PAUC)—one of two measures used under the Nunn-McCurdy provision for measuring cost growth[37]—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.[38] 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.

[35] For more on the Nunn-McCurdy provision, see CRS Report R41293, *The Nunn-McCurdy Act: Background, Analysis, and Issues for Congress*, by Moshe Schwartz and Charles V. O'Connor.

[36] 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.

[37] 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.

[38] 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.

- 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.[39]

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.[40] 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 the following: "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."[41]

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.)

[39] 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.

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

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

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]."

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.[42]

Technical Risk and Test and Evaluation Issues

May 2019 GAO Report

A May 2019 GAO report assessing selected major DOD weapon acquisition programs stated the following of the DDG-1000 program:

> **Technology Maturity and Design Stability**
>
> The DDG 1000 program has fully matured most, but not all, of its nine current critical technologies and reports a stable design. According to the Navy, the fire suppression system, hull form, deckhouse, power system, and undersea warfare suite technologies are all mature. At the same time, the vertical launch system, infrared signature, multi-function radar, and total ship computing environment technologies each continue to approach maturity. The Navy expects to fully mature these systems as it completes ship construction, certification, and testing over the next 2 years.
>
> The program originally had 12 critical technologies, but in the last several years, the Navy removed three, including two technologies associated with the advanced gun system—the projectile and the gun—because of the projectile's high cost per round. The Navy planned to rely on these munitions for precision fires and offensive operations. Following an

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

evaluation of five other munition options, the Navy determined that no viable replacement, guided or unguided, was feasible. As a result, the guns will remain inoperable on the ships for the foreseeable future. Lastly, the Navy will use a modified multi-function radar in place of a volume search radar, which the Navy removed from the class.

As we have previously reported, the Navy and its shipbuilders had not stabilized DDG 1000's design by lead ship fabrication start in 2009—an approach inconsistent with best practices. This approach contributed to numerous design changes after the fabrication start and significant cost increases and schedule delays. Nearly 10 years later, development and shipboard testing of technologies continues, each of which could lead to discovery that could disrupt the design stability the Navy currently claims.

The Navy plans to complete software development for the class in September 2020—a delay of 24 months since our 2018 assessment. As a result, the Navy has had to delay some testing. Also that month, the program plans to complete its cyber security vulnerability evaluation along with the remainder of a 2-year regimen of certifications and several different tests. The Navy expects this regimen to demonstrate the full functionality of the ship's systems.

Production Readiness

The DDG 1000 shipbuilder is approaching completion of the hull, mechanical, and electrical (HM&E) systems for all three ships of the class. Shipbuilder delivery of the lead ship's HM&E occurred 18 months behind schedule, in part because of problems completing electrical work associated with the ship's power system. The shipbuilder also experienced problems completing the power system for DDG 1001, the second ship in the class. Following sea trials, the Navy inspected one of the ship's main turbine generators and found that the generator was damaged by a woodscrew. The damage was extensive enough that the Navy chose to replace the engine and send it for repair. Officials report that the shipbuilder delivered the ship in April 2018 and the Navy replaced the engine in September 2018 at its expense.

The Navy has scheduled DDG 1000's final delivery, including HM&E and combat systems, for May 2019. The Navy has scheduled DDG 1001's final delivery to follow in September 2020. However, the Navy is still working to correct serious deficiencies that its Board of Inspection and Survey has identified on both ships. Specifically, the board found over 320 serious deficiencies when the shipbuilder delivered DDG 1000's HM&E in May 2016, and 246 serious deficiences after the Navy conducted acceptance trials for DDG 1001 in January and February 2018. This increases the likelihood that the ship will not be fully capable and sustainable when provided to the fleet.

To limit further delays to DDG 1000 and DDG 1001 construction, the Navy has authorized its shipbuilder to take parts from DDG 1002—the third and final ship of the class, which is under construction. The Navy does not yet know the full extent to which these actions will delay DDG 1002's construction schedule, but stated that these parts typically can be borrowed and replaced without causing a delay. The Navy has scheduled the ship's HM&E delivery in March 2020 followed by final delivery in September 2022.

Other Program Issues

In a January 2018 decision memorandum, the Navy changed DDG 1000's primary mission from land attack to offensive surface strike. Navy officials are in the process of determining the operational concept for the ship within its new mission. The Navy has yet to establish testing plans to evaluate these future mission sets. According to Navy officials, the Navy's planned modifications to support the new mission will cost about $1 billion, from non-acquisition accounts.

Program Office Comments

We provided a draft of this assessment to the program office for review and comment. The program office provided technical comments, which we incorporated where appropriate. The program office also stated that it is making good progress delivering the Zumwalt class. The Navy said that, since our assessment, DDG 1000 completed combat systems availability, combat tests are underway, and final delivery is now planned for September 2019. The program office also said that DDG 1001 started combat systems availability in April 2019, and DDG 1002 is 84 percent constructed. The program office further noted that future addition of new systems onto Zumwalt-class ships will provide offensive fire capabilities.[43]

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[43] Government Accountability Office, *Weapon Systems Annual Assessment[:] Limited Use of Knowledge-Based Practices Continues to Undercut DOD's Investments*, GAO-19-336SP, May 2019, p. 106