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Report to Congressional Committees

August 2016

ARLEIGH BURKE DESTROYERS

Delaying Procurement of DDG 51 Flight III Ships Would Allow Time to Increase Design Knowledge

GAO-16-613

GAO Highlights

Highlights of GAO-16-613, a report to congressional committees

August 2016

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Delaying Procurement of DDG 51 Flight III Ships Would Allow Time to Increase Design Knowledge

Why GAO Did This Study

Over the next 10 years, the Navy plans to spend more than $50 billion to design and procure 22 Flight III destroyers, an upgrade from Flight IIA ships. Flight III ships will include the new SPY-6 radar system and Aegis (ballistic missile defense) combat system upgrades. The Navy's MYP approach requires the Navy to seek authority to do so from Congress.

House report 114-102 included a provision for GAO to examine the Navy's plans for the DDG 51 Flight III ships and AMDR. This report assesses (1) the status of efforts to develop, test, and integrate SPY-6 and Aegis in support of Flight III; (2) challenges, if any, associated with the Navy's plans to design and construct Flight III ships; and (3) the Flight III acquisition approach and oversight activities, among other issues. GAO reviewed key acquisition documents and met with Navy and other DOD officials and contractors.

What GAO Recommends

Congress should consider requiring an update of estimated savings for the current DDG 51 MYP to reflect the addition of Flight III ships. The Navy should delay procurement of the lead Flight III ship and refrain from seeking authority for a MYP contract until it can meet criteria required for seeking this authority. DOD should also designate Flight III as a major subprogram to improve oversight. DOD partially concurred with all three recommendations but is not planning to take any new actions to address them. GAO continues to believe the recommendations are valid.

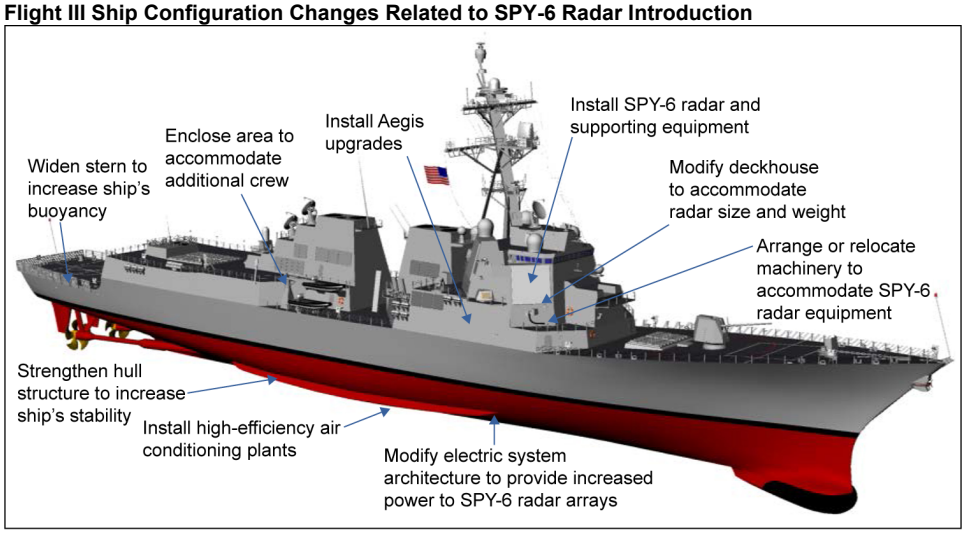
View GAO-16-613. For more information, contact Michele Mackin at (202) 512-4841 or mackinm@gao.gov.

What GAO Found

The Air and Missile Defense Radar (AMDR) program's SPY-6 radar is progressing largely as planned, but extensive development and testing remains. Testing of the integrated SPY-6 and full baseline Aegis combat system upgrade—beginning in late 2020—will be crucial for demonstrating readiness to deliver improved air and missile defense capabilities to the first DDG 51 Flight III ship in 2023. After a lengthy debate between the Navy and the Department of Defense's (DOD) Director of Operational Test and Evaluation, the Secretary of Defense directed the Navy to fund unmanned self-defense test ship upgrades for Flight III operational testing, but work remains to finalize a test strategy.

Flight III ship design and construction will be complex—primarily due to changes needed to incorporate SPY-6 onto the ship, as shown in the figure.

Flight III Ship Configuration Changes Related to SPY-6 Radar Introduction



Source: GAO (analysis); Navy (image and data). | GAO-16-613

The Navy has not demonstrated sufficient acquisition and design knowledge regarding its Flight III procurement approach and opportunities exist to enhance oversight. If the Navy procures the lead Flight III ship in fiscal year (FY) 2016 as planned, limited detail design knowledge will be available to inform the procurement. In addition, the Navy's anticipated cost savings under the FY 2013-2017 Flight IIA multiyear procurement (MYP) plan do not reflect the planned addition of Flight III ships. While the Navy did not update its cost savings with Flight III information, doing so would increase transparency and could help inform expected savings under the next MYP. The Navy plans to request authority to award new Flight III MYP contracts (FY 2018-2022) in February 2017. The Navy will be asking Congress for this authority to procure nearly half of Flight III ships before being able to meet the criteria to seek this authority. For example, detail design will not be complete and costs will not be informed by any Flight III construction history. Finally, Flight III cost and schedule performance is not distinguished from that of the overall DDG 51 ship class in annual reports to Congress. Establishing Flight III as a major subprogram would improve reporting and offer greater performance insight.

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Abbreviations

ACAT	Acquisition category
ACB	Advanced capability build
AMDR	Air and Missile Defense Radar
AWC	Air warfare commander
CAPE	Cost Assessment and Program Evaluation
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
FY	Fiscal year
IAMD	Integrated air and missile defense
IWS	Integrated Warfare Systems
MAMDJF	Maritime and Missile Defense of Joint Forces
MYP	Multiyear procurement
NDAA	National Defense Authorization Act
PEO	Program Executive Office
USD (AT&L)	Under Secretary of Defense for Acquisition, Technology, and Logistics

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U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
Washington, DC 20548

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Congressional Committees

Over the next 10 years, the Navy plans to spend more than $50 billion to design and procure 22 newly-configured DDG 51 Arleigh Burke-class destroyers—referred to as DDG 51 Flight III—to defend against air, surface, and subsurface threats. These ships are expected to provide the Navy's primary large surface combatant capability for the foreseeable future, with initial operational capability planned for 2023. Flight III ships are expected to include the new SPY-6 radar being developed by the Navy's Air and Missile Defense Radar (AMDR) program. The inclusion of SPY-6 necessitates changes to the design and the construction of the existing DDG 51 ship. The SPY-6 radar, in conjunction with an Aegis combat system upgrade, is expected to deliver advanced integrated air and missile defense (IAMD) capabilities, which enable simultaneous missile and air defense for the fleet. In 2012, we expressed concerns with the Navy's planned acquisition approach for Flight III, particularly as it related to the ship procurement strategy and program oversight.[1] The Department of Defense (DOD) subsequently elevated oversight for Flight III, with the Undersecretary of Defense for Acquisition, Technology, and Logistics (USD (AT&L)) overseeing the program's activities and working to ensure cost and schedule baselines are established that account for the program's design and technical risks.

House Report 114-102, related to a bill for the National Defense Authorization Act (NDAA) for Fiscal Year 2016, included a provision for GAO to examine risks associated with the Navy's planned acquisition strategy for DDG 51-class ships and the AMDR program, including, among other things, the development, test, and integration plans for these programs.[2] This report assesses (1) the status of the Navy's efforts to develop, test, and integrate the SPY-6 radar and Aegis combat system in

[1] GAO, *Arleigh Burke Destroyers: Additional Analysis and Oversight Required to Support the Navy's Future Surface Combatant Plans,* GAO-12-113 (Washington, D.C.: Jan. 24, 2012).

[2] H.R. Rep. No. 114-102, at 27-28 (2015). This report accompanied H.R. 1735, which was vetoed by the president on October 22, 2015. Instead, S. 1356 became the NDAA for Fiscal Year 2016, Pub. L. No. 114-92 when it was signed into law on November 25, 2015.

support of DDG 51 Flight III, including plans for operational testing; (2) challenges, if any, associated with the Navy's plans to design and construct Flight III ships; (3) the Flight III acquisition approach and oversight activities, including reporting on cost, schedule, and performance; and (4) the capabilities that Flight III ships are expected to provide and the extent to which these capabilities fulfill the Navy's existing and future surface combatant needs. We are also issuing a classified annex, *Arleigh Burke Destroyers: Classified Annex to GAO-16-613, Delaying Procurement of DDG 51 Flight III Ships Would Allow Time to Increase Design Knowledge,* GAO-16-846C, which contains supplemental information related to operational testing and the use of an unmanned self-defense test ship to demonstrate Flight III self-defense capabilities. The annex will be available upon request to those with the appropriate clearance and a validated need to know.

To conduct our work, we reviewed documentation from and interviewed DOD officials responsible for weapon systems requirements, acquisition, and testing, as well as contractor representatives involved with DDG 51-class ship construction and major weapon systems development related to Flight III. Our work included assessment of the design, development, test, and procurement activities for DDG 51, AMDR, Aegis, and other related programs, such as the Evolved Sea Sparrow Missile. We also reviewed DOD studies and past GAO work concerning Navy requirements and acquisition activities for its surface combatants to assess the decision to pursue DDG 51 Flight III and how this ship configuration is expected to address current and future threats. For more information on our scope and methodology, see appendix I.

We conducted this performance audit from July 2015 to August 2016 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

The Navy delivered its first DDG 51 destroyer in April 1991, and 62 ships currently operate in the fleet. Two shipbuilders (Bath Iron Works Corporation in Bath, Maine, and Huntington Ingalls Industries in Pascagoula, Mississippi) build DDG 51 destroyers, with four separate configurations in the class (Flights I, II, IIA, and III) that reflect upgrades over the last 25 years to address the growing and changing capability

demands on the Navy's surface combatants. Table 1 provides details on each DDG 51 configuration.

Table 1: DDG 51 Ship Configurations

DDG 51	Fiscal years	Ship Designation	Number of ships	Description
Flight I	1985-1992	DDG 51-71	21	Original design, including the SPY-1D radar for area defense anti-air warfare capability.
Flight II	1992-1994	DDG 72-78	7	Incorporated improvements to the SPY radar and communications systems, and added active electronic countermeasures
Flight IIA	1994-2016	DDG 79-124[a]	46	Added, among other improvements, mine-avoidance capability, helicopter hangars for MH-60 helicopters, and advanced networked systems.
Flight III	2016-	TBD	22 (planned)	Primary changes related to introduction of SPY-6 radar; includes structural changes, improved damage stability, a new electrical plant and new cooling plants.

Source: GAO analysis of Navy data. I GAO-16-613

[a]The Navy has not yet established the ship designation for the forty-sixth Flight IIA ship; the Navy added this ship in fiscal year 2016 in response to additional DDG 51 ship construction funding provided by Congress.

Introduction of DDG 51 Flight III

In 2007, the Navy determined, based on its Maritime and Missile Defense of Joint Forces (MAMDJF) Analysis of Alternatives, that a larger, newly-designed surface combatant ship with a very large radar was needed to address the most stressing ballistic and cruise missile threats. In response to the MAMDJF Analysis of Alternatives results, the Navy initiated development of a new cruiser, known as CG(X), and AMDR (SPY-6)—an advanced, scalable radar with a physical size that can be changed as needed to respond to future threats. Subsequently, in 2008, the Navy expressed an increasing need for greater integrated air and missile defense capability. Noting that DDG 51 ships demonstrated better performance than DDG 1000 ships for ballistic missile defense, area air defense, and some types of anti-submarine warfare, the Navy determined to restart production of DDG 51 Flight IIA ships to combat the increasing ballistic missile threats.[3]

[3] The Navy had planned to end DDG 51 production in 2011 and shift its attention toward the new DDG 1000 Zumwalt-class destroyer and CG(X).

In January 2009, USD (AT&L) issued a memorandum stating that the Navy's plan to buy additional DDG 51 Flight IIA ships would be followed by a procurement of either DDG 1000- or DDG 51-based destroyers that could carry the SPY-6 radar. To fulfill this demand, the Navy conducted a limited study in 2009, referred to as the Radar/Hull Study, which examined existing DDG 51 and DDG 1000 designs with several different radar concepts to determine which pairing would best address the integrated air and missile defense needs at lower cost than the planned CG(X). Following the Radar/Hull Study, the Navy validated the need for a larger, newly designed surface combatant with a very large radar to counter the most stressing threats. However, based on the analysis of the Radar/Hull Study, the Navy decided to pursue a new DDG 51 configuration instead—now referred to as DDG 51 Flight III—that would include a new advanced, but smaller, radar and an upgraded Aegis combat system.[4] The Navy also cancelled the CG(X) program.

We found in 2012 that the Navy's decision to pursue new DDG 51 destroyers equipped with a new air and missile defense radar represented a substantial commitment that was made without a solid analysis and that the planned oversight and visibility into the program was insufficient given the level of investment and potential risks. We also found that the Navy's plan to buy the Flight III lead ship as part of an existing multiyear procurement of Flight IIA ships was not sound due to a lack of design and cost knowledge about the Flight III ships. Multiyear contracting is a special contracting method used to acquire known requirements for up to 5 years if, among other things, a product's design is stable and the technical risk is not excessive. Based on our findings, we recommended that 1) the Navy complete a thorough analysis of alternatives for a future surface combatant program; 2) DOD increase the level of oversight for DDG 51 Flight III by changing the program designation to acquisition category (ACAT) 1D; and 3) the planned fiscal year 2013 DDG 51 multiyear procurement request not include a Flight III

[4] A combat system is a naval defense architecture that uses computers to integrate sensors, such as a radar with shipboard weapon systems, and can recommend weapons to the sailor through a command and control function.

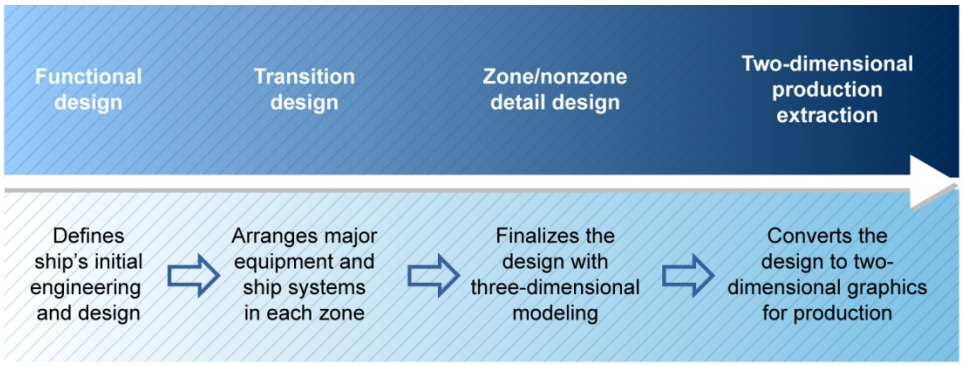
ship.[5] Subsequent to our recommendations, the DDG 51 program was elevated to ACAT 1D status—with Flight III remaining an upgrade within the overall program—but a new analysis of alternatives was not undertaken and the fiscal year 2013 DDG 51 multiyear procurement was awarded as planned, with the Navy intending for the lead Flight III ship to be part of this procurement.

Flight III Shipbuilding

The two existing DDG 51-class shipbuilders—Bath Iron Works and Huntington Ingalls Industries—will complete design changes to the existing DDG 51 hull form to support Flight III configuration needs and will construct the ships. In February 2015, the Navy modified its existing design contracts with the shipbuilders to begin Flight III detail design work, with initial construction planned for 2018. The detail design process, as shown in figure 1, begins at a high level for the overall ship. As the needs for the ship are better defined, the granularity of the design for individual units, or zones, of the ship comes into focus.

[5] According to DOD Instruction 5000.02 *Operation of the Defense Acquisition System* (Jan. 7, 2015), a program is designated as ACAT 1 if it is either a Major Defense Acquisition Program—defined as a program identified by DOD with a dollar value for all increments estimated to require eventual total expenditure for research, development, test, and evaluation of more than $480 million, or for procurement of more than $2.79 billion, in fiscal year 2014 constant dollars—or if it is designated by the Milestone Decision Authority as a special interest program. For ACAT 1C, the head of the DOD component (e.g. Navy, Army, or Air Force) is generally the Milestone Decision Authority. For ACAT 1D, the Defense Acquisition Executive—USD (AT&L)—is generally the Milestone Decision Authority.

Figure 1: Shipbuilders' Detail Design Process for DDG 51 Flight III



Source: Navy and shipbuilder data. | GAO-16-613

The shipbuilders use computer-aided design product models to design the ship. The product models generate a detail design, which allows engineers at the shipbuilders to visualize spaces and test the design. This validates elements of the design prior to construction, thereby avoiding potentially costly rework. During product modeling, the designers finalize the interfaces between zones, complete the design for ship-wide cables and pipes, and add all detail necessary to support ship construction. The Navy reviews the progress of each zone when it is 50 and 90 percent complete with product modeling. At these critical reviews, the Navy and other stakeholders assess the zone design progress and provide input to ensure that the design meets specifications. Once a zone is 50 percent complete, more detailed design tasks are undertaken by the shipbuilders to finalize and incorporate all outstanding data from the key systems. When the zone is 90 percent complete, it is essentially considered to be finished with detail design, and the shipbuilder will subsequently convert the design into drawings to support construction.[6]

IAMD Systems for Flight III

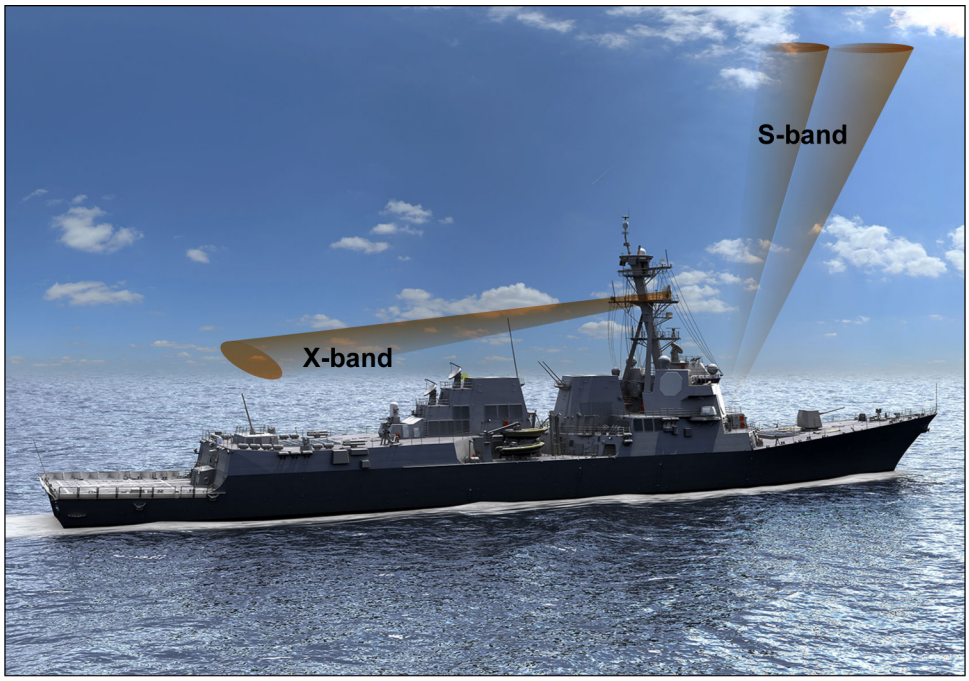
The Navy's AMDR program, which began development in 2013, will provide key IAMD capability for Flight III. The program includes engineering and manufacturing development of a new S-band radar—

[6] The two-dimensional drawings include build strategies, construction drawings, and final lists of needed construction materials.

known as SPY-6—that is being executed by the Raytheon Company to provide volume search capability for air and ballistic missile defense. The radar is expected to have a sensitivity for long-range detection and engagement of advanced threats of at least “SPY+15”, referring to its improved capability compared to the current SPY-1D(V) radar used on existing DDG 51 ships.[7] In addition, the contractor is developing a radar suite controller to provide radar resource management and coordination, and to interface with the Aegis combat system upgrades for Flight III. The Navy is leveraging an existing X-band radar—SPQ-9B—to provide horizon and surface search capabilities, as well as navigation and periscope detection and discrimination functions for the majority of currently planned Flight III ships. The Navy intends to develop a new X-band radar with improved capabilities that will be installed on later Flight III ships. Figure 2 depicts a notional employment of the S-band and X-band radars on a Flight III ship.

[7] For a radar like SPY-6, “SPY+” is used by the Navy to quantify the difference (in decibels) equating to the increase in target tracking range for a fixed amount of resources over the SPY-1D(V) radar on existing DDG 51 ships. For example, SPY+15 has a 32 times better signal to noise factor—or intensity of the returning radar signal echoing off a target over the intensity of background noise—than a SPY-1D(V) radar.

Figure 2: Radar Capabilities on Notional DDG 51 Flight III Ship



Source: GAO (analysis); © 2015 Raytheon Company (image). | GAO-16-613

Along with AMDR development, the Navy is working with the prime contractor for the Aegis combat system—Lockheed Martin—to upgrade the system for Flight III ships. Aegis, which integrates ship sensors and weapons systems to engage anti-ship missile threats, has been providing the Navy with some form of surface defense capability for decades. Over that time, the system has been regularly upgraded, with Aegis Advanced Capability Builds (ACB) providing new, expanded capabilities. The most recently completed build—ACB 12—provides initial integrated air and missile defense capability for DDG 51 Flight IIA ships.[8] ACB 16 is currently in development and is expected to provide, among other things, new electronic warfare capability and expanded missile capability options.

[8] The ACB number denotes the year (i.e., ACB 12 is 2012) that the software is expected to be installed and initially tested on a ship or land-based platform—an event known as Aegis Light Off.

Flight III will incorporate ACB 20, a combat system upgrade that includes support for the SPY-6 radar.

Developmental and Operational Testing

As with any DOD weapon system, test and evaluation activities are an integral part of developing and producing DDG 51 Flight III, AMDR, and Aegis systems. Test activities provide knowledge of system capabilities and limitations as they mature and are eventually delivered to the warfighter.

Developmental testing is intended to provide feedback on the progress of a system's design process and its combat capability as it advances toward initial production or deployment. For Flight III systems, developmental testing occurs at contractor or government land-based test sites, and will eventually expand to include testing of systems on board the ship after installation—known as shipboard testing.

Operational test and evaluation is intended to assess a weapon system's capability in a realistic environment when employed in combat conditions against simulated enemies. During this testing, the ship is exposed to as many operational scenarios as practical to reveal the weapon system's capability under stress. The Navy's operational test agency plans and executes operational testing for DDG 51 and AMDR, as well as other selected programs—such as Aegis. The Director, Operational Test and Evaluation (DOT&E) within the Office of the Secretary of Defense coordinates, monitors, and reviews operational test and evaluation for major defense acquisition programs.[9] DOT&E's statutory responsibilities include (1) approval of test and evaluation master plans and operational test plans for systems subject to its oversight, (2) analyzing the results of the operational test and evaluation conducted for such systems to determine whether the test and evaluation performed were adequate and whether the results confirm the operational effectiveness and suitability

[9] By law, DOT&E is responsible for overseeing the operational test and evaluation of all major defense acquisition programs, as well as any other acquisition programs it determines should be designated for oversight. Non-major defense acquisition programs typically receive DOT&E oversight if they require joint or multi-service testing, have a close relationship to or are a key component of a major program, are an existing system undergoing major modification, or are of special interest—often based on input or action from Congress.

for combat, and (3) reporting the evaluation results of operational testing to the Secretary of Defense and congressional defense committees.[10]

Radar Development Is on Schedule, with Considerable Development, Testing, and Integration with the Combat System Remaining to Meet Flight III Needs

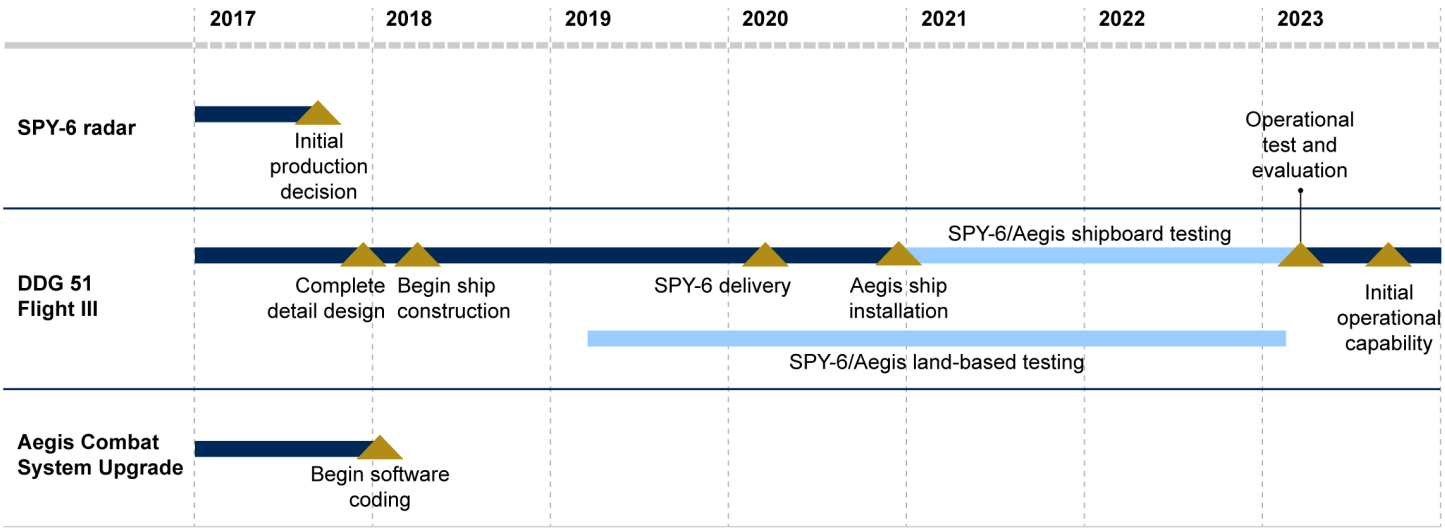
The Navy's AMDR program is progressing largely as planned toward final developmental testing of the SPY-6 radar. An extensive technology developmental phase for the new radar helped increase the maturity of critical technologies, thereby reducing risk prior to beginning the program. Barring any setbacks during final developmental testing, the Navy plans to make an initial production decision for the SPY-6 radar in September 2017 and deliver the first radar to the shipyard for installation on the lead Flight III ship in 2020. In contrast, the Navy is still defining requirements for the Aegis combat system ACB 20 upgrades for Flight III and will not begin development until 2018. The Aegis development schedule appears ambitious when compared to previous combat system iterations and presents risks for shipboard testing. Further, integrating the Aegis combat system with the SPY-6 radar requires a significant amount of development and testing in a relatively short period of time, relying on concurrent land-based and shipboard testing; the Navy's target date for initial operational capability of Flight III ships is 2023.[11] Although the Navy is making a concerted effort to reduce risks associated with integrating the radar and combat system, the benefits of these efforts will be largely unknown until the start of combat system development and testing in 2018. The Navy must also complete an integrated test strategy and receive approval from DOT&E. After a lengthy debate with DOT&E over the need for an unmanned self-defense test ship equipped with Aegis and SPY-6 in initial operational test and evaluation plans, the Navy has begun to budget for the test ship at the direction of the Secretary of Defense.

Figure 3 provides an overview of planned and completed activities for SPY-6, Aegis upgrade, and Flight III, including the anticipated time frame for installing the radar and combat system upgrade onto the ship and conducting operational testing.

[10] 10 U.S.C. §§ 139, 2399.

[11] Requirements to reach initial operational capability include: 1) initial operational test and evaluation is successfully completed; 2) all maintenance and training materials, including embedded maintenance training and technical manuals, are available to a ship's crew; and 3) logistics support is in place, including onboard spares, supply support, and shore-based distance support.

Figure 3: Integrated Schedule for SPY-6 Radar, Aegis Combat System Upgrade, and DDG 51 Flight III Ships



Source: GAO analysis of Navy documentation. | GAO-16-613

The Navy Has Made Progress Maturing SPY-6 Radar Technologies, with Key Developmental Testing Remaining to Demonstrate Radar Capability

Prior to the start of the AMDR program, a 2-year technology development phase from 2010 to 2012 helped mature critical technologies required for the SPY-6 radar and reduce technical risk for the program. Table 2 describes the AMDR program's four critical technologies for SPY-6 and their development status.

Table 2: Status of SPY-6 Critical Technologies

Technology	Description	Status
Transmit/receive modules	Individual units containing both gallium arsenide- and gallium nitride-based semiconductors that emit the radar signal	Modules have been tested in a relevant environment via developmental testing, and have completed lifetime testing to demonstrate reliability.
Distributed receiver/exciters	Includes (1) dual channel converters, (2) auxiliary power/controller card, and (3) frequency synthesizer, which collectively create the waveforms and convert signals to S-band	Final assembly test failures with distributed receiver/exciter units required fixes and additional testing. Land-based testing at the Advanced Radar Detection Laboratory in Hawaii will support final resolution of issues.

Technology	Description	Status
Digital beamforming	Advanced software algorithms that digitize the radar signal into beams and enable simultaneous generation and processing of multiple beams	Final delivery of the digital beamforming software was completed in May 2016. Some activities were deferred until after shipment of the SPY-6 array engineering development model (e.g., production-representative system) to the Advanced Radar Detection Laboratory.
Multi-mission scheduling and discrimination software	Capable of performing integrated air & missile defense missions simultaneously; adapts to mission circumstances continuously to identify the best way to respond to those circumstances, and includes a flexible architecture able to run multiple databases and algorithms simultaneously and easily add features as a threat evolves	Multi-mission schedule has been operational since 2015 using engineering and manufacturing development software. Discrimination software has been employed in the high fidelity Raytheon Air & Missile Simulation, which is operational and in use by the Navy.

Source: GAO analysis of Navy and contractor data. I GAO-16-613

In 2012, we found that two of the technologies—digital beamforming and transmit/receive modules—had challenges to overcome in order to achieve the required capabilities.[12] At that time, the ability to use gallium nitride-based semiconductors, which provide higher power and efficiency than previously used materials, was untested on a radar the size of SPY-6. The Navy has since demonstrated each of the critical technologies using prototypes during the technology development phase, including a full-scale, single-face SPY-6 radar array engineering development model to demonstrate radar capability.[13] According to Raytheon, performance of this SPY-6 engineering development model has exceeded requirements, demonstrating SPY+17 decibels (greater than 50 times the sensitivity of the SPY-1D(V) radar currently being fielded on DDG 51 Flight IIA ships).

More recently, the prime contractor experienced some challenges with digital beamforming and distributed receiver/exciter technologies that the Navy, Defense Contract Management Agency, and Raytheon indicated have been, or are being, addressed. As reported by the Defense Contract

[12] GAO-12-113.

[13] An engineering development model—which can be viewed as an advanced prototype of a system and, in the case of SPY-6, is a production-representative system—is acquired during the engineering and manufacturing development phase of the DOD acquisition process and is built from approved critical design review drawings. It may be used for developmental and operational testing to demonstrate maturing performance during the latter stages of development and to finalize proposed production specifications and drawings.

Management Agency, Raytheon and its subcontractors significantly underestimated the design, development, and test efforts required for these technologies to meet their performance requirements, leading to some cost growth but no delay to the start of the final developmental test phase in summer 2016.[14] Final developmental testing will include testing the SPY-6 engineering development model in a maritime environment for the first time at the Navy's land-based Advanced Radar Detection Laboratory in Hawaii, including live tracking of air, surface, and ballistic missile targets. These tests will help validate previous modeling and simulation tests at the prime contractor's facilities. Final developmental testing is expected to be completed in time to inform an AMDR program low-rate initial production decision by USD (AT&L) in September 2017. The first SPY-6 radar system is scheduled to be delivered to the shipyard constructing the lead Flight III ship in 2020; this radar will be used in shipboard testing with Aegis ACB 20 in the lead up to Flight III initial operational capability, which is planned for 2023.

Despite Navy Efficiency Efforts, Aegis Upgrade Development Schedule Is Optimistic

The Aegis combat system upgrade—ACB 20—planned for DDG 51 Flight III will require significant changes to the version of Aegis currently fielded on DDG 51 Flight IIA ships in order to introduce new and expanded IAMD capabilities. Requirements for ACB 20 are not expected to be fully defined until the program completes its System Requirements Review planned for August 2016, but the Navy has established plans to field ACB 20 capabilities in two phases. The first phase—known as Phase 0—is intended to meet baseline anti-air, anti-surface, and anti-submarine warfare capability requirements for Flight III initial operational capability. The Navy has indicated that the first three Flight III ships will include Phase 0 capabilities. Improved ballistic missile defense and electronic warfare systems are expected to be introduced on Flight III ships as part of ACB 20 Phase 1 beginning in fiscal year 2025.

Extensive Changes Needed to Integrate ACB 20 with the SPY-6 Radar

The most extensive ACB 20 changes involve the replacement of the legacy SPY-1D(V) radar with the new SPY-6 radar. According to Lockheed Martin, ACB 20 must include an expanded and modified interface between the SPY-6 radar and the Aegis combat system in order

[14] The Defense Contract Management Agency provides oversight to help ensure that DOD, Federal, and allied government supplies and services provided by contractors are delivered on time, at projected cost, and meet all performance requirements.

to address the significant increase in data generated by the new radar. In general, the interface changes are intended to ensure data are packaged to take advantage of the radar's capabilities and effectively provide operators with information to support IAMD needs. Table 3 outlines the Aegis combat system changes that are needed to interface with the SPY-6 radar.

Table 3: Expected Interface Changes for the Aegis Combat System Related to the SPY-6 Radar

Combat system functions	Functional changes related to SPY-6
Radar tasking and control	• A single combat system source will now provide the radar with requests for services • Combat system must now assign radar activity priorities (e.g., acquiring a track) • Combat system will exclusively assign mission priorities (e.g., ballistic missile defense engagement) • New resource management scheme will communicate radar settings, modes, and states
Track management	• Combat system will use individual track reports tailored for different users to support interoperability across the combat system, instead of a single combined report
Training and test support	• Combat system must be tailored to stimulate the enhanced SPY-6 capability
Weapons control	• Additional layer added to radar's interface for missile communications
Operator control and displays	• Operator will now direct radar taskings through the combat system instead of directly controlling the radar • Combat system displays and interface must be modified to support SPY-6 functionality

Source: GAO analysis of Navy data. I GAO-16-613

Ambitious Schedule for Developing ACB 20

We found in 2012 that the Navy eliminated integration of SPY-6 from ACB 16 plans, effectively deferring integration activities to the ACB 20 upgrade. We concluded that this plan would leave little margin for addressing any problems with the radar's ability to communicate with the combat system before Flight III's initial operational capability in 2023.[15] Since that time, the Navy and Lockheed Martin have established an

[15] GAO-12-113.

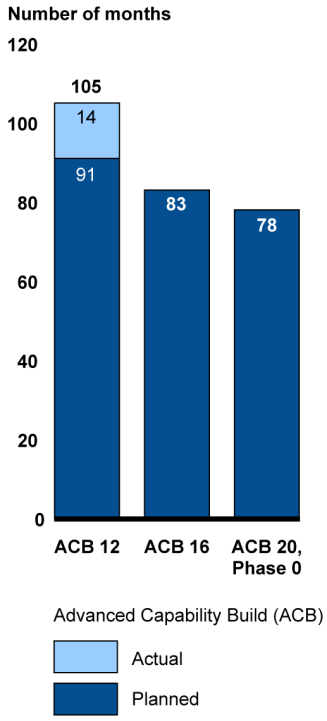
ambitious schedule for ACB 20 development. The schedule is optimistic, particularly due to ACB 20's interdependencies with the ACB 16 capabilities that are still being developed. For example, recent changes to ACB 16—which will provide the base capability for ACB 20—may affect the Navy's ability to achieve the ACB 20 schedule. Specifically, the Navy added requirements to ACB 16 that resulted in a 184 percent increase in new and modified software code for ACB 16. As a result, ACB 16 software development will take longer than planned and will overlap with ACB 20 development. This introduces the potential for software deficiencies discovered during ACB 16 development to negatively affect the ACB 20 development schedule.

In addition, our comparison of the ACB 20 schedule to the schedule for the most recently fielded Aegis build—ACB 12—indicates that ACB 20 has a significantly shorter development timeline. ACB 12, which included a significant capability upgrade to enable limited IAMD for the first time on DDG 51-class ships, required substantially more development time than the Navy has planned for ACB 20. We found in 2012 that the Navy experienced several setbacks during ACB 12 development and testing, including challenges with coordinating combat system and ballistic missile defense development and testing, as well as an underestimation of the time and effort required to develop and integrate the signal processor with the radar, which led to schedule delays and cost growth.[16]

Figure 4 compares the planned timeline from the System Requirements Review—a review to ensure readiness to proceed into initial system development—to certification of the build's capabilities for ACB 12, ACB 16, and ACB 20, Phase 0.

[16] GAO-12-113.

Figure 4: Comparison of Aegis Advanced Capability Build (ACB) Development Timelines from Requirements Setting to Certification



Source: GAO analysis of Department of Defense (DOD) data. | GAO-16-613

ACB 20 Development Relies on Concurrent Shipboard and Land-Based Testing

To execute this aggressive ACB 20 development plan, the Navy plans to test the fully-developed ACB 20 Phase 0 for the first time after testing begins on the lead Flight III ship at the end of 2020, adding risk to the program.[17] This decision stems, in part, from the Navy's late response to a July 2014 Navy requirements directive to redefine ACB 20 core capabilities, contributing to a 17-month delay for the ACB 20 requirements review. Conducting initial tests of the fully-developed ACB

[17] ACB 20 Phase 0 is scheduled to undergo contractor demonstration in February 2021, which effectively provides the full ACB 20 Phase 0 capability. The demonstration, which is overseen by the Navy, represents a point at which the prime contractor expects to demonstrate that all Aegis Combat System Engineering Agent contract requirements are met. Any open items with the system are expected to be addressed prior to ACB 20 Phase 0 final certification in 2023.

20 Phase 0 after ship installation introduces concurrency between the shipboard and land-based test schedules, reducing opportunities to make less-costly fixes to defects discovered during land-based testing prior to installation of the system on the ship. As we have previously found with other shipbuilding programs, concurrency introduces the potential for additional unanticipated costs if concurrent land-based testing identifies needed modifications to shipboard systems after installation.[18]

The Navy's planned approach for testing the full ACB 20 Phase 0 capability is a departure from its approach for ACB 12, which demonstrated its final capability 4 months before installation on its first DDG 51-class ship. ACB 12 also benefitted from installation and extensive testing on an in-service DDG 51-class ship for an additional 30 months prior to installation on a new construction ship in September 2015, an approach which is not planned for ACB 20.

Efforts to Improve ACB 20 Development Outcomes and Address Schedule Risks

Navy and prime contractor officials told us that several actions have been taken that they expect to ensure ACB 20 development can be executed under its notably compressed timeline. For example, changes have been made to the Aegis development approach in an effort to correct the underlying causes for some of the past issues or to take advantage of process efficiencies, such as:

- scheduling ACB 20 to begin software development in January 2018—a few months after the initial production decision for SPY-6—to allow time for key radar technologies to mature and for the radar design to stabilize, minimizing the risk of beginning Aegis combat system development with insufficient radar knowledge;
- coordinating with the Missile Defense Agency—including a single program manager at the prime contractor to oversee the Navy and Missile Defense Agency efforts, along with joint reviews and an integrated test strategy between the two organizations for Flight III activities; and

[18] See, for example, GAO, *Ford-Class Aircraft Carrier: Congress Should Consider Revising Cost Cap Legislation to Include All Construction Costs*, GAO-15-22 (Washington, D.C.: Nov. 20, 2014) and *Defense Acquisitions: Cost to Deliver Zumwalt-Class Destroyers Likely to Exceed Budget,* GAO-08-804 (Washington, D.C.: Jul. 31, 2008).

- using some Agile software development methods—an iterative approach that includes a series of smaller software increments that can be developed and delivered in shorter time frames, with the goal of improving quality, generating earlier insight on development progress or any potential issues, and reducing defects and rework. Navy officials emphasized that ACB 20's schedule was not compressed based on any projected efficiencies from Agile use, though it may help reduce defect discovery once the Aegis combat system is installed on the lead Flight III ship.

In addition to these programmatic changes, the Navy and the prime contractors for SPY-6 and ACB 20 are making a concerted effort to reduce integration risk through the use of radar and combat system prototypes. Because the full ACB 20 Phase 0 capability and integration with SPY-6 will not be tested until after it is installed on the ship, the Navy and the prime contractor are counting on land-based prototype testing to reduce risk. As previously shown in figure 3, ACB 20 land-based testing is scheduled to begin in 2019 and will be used to verify combat system performance. This testing will be done prior to certification of the full ACB 20 Phase 0 system in February 2023, as will integrated testing of limited ACB 20 software, combat system hardware, and the SPY-6 engineering development model at multiple land-based test sites, and modeling and simulation tests.

The Aegis combat system prototype being developed for use with the SPY-6 engineering development model is expected to reduce risk by enabling testing that can identify the interface needs and provide developmental test results in support of the SPY-6 initial production decision. According to Lockheed Martin representatives, the Aegis prototype will model approximately 44 percent of the eventual interface between ACB 20 and SPY-6, including the most complex elements described earlier in table 3. However, the full extent to which software used with combat system prototype can be utilized for ACB 20 will not be known until integration testing of the full ACB 20 Phase 0 and SPY-6 is conducted in 2021.

Secretary of Defense Has Directed the Navy to Upgrade an Unmanned Self-Defense Test Ship for Flight III Operational Testing

Recent actions taken by DOD indicate that the department supports the use of an Aegis- and SPY-6-equipped unmanned self-defense test ship. Operational test and evaluation plans for DDG 51 Flight III, SPY-6, and ACB 20 have been a source of disagreement between the Navy and DOT&E since at least early 2013. Specifically, the Navy and DOT&E disagree about the need for an unmanned self-defense test ship equipped with SPY-6 and the Aegis combat system to demonstrate Flight III self-defense capabilities through operational testing.

DOT&E has asserted that an upgraded unmanned self-defense test ship is needed to help demonstrate the end-to-end performance of Flight III systems—from initial SPY-6 radar detection of a target, such as an anti-ship cruise missile, through target interception by an Evolved Sea Sparrow Missile launched from the ship. As statutorily required, DOT&E assessed the Navy's proposed test and evaluation master plan for the AMDR and Aegis programs in May 2013 and August 2013, respectively, determining that neither plan was adequate for operational testing because they did not provide for operationally realistic testing of Flight III's self-defense capability.[19] DOT&E continues to assert this position. Specifically, DOT&E has stated that the Navy's plan to use a manned ship for testing cannot realistically demonstrate the performance of the integrated Flight III combat system against anti-ship cruise missile stream raids—a series of targets approaching the ship from the same bearing—in the self-defense zone because of range safety restrictions.[20] According

[19] 10 U.S.C. § 2399(b)(1) states that operational testing of a major defense acquisition program (or any other program designated as such by DOT&E) may not be conducted until DOT&E approves (in writing) the adequacy of the plans (including the projected level of funding) for operational test and evaluation to be conducted in connection with that program.

[20] The self-defense zone is defined as the area where other units cannot assist the ship being attacked because of proximity and that ship must take action to defeat the incoming anti-ship cruise missile with its own self-defense systems; nominally, this is within 10 nautical miles of the ship. Navy range safety restrictions require that anti-ship cruise missile targets not be flown directly at a manned ship, but at some cross-range offset, and have limitations on how close they can fly to the ship—the target flight path for a supersonic aerial target currently must be off-centered by 2.75 nautical miles from the actual ship location, fly no closer than 2.75 nautical miles from the ship, and cannot maneuver like some threats in order to avoid risk to personnel posed by targets and debris from target intercepts. Prior to Flight III operational testing, the Navy expects the cross-range offset restriction to be reduced to 1 nautical mile, with the closest point of approach restriction set at 3 nautical miles and target maneuvering restrictions still in place.

to DOT&E, it is the practice for all other warships to use an unmanned self-defense test ship for their operational test programs. Use of an unmanned self-defense test ship equipped with SPY-6 and the Aegis combat system would allow a safety offset that is much closer to the ship (less than 400 feet) and would permit the targets to conduct realistic maneuvers, which provides the ability to ensure operationally realistic stream raid effects are present and make the test adequate.

The Navy has asserted that the end-to-end testing scenarios identified by DOT&E for operationally testing Flight III self-defense capabilities can be accomplished on a manned Flight III ship. Navy officials also stated that a robust test approach that includes testing at land-based test sites, on the currently-configured self-defense test ship, and on a manned Flight III ship, can provide sufficient information to support their test needs and accredit the modeling and simulation used in testing.[21] Furthermore, the Navy's position is that using an unmanned self-defense test ship equipped with Aegis and SPY-6 for Flight III operational testing would only minimally increase knowledge of operational performance beyond what can be achieved without its use. Navy officials emphasized that (1) land-based testing is expected to provide nearly all data required to accredit the Aegis modeling and simulation capability, (2) the Evolved Sea Sparrow Missile Block 2—a key element of Flight III's self-defense capabilities—will be tested on DDG Flight IIA ships using ACB 16, and (3) live-fire end-to-end testing of Flight III systems—within the bounds of range safety restrictions—will be completed using a manned ship to provide data on operational capability.

Several factors have contributed to the different conclusions reached by the Navy and DOT&E on the need for, and value of using, a test ship equipped with the Flight III combat system to meet operational testing

[21] Modeling and simulation is used to emulate a system, entity, or environment; for Flight III, these tools can support testing scenarios that cannot otherwise be run in testing against live fire. Accreditation is the official certification that a model or simulation and its associated data are acceptable for use for a specific purpose, such as demonstrating performance of the Aegis combat system against anti-ship cruise missiles, based on a set of standards.

needs. Table 4 explains the key factors that we identified as having contributed to the different assessments of the need for a test ship.[22]

Table 4: Key Factors for the Unmanned Self-Defense Test Ship Disagreement between the Navy and the Director, Operational Test and Evaluation (DOT&E)

Factor	Navy Assessment	DOT&E Assessment
Sufficiency of testing without an unmanned test ship equipped with Flight III Aegis combat system	Use of modeling and simulation is the only way to determine Probability of Raid Annihilation requirements, meaning the measure of the ship's ability to destroy incoming missiles. End-to-end testing on a manned Flight III ship and a segmented test approach that utilizes modeling and simulation, land-based testing, manned ship testing, and testing on the currently configured test ship will provide sufficient information to demonstrate operational capability of Flight III ships and associated systems.	Without operationally realistic testing, it is not possible to determine if the DDG 51 Flight III ships can satisfy their self-defense requirements against anti-ship cruise missiles or determine the survivability of the ships. The Navy's segmented test plan is not adequate for operational testing because it cannot demonstrate the ship's end-to-end self-defense capability and cannot provide data needed to accredit a modeling and simulation suite of the ship's self-defense capability.
Aegis combat system performance in the close-in self-defense area	Aegis combat system performance will be consistent at different threat ranges; thus, a manned ship can be used to test the system's performance at a distance that complies with range safety restrictions. Close in engagements against threats are less stressing to execute than farther out engagements.	The ship self-defense area represents a very challenging portion of the total battlespace where multiple self-defense systems must operate at the same time under very restrictive time constraints to defeat anti-ship cruise missile threats that are in the most challenging phases of their flight (e.g., maneuvering). The way the Aegis weapon system attempts to defeat threats in the self-defense zone is different than how it directs longer-range engagements. Also, the employment ranges of critical elements of the ship's self-defense suite—Evolved Sea Sparrow Missile and the Close-In Weapon System—are limited to ranges that can only be tested on an unmanned test ship. For these reasons, extrapolating performance results for regions of the battlespace where no testing can occur and that are fundamentally different than other regions of the battlespace is not possible and would provide inaccurate data.

[22] We are also issuing a classified annex, *Arleigh Burke Destroyers: Classified Annex to GAO-16-613, Delaying Procurement of DDG 51 Flight III Ships Would Allow Time to Increase Design Knowledge,* GAO-16-846C, which contains additional details on the Navy's and DOT&E's positions regarding the use of an unmanned self-defense test ship for Flight III testing. The annex will be made available upon request to those with the appropriate clearance and a validated need to know.

Factor	Navy Assessment	DOT&E Assessment
Use of test data for missile systems not integrated with Aegis	Missile testing in the close-in self-defense area on the currently configured self-defense test ship (without Aegis), when combined with testing on a manned ship of the Aegis combat system against threats at greater distances from the ship, can provide data to verify, validate, and accredit the Evolved Sea Sparrow Missile model that can be used in the Aegis Testbed integrated modeling and simulation suite.	Evolved Sea Sparrow Missile performance, Block 2 or otherwise, on Flight III ships cannot be determined by testing on platforms, such as the currently-configured self-defense test ship, that are not equipped with SPY-6 and the Aegis combat system because the missiles are not employed in the same way. The Navy's plans are not adequate for operational testing because they do not include the use of an unmanned self-defense test ship equipped with SPY-6 and Aegis, which is the only venue where these systems can be tested against threat representative anti-ship cruise missile surrogates.
Test value gained using a modified unmanned test ship	The additional learning or data gained from using an unmanned test ship with Flight III systems is not commensurate with its cost. The Navy is spending hundreds of millions of dollars to test these systems. By accepting a reasonable amount of additional risk, testing can be accomplished to support operational testing without incurring the significant additional cost—estimated at about $350 million—to modify an unmanned test ship.	The cost to modify an unmanned test ship and use it to support Flight III operational testing is not trivial, but the cost is a small fraction—likely 1-2 percent—of the $50 billion or more the Navy intends to spend on the development and acquisition of the 22 DDG 51 Flight III ships that are expected to defend themselves, aircraft carriers, and amphibious assault ships from anti-ship cruise missile threats. This marginal cost is similar to the average marginal cost DOT&E found past programs incurred for operational test and evaluation.[a] Further, much of the cost could be recovered in out-years because the SPY-6 and Aegis equipment installed on the test ship could, if the Navy so chooses, be used on a later Flight III hull once testing was completed.

Source: GAO analysis of Navy and DOT&E documentation. I GAO-16-613

Note: We are also issuing a classified annex, *Arleigh Burke Destroyers: Classified Annex to GAO-16-613, Delaying Procurement of DDG 51 Flight III Ships Would Allow Time to Increase Design Knowledge,* GAO-16-846C, which contains additional details on the Navy's and DOT&E's assessments regarding the use of an unmanned self-defense test ship for Flight III operational testing. This annex will be made available upon request to those with the appropriate clearance and a validated need to know.

[a]In 2011, DOT&E assessed 78 recent acquisition programs and found the average marginal cost of operational test and evaluation to be about 1 percent of total program acquisition costs.

Recent actions taken by DOD indicate that the department is moving in the direction of supporting the use of the unmanned self-defense test ship.

- First, a December 2014 DOD resource management decision supporting the President's budget for fiscal year 2016 directed the Office of Cost Assessment and Program Evaluation (CAPE) within the

Office of the Secretary of Defense to conduct a study of test ship options that would satisfy DDG 51 Flight III self-defense operational testing, including an assessment of the risks and benefits, cost estimates for each option, and a recommended course of action.[23] The study, completed by CAPE in 2015 found that the lowest risk option was to equip the Navy's existing USS Paul F. Foster self-defense test ship with Flight III combat systems—at an estimated cost of about $350 million—to support operational test and evaluation. The study recommended that the Navy and DOT&E collaborate to develop an integrated test plan to determine the number of air targets and test missiles needed to support developmental testing and operational testing for key Flight III-related self-defense systems.

- Second, following the study of self-defense test ship options, a February 2016 DOD resource management decision supporting the President's budget for fiscal year 2017 directed the Navy to adjust funds within existing resources—$175 million total across fiscal years 2019 through 2021—to procure long-lead items in support of an Aegis- and SPY-6-equipped self-defense test ship. The Navy's subsequent fiscal year 2017 President's budget submission includes funding in this amount for equipment associated with the self-defense test ship starting in 2019.
- Third, as recommended in the 2015 self-defense test ship study, the Secretary of Defense directed the Navy to work with DOT&E to develop an integrated test strategy for the Flight III, AMDR, Aegis Modernization, and Evolved Sea Sparrow Missile Block 2 programs, and to document that strategy in a test and evaluation master plan or plans by July 29, 2016.

Officials from the Navy and DOT&E both questioned whether an integrated test strategy could be completed as directed based on the significant differences between the two sides. However, DOT&E officials stated in April 2016 that the Navy's integrated warfare systems program executive office had begun working on an integrated test strategy to examine the ship's anti-ship cruise missile self-defense and integrated air

[23] A resource management decision is an internal DOD document which reflects the Secretary of Defense's decisions regarding appropriate program and resource levels, including strategic tradeoffs, for the President's budget request for the following fiscal year.

and missile defense capabilities in an effort to meet the intent of the July 2016 deadline.

Although it appears progress is being made in support of the Secretary's direction, the Navy has not yet fully responded to it. If the integrated test strategy being developed by the Navy does not include the use of an unmanned self-defense test ship as directed in DOD's recent resource management decision, then DOT&E will not approve the Navy's operational test plan. If the plan is not approved, a resolution is not likely to be achieved until fiscal year 2019 when the Navy would need to begin buying SPY-6 and Aegis-related long-lead items for the unmanned self-defense test ship to maintain its plan for Flight III initial operational test and evaluation and initial operational capability in 2023.

Complex Flight III Design May Pose Challenges in Maintaining Planned Ship Construction Schedule

Integrating the SPY-6 radar with the DDG 51 hull form will require significant changes to the existing ship's hull, mechanical, and electrical systems. The Navy plans to limit the use of new technologies and introduce some Flight III equipment on Flight IIA ships first in order to reduce the program's technical risk. Flight III design is complex and the tightly-packed existing design of the DDG 51-class ship presents additional challenges for Flight III ship design and construction. The Navy recognizes the need to mature and complete all phases of Flight III design before construction begins in spring 2018. However, its Flight III design schedule is ambitious—considering the amount and complexity of the remaining design work—and the shipbuilders will have a significant amount of design work to complete in a relatively short amount of time.

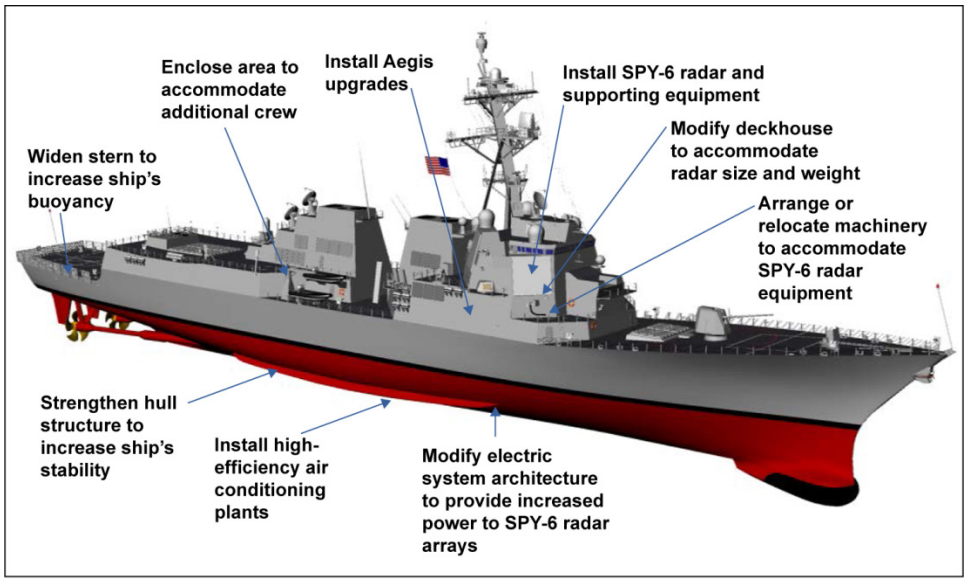
Complexity of Changes and Ship Density Create Challenges for Flight III Design and Construction

Flight III configuration changes are driven primarily by the need to integrate the SPY-6 radar with the existing DDG 51-class hull form. The design changes that make up the Flight III configuration are complex because of the need to integrate the SPY-6 radar and its supporting equipment into the densely constructed DDG 51-class ship.

SPY-6 Radar Drives Flight III Design Complexity

According to the Navy, DDG 51-class ships were selected as the platform for the SPY-6 radar because the hull form involves relatively low overall risk, as it already is integrated with the Aegis weapon system architecture and is a proven ship design. However, integrating the SPY-6 radar will require extensive changes to the ship's hull, mechanical, and electrical systems. Figure 5 illustrates key changes that will be introduced to the ship as part of the Flight III configuration in order to accommodate SPY-6.

Figure 5: Flight III Ship Configuration Changes Related to SPY-6 Radar Introduction



Source: GAO (analysis); Navy (image and data). | GAO-16-613

For example, the ship's deckhouse must be modified because the SPY-6 radar is considerably deeper and heavier than the legacy DDG 51 radar. In particular, the positioning of the SPY-6 radar arrays high on the deckhouse has a significant impact on the ship's estimated weight and center of gravity. As part of the preliminary design, the Navy introduced plans to widen the ship's stern by up to 4 feet on each side, allowing the ship to carry more weight to accommodate SPY-6 and restore available weight service life allowance.[24] Flight III's hull will be reinforced with steel to lower the ship's center of gravity and counteract the radar's additional weight. Significant upgrades to the ship's electric plant and air conditioning systems also are required to support SPY-6 radar operations. These upgrades involve the use of generators, power

[24] As stated by Naval Sea Systems Command policy, service life allowance refers to budgets for weight and center of gravity included in design to accommodate changes during the ship's operational lifetime, which tend to increase displacement and affect stability. In addition to ship design parameters of weight and vertical center of gravity above the keel (the main structural member of a ship), Flight III requirements also address installed electrical power and installed cooling capacity.

conversion modules, transformers, power distribution equipment, and high-efficiency air conditioning units that are new to the DDG 51 class of ships. The Navy also plans to introduce other Flight III changes that are not related to SPY-6 integration. Table 5 describes changes related to SPY-6 and other upgrades planned for Flight III.

Table 5: Major Ship Upgrades Introduced in Flight III Configuration

System Upgrades	Description of Changes
SPY-6 radar and combat systems equipment	• Integrate four radar arrays, radar suite controller, related processors, cooling equipment, and power distribution equipment, electronic equipment fluid coolers, and fire control system coolers
	• Modify deckhouse structure to support 14-foot radar array size and weight
	• Upgrade Aegis system, data link management, and situational awareness capabilities
	• Install faster routes for maintenance and replacement of combat system equipment
Electric plant architecture modifications	• Replace existing 450 volt generators with three 4.0 megawatt 4160 volt gas turbine generators to increase ship's power capacity
	• Install two power conversion modules to power SPY-6 radar arrays
	• Install three ship service transformers to power existing ship systems
	• Modify legacy power distribution equipment and install new distribution equipment
	• Install 4160 volt shore power connection capability
Air conditioning plant upgrades	• Replace existing air conditioning plants with five high-efficiency small capacity air conditioning plants to increase ship's cooling capacity
	• Install variable speed drive to increase efficiency and reliability of air conditioning plants
Habitability changes	• Add enclosure to provide additional crew accommodations
	• Arrange and/or relocate machinery to accommodate SPY-6 radar equipment
Structural changes	• Strengthen ship hull by increasing steel on innerbottom scantlings (e.g., thickening the structural materials to redistribute weight for ship stability)
	• Widen stern—up to 4 feet on each side—above waterline to increase buoyancy
Firefighting systems	• Replace legacy fire extinguishing system with non-ozone depleting solutions

Source: GAO analysis of Navy documentation. | GAO-16-613

The Navy has taken several steps to reduce technical risk in Flight III design, including limiting the use of new technologies. New electric and air conditioning plant technologies planned for Flight III ships are in use on ships that are currently—or soon will be—in the fleet. For example, Flight III's higher capacity generators and power conversion modules are derived from generators being used on the Zumwalt-class destroyers. Additionally, the Navy plans to retain a substantial amount of the existing electric plant design, changing the design only where necessary to provide increased power to operate the SPY-6 radar. The Navy noted that this approach should minimize design impacts and testing requirements for the electric plant. Navy officials acknowledged, however, that the new Flight III systems are evolutions of existing technologies and may require some modifications. To further reduce risk, the Navy plans to introduce some technologies required for Flight III on earlier Flight IIA ships. For example, an Aegis hardware upgrade and a new power conversion system will be introduced on DDG 51 Flight IIA ships beginning with DDG 121, which will be delivered in July 2020.

DDG 51 Density Creates Design and Construction Challenges

In addition, the density of the existing DDG 51-class ship design presents challenges for Flight III ship design and construction. As we have previously found with shipbuilding, density—the extent to which ships have equipment, piping, and other hardware tightly packed within ship spaces—affects design complexity and cost.[25] Density can complicate the design of the ship, as equipment will need to be rearranged to fit new items. Construction costs can increase because of the inefficiencies caused by working in spaces that are difficult to access. Although in this case the two shipbuilders have extensive experience in building the DDG 51 hull form, Navy officials acknowledged the significant effort required to integrate the SPY-6 radar on the ship and the space and power constraints it poses for adding new systems. Table 6 describes how ship density contributes to challenges in designing and constructing Flight III ships.

[25] GAO-12-113.

Table 6: Flight III Ship Density Challenges

System Upgrade	Design and Construction Challenges
SPY-6 and combat systems equipment	• Significant design work was required and has been completed to define the physical arrangement of the radar and supporting equipment on the ship. As zone design progresses and space and configuration constraints within the ship are better understood, the Navy and the shipbuilders must refine design arrangements, such as the routing of cable, to minimize cable length between the radar arrays and supporting equipment as well as weight.
Electric plant architecture modifications	• Flight III configuration is the first time the Navy is integrating a more powerful generator with an existing lower-power electrical distribution system. To mitigate the challenges associated with this integration and support design needs, the Navy is conducting a dynamic modeling analysis, which is about 75 percent completed. Generator integration remains as a risk, though the Navy indicated that completion of a critical design review for the generator in May 2016 helped reduce risk by locking down its design.
Air conditioning plant upgrades	• The Navy stated that risk associated with heat loads and cooling capacity for the radar and other equipment has been sufficiently characterized to support detail design. The remaining risk, which the Navy considers to be low, is associated with the ability of the new air conditioning plants to meet their expected capacity. This risk cannot be retired until the unit has completed its first article testing—a test process used to determine if units meet contract specifications prior to acceptance by the government. Overcoming any issues in achieving needed cooling capacity could prove challenging based on the existing space and weight constraints.
Habitability changes	• Incorporation of the SPY-6 radar will require relocation of existing ship equipment, which will affect location of other systems and remaining available space. Arrangement of SPY-6 radar equipment also required the addition of a starboard enclosure to address displaced crew accommodations; the Navy is leveraging a previous design used for some Flight IIA ships to mitigate risk.
Structural changes	• According to Navy officials, this is the first time that the Navy has widened the stern of a ship in this manner. The Navy considers this to be low risk because its technical community has assessed and accepted this design and the change does not affect ship distributed systems.

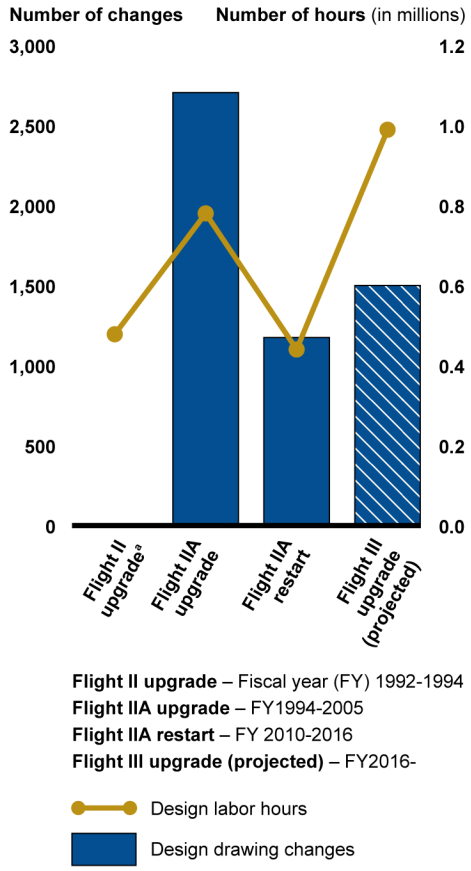
System Upgrade	Design and Construction Challenges
Firefighting systems	• Placement within the ship of the fire extinguishing system's nozzles remains a design challenge. The Navy noted that, based on preliminary design, there is little margin for additional nozzles and a larger pump for the fire extinguishing system due to pump room volume, tank size, and power limitations. The program is using more extensive modeling and reviews for this system than in previous programs to reduce risk. Still, the Navy has acknowledged that the ship may be well into construction before it knows how many nozzles are needed.

Source: GAO analysis of Navy documentation. | GAO-16-613

Flight III Upgrade Requires Extensive Design Changes

The Flight III upgrade requires extensive changes to the DDG 51 design. Navy officials estimate that approximately 45 percent of the ship's design drawings will need to be changed. The shipbuilders estimate that 72 of 90 ship design zones will also require revisions. At the same time, however, Navy program officials have stated that the design work associated with the Flight III upgrade is no more complicated than previous DDG 51 upgrades. They noted, for example, that the number of drawing changes for Flight III is fewer than the Flight IIA upgrade. While this is true based on current estimates, the Flight III estimate is a projection and may increase once the final design is complete. Moreover, the Flight III design is projected to require nearly 1 million design hours to incorporate the changes that the Navy attributed, at least in part, to additional quality assurance and design reviews to accommodate stricter government oversight than with previous upgrades. The projected design hours for Flight III are notably more than what were required on previous upgrades, as seen in figure 6.

Figure 6: Design Change Results for Different DDG 51-Class Ship Configurations



Source: GAO analysis of Navy and shipbuilder data. | GAO-16-613

[a]Flight II design was issued as a series of manual design drawings, which are not comparable to computer-generated drawings issued for subsequent upgrades.

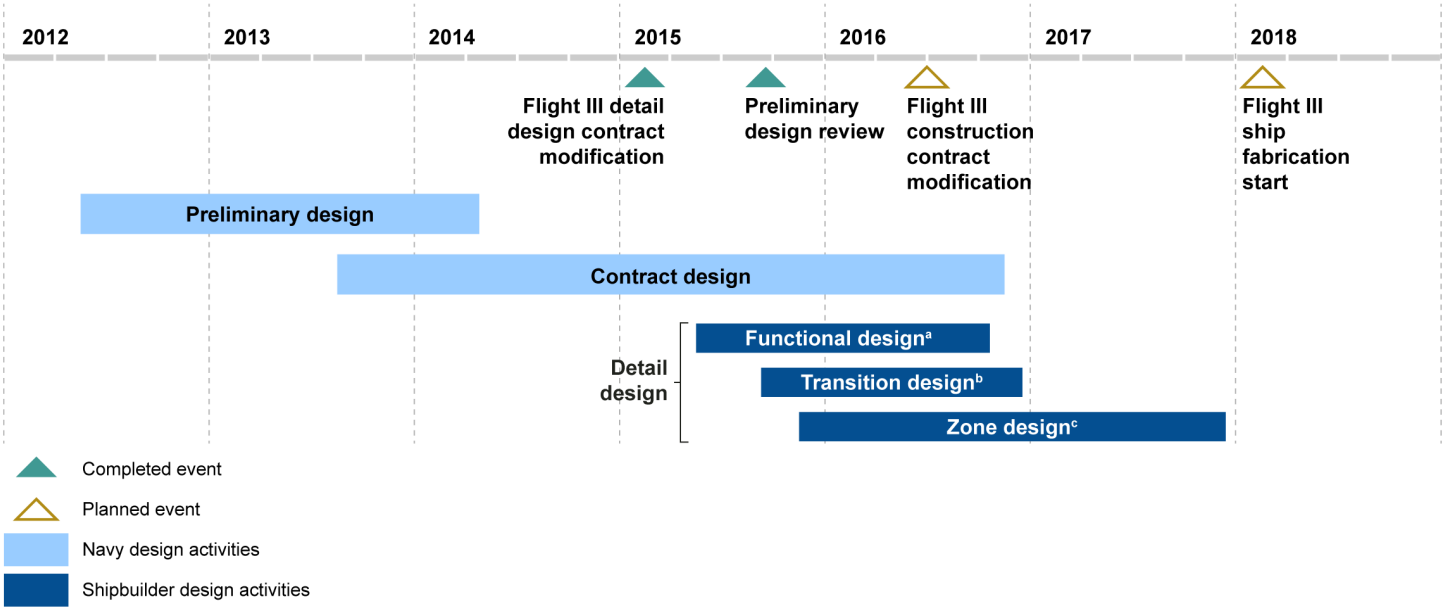
The Navy Is Pursuing an Aggressive Schedule to Complete Ship Design Prior to Construction

The Navy recognizes the need to mature and complete all phases of Flight III design before construction begins, currently projected for spring 2018. Our prior work on shipbuilding has identified this practice as a key factor in better ensuring that ships are delivered on time, within planned costs and with planned capabilities.[26] The Navy has completed most of

[26] GAO, *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding,* GAO-09-322 (Washington, D.C.: May 13, 2009).

the two initial phases of ship design (preliminary and contract design) as shown in Figure 7 below.

Figure 7: DDG 51 Flight III Design Schedule



Source: GAO analysis of Navy data. | GAO-16-613

Note: Flight III construction contract modification was planned for spring 2016 but had not been completed as of July 2016.

[a]Functional design includes activities that define the ship's initial engineering and design.

[b]Transition design activities include the arrangement of major equipment and ship systems in each zone (individual units that make up the ship's design).

[c]Zone design activities include finalizing ship design with three-dimensional product modeling of the ship's zones.

These design efforts are aimed at the production of technical data packages, preliminary drawings, and ship specifications needed for detail design and construction. In February 2015, the Navy modified its existing design contracts with the two DDG 51-class shipbuilders—Bath Iron Works and Huntington Ingalls Industries—to begin Flight III detail design

work, which includes three-dimensional product modeling of the ship's individual zones, also referred to as zone design.[27]

The shipbuilders began Flight III zone design activities for their respective ship designs in October 2015, using a computer-aided design product model to make changes to the zones that make up the design of the ship. Shortly before beginning zone design, the shipbuilders revised their design approach in an effort to better manage and complete the activities. The Navy had originally planned to split zone design between the two shipbuilders, requiring both shipbuilders to ensure that their designs were compatible with one another. According to the shipbuilders, a change was made so now each shipbuilder will complete its own design for the ships built at their respective yards.

The Navy's design schedule is ambitious, considering the amount and complexity of the remaining design work. For example, as of April 2016, one shipbuilder stated that it had completed product modeling of 7 percent of the ship's zones and had held a 50 percent milestone review for three of the 72 zones that require design changes as part of the Flight III upgrade. The lead shipbuilder plans to complete about 25 percent of zone design by October 2016. Flight III detail design work is planned to be completed by December 2017, as directed by the Navy. The shipbuilders are scheduled to complete detail design about 3 months earlier than they originally planned, which provides more time between design completion and the start of ship construction. However, under the current schedule, the shipbuilders will have a significant amount of design work to complete in a relatively short amount of time. In addition to design time, one shipbuilder will not begin the zone design for the five zones requiring the most significant changes until December 2016, leaving less time to discover and address any design problems for some of the most complex areas of the ship. In addition, the shipbuilders will face challenges as they enter the more difficult product modeling phases—when the details of the design must be finalized to start ship construction.

[27] Zone design includes activities to design the individual units of the ship, including the distributive systems—such as cables and pipes—that pass through each zone.

The Navy Lacks Sufficient Knowledge to Procure Flight III Ships as Planned and Oversight Opportunities Are Limited by Planned Program Reporting

If the Navy purchases the first Flight III ship in fiscal year 2016 as planned by issuing a series of modifications to its existing construction contracts, it will do so without sufficient acquisition and design knowledge. As of May 2016, the Navy was still in the process of updating key acquisition documents with Flight III information, including a revised cost estimate, and had not released a request for proposals for construction of the lead Flight III ship design. In addition, because the Navy will have a significant amount of Flight III zone design work remaining at the end of fiscal year 2016, any procurement decisions will not be informed by a complete understanding of Flight III design. In addition, while the Navy did not update its anticipated cost savings under the current (fiscal year 2013-2017) multiyear procurement to reflect the addition of Flight III ships, doing so would provide Congress a more accurate savings estimate, as well as provide improved information to support future multiyear procurement savings estimates.[28] Further, in February 2017, when the Navy plans to request authority from Congress to award new multiyear procurement contracts for 10 Flight III ships in fiscal years 2018-2022, it will not be positioned to meet the criteria necessary to support the request. For example, the Navy would be required to preliminarily find by February 2017 that the Flight III design is stable, although shipbuilders will not complete detail design until December 2017.[29] Finally, while the Flight III upgrade is being managed as a continuation of the longstanding DDG 51 program, the Navy is completing many of the activities that are required for new acquisition programs, including the establishment of a new acquisition program baseline. However, information on the Flight III upgrade is not planned to be presented to Congress in Selected

[28] Multiyear contracting is a special contracting method to purchase known requirements (e.g., DDG 51 ships) for up to 5 years without having to exercise a contract option for each year after the first year if, among other things, a product's design is stable.

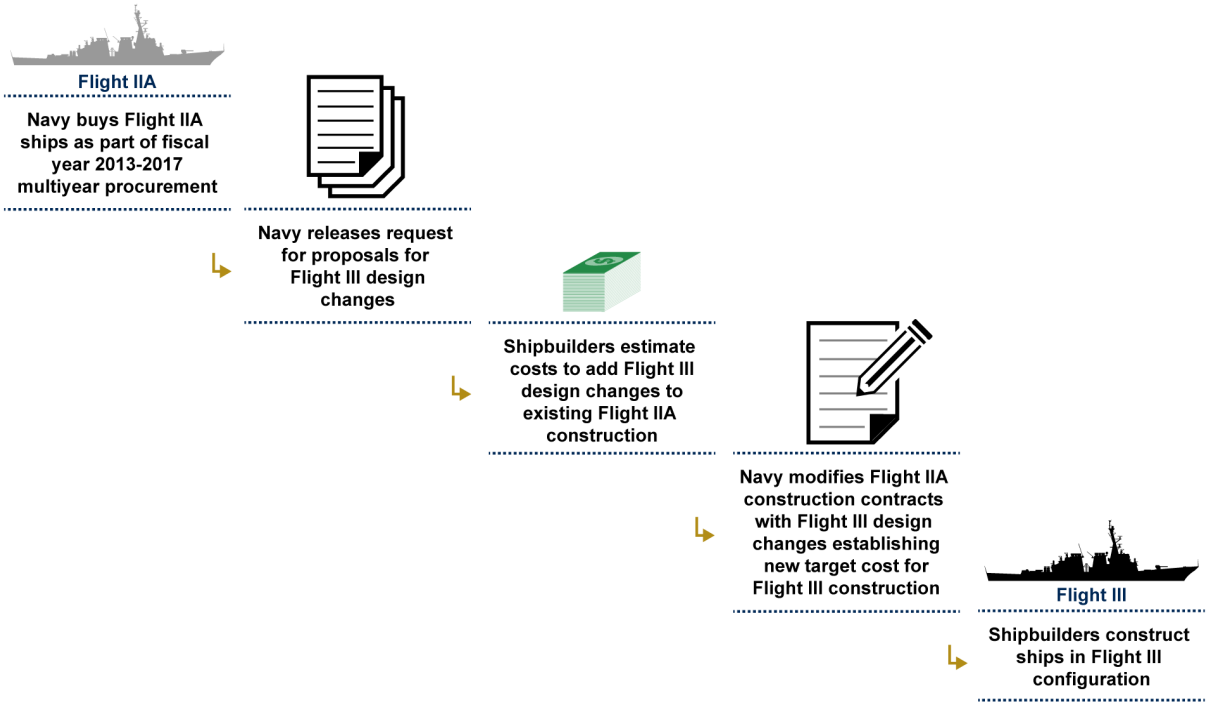
[29] The multiyear contacting statute for the acquisition of property specifies what DOD must do in order to obtain and use multiyear procurement authority. For example, DOD must submit a request for specific authorization by law to use multiyear contract authority, and include in that request a report containing preliminary findings that certain criteria will be met, as well as the basis for such findings and confirmation that the findings were made after completion of a cost analysis by CAPE. After DOD obtains multiyear procurement authority for a given program, there are additional requirements that must be met before a contract may be entered into. See e.g. 10 U.S.C. § 2306b(i)(2) & (3). For the purposes of this report, we are focusing on the first step, where DOD must make preliminarily findings related to the six criteria detailed in 10 U.S.C. § 2306b(a). Before entering into a multiyear contract using this authority, among other things, DOD will have to certify in writing that these criteria and other criteria will be met.

Acquisition Reports as a separate major sub-program of the DDG 51 class of ships, which will reduce decision makers' insight into its cost and schedule performance.

Amidst Uncertainties in the Acquisition Strategy, the Navy Plans to Contract for First Flight III Ships Beginning in Fiscal Year 2016

To construct the lead Flight III ship and the next two follow-on ships, the Navy intends to modify its existing DDG 51 multiyear procurement contracts with Bath Iron Works and Huntington Ingalls Industries. In 2013, the Navy awarded multiyear procurement contracts to these shipbuilders to construct a total of 10 DDG 51 ships from fiscal years 2013 through 2017. The Navy plans to modify these existing contracts, which are currently priced for Flight IIA ship construction, through a series of 17 design changes—also called engineering change proposals—to introduce the Flight III upgrades on up to three ships. A new target cost will be established for each Flight III ship to reflect the yet-to-be-determined cost of design changes. Figure 8 illustrates how the Navy plans to modify the existing multiyear procurement contracts to convert Flight IIA ships to Flight III ships.

Figure 8: DDG 51 Flight III Contract Modifications Process Using Fiscal Year 2013-2017 Multiyear Procurement



Source: GAO analysis of Navy data. | GAO-16-613

The Navy plans to issue the necessary modifications for the lead Flight III ship in fiscal year 2016 and do the same for the two additional Flight III ships in fiscal year 2017. The procurement approach for the lead ship recently changed due to additional funding provided by Congress. Specifically, Congress provided the Navy with an additional $1 billion in construction funding for fiscal year 2016 to procure an additional DDG 51 ship.[30] Of note, however, the $1 billion is not sufficient to procure a complete ship in either the Flight IIA or Flight III configuration. The Chief of Naval Operations included $433 million on the Navy's fiscal year 2017 unfunded priorities list provided to Congress to fully fund the additional ship. If the funding is approved, the total number of new ships would increase from 10 to 11 over the multi-year contract period.[31] The Navy originally planned to introduce the lead Flight III ship as one of the two ships procured under the multiyear contracts in fiscal year 2016. However, according to the Navy, the additional ship in fiscal year 2016 is now anticipated to become the lead Flight III ship, although the acquisition strategy has not been determined. A procurement contract for this additional ship has not been awarded and it is not currently included in the existing multiyear procurement contracts.

Table 7 provides details of how the additional fiscal year 2016 funds affect the Navy's multiyear procurement contracting strategy.

[30] 161 Cong. Rec. H9897 (2015) incorporated by reference by Consolidated Appropriations Act, 2016, Div. C, Department of Defense Appropriations Act, 2016, Pub. L. No. 114-113, §§ 4, 8006 (2015); NDAA for Fiscal Year 2016, Pub. L. No. 114-92, § 125 (2015). The NDAA authorized the Navy to procure one additional Arleigh Burke-class (DDG 51) destroyer in fiscal year 2016; the Navy had budgeted for two destroyers. The Act also stated the procurement could be as an addition to the fiscal year 2013-2017 multiyear procurement or made under a separate contract in fiscal year 2018. The Department of Defense Appropriations Act, 2016, provided the Navy with $1 billion in funding above what was requested in the President's budget.

[31] H.R. 4909, a bill for the 2017 NDAA recommended authorizing $433 million for the additional ship. Similarly, S. 2943, a bill for the 2017 NDAA, recommended authorizing $49.8 million to fund the additional ship. Both the House and Senate bills related to the 2017 Department of Defense Appropriation Act include funds for the additional ship.

Table 7: Navy's Multiyear Procurement (MYP) Strategy for Fiscal Years (FY) 2013-2017

	Navy's Original Strategy	Navy's Current Strategy (reflects additional FY 2016 funds)
Total number of ships Navy plans to purchase under FY2013-2017 MYP contracts	**10**	**10-11[a]**
Number of Flight IIA ships	7	7-8
Number of Flight III ships	3	3
Number of ships Navy plans to purchase under MYP contracts in FY2016	**2**	**2-3**
Number of Flight IIA ships	1	1-2
Number of Flight III ships (lead ship)	1	1
Number of ships Navy plans to purchase under MYP contracts in FY2017	**2**	**2**
Number of Flight IIA ships	0	0
Number of Flight III ships	2	2

Source: GAO analysis of Navy documentation. | GAO-16-613

[a]The Navy is authorized to award the additional DDG 51 ship as either an addition to the FY 2013-2017 MYP contract or under a separate contract in FY 2018.

In addition, the Navy no longer plans to introduce limited competition between the two shipbuilders for the lead Flight III ship construction. The Navy's acquisition strategy for the first three Flight III ships included use of a contracting strategy to introduce limited competition between the two shipbuilders for the Flight III procurement. As part of this strategy, both shipbuilders would submit proposals for the additional work associated with Flight III changes. The shipbuilder that submitted the lowest proposal for the work would have received a higher percentage of target profit and would have been awarded the contract modifications to build the lead Flight III ship in fiscal year 2016 and build one of the fiscal year 2017 ships; the other shipbuilder would build one fiscal year 2017 Flight III ship. In April 2016, the Navy issued a pre-solicitation notice, stating that it now intends to issue a request for proposal to Bath Iron Works for the lead Flight III ship, which would be a sole-source award for the lead ship with

no competition between the shipbuilders for profit.[32] The extent to which the Navy plans to introduce limited competition into the Flight III modifications for the two fiscal year 2017 ships and how such competition would be structured remains uncertain.

The Navy Has Not Gained Sufficient Acquisition and Design Knowledge to Award Lead Flight III Ship in Fiscal Year 2016

As of May 2016, the Navy had not demonstrated sufficient knowledge regarding its Flight III acquisition approach to modify the current multiyear procurement contracts to introduce these upgrades. In a June 2014 Flight III Acquisition Decision Memorandum, USD (AT&L)—the decision authority for the DDG 51 program—approved a plan to support a fiscal year 2016 program review of the Flight III upgrade prior to modifying ship construction contracts. Under this plan, the Navy is required to update its acquisition program baseline and test and evaluation master plan, among other documents, with Flight III-specific information. According to officials from the DDG 51 program and the Office of the Secretary of Defense, as of May 2016, the Navy was still in the process of updating these documents.

The 2014 plan also requires the Navy to ensure that the Flight III program is fully funded in the Future Years Defense Plan and that CAPE assess the Navy's Flight III cost estimate. A prior Navy cost estimate completed in 2014 lacked knowledge on the current Flight III baseline, making it difficult to use the estimate as support for construction award decisions. CAPE officials stated they began working with the Navy Center for Cost Analysis in November 2015 to ensure the Navy cost estimate being developed in response to the 2014 direction incorporates data on all of the relevant factors that will influence the cost of Flight III ships. These factors include historical DDG 51 ship construction hours, maintenance cost trends, and shipyard labor cost trends, among others. According to a CAPE official, as of May 2016, the Navy had yet to provide a revised cost estimate to be assessed, thus the estimate was not expected to be

[32] The Navy stated that its intention to award the lead Flight III ship to Bath Iron Works is consistent with the long-standing "hull swap agreement" in which the Navy awarded a contract to Huntington Ingalls Industries in December 2015 for construction of a San Antonio-class amphibious transport dock ship. As part of the agreement, according to officials, the Navy would also award a contract to Bath Iron Works to build an additional DDG 51 destroyer. The Navy has stated that it plans to use the exception to full and open competition found at 10 U.S.C. § 2403(c)(3)(industrial mobilization; engineering, development or research capability; or expert services).

completed until the summer of 2016 at the earliest. Until this estimate is finalized and assessed by CAPE, the Navy will not have an independent perspective on its Flight III costs and, pursuant to USD (AT&L)'s 2014 requirements, cannot move forward with a contract for Flight III ships.

The Navy originally scheduled a program review in March 2016 to approve its plans to award the lead Flight III ship, but the review was postponed because key contract-related activities had not been accomplished. Specifically, the Navy is required to release requests for proposals to modify the fiscal years 2016 and 2017 Flight III multiyear procurement and to evaluate the shipbuilders' proposals prior to this review. As of May 2016, the Navy had yet to release these requests for proposals. Until the Navy complies with the documentation requirements established by USD (AT&L) in June 2014, releases the requests for proposals, and receives and evaluates shipbuilder proposals, it will not have achieved sufficient knowledge about its acquisition approach to make an informed decision to proceed with the Flight III modifications to the existing multiyear procurement contracts.

Even if the Navy fulfills its documentation requirements, procuring the lead Flight III ship in fiscal year 2016 as currently planned increases the cost risk with the lead ship because cost estimates will be based on limited detail design knowledge. The lead shipbuilder expects to have about 75 percent of zone design work remaining at the end of fiscal year 2016 and, as a result, procurement activities—including the shipbuilder proposal development, Navy completion of construction cost estimates, and finalization of the target cost for constructing the lead Flight III ship—will not be informed by a more complete understanding of Flight III design. Our prior work has found that over time, cost estimates become more certain as a program progresses—as costs are better understood and program risks identified.[33] According to both shipbuilders, waiting until fiscal year 2017 to procure the lead Flight III ship would allow Flight III design to further mature, which would provide greater confidence in their understanding of the Flight III design changes and how these changes will affect ship construction costs. By completing more detail design activities prior to procuring a Flight III ship, the Navy—and both

[33] GAO, *GAO Cost Estimating and Assessment Guide,* GAO-09-3SP (Washington, D.C.: March 2009).

shipbuilders—will be better positioned for Flight III procurement and construction. One shipbuilder also noted that waiting until fiscal year 2017 to procure the lead Flight III ship would enable the Navy to coordinate government furnished equipment delivery schedules with suppliers that support the shipyard production need dates.

Flight III Ships Will Offset Navy's Estimated Cost Savings for Its Current Contracts and Meeting Criteria for New Multiyear Procurement Will Be Challenging

Congress authorized procurement of up to 10 DDG 51 ships under the Navy's current multiyear procurement for fiscal years 2013 through 2017; the Navy's estimated cost savings of $1.54 billion did not take into account the differing costs between Flight IIA and Flight III ships. With the Navy planning for up to three of the ships to be in the Flight III configuration, some of the projected cost savings will be offset by the additional costs associated with Flight III ship construction. The Navy updated the estimated savings to $2.35 billion in September 2014 for 10 Flight IIA ships based on (1) additional savings achieved through DOD's Better Buying Power principles, (2) exercising the option for a tenth DDG 51 ship, and (3) lower cost estimates for the purchase of ship equipment.[34] According to DDG 51 program officials, the Navy did not provide a revised estimate of savings based on the Flight III changes. While it is not known at this point whether or not the Navy may still achieve cost savings with the addition of Flight III ships in the fiscal year 2013-2017 multiyear procurement, the cost increases associated with the modifications for the Flight III upgrade will reduce the extent of the savings. The multiyear procurement statute does not require that existing savings estimates be updated to include costs associated with design changes, but doing so for Flight III changes would provide improved transparency of costs for Congress and the taxpayers. It would also help inform a more realistic basis for estimating future multiyear procurement savings.

Once the current DDG 51 multiyear procurement ends in 2017, the Navy plans to award new multiyear procurement contracts to both shipyards, covering fiscal years 2018-2022, for the construction of the next 10 Flight

[34] Better Buying Power is the implementation of best practices to strengthen DOD's buying power, improve industry productivity, and provide an affordable, value-added military capability to the warfighter. It encompasses a set of fundamental acquisition principles to achieve, among other things, greater efficiencies through affordability, cost control, and promotion of competition.

III ships. In order to request authority from Congress to use a multiyear procurement contract to procure Flight III ships, the Navy must preliminarily find that several criteria will be met.[35] However, based on our analysis, the Navy is not likely to be positioned to meet all of the criteria for requesting multiyear procurement authority in time to seek authority to award the Flight III multiyear contracts in fiscal year 2018. This request for multiyear contracting authority would have to be submitted with the fiscal year 2018 President's budget request, scheduled to be released in February 2017.

Table 8 shows the statutory criteria for requesting authority to use a multiyear procurement contract and the extent to which the Navy will be positioned to preliminarily find they would be met by February 2017.

Table 8: Extent to Which the Navy Will Be Positioned to Seek Fiscal Year 2018 Multiyear Procurement Authority from Congress for Flight III Ships by February 2017

Criteria[a]	Description	GAO assessment of expected criteria fulfillment by February 2017
Significant savings	Use of a multiyear contract will result in significant savings in the total estimated costs when compared to the use of a series of annual contracts for the same procurement.	◑
Realistic cost estimates	Realistic estimates of contract cost and projected multiyear savings/cost avoidance through the use of a multiyear contract strategy.	◑
Stable need for items	Minimum need to be purchased in terms of production rate, procurement rate, and total quantities is expected to be substantially unchanged during the multiyear contract period.	●
Stable design	Technical risks that are not excessive over the multiyear period and there is a stable design for the property to be acquired.	◑
Stable funding	There is reasonable expectation that the head of the agency will request funding for the contract throughout the contract period to avoid contract cancellation.	●
National security	Use of a multiyear procurement for Department of Defense programs will promote the national security interests of the United States.	●

Legend: ● Criteria will be fully met ◑ Criteria will be partially met

Source: GAO analysis of 10 U.S.C. § 2306b(i)(2) and Navy documentation. | GAO-16-613

[a]Per 10 U.S.C. § 2306b(i)(2) the Navy would be required to preliminarily find that these criteria would be met when requesting multiyear procurement authority from Congress.

[35] 10 U.S.C. § 2306b(i)(2).

To highlight one aspect, to request authority to use a multiyear contract, the Navy will have to preliminarily find that the design of the Flight III ships is stable. As we previously stated, the most complicated aspects of Flight III design work are ongoing, and detail design will not be complete until December 2017—well after the President's budget request is submitted to Congress. In addition, the Navy plans to begin construction of the lead Flight III ship in spring 2018. Until the Navy begins construction of the lead Flight III ship, it will not have sufficient knowledge to demonstrate a realistic construction estimate or cost savings because there will be no prior cost or construction history on the Flight III upgrade.[36] Another example is that technical risk for Flight III systems—such as with Aegis upgrades—will remain and ship design stability will not yet be achieved if new multiyear procurement contracts are awarded at the start of fiscal year 2018, because software coding for the Aegis combat system upgrade will only have just begun.

Although the Navy has previously used multiyear procurement contracts for DDG 51 ships, it has typically first demonstrated production confidence by building ships in the corresponding configuration before employing a multiyear procurement approach. For example, the Navy built 10 Flight IIA ships before entering into a multiyear procurement for them. If the Navy proceeds with a multiyear procurement strategy for Flight III ships beginning in fiscal year 2018, it will be asking Congress to commit to procuring nearly half of the planned Flight III ships with an incomplete understanding of cost, and effectively, no Flight III construction history to support the decision.

[36] In addition to the criteria described above related to seeking multiyear authority, after a multiyear contract has been authorized by law, and before entering into a multiyear contract, DOD must, among other things, certify that a sufficient number of end items of the system being acquired under such contract have been delivered at or within the most current estimates of the program acquisition unit cost or procurement unit cost for such system to determine that current estimates of such unit costs are realistic. 10 U.S.C. § 2306b(i)(3)(D).

DDG 51 Acquisition Approach Limits Opportunities for Insight into Flight III Cost and Schedule

The Flight III upgrade represents a significant resource investment for the Navy, with more than $50 billion over the next 10 years devoted to designing and constructing 22 Flight III ships. Despite the magnitude of these costs and the degree of changes to the ship, DOD is not treating it as a new acquisition program. Instead, as permitted under law and regulation, the Flight III upgrade is being managed as a continuation of the existing DDG 51 program, which is currently designated as an ACAT 1D program. Two key decision reviews have been held or are planned for Flight III: one in June 2014 to approve the beginning of detail design, and one to review the readiness of the program to proceed with Flight III ship construction, which was originally scheduled for March 2016, but has not yet occurred.

The Navy is still conducting some activities for the Flight III upgrade that are commensurate with what is required of a new acquisition program, even though the upgrade is being managed as part of the existing DDG 51 program. Milestone B is normally the formal initiation of a DOD acquisition program at which, for example, the acquisition program baseline—a document which establishes a program's business case—is approved by the program's decision authority.[37] As part of the tailored plan for Flight III approved by USD (AT&L) in June 2014, the Navy is completing some, but not all, of the fundamental activities that are required at Milestone B. This includes development of a Flight III cost estimate that will be assessed by CAPE, which is being done in lieu of an independent cost estimate that would be typical for a new major defense acquisition program. Table 9 shows the degree to which the Navy is completing the fundamental activities for the Flight III upgrade that are required for new programs at Milestone B.

[37] The acquisition program baseline is an agreement between the Program Manager and the Milestone Decision Authority that reflects the approved program and contains schedule, performance, and cost parameters that are the basis for satisfying an identified mission need.

Table 9: Information Required for New Programs at Milestone B

Activity	Extent to which activity will be completed for Flight III upgrade under tailored approach
Requirements are defined and validated	●
Certification of full funding	●
Compliance with affordability goals for production and sustainment, as reflected in an independent cost estimate	○
Independent cost estimate	◑
Acquisition program baseline	●

Legend: ● Will fully complete ◑ Will partially complete ○ Will not complete

Source: GAO analysis of DOD Instruction 5000.02 and Navy documentation. | GAO-16-613

Further, while the Navy held a Milestone B-like review for Flight III and is going to establish a new acquisition program baseline, Flight III is not a distinct acquisition program or major subprogram, which has implications for reporting requirements related to cost and schedule performance. In particular, since the Flight III upgrade is part of the existing DDG 51 program, certain oversight mechanisms that are generally set in motion after passing through Milestone B—such as reporting Nunn-McCurdy breaches of unit cost growth thresholds and periodic reporting of the program's cost, schedule, and performance progress—do not apply to Flight III separately from the overall program.[38] Flight III performance measures do not have to be broken out for the DDG 51 program Selected Acquisition Report—a report submitted by DOD that provides Congress with information that is used to perform oversight functions—which

[38] 10 U.S.C. § 2433—commonly referred to as Nunn-McCurdy—requires DOD to notify Congress whenever a major defense acquisition program's unit cost experiences cost growth that exceeds certain thresholds. Significant breaches occur when the program acquisition unit cost or procurement unit cost increases by at least 15 percent over the current baseline estimate or at least 30 percent over the original estimate. For critical breaches, when these unit costs increase at least 25 percent over the current baseline estimate or at least 50 percent over the original, DOD is required to take additional steps, including conducting an in-depth reassessment of the program. Programs with critical breaches must be terminated unless the Secretary of Defense certifies to certain facts related to the program and takes other actions, including restructuring the program. 10 U.S.C. § 2433a.

diminishes transparency and encumbers oversight efforts.[39] For example, the DDG 51 program's December 2015 Selected Acquisition Report did not include schedule estimates for any Flight III events with the SPY-6 radar. Additionally, the average procurement unit cost of approximately $1.19 billion per DDG 51 ship reported in 2015 is significantly less than the average procurement unit cost currently anticipated for Flight III ships because it represents the unit cost for DDG 51 ships as a whole. Without distinct Flight III information, decision makers will not be able to distinguish cost growth associated with the overall DDG 51 program baseline from Flight III cost growth, which may limit the effectiveness of oversight mechanisms, such as Nunn-McCurdy unit cost thresholds. Further, since the Navy is not reporting key events for Flight III as part of the overall DDG 51 program, Congress and the Office of the Secretary of Defense will not be made aware of any changes to Flight III's schedule via this standard reporting mechanism for acquisition programs.

USD (AT&L) has the authority to designate major subprograms within major defense acquisition programs, like the DDG 51 program.[40] DOD's guidance states that establishing a major subprogram may be advisable when increments or blocks of capability are acquired in a sequential manner. In the case of the DDG 51 program, designating the Flight III upgrade as a major subprogram would allow for oversight of the upgrade separate from the overall DDG 51 program. For example, Nunn-McCurdy breaches could be tracked and reported separately. Treating the upgrade as a major subprogram would also offer the ability to separately baseline and track cost (including unit cost), schedule, and performance for Flight III within the overall DDG 51 Selected Acquisition Report. This more granular level of reporting would provide Congress and the Office of the Secretary of Defense with greater visibility into the cost, schedule, and performance of the Flight III upgrade.

[39] Selected Acquisition Reports are standard, comprehensive, summary status reports of major defense acquisition programs. They are to be periodically submitted to Congress. 10 U.S.C. § 2432.

[40] 10 U.S.C. § 2430a.

Flight III Ships Will Provide Improved Air and Missile Defense Capabilities to the Fleet, but Physical Constraints Limit Potential for Future Upgrades

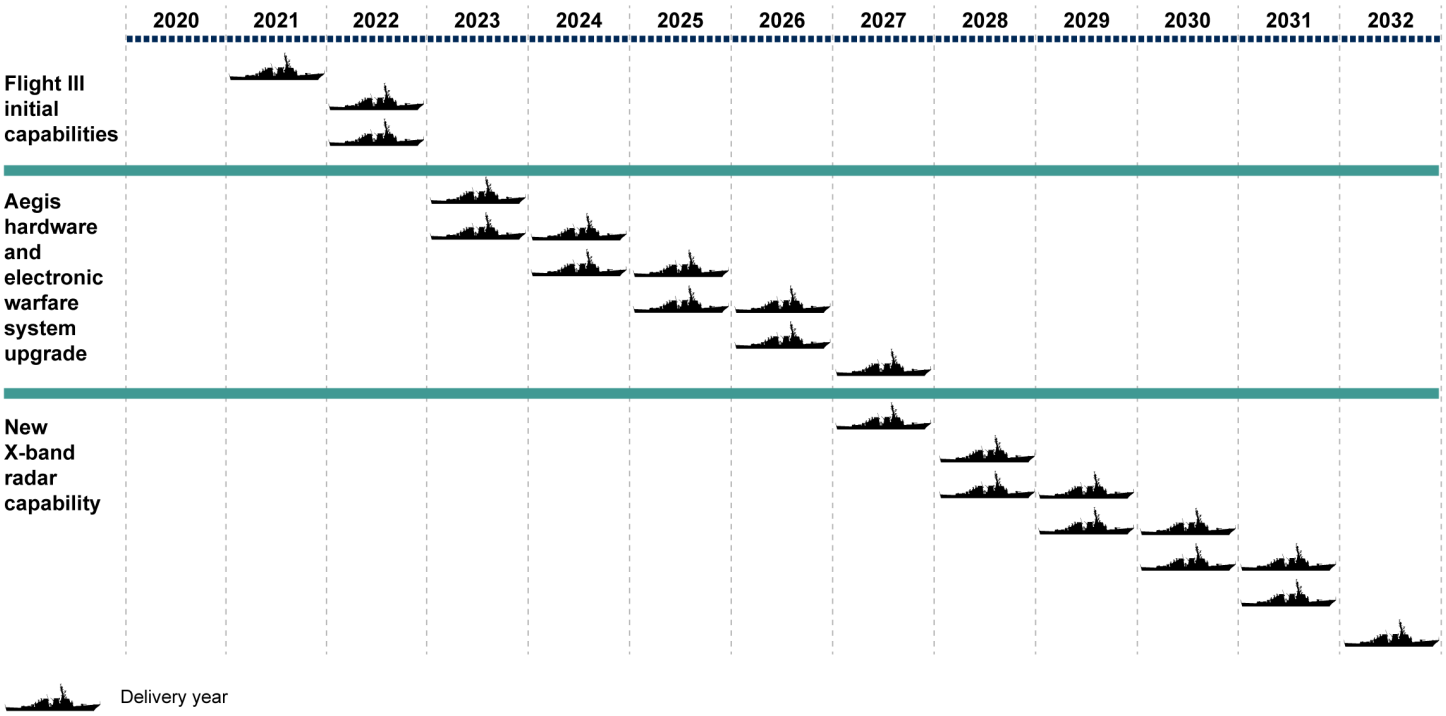
In the future, as the Navy begins assessing solutions for the next surface combatant ship, it will need to make important decisions about evolving threats and the IAMD capabilities necessary to combat those threats. The Navy expects Flight III ships to meet key operational performance requirements in 2023, with full Flight III capabilities delivered in 2027. While Flight III ships will increase the fleet's IAMD capabilities, they will not provide the level of capability that the Navy previously identified as necessary to address the more stressing IAMD threats. The limited weight and stability service life allowance of the ship due to Flight III's design changes will also affect the Navy's ability to add capabilities to the ship in the future without removing existing equipment or making significant structural changes to the ship. The Navy is also considering the extent to which Flight III destroyers may be used instead of Navy cruisers to provide air and missile defense for carrier strike groups. In 2016, the Navy began a capabilities-based assessment to identify capability gaps and potential solutions for the next surface combatant ship which, according to the Navy's annual long-range shipbuilding plan, will be introduced in 2030.

The Navy Is Using an Incremental Approach to Achieve Full Flight III Capability

The Navy plans to meet key operational performance requirements for Flight III initial operational capability in 2023, as outlined in the Navy's DDG 51 Flight III Capability Development Document, but is using an incremental approach to deliver the full capability planned for the ships. The first three Flight III ships will not include all of the Navy's planned capabilities, and full capability for a Flight III ship is expected in 2027. The incremental approach is tied to the delivery of X-band radar and Aegis combat system capabilities. For the X-band radar, the Navy changed its original Flight III plans. Specifically, the Navy intended to develop two new radars—an X-band and an S-band—under the AMDR program to support Flight III ships. However, in 2012 the Navy altered its plans, with the AMDR program reduced to a new S-band radar development effort that would be paired with the existing SPQ-9B X-band radar for the first 12 Flight III ships. This decision helped reduce the risk associated with conducting parallel radar development efforts, but also delayed the timeline for the improved X-band capability planned for Flight III until the 13th ship, anticipated to be delivered in 2027. According to Navy officials, there are no plans to retrofit the first 12 Flight III ships with the new radar once it is available. The Navy has not yet begun planning for the new X-band radar program and initial budgeting activities are not expected until at least 2018, with the new radar expected to be part of the Flight III baseline in fiscal year 2022. The first three Flight III ships will include ACB 20 core capabilities, with a second phase of capability improvements

intended to be provided beginning with the fourth ship. Figure 9 illustrates the Navy's planned approach for introducing additional capability to Flight III ships.

Figure 9: Flight III Planned Capabilities and Ship Deliveries



Source: GAO analysis of Navy data. | GAO-16-613

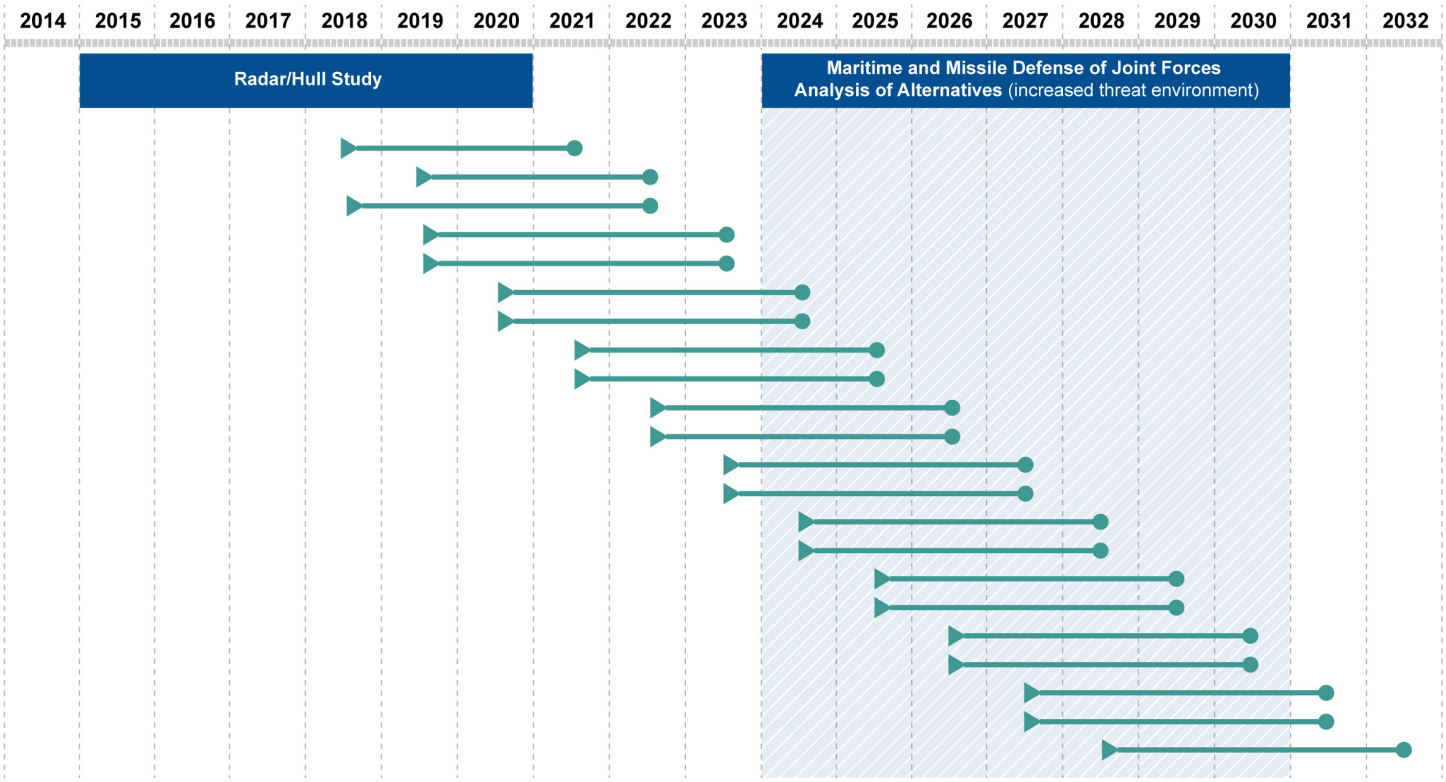
Note: All Flight III ships beginning with the fourth ship will receive the full ACB 20 capability; the first three ships will receive upgrades, but will include different hardware. The ship delivery profile is notional for all ships beginning in 2027.

Flight III Cannot Provide Needed Capability to Address the Most Stressing Anticipated Threats to Surface Combatants

Ultimately, the DDG 51 Flight III cannot provide the SPY+30 capability needed to address the threats identified in the 2007 MAMDJF analysis because the SPY-6 radar, which is as large as can be accommodated by the Flight III configuration, is not able to achieve this capability. MAMDJF stated that a large radar was needed on a surface combatant to counter the most stressing ballistic and cruise missile threats expected in the 2024 to 2030 time frame. In 2009, the Navy's Radar/Hull Study looked at ways to leverage existing Navy destroyer designs to address less stressing threats in the near-term at less cost. Raytheon representatives stated that the SPY-6 radar's performance in testing shows it provides SPY+17 capability, exceeding the SPY+15 requirement for Flight III and providing greater performance than existing radars.

DDG 51 Flight III ships with the SPY-6 radar are expected to deliver the capability necessary to counter the near-term threats identified in the Radar/Hull Study. Navy officials affirmed that the SPY-6 radar, if already available to the fleet, would help combat current threats. Navy officials also agreed that the threats identified in the 2007 Analysis of Alternatives remain valid. The actual threat environment when the first Flight III ships are delivered is more likely to reflect the threats outlined in the MAMDJF Analysis of Alternatives, as opposed to the less stressful threats outlined in the Radar/Hull Study. As shown in figure 10, the time frame for the threat environment assumed by the Radar/Hull Study will have passed by the time the lead Flight III ship is delivered to the fleet; at that point, the more stressing threat environment outlined in the MAMDJF Analysis of Alternatives timeframe will be imminent. Under the Navy's acquisition approach, six of the Flight III ships planned for the fiscal year 2018-2022 multiyear procurement, and over three-fourths of the 22 total planned ships, will be outpaced by the threat environment identified in the MAMDJF Analysis of Alternatives.

Figure 10: Flight III Threat Timeframes and Planned Ship Deliveries



Source: GAO analysis of Navy data. | GAO-16-613

Note: The ship delivery profile is notional for all ships beginning in 2027.

To account for the gap between the anticipated radar capability need and what SPY-6 can provide, the Navy may consider other maritime platforms that can accommodate a larger-scale version of SPY-6 or the use of radars on multiple ships. For example, as we found in 2012, the Navy altered its concept on the number of ships that will be operating in an IAMD environment in an effort to address the gap that exists between the 2007 Analysis of Alternatives' stated need and the expected SPY-6 capability.[41] Specifically, rather than one or a small number of ships

[41] GAO-12-113.

conducting IAMD alone and independently managing the most taxing threat environments without support, the Navy has envisioned multiple ships that can operate in concert with different ground- and space-based sensor assets to provide cueing for SPY-6 when targets are in the battlespace. The cueing would mean that the ship could be told by the off-board sensors where to look for a target, allowing for earlier detection and increased size of the area that can be covered. According to Navy requirements officers, the Navy is examining this concept—referred to as sensor netting—to augment radar capability, but the viability of this operational concept has yet to be proven.

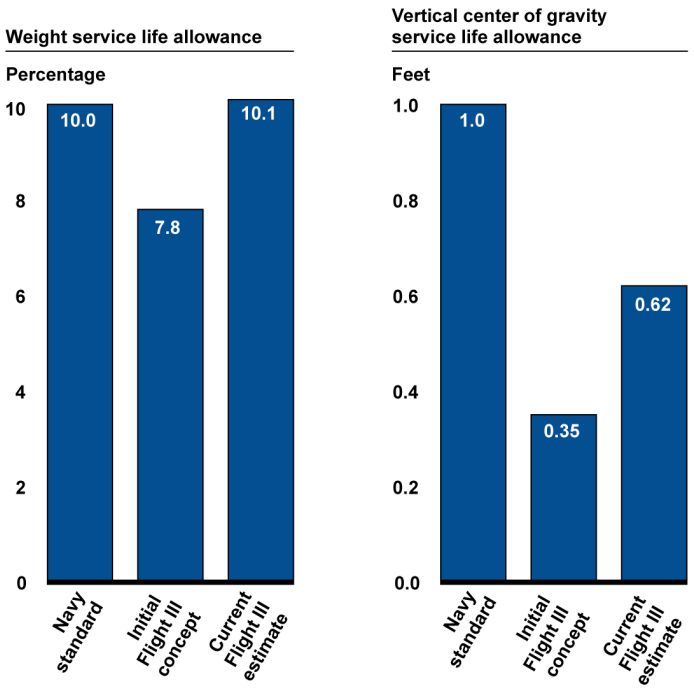
Physical Constraints of the Hull Form Limit Flight III's Future Upgrade Potential

The MAMDJF Analysis of Alternatives had originally excluded DDG 51-class ships from consideration as the platform for the SPY-6 radar due, in part, to minimal opportunity for growth and limited service life. Weight and center of gravity service life allowance limitations, in particular, affected the Navy's decisions about Flight III capabilities from the outset. Specifically, the SPY-6 radar was sized to provide the largest radar feasible for the Flight III configuration without requiring major structural changes to the hull form and design. A larger ship could have taken advantage of the scalability of the SPY-6 radar by installing a larger radar that would provide the Navy with increased capability. Thus, for any future capability upgrades to Flight III related to the radar or other systems, the Navy will have to consider significant changes to the DDG 51 hull form. Navy officials stated that adding a new section (called a plug) to the middle of the existing hull form is one option by which the Navy could achieve the additional square footage necessary to accommodate a larger radar. However, the Navy has never executed a plug for a complex, large surface combatant ship and the associated design effort would likely be complicated and costly.

The Navy's weight estimate for Flight III ships has remained relatively stable throughout design, with an overall weight growth of 159 tons since 2012. Navy officials acknowledged that the addition of the SPY-6 radar consumed a significant amount of the ship's vertical center of gravity service life allowance. Navy weight and vertical center of gravity allowances enable future changes to the ships, such as adding equipment, and reasonable growth during the ship's service life without unacceptable impacts on the ship. Ten percent of weight and a 1-foot vertical center of gravity are the Naval Sea Systems Command's architecture standards for surface combatants. According to program officials, the Navy accepts that Flight III will have less of an available service life allowance margin because DDG 51-class ships are inherently

dense by design. As figure 11 shows, according to Navy estimates, Flight III ships will essentially be right at the service life allowance standard for weight and well below the vertical center of gravity standard, even with the planned service life allowance improvements included as part of Flight III design.

Figure 11: Flight III Service Life Allowance Estimates



Source: GAO analysis of Navy data. | GAO-16-613

According to Navy requirements officers, Flight III's upgrade potential will require trade-offs with the currently planned systems and the Navy has already identified several other Flight III capability limitations as a result of DDG 51's hull size. For example, the Navy is unsure how the addition of the future X-band radar would impact the Flight III ship's center of gravity. In 2012, a Navy technical study on Flight III found that the addition of a new X-band radar would most likely require additional electric and cooling capacity beyond what is being introduced as part of Flight III configuration, which would necessitate the addition of another generator and air conditioning plant and subsequent equipment arrangement

challenges. Navy officials stated that based on their improved understanding of Flight III design, they now expect that there may be enough electric capacity to forgo the need for an additional generator. Similarly, the Navy is planning to begin a study to determine if an upgraded electronic warfare system— included in the initial Flight III concept—can be included within the ship's existing constraints.

Flight III's Ability to Fulfill Some Cruiser Responsibilities Is Being Considered as Navy Begins Planning for New Surface Combatant

With the pending retirement of the CG 47 Ticonderoga-class of cruisers and no new cruiser currently being developed, the Navy has expressed concern about a destroyer supporting the Navy commander's role in providing air and missile defense for a carrier strike group. Specifically, an air warfare commander (AWC), who is typically the commanding officer of a Navy cruiser within a carrier strike group, is responsible for defense against air and missile threats and requires crew and command, control, communications, and computer resources to fulfill this role.[42] While destroyers and cruisers both utilize the Aegis combat system and can accommodate AWC staff, the Navy has noted that the cruisers were built to support an AWC and are the most capable ships for fulfilling this role. Further, the Navy found through analysis of a Flight III technical feasibility study that the Flight III design does not have an increased capacity to readily enable the functionality required by a major warfare commander. A former Commander of Naval Surface Forces identified some notable differences for meeting AWC responsibilities on the different ships, including:

- The cruisers are commanded by a captain and have a more senior staff on the ship, with more individuals dedicated to the planning and execution of the air defense mission for the carrier strike group. By contrast, the destroyers are commanded by a commander with a less experienced, though capable, staff that will typically operate in a support role. If the AWC role were to transition permanently to the destroyers, additional training and expertise would be required for the staff. In the second year of its analysis of DDG 51 Flight III technical feasibility, the Navy estimated that for the AWC role to be executed on

[42] A carrier strike group is the Navy's largest operational unit, and is typically composed of an aircraft carrier, a cruiser, two destroyers, an attack submarine, and a combined ammunition/oiler/supply ship to gain and maintain sea control. The composition of each carrier strike group can vary.

a Flight III, personnel would need to be increased to fill 15-18 additional positions. The total amount needed is dependent on ballistic missile defense capability requirements.

- Unlike destroyers, the cruisers have radar array and transmitter redundancies that help avoid losing radar capability if the ship is damaged in combat. The cruisers also have a greater capacity—about 25 percent more than a Flight IIA—for launching surface-to-air missiles in support of the air defense mission. The cruisers have increased command-and-control capability over the guided-missile destroyers. This includes greater radio and satellite communication suites than a destroyer, as well as extra space for AWC staff—20 consoles in the combat information center compared to 16 on a DDG 51.

Navy requirements and DDG 51 program officials stated there are no current plans to have Flight III ships permanently replace the cruisers with respect to AWC operations. The Navy included a requirement for AWC equipment and crew accommodations in the Flight III upgrade. According to Navy officials, the equipment and accommodations will provide enhanced ballistic missile defense capability and can provide temporary AWC capability; however, Flight III ships do not meet the longevity requirement for AWC operations, making their use as a one-for-one replacement for the cruiser less viable. The AWC requirement for Flight III ultimately is an effort to reduce—but not eliminate—the capability gap created by the upcoming cruiser retirements.

The Navy is currently conducting a capabilities-based assessment for future surface combatants, which will assess capability shortfalls and risks in the mid-21st century for surface combatant forces. According to Navy officials, this assessment will take into account the findings and gaps identified in the MAMDJF Analysis of Alternatives. The assessment is intended to provide a better understanding of the capability challenges that will result from the retirements of cruiser, littoral combat, and DDG 51 Flight IIA ships in the coming decades, but will not identify potential solutions to address those challenges. In addition to this ongoing assessment, the Navy identified plans in its fiscal year 2016 annual long-range shipbuilding plan, submitted to Congress, for a future surface combatant ship, referred to as DDG(X), with the procurement of 37 ships to begin in 2030. This was a change from the Navy's 2012 annual long-range plan, which included a future DDG 51 Flight IV, with the procurement of 22 ships to begin in 2032.

Conclusions

The Navy is in the early stages of its planned investment of more than $50 billion over the next 10 years to design and construct 22 DDG 51 Flight III destroyers. While the Navy has made some good decisions in support of DDG 51 Flight III, including taking an incremental approach to developing and delivering new radar and Aegis combat system capabilities, several challenges in design, development, integration and testing of the radar, upgraded combat system, and the ship itself will need to be overcome going forward. The Navy has implemented a number of practices to reduce program risk. However, the Navy is still defining requirements for an upgraded Aegis combat system, which must be successfully developed, integrated, and tested with the SPY-6 radar under a relatively compressed schedule that includes increased risk in order to meet Flight III's schedule needs. Further, substantial design changes remain before the Navy will have a sufficient understanding of the resources required to support ship construction. Nevertheless, the Navy intends to ask Congress to commit to the initial ships and the succeeding multiyear procurement beginning in fiscal year 2018 with limited design and cost information in hand. This approach portends risk in the future, which amplifies the need for improved oversight mechanisms to facilitate greater transparency of the cost, schedule, and performance for Flight III.

The considerable cost of the Flight III, AMDR, and Aegis programs, as well as the challenges the Navy faces in working to effectively synchronize their schedules, emphasizes the need to ensure a knowledge-based contracting approach and adequate program oversight. Many unknowns remain with regards to cost and the design of Flight III. In particular, the Navy's plan to issue the lead Flight III ship construction modifications with limited design knowledge puts the government at greater risk that the contract modifications may not represent the true cost to implement the changes during construction. A realistic assessment of Flight III costs gained through completing more of the ship design prior to procuring the lead ship would put the government in a better negotiating position—which is particularly important given that the lead ship is anticipated to be awarded on a sole source basis. Further, the Navy's estimate of $2.35 billion in cost savings that it expects to achieve through the fiscal year 2013-2017 multiyear procurement has not been updated to reflect the additional costs to design and construct the Flight IIIs. A more accurate assessment of the estimated cost savings for this current multiyear procurement would increase transparency into the expected cost savings. It would also provide valuable insight into expected savings for the next planned multiyear procurement of Flight III ships. The timing of the Navy's request for authority for the next procurement is also a

matter of concern. The Navy's plan to request, in February 2017, multiyear procurement authority for fiscal years 2018-2022, means it would ask Congress to commit to procuring nearly half of the planned Flight III ships with an incomplete understanding of cost and, effectively, no Flight III construction history to support the decision.

Although the department responded to our 2012 recommendation to improve program oversight by elevating the program's milestone decision authority, Flight III's status as a new configuration within the existing DDG 51 program, as opposed to its own acquisition program or a major subprogram, reduces congressional insight into cost and schedule plans and performance. Greater transparency of Flight III performance against cost and schedule goals, for example, in standard Selected Acquisition Reports to Congress on the DDG 51 class, would assist DOD and Congress in performing their oversight responsibilities. This oversight continues to be important, as the Navy still has risks to overcome in achieving the intended capabilities of Flight III ships. Greater transparency could also increase awareness of how any future Navy decisions to add capabilities to Flight III will affect the program, such as those related to the cost and schedule plans for the future X-band radar or plans to upgrade electronic warfare systems for later ships.

Matter for Congressional Consideration

To ensure a more accurate estimate of the expected cost savings under the fiscal year 2013-2017 multiyear procurement, Congress should consider requiring the Navy to update its estimate of savings, which currently reflects only Flight IIA ships, to increase transparency for costs and savings for Congress and the taxpayers, as well as provide improved information to support future multiyear procurement savings estimates.

Recommendations for Executive Action

We recommend that the Secretary of Defense take the following three actions:

To ensure the department and the shipbuilder have sufficient knowledge of the Flight III design and anticipated costs when making decisions on the award of the lead ship, we recommend that the Secretary of Defense direct the Secretary of the Navy to:

- Delay the procurement of the lead Flight III ship until detail design is sufficiently complete to allow the government to have a more thorough understanding of the costs and risks associated with Flight III ship construction.

To ensure sufficient knowledge of Flight III design and enable some Flight III construction history to inform cost expectations for future multiyear procurement decisions, we also recommend that the Secretary of Defense direct the Secretary of the Navy to:

- Refrain from seeking authority from Congress for multiyear authority for the procurement of Flight III ships, as currently planned for 2018, until the Navy is able to preliminarily find, relying on DDG 51 Flight III data, that the Flight III configuration will meet criteria for seeking multiyear procurement authority, such as a stable design and realistic cost estimates.

To better support DDG 51 Flight III oversight, we recommend that the Secretary of Defense:

- Designate the Flight III configuration as a major subprogram of the DDG 51 program in order to increase the transparency, via Selected Acquisition Reports, of Flight III cost, schedule, and performance baselines within the broader context of the DDG 51 program.

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for review and comment. Its written comments are reprinted in appendix II of this report. DOD partially concurred with our three recommendations.

In regards to our recommendation to delay procurement of the lead Flight III ship until more detail design information will be available, DOD acknowledged the importance of a thorough understanding of the costs and risks prior to making procurement decisions but does not believe the procurement should be delayed. We continue to believe that waiting until at least fiscal year 2017 to procure the lead Flight III ship would result in additional time to develop the detail design for Flight III and would in turn support a more refined understanding of design changes and their implications on ship construction and costs prior to making significant contractual commitments. As noted in our report, both shipbuilders support this delay. Additionally, the Flight III program has yet to finalize its request for proposal for the lead ship and receive a shipbuilder response, both of which are required prior to the planned Defense Acquisition Board review—which was postponed indefinitely earlier this year—and are needed in order to proceed with the procurement of the lead Flight III ship. The positive aspects of delaying the lead ship procurement, when combined with the reality that the department will be challenged to accomplish all of its requisite activities to procure the first Flight III ship

before the end of fiscal year 2016, support lead ship procurement based on improved design knowledge in fiscal year 2017.

Regarding our recommendation on the next planned multiyear procurement for DDG 51 Flight III ships, the department agrees that the criteria for seeking multiyear procurement authority must be met but disagreed that it should refrain from seeking multiyear procurement authority based on the current state of information available on the Flight III configuration. As we have emphasized, the Navy is unlikely to meet all of the criteria for requesting multiyear procurement authority using data from Flight III—particularly as they relate to cost and design stability—in time to seek authority to award the Flight III multiyear contracts planned for fiscal year 2018. Flight III detail design will be nearly a year away from completion when the President's budget request for fiscal year 2018 would need to be submitted for such a procurement. Further, construction of the first Flight III ship will be about to begin, meaning there will be no Flight III construction history to inform any estimates of ship costs or the savings from use of multiyear procurement. We believe the Navy's Flight III multiyear procurement strategy lacks sufficient knowledge on design and cost, and poses significant risk to the government. This includes the risk of Congress committing to procure nearly half of the planned Flight III ships without adequate information to support such a decision.

Finally, while the department agreed that visibility into Flight III cost, schedule, and performance is important for oversight, and noted planned activities to provide such visibility, DOD does not plan to designate Flight III as a major subprogram. Instead, the department intends to continue reporting on DDG 51-class ships as a single major program in the Selected Acquisition Reports as it has done through previous Flight upgrades. DOD stated that the major impediment to implementing our recommendation is the difficulty in allocating research, development, test, and evaluation costs for the Aegis weapon system. Although the Flight III information that the department stated it intends to provide in next fiscal year's budget documentation and future Selected Acquisition Reports may help support oversight activities, we believe that designating Flight III as a major subprogram would enhance Flight III oversight efforts and is befitting for an acquisition that is expected to cost more than $50 billion over the next decade. We acknowledge the challenge noted by the department regarding the allocation of costs for the Aegis weapon system. However, the Navy has demonstrated the ability to provide sufficient Aegis funding information to support reporting on specific Aegis advanced capability builds that are designated to specific DDG 51 ships. For example, the fiscal year 2016 President's budget submission outlines

funding for different builds, including ACB 20 that is being developed for Flight III. We understand that some elements of Aegis cost may be more difficult to associate with Flight III because of software components shared across different baselines of the system. The Navy could communicate any limitations to the information as part of reporting Aegis cost information for Flight III. We continue to believe that the improved transparency that would be achieved by formally recognizing Flight III as a major subprogram would be beneficial to Congress and to the taxpayers.

DOD also separately provided technical comments on our draft report. We incorporated the comments as appropriate, such as to provide additional context in the report. In doing so, we found that the findings and message of our report remained the same. In a few cases, the department's suggestions or deletions were not supported by the preponderance of evidence or were based on a difference of opinion, rather than fact. In those instances, we did not make the suggested changes.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, the Secretary of the Navy, and other interested parties. In addition, this report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-4841 or mackinm@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.

Michele Mackin
Director, Acquisition and Sourcing Management

List of Committees

The Honorable John McCain
Chairman
The Honorable Jack Reed
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Thad Cochran
Chairman
The Honorable Richard J. Durbin
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Mac Thornberry
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Rodney Frelinghuysen
Chairman
The Honorable Pete Visclosky
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Objectives, Scope, and Methodology

This report evaluates the Navy's planned acquisition strategies for the DDG 51-class Flight III ships and the Air and Missile Defense Radar (AMDR) programs. Specifically, we assessed (1) the status of the Navy's efforts to develop, test, and integrate the SPY-6 radar and Aegis combat system in support of DDG 51 Flight III, including plans for operational testing; (2) challenges, if any, associated with the Navy's plans to design and construct Flight III ships; (3) the Flight III acquisition approach and oversight activities, including reporting on cost, schedule, and performance; and (4) the capabilities that Flight III ships are expected to provide and the extent to which these capabilities fulfill the Navy's existing and future surface combatant needs.

To assess the status of the Navy's effort to develop, test, and integrate the SPY-6 radar and Aegis combat system in support of DDG 51 Flight III, we reviewed program briefings and schedules, results from recent test and design reviews, and other Navy, Department of Defense (DOD), and contractor documentation to assess the cost, schedule, and performance risks of the AMDR and Aegis combat system programs. We assessed the maturity of the technologies that make up AMDR to determine remaining risks to their development. We reviewed the acquisition program baseline, selected acquisition reports, and Defense Contract Management Agency assessments to determine the cost risk that exists within the program. We assessed the progress and existing risks for the SPY-6 radar and identified integration challenges with Aegis. We reviewed the results of the current Aegis testing and schedules for software development, including the Navy's plans for the Aegis iteration that will support DDG 51 Flight III. To corroborate documentary evidence and gather additional information in support of our review, we met with officials from the Navy's Program Executive Office (PEO) Integrated Warfare Systems (IWS) 1.0 and 2.0, which manage the Aegis and AMDR programs, respectively, and the Missile Defense Agency. Additionally, we met with representatives from Raytheon and Lockheed Martin, the prime contractors for the SPY-6 radar and Aegis combat system, respectively, to discuss the development efforts, test plans, and initial integration efforts for each capability. We met with officials from the Defense Contract Management Agency to discuss Raytheon's SPY-6 radar development activities and performance. We also met with officials from the Navy's office of the Deputy Assistant Secretary of the Navy (Test and Evaluation) and relevant PEOs, as well as DOD's offices of the Director, Operational Test and Evaluation, Deputy Assistant Secretary of Defense for Developmental Test and Evaluation, and Cost Assessment and Program Evaluation (CAPE) to discuss the use of a self-defense test ship for operational testing. This included discussion of how the Flight III integrated air and missile defense systems—

particularly the SPY-6 radar, Aegis, and Evolved Sea Sparrow Missile systems—could be effectively tested to demonstrate the ship's self-defense capabilities. We reviewed the Navy's planned test approach and the technical aspects of the approach that have been the subject of disagreement between the Navy and DOT&E regarding the use of an unmanned self-defense test ship. We assessed the fundamental differences between the two positions, including the costs associated with use of a self-defense test ship for operational testing. In addition to the contents within this report, we are also issuing a classified annex, *Arleigh Burke Destroyers: Classified Annex to GAO-16-613, Delaying Procurement of DDG 51 Flight III Ships Would Allow Time to Increase Design Knowledge,* GAO-16-846C, which contains supplemental information on the self-defense test ship issue for Flight III.

To determine what challenges, if any, are associated with the Navy's approach to design and construct Flight III ships, we reviewed Navy and contractor documents that address the technologies being introduced as part of Flight III, including program schedules and briefings, test reports, and design progress reports. We compared Flight III design changes—including number, type, and location of those changes—to Navy and contractor estimates and to previous DDG 51-class upgrades to assess the complexity of Flight III design. We evaluated Navy and contractor documents outlining schedule parameters for DDG 51 Flight III ships, including budget submissions, contracts, cost estimates, reports to Congress, and program schedules and briefings. We analyzed the extent to which these parameters have changed over time for Flight III and compared them with our prior work on shipbuilding best practices.[1]

To assess the Flight III acquisition approach and oversight activities, including reporting on cost, schedule, and performance, we reviewed the acquisition strategy and other key documents, including DOD memorandums and reports to Congress, which outlined the Navy's acquisition approach for Flight III. We compared the Navy's acquisition strategy against the documentation and requirements typically necessary for a new acquisition program based on DOD acquisition guidance. We reviewed Navy program briefings, reports to Congress, and testimony

[1] GAO, *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding,* GAO-09-322 (Washington, D.C.: May 13, 2009).

statements to identify how the Flight III acquisition strategy has changed over time and the extent to which the Navy has completed key activities that are part of its acquisition approach, including updating documents and holding program reviews. We also assessed the Flight III contracting strategy by comparing the Navy's knowledge of Flight III design and construction to statutory criteria required for requesting authorization to use a multiyear contract.[2] To further corroborate documentary evidence and gather additional information in support of our review, we conducted interviews with relevant Navy officials responsible for managing the design and construction of DDG 51 Flight III ships, such as those within PEO Ships, DDG 51 program office, Electric Ships program office, PEO IWS, Naval Sea Systems Command's Naval Systems Engineering, and Supervisor of Shipbuilding, Conversion, and Repair. We also met with representatives from the lead and follow shipyards—Bath Iron Works Corporation and Huntington Ingalls Industries—to understand their role in Flight III design and development. To understand Flight III cost considerations, we interviewed CAPE about cost estimation activities for the program.

To assess what capabilities Flight III ships are expected to provide and the extent to which these capabilities fulfill the Navy's existing and future surface combatant needs, we compared the Navy's 2009 Radar/Hull Study—which was the main tool the Navy used to identify the DDG 51 Flight III as the platform for AMDR—with the Navy's Maritime Air and Missile Defense of Joint Forces (MAMDJF) Analysis of Alternatives, a 2007 Navy study related to ballistic missile defense and integrated air and missile defense. We reviewed the Capability Development Documents for both DDG 51 Flight III and AMDR and other Navy documentation to determine the capabilities that the Navy had originally planned to include as part of the Flight III configuration. We compared these capabilities against those that are currently expected to be delivered as part of the first three Flight III ships. We assessed the extent to which Flight III and AMDR planned capabilities fulfill requirements for surface combatants based on MAMDJF stated requirements. We also reviewed the potential for Flight III to fulfill air and missile defense requirements that are currently the responsibility of the Navy's cruiser fleet. We examined ship weight reports and other Navy, DOD, and contractor documentation to

[2] 10 U.S.C. § 2306b.

analyze Fight III's service life allowance and determine the extent to which future upgrades can be introduced onto the ship. To further corroborate documentary evidence and gather additional information to support our review, we met with officials from the office of the Chief of Naval Operations to discuss the status Navy's current and any future studies related to surface combatants and integrated air and missile defense capabilities. We also met with officials from the PEO Ships, PEO IWS, and the Joint Staff.

We conducted this performance audit from July 2015 to August 2016 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Comments from the Department of Defense

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
3015 DEFENSE PENTAGON
WASHINGTON, DC 20301-3015

ACQUISITION

JUL 18 2016

Ms. Michele Mackin
Director
Acquisition and Sourcing Management
U.S. Government Accountability Office
441 G Street, N.W.
Washington, DC 20548

Dear Ms. Mackin:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-16-613, 'ARLEIGH BURKE DESTROYERS: Delaying Procurement of DDG 51 Flight III Ships Would Allow Time to Increase Design Knowledge,' dated June 16, 2016 (GAO Code 100143). The Department acknowledges receipt of the draft report and notes that it contains three recommendations for DoD action as a result of your review.

The Department partially concurs with each of the three recommendations in the draft report for the reasons stated in the enclosure.

The Department appreciates the opportunity to comment on the draft report. For further questions concerning this report, please contact Dr. James Moreland, Deputy Director, Tactical Warfare Systems, Naval Warfare, at james.d.moreland18.civ@mail.mil or 703-614-3170.

Sincerely,

James A. MacStravic
Acting Principal Deputy Assistant Secretary of Defense for Acquisition
Performing the Duties of the Assistant Secretary of Defense for Acquisition

Enclosure:
As stated

GAO DRAFT REPORT DATED JUNE 16, 2016
GAO-16-613 (GAO CODE 100143)

"ARLEIGH BURKE DESTROYERS: DELAYING PROCUREMENT OF DDG 51 FLIGHT III SHIPS WOULD ALLOW TIME TO INCREASE DESIGN KNOWLEDGE"

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATION

RECOMMENDATION 1: To ensure the Department and the shipbuilder have sufficient knowledge of the Flight III design and anticipated costs when making decisions on the award of the lead ship, GAO recommends that the Secretary of Defense direct the Secretary of the Navy to delay the procurement of the lead Flight III ship until detail design is sufficiently complete to allow the government to have a more thorough understanding of the costs and risks associated with Flight III ship construction.

DoD RESPONSE: Partial Concur. The Department agrees that the procurement of the lead Flight III ship should be informed by a thorough understanding of the costs and risks associated with Flight III ship construction. The risks associated with the ship and the radar were identified previously and the planned activities to reduce and retire those risks remain on schedule, as annotated in the GAO report. The Department acknowledges that efforts remain in both ship design and radar testing, however, the timeline for execution of that work scope has not changed since Congressional enactment of the 2016 budget, where funding was authorized and appropriated for the first DDG 51 Flight III ship. The Department agrees that the start of construction should be a knowledge based decision. In June 2014, the Navy was directed to evaluate shipbuilder costs for implementation of the Flight III Engineering Change Proposals before seeking approval to proceed with Flight III construction. The Navy expects to have these evaluated costs and an understanding of the risks prior to the Defense Acquisition Board review, when the Navy will request approval from the Defense Acquisition Executive to proceed with construction of the Flight III lead ship. Pending that decision, the Department disagrees that this will require any delay in the procurement of the Flight III lead ship. Delaying procurement of the lead DDG 51 Flight III ship could impact the ability to meet the validated Initial Operational Capability date and create risk in fulfilling the joint warfighters' needs. For reference purposes this item will be identified as GAO-16-613-01.

RECOMMENDATION 2: To ensure sufficient knowledge of Flight III design and enable some Flight III construction history to inform cost expectations for future multiyear procurement decisions, GAO also recommends that the Secretary of Defense direct the Secretary of the Navy to refrain from seeking authority from Congress for multiyear authority for the procurement of Flight III ships, as currently planned for 2018, until the Navy is able to preliminarily find, relying on DDG 51 Flight III data, that the Flight III configuration will meet criteria for seeking multiyear procurement authority, such as a stable design and realistic cost estimates.

DoD RESPONSE: Partial Concur. The Department agrees that the criteria for seeking multiyear procurement authority must be met, if the Department decides to make such a request

for the 2018 procurement of DDG 51 Class ships. The Department disagrees that it should refrain from seeking multiyear procurement authority based on the current state of information available on the Flight III configuration. Information about the stability of the design as well as cost realism will be evaluated in the normal work-up to any multiyear procurement authority request and a decision will be made at that time on whether the criteria for requesting multiyear procurement authority are met. For reference purposes this item will be identified as GAO-16-613-02.

RECOMMENDATION 3: To better support DDG 51 Flight III oversight, GAO recommends that the Secretary of Defense designate the Flight III configuration as a major subprogram of the DDG 51 program in order to increase the transparency, via Selected Acquisition Reports, of Flight III cost, schedule and performance baselines within the broader context of the DDG 51 program.

DoD RESPONSE: Partial Concur. The Department agrees that visibility on cost, schedule, and performance relative to Flight III construction is important for oversight of the program. This will be accomplished as follows. From a cost visibility standpoint, beginning in Fiscal Year (FY) 2017 all new DDG 51 ships will be Flight III and annual budget documents will break out that cost data separately. Likewise, for the Air and Missile Defense Radar, AN/SPY-6(V), cost visibility will be provided in budget documents through a separate P-35 budget exhibit. From a schedule and performance perspective, Flight III schedule milestones and performance parameters will be identified in future Selected Acquisition Reports (SAR) once an update to the Acquisition Program Baseline is approved. Approval is expected in time to support the next SAR submission. The Department disagrees that Flight III should be designated as a major subprogram of the DDG 51 program. The primary obstacle to such designation is the allocation of RDT&E costs for the Aegis Weapon System. Because many of the software components that make up the Aegis Weapon System are shared among Aegis baselines, both future and legacy, it would be difficult to accurately allocate all of those costs between the two subprogram elements, Flight IIA and prior ships as one subprogram and Flight III ships as a second subprogram. The Department intends to continue reporting DDG 51 as a single major program as it has done through two previous significant Flight upgrades, Flight II and Flight IIA. For reference purposes this item will be identified as GAO-16-613-03.

Appendix III: GAO Contacts and Staff Acknowledgments

GAO Contact

Michele Mackin, 202-512-4841 or mackinm@gao.gov.

Acknowledgments

In addition to the contact above, Diana Moldafsky, Assistant Director; Pedro Almoguera; Laura Greifner; Laura Jezewski; C. James Madar; Sean Merrill; Garrett Riba; Roxanna Sun; James Tallon; Hai Tran; and Alyssa Weir made key contributions to this report.

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