United States Government Accountability Office

Report to Congressional Committees

November 2014

FORD-CLASS AIRCRAFT CARRIER

Congress Should Consider Revising Cost Cap Legislation to Include All Construction Costs

GAO-15-22

GAO Highlights

Highlights of GAO-15-22, a report to congressional committees

November 2014

FORD-CLASS AIRCRAFT CARRIER

Congress Should Consider Revising Cost Cap Legislation to Include All Construction Costs

Why GAO Did This Study

Ford-class aircraft carriers will feature new technologies designed to reduce life-cycle costs. The lead ship, CVN 78, has been under construction since 2008, and early construction on CVN 79 is underway. In 2007 Congress established a cap for procurement costs—which has been adjusted over time. In September 2013, GAO reported on a $2.3 billion increase in CVN 78 construction costs.

GAO was mandated to examine risks in the CVN 78 program since its September 2013 report. This report assesses (1) the extent to which CVN 78 will be delivered within revised cost and schedule goals; (2) if CVN 78 will demonstrate its required capabilities before ship deployment; and (3) the steps the Navy is taking to achieve CVN 79 cost goals. To perform this work, GAO analyzed Navy and contractor data, and scheduling best practices.

What GAO Recommends

Congress should consider revising the cost cap legislation to improve accountability of Ford-class construction costs, by requiring that all work included in the initial ship cost estimate is counted against the cost cap. If warranted, the Navy would be required to seek statutory authority to increase the cap. GAO is not making new recommendations, but believes previous recommendations, including a re-examination of requirements and improvements to the test plan, remain valid. DOD agreed with much of the report, but disagreed with GAO's position on the cost caps. GAO believes that changes to the legislation are warranted to improve cost accountability.

View GAO-15-22. For more information, contact Michele Mackin at (202) 512-4841 or mackinm@gao.gov.

What GAO Found

The extent to which the lead Ford-class ship, CVN 78, will be delivered by its current March 2016 delivery date and within the Navy's $12.9 billion estimate is dependent on the Navy's plan to defer work and costs to the post-delivery period. Lagging construction progress as well as ongoing issues with key technologies further exacerbate an already compressed schedule and create further cost and schedule risks. With the shipbuilder embarking on one of the most complex phases of construction with the greatest likelihood for cost growth, cost increases beyond the current $12.9 billion cost cap appear likely. In response, the Navy is deferring some work until after ship delivery to create a funding reserve to pay for any additional cost growth stemming from remaining construction risks. This strategy will result in the need for additional funding later, which the Navy plans to request through its post-delivery and outfitting budget account. However, this approach obscures visibility into the true cost of the ship and results in delivering a ship that is less complete than initially planned.

CVN 78 will deploy without demonstrating full operational capabilities because it cannot achieve certain key requirements according to its current test schedule. Key requirements—such as increasing aircraft launch and recovery rates—will likely not be met before the ship is deployment ready and could limit ship operations. Further, CVN 78 will not meet a requirement that allows for increases to the size of the crew over the service life of the ship. In fact, the ship may not even be able to accommodate the likely need for additional crew to operate the ship without operational tradeoffs. Since GAO's last report in September 2013, post-delivery plans to test CVN 78's capabilities have become more compressed, further increasing the likelihood that CVN 78 will not deploy as scheduled or will deploy without fully tested systems.

The Navy is implementing steps to achieve the $11.5 billion congressional cost cap for the second ship, CVN 79, but these are largely based on ambitious efficiency gains and reducing a significant amount of construction, installation, and testing—work traditionally completed prior to ship delivery. Since GAO last reported in September 2013, the Navy extended CVN 79's construction preparation contract to allow additional time for the shipbuilder to reduce cost risks and incorporate lessons learned from construction of CVN 78. At the same time, the Navy continues to revise its acquisition strategy for CVN 79 in an effort to ensure that costs do not exceed the cost cap, by postponing installation of some systems until after ship delivery, and deferring an estimated $200 million - $250 million in previously planned capability upgrades of the ship's combat systems to be completed well after the ship is operational. Further, if CVN 79 construction costs should grow above the legislated cost cap, the Navy may choose to use funding intended for work to complete the ship after delivery to cover construction cost increases. As with CVN 78, the Navy could choose to request additional funding through post-delivery budget accounts not included in calculating the ship's end cost. Navy officials view this as an approach to managing the cost cap. However, doing so impairs accountability for actual ship costs.

Contents

Figures

Abbreviations

AAG	advanced arresting gear
CP	construction preparation
DOD	Department of Defense
DOT&E	Director for Operational Test and Evaluation
DT&E	Developmental Test and Evaluation
DBR	dual band radar
EMALS	electromagnetic aircraft launch system
IOT&E	initial operational test and evaluation
SGR	sortie generation rate
TEMP	test and evaluation master plan

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

November 20, 2014

Congressional Committees

The Navy is developing the Ford-class nuclear-powered aircraft carrier to serve as the future centerpiece of the carrier strike group. The Ford class is the successor to the Nimitz-class aircraft carrier designed in the 1960s and is introducing a number of advanced technologies to the fleet in the areas of propulsion, aircraft launch and recovery, weapons handling, and survivability. These technologies are intended to create operational efficiencies while enabling a 25 percent increase in sortie rates (operational flights by aircraft) as compared to legacy Nimitz-class aircraft carriers. In addition, the Navy anticipates that these technologies will enable Ford-class carriers to operate with reduced manpower as compared to the legacy carriers. The Navy plans to invest over $43 billion to develop, design, construct, and test three Ford-class carriers. At present, the lead ship, *Gerald R. Ford* (CVN 78), is about 80 percent complete and early construction work is under way for the first follow-on ship, *John F. Kennedy* (CVN 79).

Since 2008, the Navy has increased its budget estimate for construction of the lead ship from $10.5 billion to $12.9 billion in then-year dollars—an increase of over 20 percent above initial estimates, and delayed delivery from September 2015 to March 2016. We found in September 2013 that continued cost growth has the potential to derail the Navy's ability to deliver Ford-class aircraft carriers on its schedule with expected capabilities. In light of our September 2013 report, a Senate report accompanying a bill for the National Defense Authorization Act for Fiscal Year 2014 mandated GAO to review the Navy's acquisition of the Ford-class.[1] This report examines remaining risks in the CVN 78 program since September 2013 by assessing: (1) the extent to which CVN 78 will be delivered to the Navy within its revised cost and schedule goals; (2) if, after delivery, CVN 78 will demonstrate its required capabilities through testing before the ship is deployment ready; and (3) the steps the Navy is taking to achieve CVN 79 cost goals.

[1] S. Rep. 113-44, at 21-22 (2013).

To identify challenges in delivering the lead ship within current budget and schedule estimates, we analyzed Navy budget submissions, contract performance reports, and briefings, and historical cost performance on previous carriers. To evaluate the Navy's strategy to demonstrate CVN 78's capabilities, we met with system developers and analyzed the program's test and evaluation master plan, as well as test plans, development schedules, and reliability data for key CVN 78 systems. To assess the steps the Navy is taking to achieve CVN 79 cost goals, we met with Navy and shipbuilder officials, analyzed CVN 79 construction preparation contract documents and scopes of work as well as the shipbuilder's performance for related work activities. We also reviewed the shipbuilder's plans for process improvements and labor hour reduction efforts and the associated cost savings, and analyzed construction schedules for CVN 78 and CVN 79 and compared them with scheduling best practices. Lastly, we evaluated the Navy's revised build strategy for CVN 79 and compared it with the ship's previous acquisition schedule. To corroborate information for each of these objectives, we interviewed DOD officials and the shipbuilder responsible for the Ford-class carrier requirements, development, acquisition, and testing. A more detailed description of our scope and methodology is presented in appendix I.

We conducted this performance audit from December 2013 to November 2014 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 Ford class features a number of improvements over existing aircraft carriers that the Navy believes will improve the combat capability of the carrier fleet while simultaneously reducing acquisition and life cycle costs. These improvements include an increased rate of aircraft deploying from the carrier (sorties), reduced manning, significant growth in electrical generating capability, and larger service life margins for weight and stability to support future changes to the ship during its expected 50-year service life.

To meet its requirements, the Navy developed over a dozen new technologies for installation on Ford-class ships (see appendix II). For example, advanced weapons elevators, using an electromagnetic field to transport weapons within the ship instead of cables, are expected to increase payload capacity by 229 percent as compared to Nimitz-class carriers, while also facilitating reduced manning and higher sortie generation rates. Other technologies allowed the Navy to implement favorable design features into the ship, including an enlarged flight deck, a smaller, aft-positioned island, and a flexible ship infrastructure to accommodate changes during the ship's service life. As we have previously reported, of the critical technologies, three have presented some of the greatest challenge during development and construction:[2]

- **Electromagnetic Aircraft Launch System** (EMALS), which uses an electrically generated moving magnetic field to propel aircraft that places less physical stress on aircraft as compared to legacy steam catapult launchers on Nimitz-class carriers.
- **Advanced Arresting Gear** (AAG) is an electric motor based aircraft recovery system that rapidly decelerates an aircraft as it lands. AAG replaces legacy hydraulic arresting equipment currently in use on Nimitz-class carriers.
- **Dual Band Radar** (DBR) integrates two component radars—the multifunction radar and the volume search radar—to conduct air traffic control, ship self-defense, and other operations. The multifunction radar includes horizon search, surface search, navigation, and missile communications. The volume search radar includes long-range, above horizon surveillance and air traffic control capabilities.

Shipbuilding Phases

As is typical in Navy shipbuilding, Ford-class carrier construction occurs in several phases and includes several key events, including the following:

- **Pre-construction and planning:** Long-lead time materials and equipment are procured and the shipbuilder plans for beginning ship construction.
- **Block fabrication, outfitting, and erection:** Metal plates are welded together to form blocks, which are the basic building components of

[2] GAO, *Ford-class Carriers: Lead Ship Testing and Reliability Shortfalls Will Limit Initial Fleet Capabilities,* GAO-13-396 (Washington, D.C.: Sept. 5, 2013; and *Defense Acquisitions: Navy Faces Challenges Constructing the Aircraft Carrier* Gerald R. Ford *within Budget,* GAO-07-866 (Washington, D.C.: Aug. 23, 2007).

the ship. The blocks are assembled and outfitted with pipes, brackets for machinery or cabling, ladders, and any other equipment that may be available for installation. Groupings of blocks form superlifts, which are then lifted by crane into dry dock and welded into the respective location of the ship.

- **Launch:** After the ship is watertight, it can be launched—floated in the water—then towed into a quay or dock area where remaining construction and outfitting of the ship occurs.
- **Shipboard testing:** Once construction and system installations are largely complete, the builder will test the ship's hull, mechanical and electrical systems, and key technologies to demonstrate compliance with ship specifications and provide assurance that the items tested operate satisfactorily within permissible design parameters.
- **Delivery:** Once the Navy is satisfied that the ship is seaworthy and the shipbuilder has met requirements, the shipyard transfers custody of the ship to the Navy.[3]
- **Post-delivery activities:** After ship delivery, tests are conducted on the ship's combat and mission-critical systems, the ship's air wing—consisting of the assigned fixed and rotary wing aircraft, pilots, support and maintenance personnel—is brought onto the ship, and the crew begins training and operating the ship while at sea. A period of planned maintenance, modernization, and correction of government-responsible deficiencies follows—referred to as Post Shakedown Availability.
- **Deployment ready:** The last stage of the ship acquisition process occurs when all crew and system operational tests, trainings, and certifications have been obtained and the ship has achieved the necessary level of readiness needed to embark on its first deployment.

[3]The process by which the Navy delivers an aircraft carrier differs slightly from a traditional Navy shipbuilding project. During construction of nuclear powered ships, including submarines and aircraft carriers, the Navy assumes custody of individual compartments upon completion by the shipbuilder and the ship's crew subsequently begins boarding and training. In contrast, during a non-nuclear Navy shipbuilding project the shipbuilder maintains custody of the ship until the ship is delivered to the Navy, upon the signing of a Material Inspection and Receiving Report.

Test Events

During and after construction, DOD acquisition policy requires major defense programs, including shipbuilding programs, to execute and complete several types of testing, while the ship progresses toward operational milestones including the point during the acquisition process when the fleet initially receives and maintains the ship:

- **Developmental testing** is intended to assist in the maturation of products, product elements, or manufacturing or support processes. For ship technologies, developmental testing typically includes land-based testing activities prior to introducing a new technology in a maritime environment and commencing with shipboard testing. Developmental testing does not include testing systems in concert with other systems.
- **Integration testing** is intended to assess, verify, and validate the performance of multiple systems operating together to achieve required ship capabilities. For example, integration testing would include among other things, testing the operability of the DBR in a realistic environment where multiple antennas and arrays are emitting and receiving transmissions and multiple loads are placed upon the ship's power and cooling systems simultaneously.
- **Initial Operational Test and Evaluation** (IOT&E) is a major component of post-delivery testing intended to assess a weapon system's capability in a realistic environment when maintained and operated by sailors, subjected to routine wear-and-tear, and employed in combat conditions against simulated enemies. During this test phase, the ship is exposed to as many actual operational scenarios as possible to reveal the weapon system's capability under stress.

The Navy schedules and plans these test phases and milestones using a test and evaluation master plan (TEMP) that is approved by the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation (DT&E) and the Director for Operational Test and Evaluation (DOT&E). The Deputy Assistant Secretary of Defense for DT&E leads the organization within the Office of the Secretary of Defense that is responsible for providing developmental test and evaluation oversight and support to major acquisition programs. The Director, DOT&E leads the organization within the Office of the Secretary of Defense that is responsible for providing operational test and evaluation oversight and support to major defense acquisition programs.[4]

Ford-Class Contracts

Due to their vast size and complexity, aircraft carriers require funding for design, long-lead materials, and construction over many years. To accomplish these activities on the Ford class, the Navy has awarded contracts for two phases of construction—construction preparation and detail design and construction—which are preceded by the start of advance procurement funding. Since September 2008, Newport News Shipbuilding has been constructing CVN 78 under a cost-reimbursement contract for detail design and construction of CVN 78. This contract type places significant cost risk on the government, which may pay more than budgeted should costs be more than expected. The Navy now expects to largely repeat the lead ship design for CVN 79, with some modifications, and construct that ship under a fixed-price incentive contract, which generally places more risk on the contractor.

Ford-Class Legislative Cost Caps

To ensure the Navy adheres to its cost estimates, Congress, in the National Defense Authorization Act for Fiscal Year 2007, established a $10.5 billion procurement cost cap for CVN 78, and an $8.1 billion cost cap for each subsequent carrier.[5] If the Navy determines adjustments to the cost cap are necessary, it must first obtain statutory authority from Congress, which means it would be required to submit a proposal to Congress increasing the cost cap. The 2007 legislation also contains six provisions that allow the Navy to make adjustments to the cost cap (increasing or decreasing) without seeking statutory authority:

- cost changes due to economic inflation;
- costs attributable to shipbuilder compliance with changes in Federal, State, or local laws;
- outfitting and post-delivery costs;
- insertion of new technologies onto the ships;

[4] 10 U.S.C. § 139 and DOD Directive 5141.02, Subject: Director of Operational Test and Evaluation, Feb. 2, 2009.

[5] Pub. L. No. 109-364, § 122(a)(1) and (a)(2) (2006). Dollars are then-year.

- cost changes due to nonrecurring design and engineering; and
- costs associated with correction of deficiencies that would otherwise preclude safe operation and crew certification.

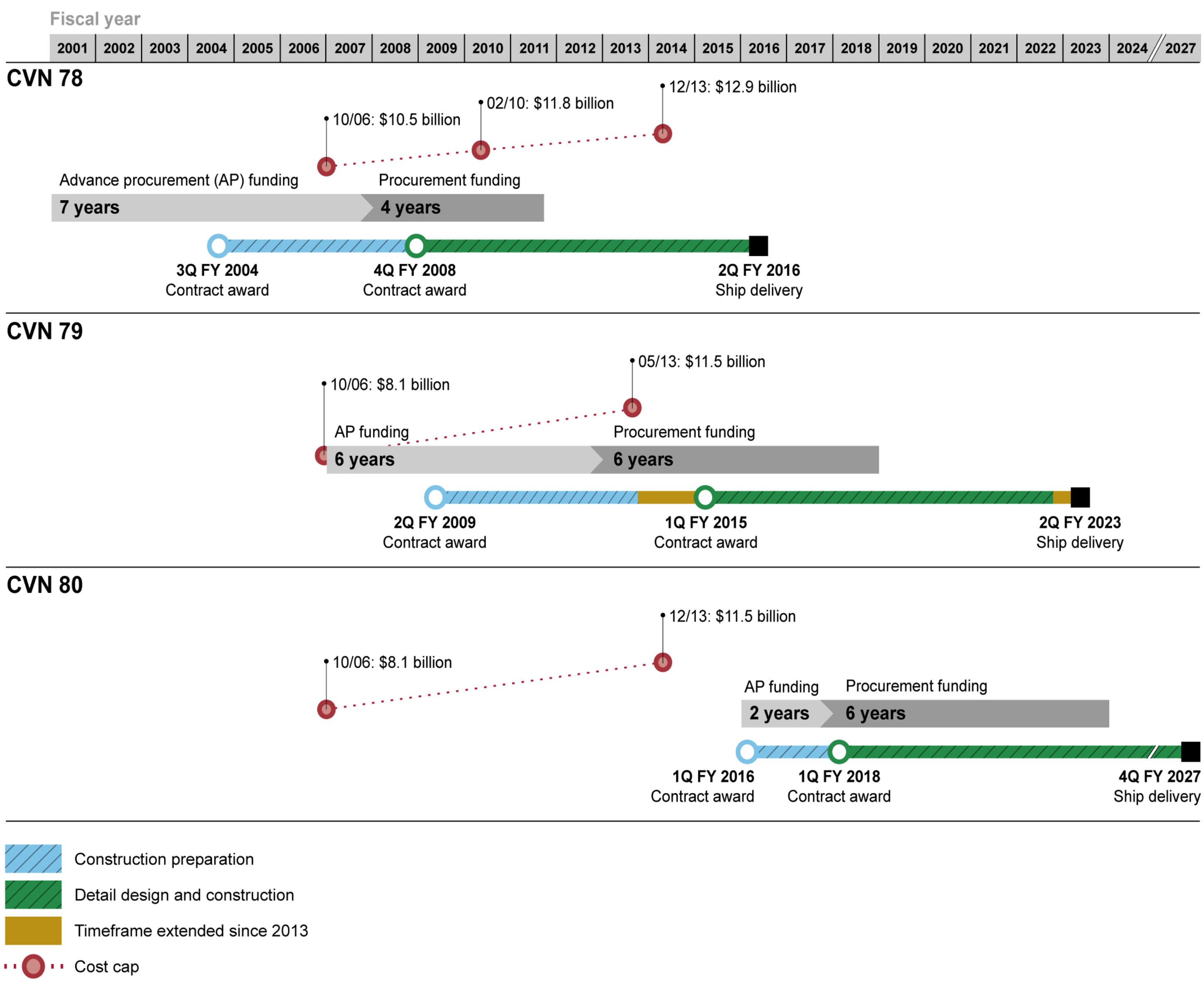
The National Defense Authorization Act for Fiscal Year 2014 further expanded the list of allowable adjustments, solely for CVN 78, to include cost changes due to urgent and unforeseen requirements identified during shipboard testing.[6]

Since 2007, the Navy has sought and been granted adjustments to CVN 78's cost cap to the current amount of $12.9 billion, which were attributed to construction cost overruns and economic inflation. In 2013, the Navy increased CVN 79's cost cap to $11.5 billion, citing inflation and additional non-recurring design and engineering work. Subsequently, the National Defense Authorization Act for Fiscal Year 2014 increased the legislated cost cap for any follow-on ship in the Ford-class to $11.5 billion. In addition, the Navy delayed CVN 79's delivery by 6 months, from September 2022 to March 2023, to reflect changes in the ship's budget.

Figure 1 outlines the Navy's acquisition timeline for the Ford class, along with adjustments made to the legislated cost cap throughout the course of the shipbuilding program.

[6]Pub. L. No. 113-66, § 121 (2013).

Figure 1: Cost Cap Increases During Acquisition of the Ford Class



Source: GAO analysis of Navy data. | GAO-15-22

Our Prior Recommendations

In August 2007 and September 2013, we reported on the programmatic challenges associated with technology development, design, construction, and testing of the lead ship (CVN 78). In our 2007 report, we noted that delays in Ford-class technology development and overly optimistic cost estimates would likely result in higher lead ship costs than what the Navy allotted in its budget. We recommended actions to improve the realism of the CVN 78 budget estimate and the Navy's cost surveillance capacity, as well as develop carrier-specific tests of the DBR to ensure the radar meets carrier-specific requirements. The Navy addressed some, but not all, of our recommendations[7].

Our 2013 report found delays in technology development, material shortfalls, and construction inefficiencies were contributing to increased lead ship construction costs and potential delays to ship delivery. We also found the Navy's ability to demonstrate CVN 78's capabilities after delivery was hampered by test plan deficiencies, and reliability shortfalls of key technologies could lead to the ship deploying without those capabilities. Lastly, we concluded that ongoing uncertainty in CVN 78's construction could undermine the Navy's ability to realize additional cost savings during construction of CVN 79—the follow on ship. These findings led to several recommendations to DOD:

- conduct a cost-benefit analysis on required CVN 78 capabilities, namely reduced manning and the increased sortie generation rate, in light of known and projected reliability shortfalls for critical systems;
- update the Ford-class program's test and evaluation master plan to allot sufficient time after ship delivery to complete developmental test activities prior to beginning integration testing;
- adjust the planned post-delivery test schedule to ensure that system integration testing is completed before IOT&E;
- defer the CVN 79 detail design and construction contract award until land-based testing for critical systems is complete; and,
- update the CVN 79 cost estimate on the basis of actual costs and labor hours needed to construct CVN 78.

While DOD agreed with some of our recommendations, it did not agree with our recommendation to defer the award of CVN 79's detail design

7 GAO-07-866.

and construction contract until certain testing of critical technology systems were completed, noting that deferring contract award would lead to cost increases resulting from the required re-contracting effort, among other things. Shortly after we issued our report, however, the Navy postponed awarding the construction contract until the first quarter of fiscal year 2015, citing the need for additional time to negotiate more favorable pricing with the shipbuilder as well as for the shipbuilder to continue to implement and demonstrate cost savings.

With Risks Remaining in CVN 78 Construction, the Navy Plans to Defer Work in an Effort to Meet Delivery Schedule and Cost Cap Goals

The extent to which CVN 78 will be delivered within the Navy's revised schedule and cost goals is dependent on deferring work and costs to the ship's post-delivery period. Meeting CVN 78's current schedule and cost goals will require the shipbuilder to overcome lags in the construction schedule. Successful tests of the equipment and systems now installed on the ship (referred to as shipboard testing) will also be necessary. However, challenges with certain key technologies are likely to further exacerbate an already compressed test schedule. With the shipbuilder embarking on one of the most complex phases of construction with the greatest likelihood for cost growth, cost increases beyond the current $12.9 billion cost cap appear likely. In response, the Navy is deferring work until after ship delivery to create a reserve to help ensure that funds are available to pay for any additional cost growth stemming from remaining construction risks. In essence, the Navy will have a ship that is less complete than initially planned at ship delivery, but at a greater cost. The strategy of deferring work will result in the need for additional funding later, which the Navy plans to request through its post-delivery and outfitting budget account—Navy officials view this plan as an approach to managing the cost cap. However, increases to the post-delivery and outfitting budget account are not captured in the total end cost of the ship, thereby obscuring the true costs of the ship.

Lags in Construction Progress May Signal Slip in Delivery Date and Increased Costs

The shipbuilder appears to have resolved many of the engineering and material challenges that we reported in September 2013. These challenges resulted in inefficient and out-of-sequence work that led to a revision of the construction and shipboard test schedules and contributed to an increase to the ship's legislated cost cap from $10.5 billion to the current $12.9 billion.[8] Nevertheless, with about 20 percent of work remaining to complete construction and the shipboard test program under way, the lagging effect of these issues is creating a backlog of construction activities that further threaten the ship's revised delivery date and that may lead to further increased costs. As we have found in our previous work, additional cost increases are likely to occur because the remaining work on CVN 78 is generally more complex than much of the work occurring in the earlier stages of construction.

As shown in table 1, the shipbuilder continues to face a backlog of construction activities, including

- completing work packages, which are sets of defined tasks and activities during ship construction and are how the shipbuilder manages and monitors construction progress through the construction master schedule;
- outfitting of individual compartments on the ship; and
- transferring custody of completed compartments and hull, mechanical, and electrical systems to the Navy, referred to as "compartment and system turnover."

[8] Enacted in December 2013, Section 121 in the National Defense Authorization Act for Fiscal Year 2014 increased the cost cap for the lead ship (CVN 78) to $12.9 billion.

Table 1: Indicators of Lagging Construction Progress on CVN 78

Work package completion rates	The shipbuilder has a backlog of over 5,300 delinquent work packages (approximately 10 percent of the total work packages scheduled).This is compounded by lagging performance of the ship assembly trades, such as the painting and sheet metal departments. According to the latest available data (August 2014), the shipbuilder was in the process of developing a plan on how to complete the delinquent work packages.
Compartment outfitting and completion	According to the latest available data (August 2014), the shipbuilder had completed construction on 73 percent of the 777 compartments scheduled to be completed by that date. Late delivery of government furnished equipment has contributed to the delays. To meet the current schedule, the shipbuilder will need to complete construction of 2,608 compartments by February 2016.
Compartment and system turnover to the Navy	According to the latest available data (August 2014), the shipbuilder was about 25 percent behind schedule in transferring custody of completed compartments and hull, mechanical, and electrical systems to the Navy, and is generally falling short of achieving the weekly scheduled turnovers. The Navy is piloting an approach that incorporates personnel from the ship's crew to assist the Supervisor of Shipbuilding, Conversion and Repair (the Navy's shipbuilding contract oversight and project management organization) with the turnover process.

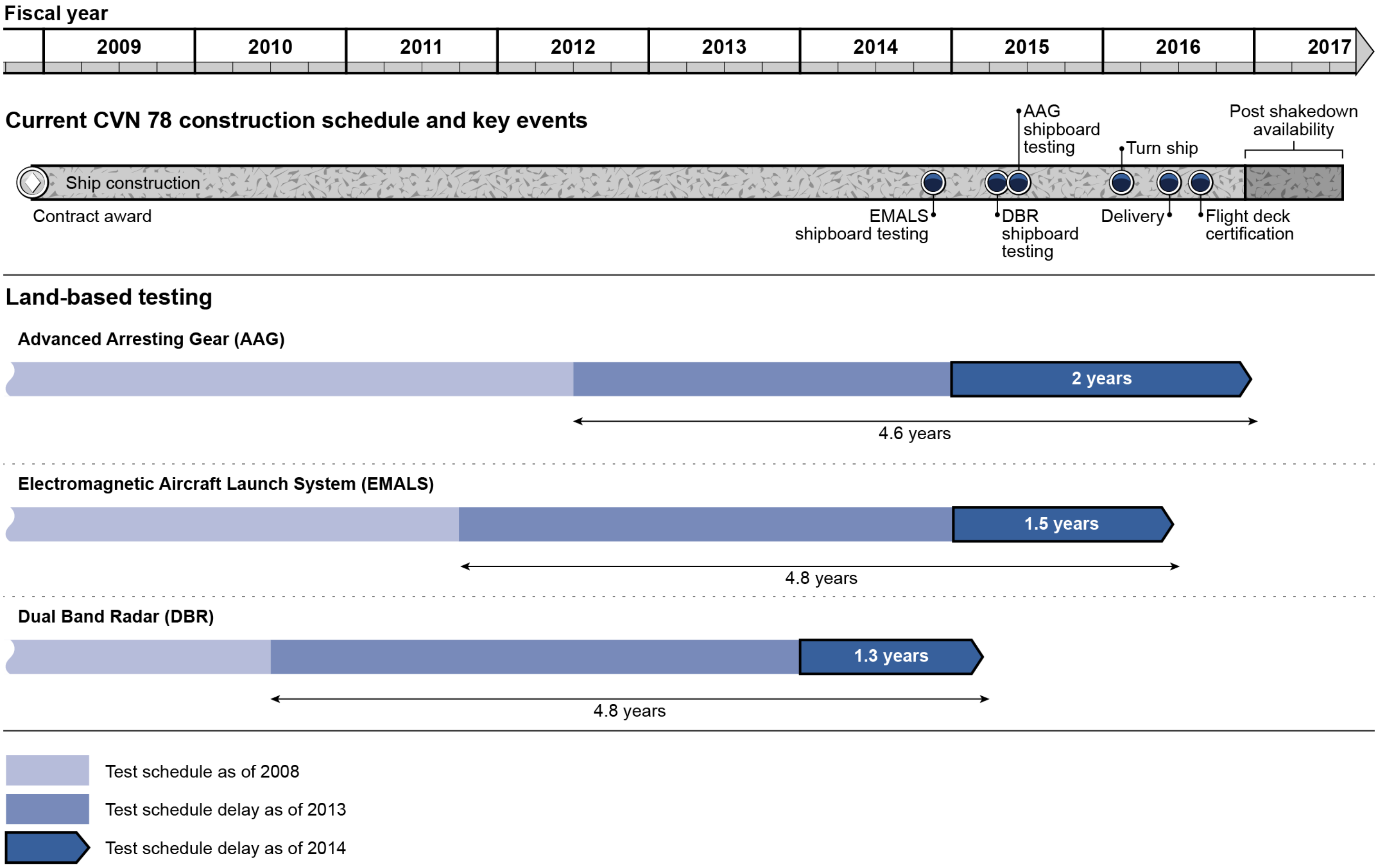
Sources: GAO analysis based on Navy and shipbuilder data. | GAO-15-22

Delays in Shipboard Testing Likely Because of Issues Discovered During Land-Based Testing of Key Technologies

As the shipbuilder completes construction and compartment outfitting activities, the shipboard testing phase of the project commences. This testing is scheduled to be completed by early February 2016 on the ship's hull, mechanical, and electrical systems, about 2 months before the anticipated end of March 2016 delivery date. The shipboard test program is meant to ensure correct installation and operation of the equipment and systems in a maritime environment. This is a complex and iterative process that requires sufficient time for discovering problems inherent with the start-up and initial operation of a system, performing corrective work, and retesting to ensure that the issues have been resolved. However, as a result of previous schedule delays, the shipbuilder compressed the shipboard test plan, resulting in a schedule that leaves insufficient time for discovery and correction should problems arise. Further, the construction delays discussed above directly affect the builder's ability to test the ship's hull, mechanical, and electrical systems, thus increasing the likelihood of additional testing delays. For example, testing of the ship's fire sprinklers was delayed because construction of the sprinkling system was not completed on time. In other instances, delays stemming from construction can have a cascading effect on the test program. As another example, testing of the ship's plumbing fixtures was delayed until testing of the potable water distribution system was completed and the system activated.

Another integral part of the shipboard test program is testing the ship's key technologies, many of which are being operated for the first time in a maritime environment, and ensuring that these technologies function as intended. Four of these technologies are instrumental in executing CVN 78's mission—AAG, EMALS, DBR, and the advanced weapons elevators. Although these technologies are, for the most part, already installed on the ship, certain technologies are still undergoing developmental land-based testing. Except for the advanced weapons elevators, which are managed by the shipbuilder, the other technologies are being developed by separate contractors, with the government providing the completed system to the shipbuilder for installation and testing. The shipboard test programs for EMALS and the advanced weapons elevators are currently under way, while AAG and DBR testing is scheduled to commence in fiscal year 2015. However, developmental testing for AAG, EMALS, and DBR is taking place concurrently at separate land-based facilities (as well as aboard the ship). This situation presents the potential for modifications to be required for the shipboard systems that are already installed if land-based testing reveals problems. Three of the systems we reported on in our last report in September 2013—AAG, EMALS, and DBR—have since experienced additional developmental test delays (as shown in figure 2).

Figure 2: System Developmental Testing Delays



Source: GAO analysis of Navy data. | GAO-15-22

Following is more information on the status of testing of these key technologies.

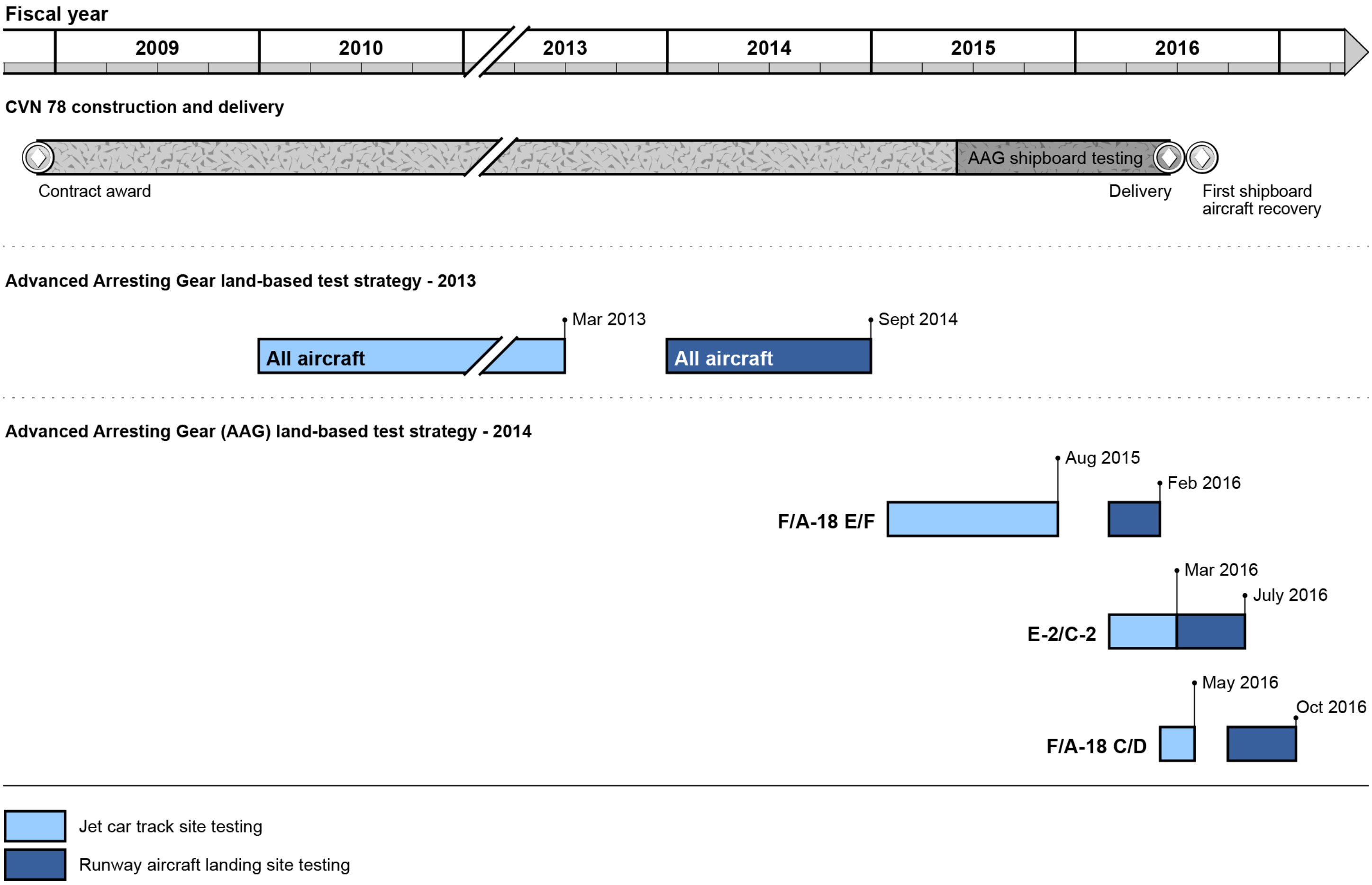
AAG

Shipboard testing for AAG is scheduled to begin in March 2015, but according to the CVN 78 program office, the AAG contractor is redesigning equipment on the system's hydraulic braking system by adding additional filtration and the shipbuilder is replacing associated piping, which will likely delay the start of system testing. In addition, the AAG contractor has to complete over 50 modifications to the systems before shipboard testing can begin; these modifications are needed to address issues identified during developmental testing at the land-based test site. As we previously found, AAG experienced several failures during land-based testing, which led to redesign and modification of several subsystems, most notably the water twisters—a device used to absorb energy during an aircraft arrestment. CVN 78 program officials expressed concerns that the rework cannot be completed on time to support the current shipboard test schedule, and attribute the delays to the immaturity of AAG when it was installed on the ship.

The shipboard test program is further at risk because additional design changes and modifications to the shipboard AAG units remain likely. This is because the Navy will now be conducting land-based testing of AAG even as shipboard testing is under way. As a result of issues discussed above, the Navy further delayed the schedule for land-based testing (as shown in figure 2) and changed the test strategy to better ensure that it could meet the schedule for testing live aircraft aboard the ship. AAG's previous land-based test plan was to sequentially test each aircraft type planned for CVN 78 as a simulated load on a jet car track.[9] After completing jet car track testing for all aircraft types, the actual aircraft were to be tested with the AAG system on a runway. This strategy allowed for discovery of issues with each aircraft type prior to advancing to the next stage of testing. However, earlier this year the AAG program office changed its strategy so that each aircraft type will be tested sequentially at the jet car track and runway sites. Once an aircraft completes both types of testing, testers will re-configure the sites to test the next type of aircraft, according to AAG program officials. Figure 3 shows the difference in AAG test strategies along with the overall ship test schedule. The program office plans to complete this revised testing approach with the F/A-18 E/F Super Hornet fighter first, as this aircraft will be most in use aboard the carrier.

[9]The Navy plans for the carrier variant of the Joint Strike Fighter (F-35C) to become part of the Ford-class air wing; however, the aircraft is not included in the AAG land-based test schedule.

Figure 3: Comparison of AAG Test Strategies



Source: U.S. Navy. | GAO-15-22

While the Navy stated that this change was necessary to ensure that at least one aircraft type would be available to certify the system for shipboard testing, it further increases the potential for discovering issues well past shipboard testing and even ship delivery.

EMALS

The shipbuilder began EMALS activation and shipboard testing activities in August 2014, as planned. This is the first time EMALS is being operated and tested in a maritime environment, in a multiple catapult configuration, using a shared power source, with multiple electromagnetic fields. Any additional delays with the EMALS shipboard test schedule will directly affect CVN 78's delivery date. Specifically, a key aspect of the test program is testing the system's launch capabilities by using weighted loads that simulate an aircraft—referred to as dead-loads—off of the flight deck of the carrier. This test must be completed by November 2015, the point at which the shipbuilder is scheduled to turn the front of the ship toward the dock to begin testing the ship's propulsion system in preparation for subsequent sea trials. At the same time, land-based testing for EMALS is still on-going and the Navy now anticipates testing will be completed during the third quarter of fiscal year 2016.

DBR

Shipboard testing is scheduled to begin in January 2015, but according to the CVN 78 program office, the DBR contractor must first make 5 modifications to the installed radar system prior to its initial activation. In particular, the power regulating system needs to be modified, which requires removal, modification, and re-installation of certain power control modules. Shipbuilder officials told us that any delay to the installation of these items will likely affect the DBR shipboard test schedule, but according to the DBR program office, software and hardware modifications to correct this issue are complete and the ship-set units are in production.

Program officials do not anticipate additional changes to the system's hardware prior to commencing shipboard testing, but they do expect further software modifications as land-based development testing progresses. As a result, there is the risk that additional modifications to the shipboard DBR system will be required. In addition, land-based testing of the DBR is based on a conglomeration of engineering design models that is not representative of the version of the radar installed on the ship, which further increases the likelihood that shipboard testing will require more time and resources than planned.

Advanced Weapons Elevators

Shipboard testing of components to the advanced weapons elevators began in February 2012, but testing has not proceeded as planned. As of August 2014, the shipbuilder had operated 4 of the ship's 11 weapons elevators, but testing delays have occurred due to faulty components and software integration challenges, and premature corrosion of electrical parts. The shipbuilder has increased the amount of construction labor allocated to the weapons elevators in an effort to recover from these schedule delays.

CVN 78's schedule has limited ability to absorb the additional delays that appear likely, given the remaining construction and testing risks. A delay in the ship's planned March 2016 delivery could result in a breach of DOD's acquisition policy. Among other things, a breach would require the CVN 78 program manager to seek approval from the Navy and DOD to further revise the schedule. Shipbuilder officials maintain that they can meet the ship's revised delivery date, but acknowledge that the revised shipboard test plan is proving challenging because of delays associated with construction and concurrent developmental testing of key technologies discussed above. To regain lost schedule, the shipbuilder may choose to expend additional labor hours by paying workers overtime or hiring subcontracted labor; however, these actions would result in additional and unanticipated costs.

Navy Deferring Work to Post-Delivery, but Funding Not Sufficient to Cover All Likely Cost Growth

The CVN 78 program's costs are approaching the legislative cost cap budget of $12.9 billion, but further cost growth is likely based on performance to date as well as ongoing construction, shipboard testing and technology development risks. To improve the likelihood of meeting the March 2016 delivery date and to compensate for potential cost growth, the Navy is (1) removing work from the scope of the construction contract and (2) deferring purchase and installation of some mission-related systems provided by the government to the shipbuilder until after ship delivery. Consequently, completion of CVN 78 may not occur until years later than initially planned.

According to the CVN 78 program office, this approach creates a funding reserve to cover cost growth due to unknowns in the shipboard test program, particularly given that many of the ship's systems are being operated and tested for the first time in a maritime environment. However, the value of the deferred work may not be adequate to fully fund all remaining costs needed to produce an operational ship. Table 2 shows the type of work being deferred from the current plan to post-delivery, and the program office's estimated value of the work. As of September 2014, program officials said they are still negotiating with the shipbuilder on the dollar value of construction labor that it plans to descope from CVN 78's construction contract.

Table 2: CVN 78 Planned Work Deferred to Post-Delivery to Create Funding Reserve

Types of deferrals	Status	Estimated value
Deferred ship construction scope	367 compartments were removed from the scope of the construction contract, such as air wing habitability compartments. Deferred scope of work consists of deck coverings, final paint, hardware and furniture installation, and some electrical work.	$36 million
Deferred correction of deficiencies	Correction of certain defects, such as repairs to the magazine sprinkling system.	$32 million
Deferred installation of mission-related systems	Installation of certain systems, including some shipboard network equipment and a next generation maritime military satellite communications terminal.	Approximately $28 million for the hull, mechanical, and electrical and aviation items
Total estimated value of deferred work		**Approximately $96 million**

Source: U.S. Navy. | GAO-15-22

The program office plans to use this approximately $96 million reserve in the likely event there is additional cost growth above the $12.9 billion budgeted cost cap. However, given the on-going construction and testing risks previously discussed, this cash reserve is unlikely to be adequate to cover the entire expected cost growth of the ship. As shown in Table 3, the shipbuilder, CVN 78 program office, and the Naval Sea Systems Command Cost Engineering Office (the Navy's cost estimators), are all forecasting a cost overrun at ship completion ranging from $780 million to $988 million. According to shipbuilder and CVN 78 program office estimates, the program will meet the $12.9 billion legislated cost cap and has sufficient funds to cover the anticipated cost overruns. If, however, costs increase according to the Naval Sea Systems Command Cost Engineering Office's estimate or higher, additional funding will be needed above the cash reserve amount.

Table 3: CVN 78 Construction Contract Estimated Costs at Ship Completion

Dollars (in millions)

	CVN 78 shipbuilder estimate (April 2014)	**CVN 78 program office estimate (June 2014)**	**Naval Sea Systems Command Cost Engineering office estimate (March 2014)**
Current construction labor cost estimate at ship completion	$4,537	$4,641	$4,745
Estimated construction labor cost overrun at ship completion	$780	$884	$988
Estimated CVN 78 end cost including estimated cost overruns[a]	$12,783	$12,887	$12,991
Estimated CVN 78 end cost less the estimated value of deferred work ($96 million)	$12,687	$12,791	$12,895

Sources: GAO analysis based on Navy and Shipbuilder data. | GAO-15-22

Note: The current legislative cost cap is $12.9 billion.

[a]The estimates provided take into account only the effects of estimated cost overruns of construction labor and does not include other programmatic and construction costs included in the ship's end cost. End cost refers to the appropriated funds that are available for the construction of the ship.

Further, cost and analyses offices within the Office of the Secretary of Defense have tracked the ship's costs for several years and report that without significant improvements in the program's overall cost performance, CVN 78's total costs will likely exceed the program's $12.9 billion cost cap by approximately $300 million to $800 million.[10] If costs fall within this range, the Navy will need to either defer additional work to post-delivery or request funding under the ship's procurement budget line above the $12.9 billion cap. Under the cost cap legislation, such an action would require prior congressional approval.

To fund work deferred to the post-delivery period in the event of unbudgeted cost growth, the CVN 78 program office is considering using

[10]The range of cost growth is a compilation of estimates by various offices within the Office of the Secretary of Defense, including (1) Office of the Secretary of Defense, Office of Performance Assessments and Root Cause Analyses, CVN 78 earned value management assessment (June 2014); (2) Office of the Secretary of Defense, Defense Acquisition Executive Summary Program, CVN 78 cost assessment (2013); and (3) Office of the Secretary of Defense, Director of Cost Assessment & Program Evaluation, CVN 78 cost assessment (2011).

funding from the Outfitting and Post-Delivery budget account. Program officials noted that other Navy shipbuilding programs have also used funds from the outfitting and post-delivery accounts to complete deferred construction work. Navy officials view this as an approach to managing the cost cap. At the same time, however, because the Navy considers post-delivery and outfitting activities as “non end-cost” items—meaning that funds from this account are not included when calculating the total construction cost of the ship—visibility into the ship’s true construction cost is obscured.[11]

CVN 78 Will Not Demonstrate Key Capabilities Prior to Deployment and Faces Continued Post-Delivery Testing Challenges

CVN 78 will not demonstrate its required capabilities prior to deployment because it cannot achieve certain key requirements according to its current test schedule. Specifically, the ship will not have demonstrated its increased sortie generation rate (SGR), due to low reliability levels of key aircraft launch and recovery systems, and required reductions in personnel remain at risk. The Navy expected both of these requirements to contribute to greater capability and lower costs than Nimitz-class carriers. Further, the ship is likely to face operational shortfalls resulting from a ship design that restricts accommodations. Finally, tight time frames for post-delivery testing of key systems due to aforementioned technology development delays could result in the ship deploying without fully tested systems if deployment dates remain unchanged.

CVN 78 Will Not Demonstrate all Key Capabilities Prior to Deployment

The Navy’s business case for acquiring the Ford-class depended on significantly improved capabilities over legacy Nimitz-class carriers, specifically an increased SGR and reduced manning profile. The Navy anticipated that these capabilities would reduce total ownership costs for the ship. Our September 2013 report found several shortfalls in the Navy’s projections for meeting the SGR and reduced manning requirements, and our current work found continuing problems in these areas.

Sortie Generation Rate

The Navy used the SGR requirement to help guide ship design, but CVN 78 will not be able to fully demonstrate this capability before the ship is

[11] In the Fiscal Year 2015 President’s Budget submission, the Navy did not include funding for outfitting and post delivery activities in the CVN 78 end cost estimate. CVN 78’s current cost cap is set to the ship’s end cost estimate.

deployment ready. As shown in table 4, CVN 78's SGR requirements are higher than the demonstrated performance of the Nimitz-class.

Table 4: Nimitz-Class and Ford-Class Sortie Generation Rates

	Nimitz-class demonstrated SGR[a]	Ford-class required SGR
Sustained[b]	120	160
Surge[c]	240[d]	270

Sources: DOT&E and U.S. Navy. | GAO-15-22

Notes:

[a]The Nimitz-class shipbuilding program did not have a sortie generation requirement, but DOT&E identified its SGR capability.

[b]The Ford-class sustained sortie rate requirement is an average sortie rate achieved during 12 hours of launching per day sustained over 30 days (26 flying and 4 non-flying days).

[c]The Ford-class surge requirement is an average sortie rate achieved during 24-hour operations over 4 continuous days.

[d]The Nimitz class was not required to demonstrate surge capabilities.

The increased SGR requirement for the Ford-class reflected earlier DOD operational plans to mount campaigns in two theaters simultaneously. Under this scenario, a high SGR was essential to quickly achieving warfighting objectives, but according to Navy officials, this requirement is no longer reflective of current operational plans.

The Navy plans to demonstrate CVN 78's SGR requirement using a modeling and simulation program in 2019, near the end of CVN 78's IOT&E period. As the modeling and simulation program continues to mature and develop, the Navy, according to the TEMP, plans to collect data from a sustained and surge flight operation and then incorporate these data into the model. Once this is completed and the model is accredited, the Navy will subsequently run a simulation of the full SGR mission.

Current runs of the model indicate the ship can meet the required sustained and surge sortie rates, which Navy and shipbuilding officials involved with the modeling and simulation effort explained is primarily due to flight deck redesign and not the ship's new aircraft launch and recovery technologies. However, ongoing issues with the development of EMALS and AAG are resulting in low levels of system reliability that will be a barrier to achieving required SGR rates once the model is populated with actual data from these technologies. System reliability is critical to the carrier's ability to meet the SGR requirement and is measured in terms of mean cycles between critical failures, or the average number of times each system launches or recovers aircraft before experiencing a failure.[12] As shown in table 5, the most recent available metrics from January 2014 show that EMALS and AAG show such low reliability rates that it is unlikely that these systems will achieve reliability rates needed to support SGR requirements before the demonstration event in 2019 or for years after the ship is deployment ready.

Table 5: Current Reliability Rates for EMALS and AAG Systems

System[a]	Required reliability[b]	Current reliability	Current reliability percentage
EMALS – 4 of 4 catapults operating	1,800 cycles	not available	not available
EMALS – 3 of 4 catapults operating	4,166 cycles	240 cycles	5.8
AAG	16,500 cycles	20 cycles	0.01

Source: GAO analysis of DOT&E and U.S. Navy data. | GAO-15-22

Notes:

[a]EMALS has two reliability metrics, depending on the number of the system's catapults that are operating.

[b]The Navy measures reliability in terms of mean cycles between critical failures.

As a result of these systems' low reliability, we questioned the Navy's sortie generation requirement in our September 2013 report and recommended that the Navy re-examine whether it should maintain this requirement or modify it—seeking requirements relief from the Joint Requirements Oversight Council if the Navy found it was not operationally necessary. DOT&E has also raised questions about the need for increased sortie generation. DOT&E analyzed past aircraft carrier operations in major conflicts and reported that the CVN 78 SGR requirement is well above historical levels. In its January 2014 annual report, DOT&E cited the poor reliability of critical systems, such as EMALS and AAG, noting that performance of these systems could cause a series of delays during flight operations that could make the ship more vulnerable to attack. DOT&E plans to assess CVN 78 performance during IOT&E by comparing its demonstrated SGR to the demonstrated performance of the Nimitz-class carriers. Although the carrier would not

[12]Different types of "failure" count against systems' reliability growth, including errors in software, hardware problems, and any other issue that causes EMALS or AAG to fail to launch or arrest a real or simulated aircraft.

meet its required capability, DOT&E stated that a demonstrated SGR less than the CVN 78 requirement, but equal to or greater than the performance of the Nimitz-class, could potentially be acceptable. However, the Navy would still be required to obtain approval from the Joint Requirements Oversight Council to lower the requirement.

Reduced Manning and Habitability Requirements

Another CVN 78 key performance requirement is a reduced ship's force, relative to the Nimitz-class, with the goal of lowering total operational costs. "Ship's force" refers to all personnel aboard a carrier except those designated as part of the air wing and in certain support or other assigned roles. The Navy's reduced manning requirement for CVN 78 is a ship's force that has 500 to 900 fewer personnel than Nimitz-class carriers. Table 6 compares manning totals for the Nimitz class with Ford-class manning projections.

Table 6: Ship's Manning Totals for Nimitz- and Ford-Class Aircraft Carriers as of September 2014

	Nimitz-class (actual)	Ford-class required reduction range	CVN 78 projected manning
Ship's force	3,291	2,391-2,791	2,628

Source: U.S. Navy. | GAO-15-22

Note: While ship's force is the number set forth in the carrier requirements, the number of CVN 78 air wing and other embarked personnel is also projected to be lower for the Ford class.

As of September 2014, the Navy projects a 663-sailor reduction in the ship's force, which represents a 163-person margin over the minimum required reduction of 500 personnel. But our analysis found that the carrier is not likely to achieve this level of reduction and still meet its intended capabilities. Key factors contributing to the difficulties in meeting the reduced manning requirement include the following:

- Poor reliability of key systems—including EMALS and AAG—and sailors' limited experience in operating these systems in a maritime environment, which may require additional personnel. For example, AAG will require additional maintenance than planned due to changes to the system's hydraulic braking system, according to Navy officials.
- Additional ship's force personnel will be needed to meet the surge SGR of 270 sorties per day, based on the Navy's most recent operational test and evaluation force assessment.

- Additional operational personnel, particularly in the supply department, will likely be needed on the ship, according to the CVN 78 pre-commissioning unit—the crew assigned to the ship while it is under construction.[13]

These factors are likely to increase the total number of personnel on CVN 78.

As a reflection of the Navy's confidence in reducing manning on the Ford class, the ships were designed with significantly fewer berths (4,660) as compared to the Nimitz class to accommodate the ship's force, air wing, and all other embarked personnel. However, now the number of berthings is fixed and the ship cannot accommodate additional manpower without significant design changes. Further, the Navy requires new ship designs, including CVN 78, to provide a habitability margin—a percentage of extra berths above the projected ship's force to accommodate potential personnel growth throughout the service life of the ship. This margin includes berths as well as support services for personnel aboard the ship, such as food and sanitation facilities. Given current manning projections and available accommodations, as shown in table 7, the Navy recognizes that CVN 78 falls well short of meeting its required habitability margin. This required margin is equivalent to 10 percent of the ship's force or 263 berths. As a result, the CVN 78 program office plans to request a waiver for this requirement from the Chief of Naval Operations.

Table 7: CVN 78 Current Projected Manning and Available Accommodations

<table>
<tr><th></th><th>Personnel on board</th><th>Available accommodations</th><th>Remaining berths</th><th>Required margin</th></tr>
<tr><td>CVN 78 projected total force</td><td>4,533[a]</td><td>4,660</td><td>127</td><td rowspan="2">263</td></tr>
<tr><td>Estimated personnel temporarily on board CVN 78</td><td>63-122[b]</td><td>127</td><td>5-64</td></tr>
</table>

Source: U.S. Navy, Commander, Operational Test and Evaluation Force. | GAO-15-22

Notes:

[a]Total projected force on CVN 78 equals the ship's force (2,628) plus the air wing and other embarked personnel (1,905).

[13]The CNV 78 pre-commissioning unit, Naval Air Systems Command, and the Navy's Manpower Analysis Center have all identified changes to the ship's manning profile, according to Navy officials. Such proposals are directed to the CVN 78 program office for review and approval.

[b] The number of personnel temporarily on board the ship varies but will remain within a minimum estimated range. Such personnel may consist of temporary detachments, distinguished visitors, and trainers.

In fact, the carrier currently has so few extra berths that it can only accommodate a slight increase in personnel. And the Navy's estimated accommodation needs do not take into account the likelihood that additional personnel will be needed above and beyond the Navy's current projected ship's force (2,628 sailors). In addition, spare berthing is also used for personnel temporarily assigned to the ship, such as inspectors, trainers, or visitors. If CVN 78 must enlarge its ship's force as well as accommodate personnel temporarily assigned to the ship, it is likely that no actual accommodations would be available. Consequently, CVN 78 must be "manning neutral," so that personnel coming aboard must be matched by personnel debarking, in accordance with the ship's operational needs and personnel specialties.

This situation is further exacerbated because the Navy will need to operate CVN 78 with a greater percentage of its crew than the Nimitz class. According to the Navy's most recent (2011) analysis of manning options for CVN 78, staffing the ship at less than 100 percent; that is, with fewer personnel than the current projected total force of 4,533, had an adverse effect on quality of life at sea because the crew had to perform additional duties or remain on duty for longer periods. This manning analysis also found that reducing staffing to 85 percent—which is typical for a Nimitz-class ship—compromised ship operations. The analysis concluded that careful management of personnel specializations will be needed and recommended cross-training personnel in key departments to minimize the risk to ship operations. Future costs for the ship could also increase if the Navy must eventually convert spaces to accommodate additional berthing.

Changes to Post-Delivery Test Plans Coupled with Key Systems' Developmental Delays Could Result in CVN 78 Deploying Without FullyTested Systems

The Navy has further compressed post-delivery plans to test CVN 78's capabilities and increased concurrency between test phases since our last report in September 2013. This means that there will be less time for operational testing, which is the Navy's opportunity to test and evaluate the ship against realistic conditions before its first deployment.

Revised Test Plan Provides Less Time for Operational Testing

As we reported in September 2013, the Navy added in 2012 an additional integration test period to the CVN 78 TEMP as recommended by the Deputy Assistant Secretary of Defense for DT&E and the Director, DOT&E. This integration testing is important because it allows ship systems still in development—such as EMALS and AAG—to be tested together in their shipboard configuration. In our report, we recommended that the Navy adjust its planned post-delivery test schedule to complete this integration testing before commencing IOT&E.[14] The Navy did not agree and overlap between integration testing and IOT&E remains and is now longer. This situation constrains the Navy's ability to discover and resolve problems during the integration testing phase and before beginning IOT&E, which further limits opportunities for the Navy to resolve problems discovered during testing and risks additional discovery during IOT&E. In addition, the Navy and DOD still have not resolved whether CVN 78 will be required to conduct the Full Ship Shock Trial for the Ford-class. As we reported last year, the program office deferred this testing to the follow-on ship, CVN 79; a strategy that did not receive DOT&E approval. According to program officials, final determination of whether the trial will be conducted on CVN 78 or CVN 79 will be made by the Under Secretary of Defense for Acquisition, Technology, and Logistics near the end of 2014.

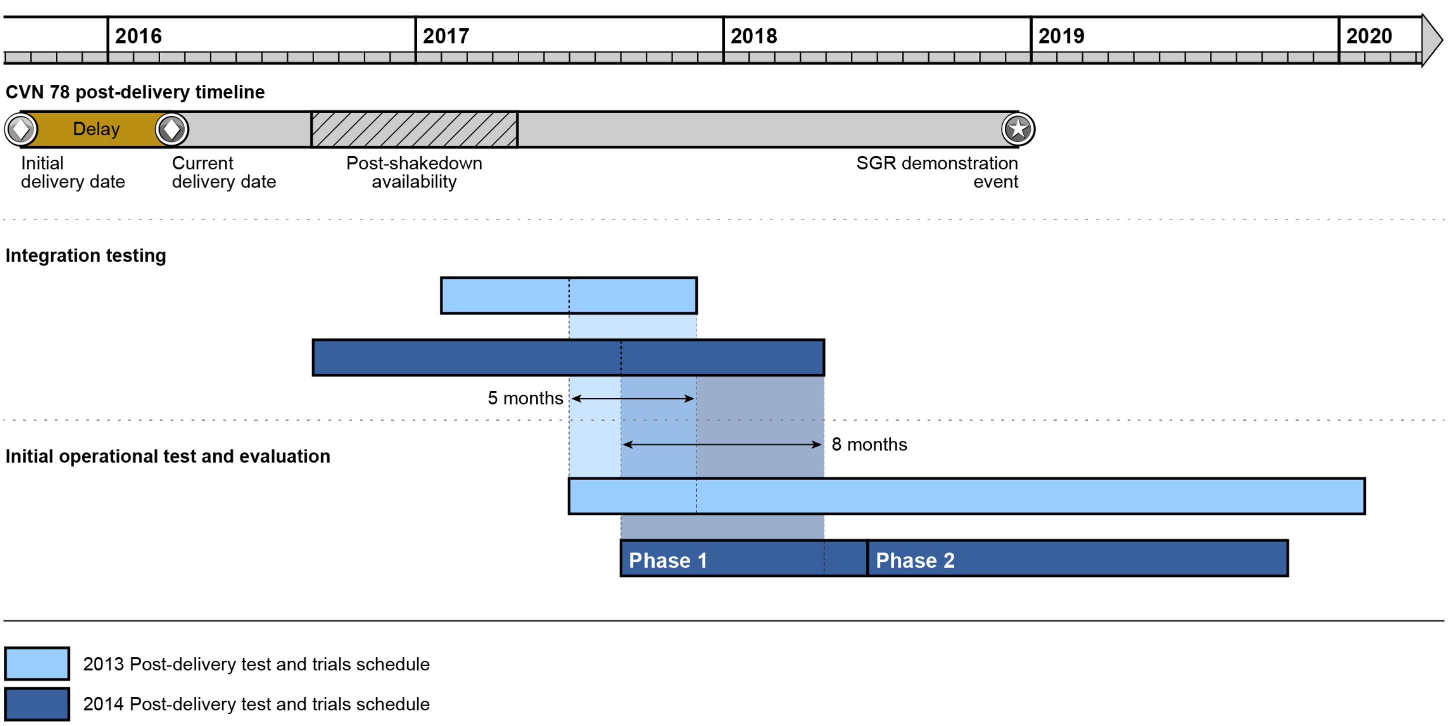
Since our last report, the Navy doubled the length of the new integration testing period, but clarified that this testing also includes ongoing developmental testing of key systems, assessment of prior test results, and repairs or changes to fix deficiencies identified in earlier test periods. In fact, the Navy plans to conduct well over a dozen certifications and major ship test events during this period. For example, it plans to conduct a total ship survivability trial—testing CVN 78's capability to recover from a casualty situation and the extent of mission degradation in a realistic operational combat environment. If the Navy discovers significant issues during testing, or events cause additional delays to testing, it will have to choose whether deploy a ship without having fully tested systems or delay deployment until testing is complete.

To help manage this risk, the Navy plans to divide operational testing into two phases. According to program officials, this approach will allow developmental testing, deficiency correction, and integration testing to

[14] GAO-13-396.

continue on the mission-related systems installed after ship delivery and on those systems that are not required to support the first phase of operational testing. The first phase of operational testing will focus on testing the ship's ability to accomplish basic tasks by stressing the ship's crew, aviation facilities, and the combat and mission-related systems installed prior to delivery under realistic peacetime operating conditions. The second phase of operational testing incorporates embarked strike groups and other detachments that support operations and tests CVN 78's ability to conduct major combat operations, particularly the tactical employment of the air wing in simulated joint, allied, coalition, and strike group environments. The goal is to stress CVN 78's aviation, combat and mission-related systems, particularly those systems installed after ship delivery. Figure 4 shows these changes to the CVN 78 post-delivery test schedule.

Figure 4: Changes to CVN 78 Post-Delivery Test Schedule Since 2013



Source: U.S. Navy. | GAO-15-22

The current test schedule is optimistic, with little room for delays that may occur as a result of issues identified during the integration and operational test phases. Even if the Navy meets the current schedule, it will not complete all necessary testing in the time remaining before the ship is deployment ready. This issue will be further exacerbated if land-based or shipboard testing discussed earlier reveals significant problems with the ship's systems, as the time needed to address such issues may interfere with the ship's integration and operational test phases. Navy officials responsible for operational testing stated that they will only conduct operational testing when shipboard systems are deemed ready. However, neither the CVN 78 program office nor the Navy's operational test personnel know how often system testing can be deferred before affecting the schedule for operational testing on other systems, particularly given the interoperation of systems on a carrier. For example, the DBR supports ship combat systems and simultaneously conducts air traffic control. If it is not ready to support flight operations in the first segment of IOT&E, combat operations in the second segment that also rely on the radar are likely to be affected.

Navy's Ability to Meet CVN 79 Cost Cap Predicated on Ambitious Efficiency Gains and Deferring Work until after Ship Delivery

To meet the $11.5 billion legislative cost cap for CVN 79, the Navy is assuming the shipbuilder will make efficiency gains in construction that are unprecedented for aircraft carriers and has proposed a revised acquisition strategy for the ship. With shipbuilder prices for CVN 79 growing beyond the Navy's expectations, the Navy extended the construction preparation (CP) contract to allow additional time for the shipbuilder to reduce cost risks prior to awarding a construction contract. In addition, the Navy's proposed revision to the ship's acquisition strategy would reduce a significant amount of work needed to make the ship fully operational until after ship delivery. While this strategy may enable the Navy to initially achieve the cost cap and is allowed under the cost cap provision without the need for congressional approval, it also results in transferring the costs of planned capability upgrades—previously included in the CVN 79 baseline—to future maintenance periods to be paid through other (non-CVN 79 shipbuilding) accounts.

Current and Historical Performance Suggests Shipbuilder Is Unlikely to Achieve Efficiency Gains Needed to Realize Cost Goals

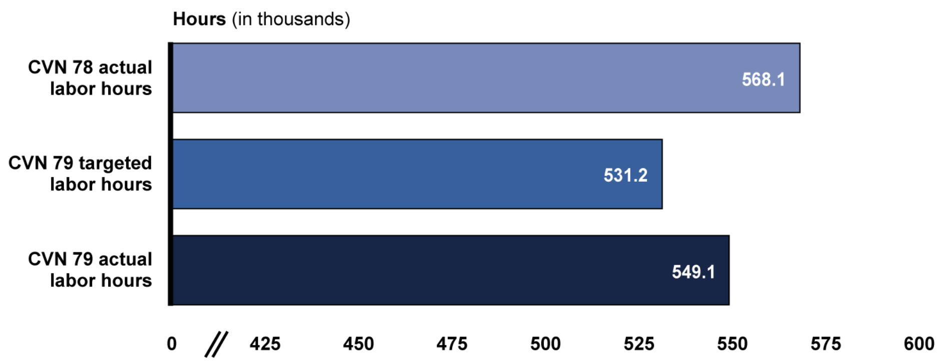
The Navy's $11.5 billion cost estimate for CVN 79 is underpinned by the assumption that the shipbuilder will significantly lower construction costs through realizing efficiency gains. While performance to date has been better than that of CVN 78, early indicators suggest that the Navy is unlikely to realize anticipated efficiencies at the level necessary to meet cost and labor hour reduction goals. In its May 2013 report to Congress on CVN 79 program management and cost control measures, the Navy stated that 15-25 percent fewer labor hours (about 7 million to 12 million hours) will be needed to construct CVN 79 as compared to CVN 78. Although the Navy and shipbuilder continue to look for labor hour reduction opportunities, thus far, shipbuilder representatives have identified improvements that they stated will save about 800,000 labor hours. As we identified in September 2013, many of the proposed labor hour reductions are attributed to lessons learned during construction of CVN 78 and revising CVN 79's build plan to perform pre-outfitting work earlier in the build process. This is because work completed earlier in the build process, such as in a shop environment, is more efficient and less costly than work done later on the ship where spaces are more difficult to maneuver within.[15] In addition, the shipbuilder's revised build plan consolidates and increases the size of superlifts—fabricated units and block assemblies that are grouped together and lifted into the dry dock—to form larger sections of the ship. Other notable labor hour savings initiatives involve increased use of new welding technologies and improved cable installation techniques.

Construction of CVN 79 is still in the initial stages, and most of the projected cost savings and labor hour reduction opportunities are in structural units and parts of the ship that are not yet under construction. However, there are indications that achieving the anticipated 7 million to 12 million hour reduction goal will be challenging. As of the end of March 2014, the shipbuilder had completed fabrication of 205 structural units—about 18 percent of the ship's total—with over a hundred more in various stages of fabrication. Although the ship is still in the early stages of construction, the cumulative labor hour reductions for the completed units fell short of the Navy and shipbuilder's expected reduction by about 3.5 percent, as shown in figure 5. Program officials stated that while the cumulative reduction has not yielded the expected results, a number of the structural units were completed prior to the shipbuilder's

[15] We discuss this issue further in GAO-13-396.

implementation of labor saving initiatives. They further added that completed units, more representative of remaining work, have yielded approximately a 16 percent reduction in labor hours for fitters and welders.

Figure 5: Comparison of the Planned and Actual Number of Labor Hours Required to Complete Advanced Construction Work for the First 205 Structural Units on CVN 79



Source: U.S. Navy data. | GAO-15-22

Note: The data above represents approximately 18 percent of the ship's 1,128 structural units.

In addition, the shipbuilder's scheduling processes may further limit insight into the effectiveness of these initiatives. We evaluated the shipbuilder's processes and tools used to plan and schedule work against GAO's best practices in scheduling.[16] We identified scheduling practices that may interfere with the shipbuilder's and Navy's ability to accurately manage and monitor the construction schedule and the way in which the shipbuilder allocates labor, equipment, and material resources. In particular, the shipbuilder's enterprise resource management system (which tracks use of labor and materials) and master construction schedule (which tracks the time required to complete work packages) are stand-alone, independent systems, which means that changes in one system are not automatically updated in the other. Consequently, the shipbuilder—and subsequently the government—lacks real time insight in to whether resources are being used according to schedule. This lack of

[16]GAO, *GAO Schedule Assessment Guide: Best Practices for Project Schedules*, GAO-12-120G (Washington, D.C.: May 2012).

insight limits management's ability to effectively respond to delays, thus driving inefficiencies into the build process, and also limits the shipbuilder's ability to take advantage of opportunities when work is completed ahead of schedule. Although the shipyard is transitioning to a new scheduling software program, the shipbuilder does not plan to revise its existing scheduling and resource management process to enable better insight for CVN 79. The legacy scheduling system the shipbuilder employed did not allow for data to be exported to the government. The new scheduling system has the ability to allow for increased Navy oversight since the data are exportable, thus allowing, among other things, the ability to independently examine the effects of schedule slippage or realism of the shipbuilder's estimated labor needs. According to program officials, the Navy intends to incorporate this data as a deliverable item in the CVN 79 construction contract.

Even with the shipbuilder's improvements, reducing construction of CVN 79 by approximately 7 million to 12 million labor hours as compared to CVN 78 would be unprecedented in aircraft carrier construction. As shown in table 8, with each successive aircraft carrier build, the number of labor hours needed to complete construction has, at most, decreased by 9.3 percent as compared to the previous ship (with CVN 69 compared to CVN 68 accounting for the largest percentage decrease). Although CVN 78 and CVN 79 are similar to CVN 68 and CVN 69 in that there is a first-to-second ship of a class transition, in most instances sizeable labor hour reductions only occurred as a result of constructing two aircraft carriers though a single contract, rather than acquiring the ships individually through separate construction contracts as is the case with the Ford class.

Table 8: Number of Construction Labor Hours Required to Build Aircraft Carriers

Hull	Total labor hours (m)	Labor hour change (m)	Percent change	Type of ship buy	Construction contract award date
CVN 68 (Nimitz-class)	34.4	0	0	Single	March 1967
CVN 69	31.2	-3.2	-9.30	Single	June 1970
CVN 70	33.7	2.5	8.01	Single	April 1974
CVN 71	40.3	6.6	19.58	Single	September 1980
CVN 72	38.0	-2.3	-5.71	Two	December 1982
CVN 73	36.2	-1.8	-4.74	Two	December 1982
CVN 74	33.2	-3.0	-8.29	Two	July 1988
CVN 75	34.4	1.2	3.61	Two	July 1988
CVN 76	39.2	4.8	13.95	Single	December 1994
CVN 77	45.5	6.3	16.07	Single	January 2001
CVN 78[a] (Ford class)	48.5	0	0	Single	September 2008
CVN 79[b]	41.2 to 36.4	-7.3 to -12.1	-15 to - 25 (target)	Single	December 2014 (anticipated)

Source: GAO analysis of U.S. Navy data. | GAO-15-22

[a]CVN 78 labor hours are based on the program office's estimated construction labor hours at completion and do not include non-recurring labor hours, such as design engineering.

[b]Total hours for CVN 79 and the labor hour change is stated as a range of labor hours based on a 15-25 percent reduction from the program office's estimated construction labor hours at ship completion.

Navy's Revised Acquisition Strategy May Create Near-Term Cost Savings but Leads to Uncertainties in Final Ship Costs

The Navy planned to award the CVN 79 detail design and construction contract in late fiscal year 2013, but subsequently delayed the award and extended the construction preparation contract because negotiations with the shipbuilder were taking longer than the Navy anticipated. As a result, the Navy now intends to award the detail and design contract at the end of the first quarter of fiscal year 2015, which program officials stated allows sufficient time to negotiate prices and demonstrate cost reductions and process improvements that will lead to lowering CVN 79's construction costs. In the meantime, more work is now being completed under the construction preparation contract, with almost 60 percent of the ship's total structural units under the CP contract, as shown in table 9 below. According to program officials, this work accounts for about 20 percent of the ship's overall construction effort.

Table 9: Scope of Advanced Construction Work under CVN 79 Construction Preparation Contract Extension Strategy

	Planned detail design and construction contract award date	Overall construction preparation contract value	Number of structural units under contract	Percent of total structural units
Acquisition strategy (as of September 2013)	September 2013	$2 billion	311	28
Revised acquisition strategy (March 2014)	December 2014	$3.3 billion	654	58

Source: U.S. Navy data. | GAO-15-22

By extending the CP contract, the program office expects that it will reduce material costs by 10-20 percent from CVN 78 and prevent late deliveries of items, such as valves, that led to significant material shortfalls and out-of-sequence construction work and contributed to that ship's cost growth, as we noted in our September 2013 report. Under the Navy's material procurement strategy, approximately 95 percent of CVN 79's material to be procured by the shipbuilder was under contract as of September 2014.

In addition, the Navy recently completed an affordability and capability review of CVN 79 in an effort to further reduce construction costs and shipbuilding requirements to ensure that it could meet the $11.5 billion cost cap—which Navy officials stated was otherwise unachievable. In response, the Navy plans to (1) institute cost savings measures by reducing some work and equipment; (2) revise the acquisition strategy to shift more work to post-delivery—including installation of mission systems—while still meeting statutory requirements for deploying CVN 79; and (3) deliver the ship with the same baseline capability as CVN 78—postponing a number of planned mission system upgrades and modernizations until future maintenance periods. Program officials told us they plan to seek approval to initiate these changes at CVN 79's upcoming program review with the Office of the Secretary of Defense, which is now scheduled for December 2014, in advance of the detail design and construction contract award.

Most notably, the Navy plans to depart from its planned installation of DBR on CVN 79, in favor of an alternative radar system, which it expects to provide a better technological solution at a lower cost. By seeking competitively awarded offers, Navy officials anticipate realizing savings of about $180 million for CVN 79.[17] Final determination of CVN 79's radar solution is not scheduled to occur until after March 2015, at least 3 months after the estimated detail design and construction contract award. It is around this time that the program office anticipates it will solicit proposals from prospective bidders. Program officials told us that they intend to work within the current design parameters of the ship's island, which they say would limit extensive redesign and reconfiguration work to accommodate the new radar. While the extent of redesign work is unknown, such a change will still result in additional ship construction costs, which could offset the Navy's estimate of DBR savings.

Other cost savings measures are wide ranging and include

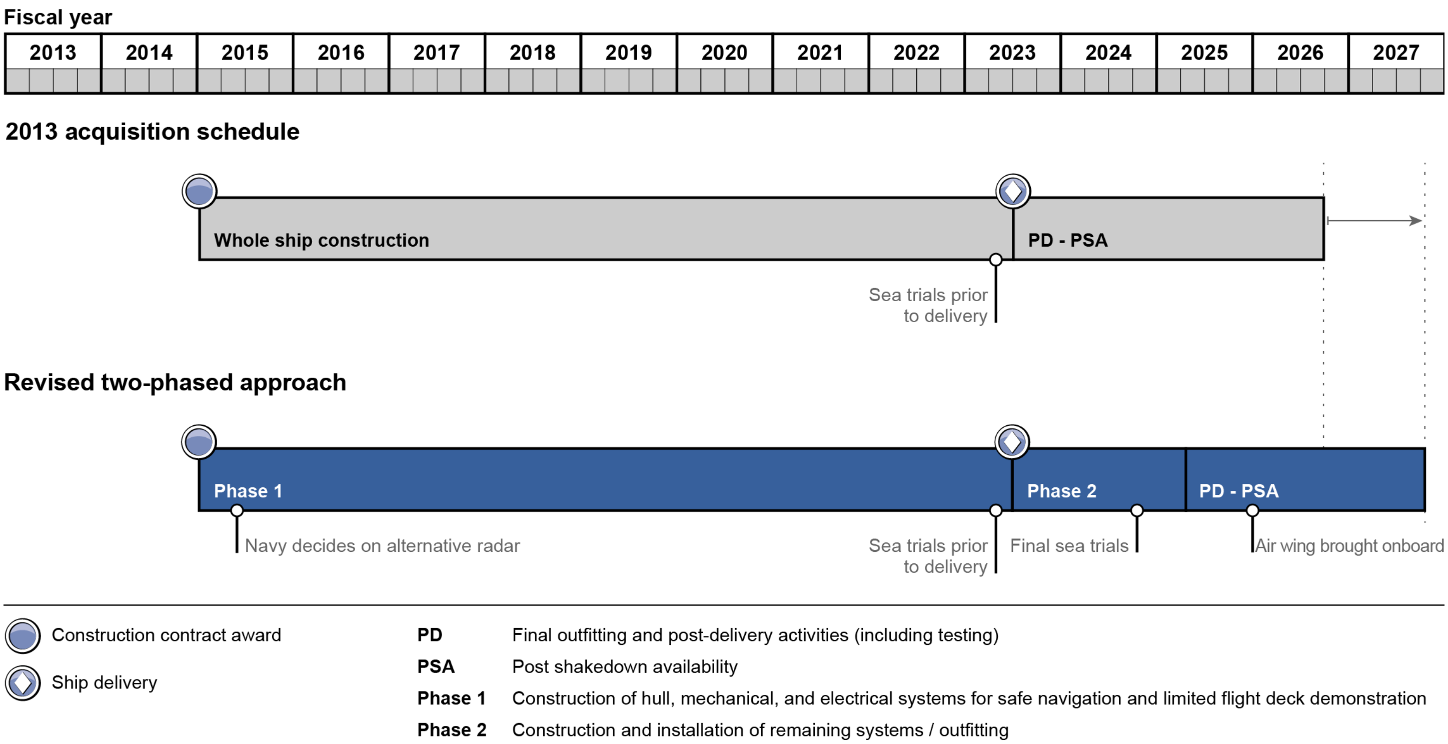
- eliminating one of the four AAG units planned for the ship (Nimitz-class carriers have 3 operational arresting units);
- eliminating redundant equipment requirements such as the ship's emergency power unit for the steering gear and spare low pressure air compressors; and
- modifying test requirements for certain mechanical systems.

In addition to these cost savings measures, the CVN 79 program office is proposing a two-phased approach for ship construction and delivery. Although the details of the Navy's revised acquisition strategy continue to evolve, the basic premise is that delivery by the shipbuilder will consist of only the hull, mechanical and electrical aspects of the ship (referred to as phase I), followed by completion of remaining construction work and installation of the warfare and communications systems during the post-delivery period (referred to as phase II). At ship delivery, CVN 79 will have its full propulsion capability, as well as the core systems for safe navigation and crew safety; and necessary equipment to demonstrate flight deck operations, such as EMALS and AAG. All remaining construction work, primarily consisting of the procurement and installation of several warfare and communications systems, will be completed post-

[17]The CVN 78 program acquired two volume search radars—one initially intended for installation on DDG 1000—after the DDG 1000 program experienced a unit cost breach and removed the volume search radar from the baseline design to save costs that it planned to install on CVN 78 and CVN 79. The Navy had planned to purchase the multifunction radar for CVN 79 and eventually another shipset for CVN 80.

delivery. The program office currently plans to maintain the ship's 2023 delivery date, but as shown in figure 6, the revised strategy extends the acquisition schedule and the ship's deployment ready date by about 15 months. Program officials stated that despite this delay in the schedule it would still meet the statutorily required minimum number of operational aircraft carriers because CVN 79 would still be deployment ready shortly after USS Nimitz (CVN 68) is currently slated to retire in fiscal year 2025.

Figure 6: Comparison of CVN 79's September 2013 and October 2014 Revised Acquisition Schedules



Source: GAO analysis of Navy data. | GAO-15-22

As currently planned, the revised strategy, by design, will result in a less capable and less complete ship at delivery. According to CVN 79 program officials, reducing the shipbuilder's scope of work, along with a reduction in some construction requirements, will lead to negotiating more favorable pricing of the detail design and construction contract. In addition, they noted that maintaining the current delivery schedule will deliberately allow for a slower pace of construction, thus potentially requiring less use of overtime or leased labor. Further, program officials state that delaying installation of warfare and communications systems—such as those systems with high obsolescence risk—can potentially limit procuring equipment that has been surpassed by technology advances by the time the ship begins phase II of the Navy's revised strategy. Finally, Navy officials believe that adopting this approach will enable the program to reduce costs by introducing additional competition for the ship's systems and installation work after delivery.

While the two-phased strategy may enable the program to initially stay within the legislated cost cap, it will transfer the costs of a number of known capability upgrades previously included in the CVN 79 baseline to other (non-CVN 79 shipbuilding) accounts.[18] As shown in table 10, the program office plans to defer installation of a number of systems to future maintenance periods.

Table 10: Planned CVN 79 System Upgrades and Modernizations Deferred Until Future Maintenance Periods

MK 53 Decoy Launching System
Surface Ship Torpedo Defense System
Surface Electronic Warfare Improvement Program 3
Joint Strike Fighter-related modifications including Joint Precision Approach and Landing System and Autonomic Logistics Information System
MK 38 Machine Gun System

Source: U.S. Navy data. | GAO-15-22

Based on current estimates, the value of the deferred systems is about $200 million - $250 million. Moreover, this strategy will result in deferring installation of systems and equipment needed to accommodate the carrier variant of the Joint Strike Fighter aircraft (F-35C) until fiscal year 2027 at the earliest.

Further, should construction costs grow above estimates, the Navy may subsequently choose to use funding intended for phase II work to pay for construction cost increases without increasing the cost cap. The Navy would have this option because additional funding through post delivery

[18] For shipbuilding programs, construction is generally funded through the Shipbuilding and Conversion, Navy budget account. The Navy intends on funding CVN 79's capability upgrades through the Other Procurement, Navy budget account.

budget accounts are not included in calculating the ship's end cost, similar to the aforementioned situation with CVN 78. According to Navy officials, this approach allows the program to manage the cost cap without seeking statutory authority.

Conclusions

Constructing and delivering an aircraft carrier is a complex undertaking. The Ford-class program, in particular, has faced a steep challenge due to the development, installation and integration of numerous technologies—coupled with optimistic budget and schedule. The Ford class is intended to provide significant operational advantages over the Nimitz class. However, with about 80 percent of the lead ship constructed, the program continues to struggle with construction inefficiencies, development issues, testing delays, and reliability shortfalls. These are issues that have been mounting for a number of years. Now, as the program embarks on its most challenging phase—shipboard testing—additional cost increases in excess of the $2.3 billion since 2009 appear likely. To manage this risk, the Navy is creating a cost buffer by deferring construction work and installation of mission-related systems to the post-delivery period. This strategy may provide a funding cushion in the near term, but it may not be sufficient to cover all potential cost increases. After raising the cost cap several times, the Navy is now managing the cost cap by reducing the scope of the delivered ship and is considering paying for the deferred scope through a budget account normally used for post-delivery activities. This contradicts the purpose of the congressional cost cap, which is to hold the Navy accountable for the total cost estimate for buying a deployable ship.

Further, after an investment of at least $12.9 billion, CVN 78 may not achieve improved operational performance over the Nimitz class of aircraft carriers as promised for some time to come. Reliability shortfalls and development uncertainties in key Ford-class systems will prevent the ship from demonstrating its required sortie generation rate before initial deployments. Personnel accommodation restrictions resulting from the ship's design has the potential of causing operational limitations that the Navy will have to manage closely—a constraint that does not exist in the Nimitz class. We previously recommended re-assessing these requirements; the Navy agreed that such an analysis is appropriate, but one that it would not pursue until the conclusion of operational testing. As we previously concluded, waiting until this point would be too late to make effective tradeoffs among cost, schedule, and performance for follow-on ships.

As the Navy prepares to award the detail design and construction contract for the next Ford-class ship, CVN 79, it is clear that achieving the cost cap will be challenging. While the Navy and the shipbuilder are working to reduce costs, the Navy's ability to achieve the congressional cost cap relies, in part, on deferring planned capability improvements until later maintenance periods. From an accountability and oversight standpoint, it would be preferable to keep the scope of the delivered ship constant—an essential component of a baseline—and raise the cost cap accordingly.

Matter for Congressional Consideration

The legislated cost cap for Ford-class aircraft carrier construction provides a limit on procurement funds. However, the legislation also provides for adjustments to the cost cap. To understand the true cost of each Ford-class ship, Congress should consider revising the cost cap legislation to ensure that all work included in the initial ship cost estimate that is deferred to post-delivery and outfitting account is counted against the cost cap. If warranted, the Navy would be required to seek statutory authority to increase the cap.

Recommendations for Executive Action

We are not making any new recommendations, but our recommendations from our September 2013 report remain valid.

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for comment. In its written comments, which are reprinted in appendix III, DOD agreed with much of the report but disagreed with our position on cost cap compliance. In particular, DOD disagreed that a change in cost cap legislation is necessary because it believes all procurement funds are counted toward the cost cap. While it is true that the current cost cap legislation does require the inclusion of all procurement funds, up to this point the Navy has not included funding for outfitting and post delivery costs in its end cost estimates. Further, the current legislation allows the Navy to make changes to the ships' outfitting and post-delivery budget accounts without first seeking statutory authority. In the event that costs increase above the Navy's current estimates, the Navy is considering deferring work until the post-delivery period and funding it through the outfitting and post delivery accounts, which would limit visibility into the ship's true end cost. Our intention is not necessarily, as DOD states, to keep the post-delivery and procurement accounts separate, but rather to create a stable cost baseline for accountability and oversight purposes.

DOD also disagreed with our conclusion that constructing CVN 79 within the current cost cap might not be achievable, but agreed that it will be challenging. DOD stated that the cost cap for CVN 79 is achievable largely due to the Navy's two-phased acquisition approach, which is now intended to deliver the next carrier with the same capabilities as CVN 78. We agree that reducing the scope of CVN 79 prior to ship delivery should also reduce the cost estimate in the near term. As we noted in our report, however, the Navy initially included planned capability improvements in CVN 79's baseline estimate. These improvements will now occur during a later maintenance period, the costs of which are to be shifted to other (non-CVN 79 shipbuilding) accounts at a later date. While the Navy's approach to CVN 79's cost estimate may initially appear to meet the cost cap, it serves to obscure the ship's true cost. As we concluded in the report, from an accountability standpoint, it would be preferable to keep the scope of CVN 79 constant and raise the cost cap accordingly, if needed.

In addition, DOD provided technical comments that were incorporated as appropriate. These comments included, among others, additional information on CVN 78's shipboard test program and the Navy's two-phased approach to constructing and delivering CVN 79.

We are sending copies of this report to interested congressional committees, the Secretary of Defense, and the Secretary of the Navy. In addition, the 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 IV.

Michele Mackin
Director
Acquisition and Sourcing Management

List of Committees

The Honorable Carl Levin
Chairman
The Honorable James M. Inhofe
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Howard P. "Buck" McKeon
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

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

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

Appendix I: Scope and Methodology

This report examines remaining risks in the CVN 78 program since September 2013 by assessing: (1) the extent to which CVN 78 will be delivered to the Navy within its revised cost and schedule goals; (2) if, after delivery, CVN 78 will demonstrate its required capabilities through testing before the ship is deployment ready; and (3) the steps the Navy is taking to achieve CVN 79 cost goals.

To identify challenges in delivering the lead ship within current budget and schedule estimates, we reviewed Department of Defense (DOD) and contractor documents that address technology development efforts including test reports and program schedules and briefings. We also visited the lead ship of the Ford-class carriers, USS *Gerald R. Ford* (CVN 78), to observe construction progress and improve our understanding of the installation progress of the critical technologies aboard CVN 78. We evaluated Navy and contractor documents outlining cost and schedule parameters for CVN 78 Navy budget submissions, contract performance reports, quarterly performance reports, and program schedules and briefings. In addition, we reviewed the shipbuilder's Earned Value Management data and developed our own cost and labor hour estimates at ship completion and compared this with data provided by the Navy and shipbuilder. We also relied on our prior work evaluating the Ford-class program and shipbuilding best practices to supplement the above analyses.[1] To further corroborate documentary evidence and gather additional information in support of our review, we conducted interviews with relevant Navy and contractor officials responsible for managing the technology development and construction of CVN 78, such as the Program Executive Office, Aircraft Carriers; CVN 78 program office; Newport News Shipbuilding (a division of Huntington Ingalls Industries); Supervisor of Shipbuilding, Conversion, and Repair Newport News Command; Aircraft Launch and Recovery program office; and the Program Executive Office, Integrated Warfare Systems. We also held discussions with the Naval Sea Systems Command's Cost Engineering and Industrial Analysis Division; the Defense Contract Management Agency; and the Defense Contract Audit Agency.

[1]GAO-07-866; *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009); GAO-13-396; and *Navy Shipbuilding: Opportunities Exist to Improve Practices Affecting Quality*, GAO-14-122 (Washington, D.C.: Nov. 19, 2013).

To evaluate whether CVN 78 will demonstrate its required capabilities, we identified requirements criteria in the Future Aircraft Carrier Operational Requirements Document and compared requirements with reliability data and reliability growth projections for key systems. We also examined the CVN 78 preliminary ship's manning document and wargame analysis of planned manning, as well as the Commander, Operational Test and Evaluation Force's most recent operational assessment for the ship to identify potential manpower shortfalls. To evaluate whether the Navy's post-delivery test and evaluation strategy will provide timely demonstration of required capabilities, we analyzed (1) development schedules and test reports for CVN 78 critical technologies; (2) testing reports and operational assessments for CVN 78; and (3) the Navy's November 2013 revised test and evaluation master plan to identify concurrency among development, integration, and operational test plans. We corroborated documentary evidence by meeting with Navy and contractor officials responsible for developing key systems, managing ship testing, and conducting operational testing, including the Program Executive Office-Aircraft Carriers, the CVN 78 program office, Newport News Shipbuilding, the Aircraft Launch and Recovery program office, the Navy's land-based test site for EMALS and AAG in Lakehurst, N.J., the Program Executive Office for Integrated Warfare Systems, Office of the Director, Operational Test and Evaluation, Office of the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation, the Office of the Commander, Navy Operational Test and Evaluation Force, and the Office of the Chief of Naval Operations Air Warfare.

To assess the steps the Navy is taking to achieve CVN 79 cost goals, we reviewed our prior work on Ford-class carriers[2]; shipbuilder data identifying cost savings and labor hour reduction opportunities as well as lessons learned from constructing CVN 78; CVN 79 construction preparation contract and contract extensions; CVN 78 and CVN 79 labor hour data for completing advanced construction work; as well as, CVN 79 construction plans and reports, program briefings, and Navy budget submissions. We also conducted an analysis of the shipbuilder's scheduling systems and processes that are used for constructing CVN 78 and assessed this against GAO's scheduling best practices.[3] We attempted to conduct a similar analysis of CVN 79's schedule. However,

[2]GAO-13-396, GAO-07-866.

[3]GAO-12-120G.

the integrated master schedule used for construction—that is maintained by the shipbuilder—was not up to date and did not reflect the status of advanced construction work at the time of our analysis. As a result, we only reviewed the scheduling processes that the shipbuilder plans to use for CVN 79. To supplement our analysis and gain additional visibility into the Navy's actions for ensuring CVN 79 is built within the constraints of the cost cap legislation, we reviewed several years of defense authorization acts and interviewed officials from the Program Executive Office-Aircraft Carriers, CVN 78 program office, CVN 79 and CVN 80 program office; Huntington Ingalls Industries, Newport News Shipbuilding; Supervisor of Shipbuilding, Conversion, and Repair Newport News Command; Program Executive Office, Integrated Warfare Systems; the Office of the Chief of Naval Operations Air Warfare Division; and, Naval Sea Systems Command's Cost Engineering and Industrial Analysis Division.

We conducted this performance audit from December 2013 to November 2014 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: New Technologies Introduced on Ford-Class Ships

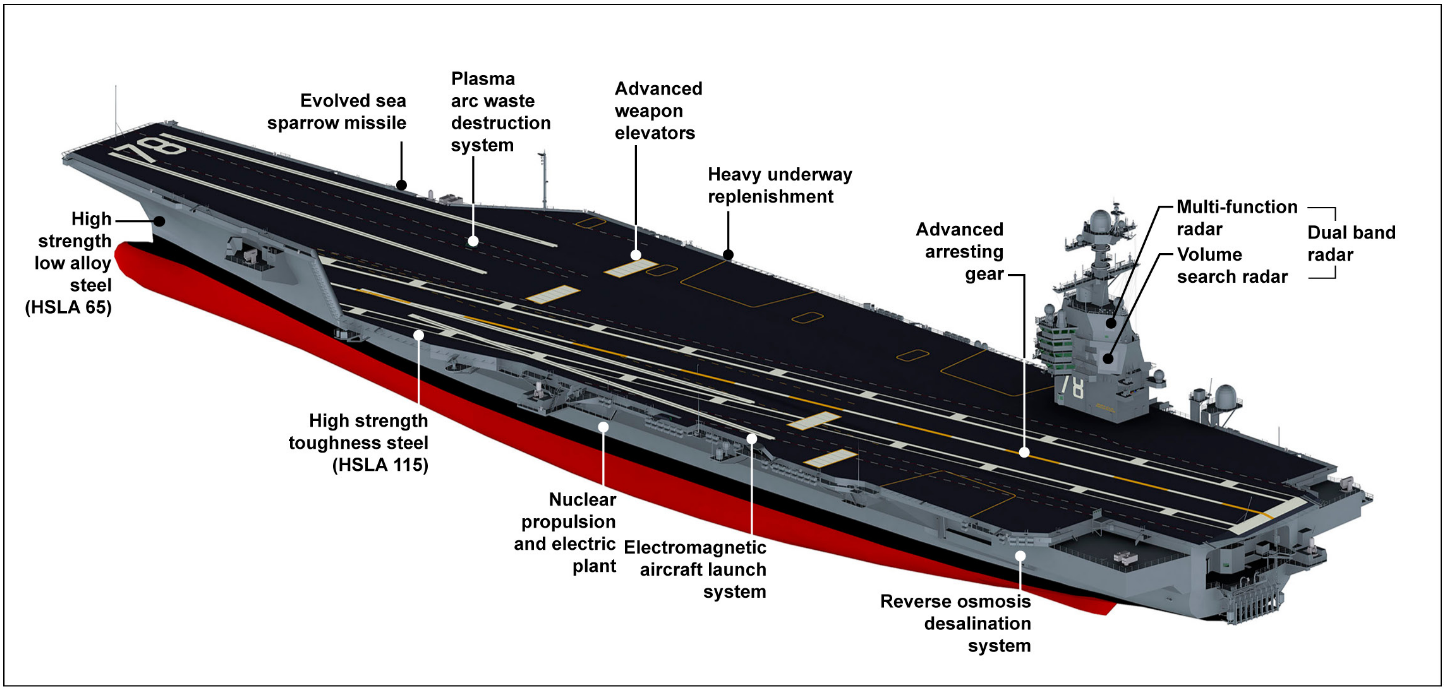
A number of new technologies are being installed on Ford-class aircraft carriers that are designed to increase the ship's capability and lower life cycle costs. Below is an overview of these key technologies along with the approximate placement on the ship.

Table 11: New Technologies for the Ford-Class Aircraft Carrier

Technology	Description and Capability Improvement
Dual Band Radar (DBR)	Two systems comprise the DBR: (1) Volume search radar includes long-range, above-horizon, surveillance, and air traffic control capabilities. (2) Multifunction radar includes horizon search, surface search and navigation, and missile communications. The DBR permits reduced manning and higher sortie generation rates aboard CVN 78 via anticipated operational availability increases and size reductions to the ship's island.
Advanced Arresting Gear (AAG)	AAG recovers current and future aircraft and contributes to reduced manning.
Electromagnetic Aircraft Launch System (EMALS)	EMALS uses an electrically generated moving magnetic field to propel aircraft, which places less physical stress on aircraft as compared to steam catapult launchers. The system is a contributor to CVN 78's reduced manning, in part because of Navy expectations about EMALS's increased operational availability.
Advanced Weapons Elevators	These elevators rely on electromagnetic fields to move instead of cables. Capability improvements include an expected 200 percent greater load capability than legacy carrier elevators. Advanced weapons elevators facilitate reduced manning and enable higher sortie generation rates.
Evolved Sea Sparrow Missile Joint Universal Weapons Link	This system supports anti-air warfare. The system provides the capability to defeat high-density raids.
Heavy Underway Replenishment Receiving Station	This system provides quicker shipboard replenishment (supply) than legacy underway replenishment systems. The system may facilitate F-35C power module replacement and higher sortie generation rates for the Ford-class.
Plasma Arc Waste Destruction System (PAWDS)	PAWDS uses extreme temperatures to convert 6,800 pounds per day of plastic and other waste into gaseous emissions. It may facilitate reduced manning aboard the ship.
Nuclear propulsion/electric plant	The system converts energy into electricity, providing a nearly threefold increase in power generation over the Nimitz-class plant. The plant design also facilitates manning reductions and supports weight and stability service life allowances.
Reverse Osmosis Desalinization System	This system desalinates water without a steam distribution system, facilitating reduced manning and improved weight and stability for the ship.
High Strength Toughness Steel (HSLA 115)	HSLA 115 is stronger and lighter than legacy ship steel types and comprises the CVN 78 flight deck. HSLA 115 improves weight and stability for the ship.
High Strength Low Alloy Steel (HSLA 65)	HSLA is stronger and lighter than legacy ship steel types and is used in bulkheads as well as deck constructions. HSLA 65 improves weight and stability for the ship.

Source: Navy and contractor documentation. | GAO-15-22

Figure 7: Critical Technologies on the Ford-Class Aircraft Carrier



Source: GAO (presentation); Navy (image). | GAO-15-22

Appendix III: Comments from the Department of Defense

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

ACQUISITION

NOV 12 2014

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-15-22, 'FORD CLASS AIRCRAFT CARRIER: Cost Cap Should Include All Costs Required to Complete Ship Construction,' dated September 29, 2014 (GAO Code 121183). The Department acknowledges receipt of the draft report and notes that it contains no recommendations for DoD action as a result of your review.

The Department agrees with much of the report, but disagrees with the conclusions reached by GAO in the areas of CVN 78 lead ship cost cap compliance and CVN 79 follow ship cost cap compliance.

CVN 78 Lead Ship Cost Cap Compliance. GAO states that the Navy cost cap strategy contradicts the purpose of the Congressional cost cap, which is to hold the Navy accountable for the total cost estimate for buying a deployable ship; and that Congress should consider revising the cost cap legislation to improve accountability of GERALD R. FORD-class construction costs by requiring that all work included in the initial ship cost estimate is counted against the cost cap. The Department disagrees that a change to the legislation is necessary because all procurement funds are included in the cost cap legislation. However, the Department understands GAO's intention of recommending separate budget accounts for post-delivery activities and procurement to gain more transparency into cost details.

CVN 79 Follow Ship Cost Cap Compliance. GAO states that it is already clear that the CVN 79 cost cap might not be achievable, that Navy's ability to achieve the cost cap relies in part on shifting costs for planned capability upgrades to the operational fleet, and that efficiency gains needed to achieve the cost cap are unprecedented in aircraft carrier construction and will be challenging to achieve. The Department disagrees based on the Navy's two-phased approach to deliver CVN 79 to the Fleet with CVN 78-like capabilities within the legislated SCN cost cap. The Department acknowledges that remaining within the cost cap is challenging, but contends that it is achievable.

The Department appreciates the opportunity to comment on the draft report. For further questions concerning this report, please contact Mr. James MacStravic, Deputy Assistant Secretary of Defense, Tactical Warfare Systems, at james.a.macstravic2.civ@mail.mil or 703-697-9386.

Sincerely,

Katrina McFarland

2

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

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

Staff Acknowledgments

In addition to the contact named above, key contributors to this report were Diana Moldafsky, Assistant Director; Christopher E. Kunitz; Brian P. Bothwell, Juana S. Collymore, Burns C. Eckert; Laura Greifner; John A. Krump; Jean L. McSween; Karen Richey; Jenny Shinn; and Oziel Trevino.

GAO's Mission

The Government Accountability Office, the audit, evaluation, and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's website (http://www.gao.gov). Each weekday afternoon, GAO posts on its website newly released reports, testimony, and correspondence. To have GAO e-mail you a list of newly posted products, go to http://www.gao.gov and select "E-mail Updates."

Order by Phone

The price of each GAO publication reflects GAO's actual cost of production and distribution and depends on the number of pages in the publication and whether the publication is printed in color or black and white. Pricing and ordering information is posted on GAO's website, http://www.gao.gov/ordering.htm.

Place orders by calling (202) 512-6000, toll free (866) 801-7077, or TDD (202) 512-2537.

Orders may be paid for using American Express, Discover Card, MasterCard, Visa, check, or money order. Call for additional information.

Connect with GAO

Connect with GAO on Facebook, Flickr, Twitter, and YouTube. Subscribe to our RSS Feeds or E-mail Updates. Listen to our Podcasts. Visit GAO on the web at www.gao.gov.

To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Website: http://www.gao.gov/fraudnet/fraudnet.htm
E-mail: fraudnet@gao.gov
Automated answering system: (800) 424-5454 or (202) 512-7470

Congressional Relations

Katherine Siggerud, Managing Director, siggerudk@gao.gov, (202) 512-4400, U.S. Government Accountability Office, 441 G Street NW, Room 7125, Washington, DC 20548

Public Affairs

Chuck Young, Managing Director, youngc1@gao.gov, (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, DC 20548