



June 2017

FORD-CLASS AIRCRAFT CARRIER

Follow-On Ships
Need More Frequent
and Accurate Cost
Estimates to Avoid
Pitfalls of Lead Ship

GAO Highlights

Highlights of [GAO-17-575](#), a report to the Committee on Armed Services, U.S. Senate

Why GAO Did This Study

The Navy intended for the Ford Class aircraft carrier to improve combat capability while reducing acquisition and life-cycle costs. However, as GAO has reported on extensively since 2007, the lead ship has experienced cost growth of nearly 23 percent, with a reduced capability expected at delivery. CVN 78 is estimated to cost \$12.9 billion, while the next ship, CVN 79, is estimated to be \$11.4 billion. The Navy plans to buy 1-2 more ships in the coming years.

The Senate Armed Services Committee Report accompanying the National Defense Authorization Act for Fiscal Year 2016 included a provision that GAO review Ford-class cost estimates, among related issues. This report assesses: (1) the extent to which the CVN 79 cost estimate is a reliable basis for meeting the cost cap and addresses known cost risks from the lead ship, and (2) the extent to which oversight mechanisms provide Congress with insight into ship costs. To do this work, GAO compared the CVN 79 cost estimate with GAO's Cost Estimating and Assessment Guide, analyzed cost reports, and interviewed relevant officials.

What GAO Recommends

The Navy should develop a new, reliable cost estimate for CVN 79 validated by cost reviews and obtain an independent cost estimate before requesting funding for future ships. The Navy partially concurred with these recommendations, but did not concur with a draft recommendation to prepare a SAR for each Ford class ship. In response to comments, GAO revised the recommendation to focus on SAR cost and funding summaries.

View [GAO-17-575](#). For more information, contact Michele Mackin at (202) 512-4841 or MackinM@gao.gov.

June 2017

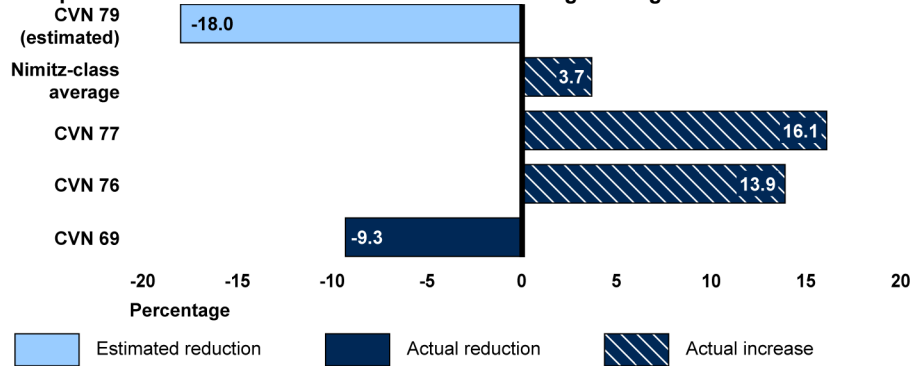
FORD-CLASS AIRCRAFT CARRIER

Follow-On Ships Need More Frequent and Accurate Cost Estimates to Avoid Pitfalls of Lead Ship

What GAO Found

The cost estimate for the second Ford-Class aircraft carrier, CVN 79, is not reliable and does not address lessons learned from the performance of the lead ship, CVN 78. As a result, the estimate does not demonstrate that the program can meet its \$11.4 billion cost cap. Cost growth for the lead ship was driven by challenges with technology development, design, and construction, compounded by an optimistic budget estimate. Instead of learning from the mistakes of CVN 78, the Navy developed an estimate for CVN 79 that assumes a reduction in labor hours needed to construct the ship that is unprecedented in the past 50 years of aircraft carrier construction, as shown in the figure below.

John F. Kennedy Aircraft Carrier (CVN 79) Estimated Labor Hour Percentage Change Compared to Actual Nimitz Class Labor Hour Percentage Change



Source: GAO analysis of Navy data. | GAO-17-575

After developing the program estimate, the Navy negotiated 18 percent fewer labor hours for CVN 79 than were required for CVN 78. CVN 79's estimate is optimistic compared to the labor hour reductions calculated in independent cost reviews conducted in 2015 by the Naval Center for Cost Analysis and the Office of Cost Assessment and Program Evaluation. Navy analysis shows that the CVN 79 cost estimate may not sufficiently account for program risks, with the current budget likely insufficient to complete ship construction.

The Navy's current reporting mechanisms, such as budget requests and annual acquisition reports to Congress, provide limited insight into the overall Ford Class program and individual ship costs. For example, the program requests funding for each ship before that ship obtains an independent cost estimate. During an 11-year period prior to 2015, no independent cost estimate was conducted for any of the Ford class ships; however, the program received over \$15 billion in funding. In addition, the program's Selected Acquisition Reports (SAR)—annual cost, status, and performance reports to Congress—provide only aggregate program cost for all three ships currently in the class, a practice that limits transparency into individual ship costs. As a result, Congress has diminished ability to oversee one of the most expensive programs in the defense portfolio.

This is a public version of a sensitive but unclassified report that GAO issued in March 2017. Information the Department of Defense deemed sensitive has been removed. Areas where redactions occurred are noted in the body of the report.

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Abbreviations

| | |
|------------|---|
| AAG | advanced arresting gear |
| CAPE | Office of Cost Assessment and Program Evaluation |
| DBR | dual band radar |
| DOD | Department of Defense |
| EMALS | electromagnetic aircraft launch system |
| NAVSEA 05C | Naval Sea Systems Command Cost Engineering and Industrial Analysis Group |
| NCCA | Naval Center for Cost Analysis |
| SAR | Selected Acquisition Report |

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June 13, 2017

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

The Navy is investing over \$43 billion to develop three Ford-Class nuclear-powered aircraft carriers. This class of ships was intended to feature an array of cutting-edge technologies to improve combat capability and create operational efficiencies by increasing the rate of aircraft launches and reducing the number of personnel needed to operate the ship. The Navy expected to achieve these improvements while simultaneously reducing acquisition and life-cycle costs. However, this expectation has not been borne out. Costs to construct the lead ship Gerald R. Ford (CVN 78) have increased from \$10.5 billion to \$12.9 billion (nearly 23 percent), and promised levels of capability have been reduced. Since 2007, we have reported extensively on issues with the Ford-Class program, including weaknesses in the program's cost estimates. To help ensure that the Navy adhered to its cost estimates, Congress established a procurement cost cap for Ford-Class ships. The lead ship is now capped at \$12.9 billion, while the follow-on ships are capped at \$11.4 billion each.¹ CVN 78 was recently delivered, in May 2017. Construction of the second ship John F. Kennedy (CVN 79) is underway, and Congress appropriated advance procurement funding for the carrier replacement program in fiscal year 2016, which the Navy has budgeted for the third ship Enterprise (CVN 80). The Navy is currently considering adding a fourth ship (CVN 81) to the program baseline.

The Senate Armed Services Committee report accompanying the National Defense Authorization Act for Fiscal Year 2016 included a provision for us to review the Ford-Class acquisition program, including the quality and reliability of cost estimates and how the Navy reports program costs to Congress. This report assesses: (1) drivers of CVN 78

¹The National Defense Authorization Act for Fiscal Year 2016 decreased the legislated cost cap for follow-on Ford-Class ships to \$11.398 billion from \$11.498 billion set by the National Defense Authorization Act for Fiscal Year 2014. Pub. L. No. 114-92, § 122 (2015).

cost growth, (2) the extent to which the CVN 79 cost estimate is a reliable basis for meeting the cost cap and addresses known cost risks from the performance of the lead ship, and (3) the extent to which Ford-Class oversight mechanisms provide Congress with insight into ship costs.

To determine the drivers of CVN 78 cost growth, we leveraged our past Ford-Class program reports and analyzed Navy budget submissions and program documentation, including memorandums to members of Congress.² To assess the reliability of the CVN 79 cost estimate, we determined the extent to which the estimate was consistent with cost estimating best practices as identified in GAO's Cost Estimating and Assessment Guide, as well as Navy cost estimating guidance.³ We also reviewed supporting documentation and conducted interviews with relevant DOD and Navy officials responsible for developing and updating the CVN 79 estimate. To determine the extent oversight mechanisms provide Congress with insight into Ford-Class ship costs, we reviewed legislation on the congressional cost caps and examined budget requests from 2001 to 2016 and Selected Acquisition Reports (SAR) from 2005 to 2015 to assess the transparency of cost information. A more detailed description of our scope and methodology is presented in appendix I.

The performance audit upon which this report is based was conducted from December 2015 to March 2017 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.

This report is a public version of a sensitive but unclassified (SBU) report issued in March 2017.⁴ After issuing that SBU report, we subsequently

²GAO, *Ford Class Aircraft Carrier: Poor Outcomes Are the Predictable Consequences of the Prevalent Acquisition Culture*, [GAO-16-84T](#) (Washington, D.C.: Oct. 1, 2015). See Related GAO Products at the end of this report for a complete list of prior reports on the Ford-Class program.

³GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, [GAO-09-3SP](#) (Washington, D.C.: Mar. 2, 2009). Naval Sea Systems Command, *2005 Cost Estimating Handbook* (Washington, D.C.: 2005).

⁴ *Ford-Class Aircraft Carrier: Follow-On Ships Need More Frequent and Accurate Cost Estimates to Avoid Pitfalls of Lead Ship*, [GAO-17-190SU](#) (Washington, D.C.: Mar. 1, 2017).

obtained comments from DOD from March 2017 to June 2017 on information the department deemed not releasable to the public. We redacted that information in order to prepare this public version of the original SBU report for public release. This public version of the report was also prepared in accordance with generally accepted government auditing standards.

Background

The Ford-Class nuclear-powered aircraft carriers are the successors to the Nimitz-Class carriers designed in the 1960s. The Navy set ambitious goals for the Ford-Class program, designing the carrier with an array of cutting-edge technologies, including an aircraft launch system that would use electromagnetics—versus steam—to propel aircraft off of the ship (EMALS), an advanced arresting gear (AAG) with an electric motor to recover aircraft, and a dual band radar (DBR) that would use two planar (stationary) radars to provide air traffic control, ship self-defense, and other capabilities. These technologies, along with new design features like a new propulsion system, an enlarged flight deck, and an aft-positioned island, would improve combat capability, while simultaneously reducing acquisition and life-cycle costs. Newport News Shipbuilding, in Newport News, Virginia, began construction of CVN 78 in September 2008 with delivery originally expected in September 2015. Delivery was delayed, however; and CVN 78 was delivered in May 2017.⁵ Construction of CVN 79 began in June 2015, with an expected initial delivery in 2022.

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—(1) construction preparation and (2) detail design and construction—which are preceded by the start of advance procurement funding. The CVN 78 detail design and construction contract was a cost-plus incentive fee contract, which means that the shipbuilder is reimbursed for its allowable costs plus a fee which is adjusted according to a formula and is capped by a negotiated maximum fee. In contrast, the CVN 79 detail design and construction contract is a fixed-price incentive fee contract, meaning the government's liability is capped at a negotiated ceiling price. However, because the Navy budgeted the ship at the target cost, any cost increases above the target would require the Navy to adjust its budget planning and request

⁵ CVN 78 was delivered after GAO-17-190SU was published.

additional funding from Congress.⁶ DOD and the Navy have conducted program reviews for each Ford-Class ship prior to major phases in the program, such as prior to awarding advanced procurement and detail design and construction contracts.

Our Prior Reports and Recommendations

We have reported extensively on issues with the cost and execution of the Ford-Class program and made a number of recommendations. DOD has addressed some but not all of our recommendations:

- In 2007, we reported that delays in Ford-Class technology development and overly optimistic cost estimates would likely result in higher lead ship costs than what the Navy planned in its budget. Among other things, we recommended actions to improve the realism of the CVN 78 budget estimate and the Navy's cost surveillance capability. We also recommended that the Navy develop carrier-specific tests of DBR to ensure that it could meet carrier-specific requirements.⁷ While DOD agreed with these recommendations and eventually acted on some of them, including improving the Navy's cost surveillance capability, the Navy's updates to CVN 78's cost estimate did not reflect its most likely costs.
- In 2013, we reported that the Navy faced technical, design, and construction challenges to completing CVN 78 that had led to significant cost increases and reduced the likelihood that a fully functional ship would be delivered on time. The Navy's strategy for providing timely demonstration of CVN 78 capabilities was hampered by post-delivery test plan deficiencies, Joint Strike Fighter aircraft delivery delays (this is one of the primary aircraft slated to operate from the carrier), and reliability shortfalls affecting key ship systems. We recommended that DOD:
 - conduct a cost-benefit analysis on required CVN 78 capabilities—namely, reduced manning and the increased rate of aircraft launches (known as the sortie generation rate)—in light of known and projected reliability shortfalls for critical systems;

⁶For additional information on the use of fixed-price incentive contracts in Navy shipbuilding, see: GAO, *Navy Shipbuilding: Need to Document Rationale for the Use of Fixed-Price Incentive Contracts and Study the Effectiveness of Added Incentives*, [GAO-17-211](#) (Washington, D.C. Mar. 1, 2017).

⁷GAO, *Defense Acquisitions: Navy Faces Challenges Constructing the Aircraft Carrier Gerald R. Ford within Budget*, [GAO-07-866](#) (Washington, D.C. Aug. 23, 2007).

-
- update the Ford-Class program’s test and evaluation master plan and adjust the planned post-delivery test schedule;
 - defer the CVN 79 detail design and construction contract award until land-based testing for critical systems was 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 to update the test plan and delayed the CVN 79 detail design and construction contract award, it partially concurred with and has taken only modest action to address our other recommendations.⁸

- In 2014, we reported that the extent to which CVN 78 would be delivered on time and within the Navy’s \$12.9 billion estimate was dependent on the Navy’s plan to defer work and costs to the post-delivery period.⁹ We found that CVN 78 would deploy without demonstrating full operational capabilities because it could not achieve certain key requirements—such as increasing launch and recovery rates—according to its test schedule. We also found that the Navy was implementing steps to achieve the congressional cost cap for CVN 79, but that they were largely based on ambitious efficiency gains and reducing a significant amount of construction, installation, and testing—work traditionally completed prior to ship delivery. We made no new recommendations in this report but noted that our 2013 recommendations remained valid. However, we suggested that Congress consider revising the cost cap legislation to ensure that all work included in the initial ship cost estimate that is deferred to post-delivery is counted against the cost cap; if warranted, we noted, the Navy could seek statutory authority to increase the cap. To date, Congress has not taken action to change the cost cap legislation; however, the National Defense Authorization Act for Fiscal Year 2016 lowered the cost cap for all follow-on ships, to include CVN 79, from \$11.5 billion to \$11.4 billion.

Cost Estimating

A reliable cost estimate is critical to the success of any program. Such an estimate provides the basis for informed investment decision making,

⁸Additional details on our prior Ford-Class recommendations and DOD’s responses are included in [GAO-16-84T](#).

⁹GAO, *Ford-Class Aircraft Carrier: Congress Should Consider Revising Cost Cap Legislation to Include All Construction Costs*, [GAO-15-22](#) (Washington, D.C.: Nov. 20, 2014).

realistic budget formulation and program funding, meaningful progress measurement, proactive course correction when warranted, and accountability for results. The GAO Cost Estimating and Assessment Guide states that reliable cost estimates reflect 4 characteristics, which encompass 20 best practices.¹⁰ The characteristics are (1) comprehensive, (2) accurate, (3) credible, and (4) well-documented, as shown in table 1 below.

Table 1: Characteristics of a High-Quality, Reliable Cost Estimate

| Cost estimate characteristic | Definition |
|------------------------------|--|
| Comprehensive | Includes all costs of a program over its full life cycle, from inception through design, development, deployment, and operation and maintenance to retirement. Program should be completely defined, reflecting the current schedule, and is technically reasonable. All cost-influencing ground rules and assumptions are documented. |
| Accurate | Estimate is based on an assessment of most likely costs. Results are unbiased and not overly conservative or optimistic. Estimate should be updated regularly to reflect significant changes in the program and actual costs. |
| Credible | Cost drivers are crosschecked, and compared with an independent cost estimate. Risk and uncertainty analysis performed. Limitations are discussed. |
| Well-documented | Detailed documentation captures the source data used, the calculations performed and their results, and the estimating methodology. Information should allow for easy replication and updating. |

Source: GAO. | GAO-17-575

For Navy shipbuilding programs, including the Ford Class, several different entities are involved in cost estimating:

- The Naval Sea Systems Command (NAVSEA) Cost Engineering and Industrial Analysis Group (05C) is responsible for developing the program life-cycle cost estimate, which is an estimate accounting for the total cost to the government of acquisition and ownership of a system over its full life.
- The Naval Center for Cost Analysis (NCCA) is responsible for developing an independent cost assessment for certain Navy programs at program milestone events in the defense acquisition system. This assessment is not a separate estimate, but rather a review of the NAVSEA 05C program life-cycle cost estimate. NCCA and NAVSEA 05C, with support from the program office, collaborate to develop the Navy Service Cost Position, based on the program life-

¹⁰GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, [GAO-09-3SP](#) (Washington, D.C.: March 2009).

cycle cost estimate and the independent cost assessment. NCCA first assessed the Ford-Class program in 2015.

- The Office of the Secretary of Defense's Office of Cost Assessment and Program Evaluation (CAPE) develops an independent cost estimate. According to DOD's Cost Analysis Guidance and Procedures, independent cost reviews are required for major defense acquisition programs at milestone events.¹¹ The Navy Service Cost Position and the CAPE independent cost estimate are compared and presented to the Under Secretary of Defense for Acquisition, Technology, and Logistics (the Milestone Decision Authority for the Ford-Class program) to establish the program acquisition baseline.¹² DOD policy states that a major defense acquisition program should budget to the independent cost estimate unless an alternative estimate is approved by the Milestone Decision Authority.
- The program office uses cost and risk information from the program life-cycle cost estimate to inform all resource and programming decisions. The program office is responsible for developing and annually updating the Cost Analysis Requirements Description, which includes the program acquisition approach, system characteristics, and preliminary schedules. This document is used as the basis for all program cost estimates.

The most recent CAPE and NCCA independent cost estimate and assessment for the Ford Class were completed in May 2015 and April 2015, respectively, to support an April 2015 Defense Acquisition Board Review prior to the Navy's June 2015 award of the CVN 79 detail design and construction contract. The Under Secretary of Defense for Acquisition, Technology, and Logistics accepted the Navy Service Cost Position as the program estimate.

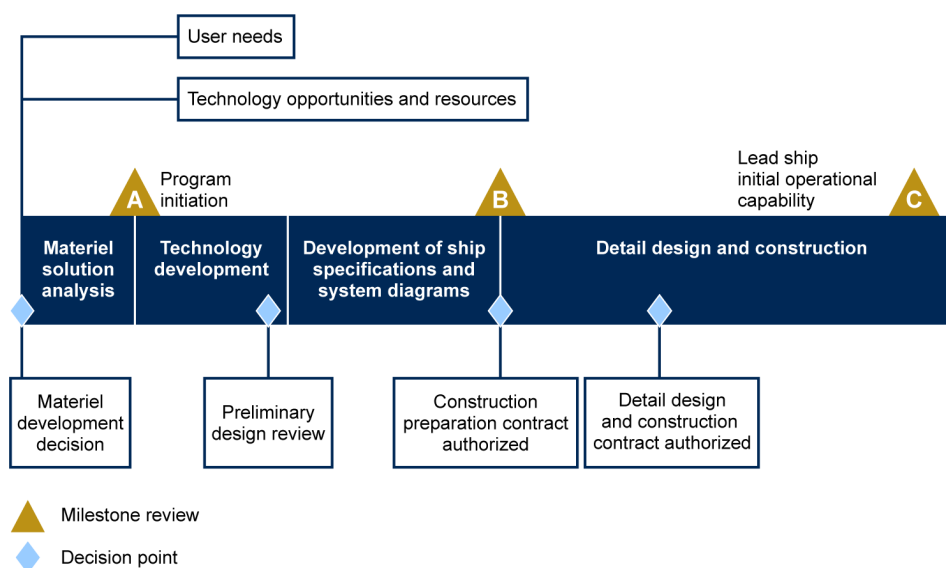
The Ford-Class program held a Milestone B review in 2004 to approve the program development decision, coinciding with the award of the construction preparation contract, as shown in figure 1 below. Milestone C was aligned with the end of operational testing, scheduled for fiscal

¹¹Reviews are conducted in advance of Milestone A or Milestone B certification, and in advance of the decision to enter low-rate initial production or full-rate production. Department of Defense Instruction 5000.73, Cost Analysis Guidance and Procedures Encl. 2 para. 2.a(1) (June 9, 2015).

¹²The Milestone Decision Authority is the sole and final decision authority for a major defense acquisition program. Department of Defense Instruction 5000.02, Operation of the Defense Acquisition System para. 5.a(4)(a) (Jan. 7, 2015).

year 2020. In 2014 the Under Secretary of Defense for Acquisition, Technology, and Logistics decided to shift this milestone review to April 2015 to take place during the planned Defense Acquisition Board Review.¹³ In 2015 the Under Secretary canceled the milestone review, and rescheduled it for fiscal year 2018.

Figure 1: Acquisition Framework for Ford-Class Carrier Program



Source: GAO analysis of Department of Defense data. | GAO-17-575

Test Events

During the acquisition process, major defense programs, including shipbuilding programs, execute several types of testing, while the ship progresses toward operational milestones including the point when the fleet initially receives 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. Shipboard testing—which occurs during both developmental and integration testing—is

¹³The Defense Acquisition Board advises the defense acquisition executive (the Under Secretary of Defense for Acquisition, Technology, and Logistics) on critical acquisition decisions. Department of Defense Instruction 5000.02, Operation of the Defense Acquisition System para. 5.a(4)(b) (Jan. 7, 2015).

meant to ensure correct installation and operation of the equipment and systems in a maritime environment. Testing in this phase is a complex and iterative process, as problems inherent with the start-up and initial operation of a system must be identified, corrected, and retested to ensure that the issues have been resolved.

Integration testing is intended to assess, verify, and validate the performance of multiple systems operating together to achieve required ship capabilities.

Operational testing occurs after delivery and assesses the ship'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.

Legislative Cost Cap of Ford-Class Ships

To ensure the Navy adheres to its cost estimates, Congress established a procurement cost cap for the Ford Class. In the National Defense Authorization Act for Fiscal Year 2007, Congress set the cap at \$10.5 billion for the lead ship and \$8.1 billion for each subsequent carrier. This legislation also established six provisions, including economic inflation and insertion of new technologies, which allow the Navy to make adjustments to the cost cap without seeking statutory authority.¹⁴ Following the 2007 legislation, Congress has twice increased the cap, which now stands at \$12.9 billion for the lead ship and \$11.4 billion for follow-on ships. 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.¹⁵

¹⁴Pub. L. No. 109-364, § 122 (2006). Dollars are then-year.

¹⁵Pub. L. No. 113-66, § 121 (2013).

Persistent Issues with Lead Ship Construction Continue to Drive Cost Uncertainty

Since August 2007, we have reported on key risks to the CVN 78 program that would impair the Navy's ability to deliver the ship at cost, on time, and with its planned capabilities. These risks have been realized, with nearly \$2.4 billion in cost growth and over a 1-year delay in delivery. While construction of CVN 78 is complete, recent technical deficiencies—discovered as the Navy continues to test the systems installed on the ship and the shipbuilder completes the latter stage of construction activities—suggest that additional costs are likely. Program officials stated they have not fully estimated these remaining costs. As a result, the current cost cap of \$12.9 billion does not represent the required budget necessary to deliver the ship.

Challenges with Technology Development, Design, and Construction, Coupled with an Optimistic Budget, Drove Lead Ship Cost Growth

Our work has shown that the key drivers of CVN 78's procurement cost growth were an ambitious technology development plan for incorporating critical technologies on the ship and the ship's incomplete design at the start of construction. These factors, along with engineering and construction challenges, contributed to inefficiencies in ship construction and have led to \$2.4 billion in cost increases as of 2016. We highlight the cost drivers to date in table 2.

Table 2: Major Gerald R. Ford Aircraft Carrier (CVN 78) Procurement Cost Drivers

| Cost driver | Description | Cost growth to date |
|--|--|---------------------|
| Overly ambitious technology development plan | <ul style="list-style-type: none"> • In 2002, the Department of Defense opted to attempt to achieve a revolutionary approach in introducing new technologies on the lead ship. The Navy sought to research, develop, and produce 14 critical technologies aimed at facilitating CVN 78's capability and efficiency gains. • Several critical technologies encountered problems in development (details in table 4 below), resulting in delays to land-based testing—a key aspect in reducing technical risk. • Navy elected to proceed with production of some critical technologies prior to fully demonstrating their capability, in an effort to maintain the construction schedule. A strategy of concurrent test and production ensued, often leading to changes in components that had already been produced. • Even after installation on the ship, developmental testing of critical technologies continued to reveal additional problems. | \$956 million |
| Design immaturity at construction start | <ul style="list-style-type: none"> • Our work on shipbuilding best practices has found that achieving design stability before starting construction is a key step in ensuring on-time delivery within planned costs. • In the case of CVN 78, a high degree of concurrency between ongoing technology development and ship detail design hampered the design process. • At construction contract award in 2008, 76 percent of the detail design was complete, but ongoing testing of the critical technologies resulted in over 19,000 design changes. The shipbuilder did not complete detail design until after ship construction was well underway. • Construction performance eroded as the shipbuilder had to implement workarounds and re-work to compensate for design issues. Issues with construction drawings and instructions contributed to inefficient work delays and restarts. | \$738 million |
| Construction and engineering challenges | <ul style="list-style-type: none"> • Construction deviated significantly from its optimal build sequence, meaning the most efficient ship construction schedule. • Government delays in the delivery of critical technologies to the shipyard and design issues noted above were coupled with significant material shortfalls leading to construction inefficiencies. For example, delays in the developmental valves led to inefficient and costly workarounds. Similarly, problems with special thin steel plating for ship decks resulted in inefficient workarounds and reduced levels of pre-outfitting. | \$846 million |

Source: GAO and Department of Navy's President's Budget requests. | GAO-17-575

Note: In a September 2015 information paper to Congress, the Navy identified \$141 million in miscellaneous cost reductions for the ship that partially offset the cost growth identified in the table.

EMALS, DBR, and AAG Drove Critical Technology Cost Increases

CVN 78’s critical technologies drove approximately 40 percent of the ship’s procurement cost growth. This cost growth was largely attributable to EMALS, DBR, and AAG, as seen in table 3.

Table 3: Gerald R. Ford Aircraft Carrier (CVN 78) Procurement Cost Growth for Selected Critical Technology Systems

Dollars in millions

| System | Fiscal year 2008 budget | Fiscal year 2017 budget | Difference in cost | Cost growth as a percent of fiscal year 2008 budget |
|--|-------------------------|-------------------------|--------------------|---|
| Electromagnetic Aircraft Launch System | 317.7 | 669.7 | 352.1 | 111% |
| Dual Band Radar | 201.9 | 481.8 | 279.9 | 139% |
| Advanced Arresting Gear | 75.0 | 147.6 | 72.6 | 97% |
| Total Cost | 594.6 | 1299.1 | 704.5 | 118% |

Source: GAO analysis of Department of Navy’s President’s Budget requests. | GAO-17-575

In addition to cost increases to buy these systems, costs to develop these systems also increased above initial estimates. For example, EMALS experienced a \$549 million increase in its development costs. Development costs for AAG and DBR are not reflected in the development costs for CVN 78, as the systems are managed through different Navy programs. Development costs for the AAG program (managed by the Naval Air Systems Command) increased by \$572 million—an over 300 percent increase above its initial estimate from 2005. The Navy initially planned to retrofit AAG on the Nimitz Class; it opted to install the system only on the Ford Class, in part as a result of cost increases. Similarly, DBR, which is managed by NAVSEA’s Integrated Warfare Systems Program Executive Office, experienced development cost increases. However, since this system was initially developed for the Zumwalt Class destroyer program, its cost increases are not accounted for in the CVN 78 program.

In our November 2014 report, we elaborated on ongoing issues with DBR, AAG, and EMALS, which were attributed to unanticipated challenges in development, as highlighted in table 4.¹⁶

¹⁶GAO-15-22.

Table 4: Key Cost Drivers for Selected Gerald R. Ford Aircraft Carrier (CVN 78) Critical Technology Systems as of November 2014

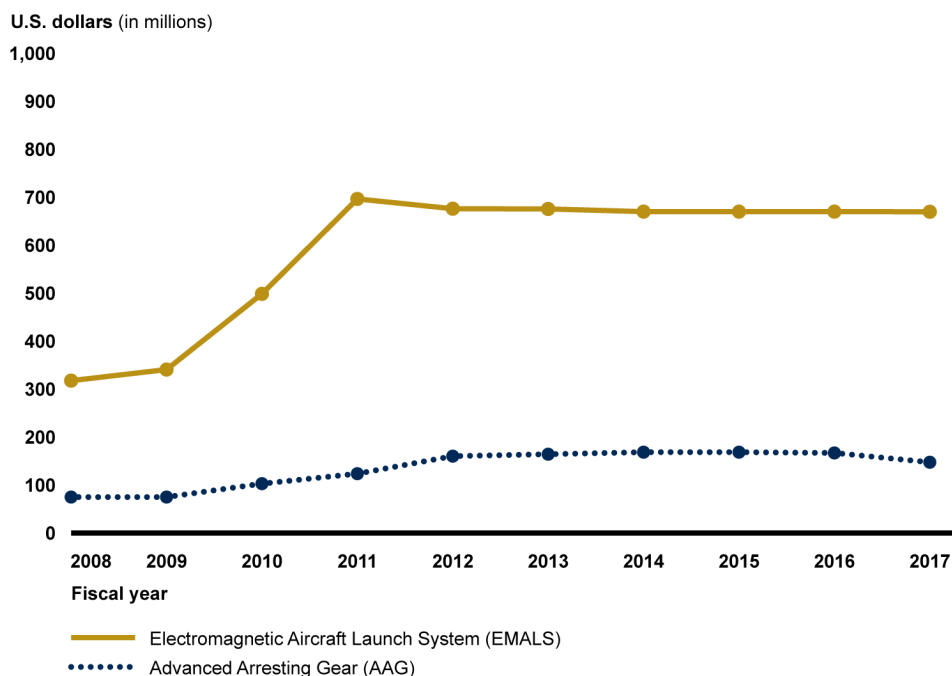
| Technology | Description | Development challenges |
|--|---|--|
| Dual Band Radar (DBR) | DBR includes: (1) Volume search radar for long-range, above-horizon, surveillance, and air traffic control capabilities and (2) Multifunction radar for horizon search, surface search and navigation, and missile communications. DBR was intended to permit reduced manning and higher sortie generation rates aboard CVN 78. | <ul style="list-style-type: none"> • Technical deficiencies with the volume search radar, in particular, slowed system development. • Land-based testing of DBR began over 2 years late, after production was underway and continued even after installation on the ship, with testing concluding close to 5 years later than planned. • Modifications to the power regulating system to address issues discovered during land-based testing had to be completed on the system after it was installed on the ship, which created inefficiencies and increased costs. |
| Advanced Arresting Gear (AAG) | AAG recovers current and future aircraft and contributes to reduced manning. | <ul style="list-style-type: none"> • Developmental test failures led to multiple system redesigns. • As a result of cost increases and schedule pressures, the Navy began land-based testing concurrent with system production and installation on CVN 78, instead of on in-service aircraft carriers as initially planned. • In response to schedule delays resulting from multiple redesigns and modifications, the Navy adopted a concurrent test schedule, with land-based testing continuing while shipboard testing was underway. • Because of AAG’s schedule delays, the Navy will not deliver CVN 78 with the capability to conduct full flight operations with all carrier aircraft types. Instead, flight operations will begin after ship delivery with only the F/A-18 E/F Super Hornet fighter. |
| 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 was expected to help reduce the number of sailors needed on board the ship. | <ul style="list-style-type: none"> • Significant challenges early on in development—including generator failures, design configuration changes, and system engineering issues—delayed the start of land-based testing. • Production of EMALS began even as land-based testing was underway. • Issues with the power interfaces and conversion systems discovered during land-based testing required changes to the system already in production. • Shipboard testing began in August 2014, as land-based testing continued. |

Source: GAO and Navy documentation. | GAO-17-575

The Navy took steps to limit procurement cost growth for EMALS and AAG, which, as noted above, are being developed and produced under contracts separate from the CVN 78 detail design and construction

contract. Most notably, in fiscal year 2010, the Navy awarded a firm fixed-price contract for production of these systems for CVN 78, which had the effect of leveling off the systems' procurement cost growth as shown in figure 2 below. The contractor developing these systems is generally responsible for any cost growth beyond the contract's firm fixed-price.

Figure 2: Electromagnetic Aircraft Launch System (EMALS) and Advanced Arresting Gear (AAG) Procurement Costs from Fiscal Year 2008 to 2017



Source: GAO analysis of President's Budget Request. | GAO-17-575

Program Budget Underpinned by an Optimistic Cost Estimate

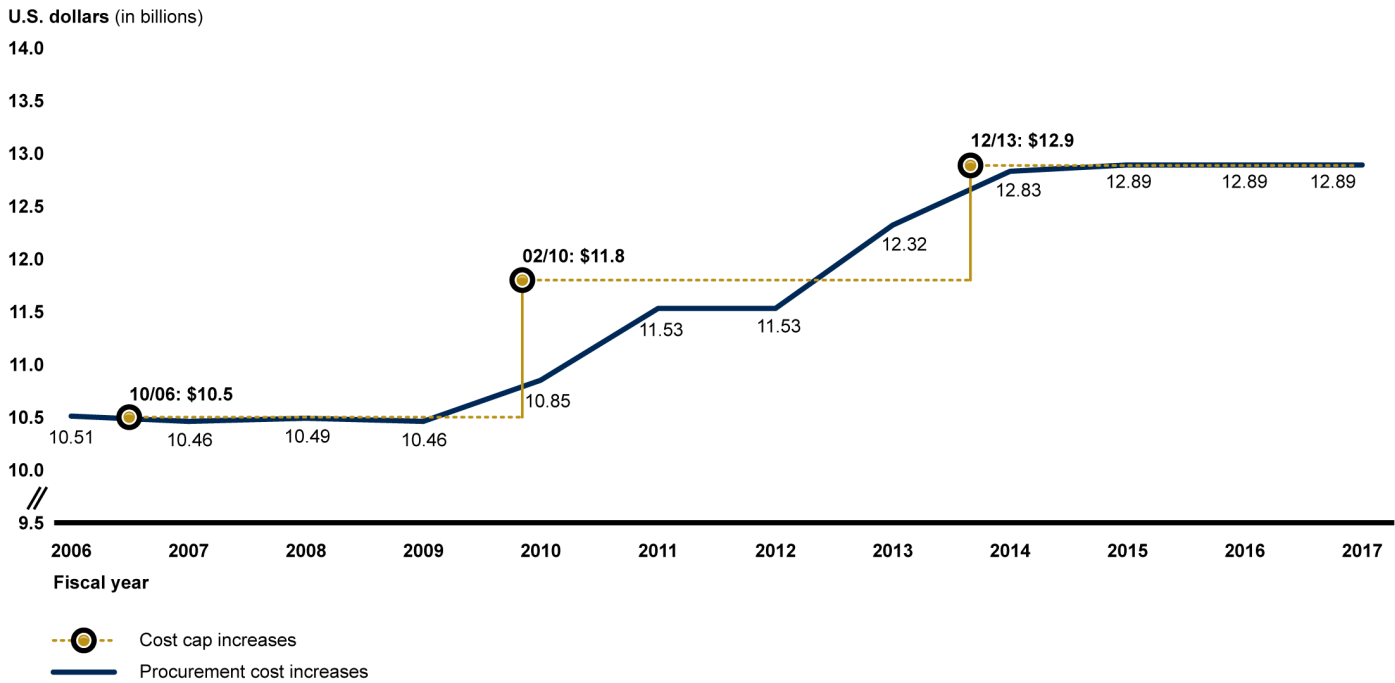
In August 2007, we found that the Navy's cost estimate of \$10.5 billion used to develop the CVN 78 budget was optimistic. We highlighted a number of concerns:

- The cost estimate made the unprecedented assumption that CVN 78 would take 2 million fewer labor hours to build than its more mature predecessor—CVN 77. We questioned the Navy's assumption that the lead ship's costs would be offset by the use of the computer-assisted product model and other investments in facilities, as these were unproven.
- Key technology costs were likely to increase because the systems were still in development.

- Material costs were uncertain. CVN 78 was already beginning to experience slips in the delivery of material in August 2007. According to the shipbuilder, none of the delays to date were expected to disrupt the construction schedule. However, late material delivery led to labor hour increases on both CVN 76 and CVN 77.

CVN 78's costs grew, as the budget did not appropriately reflect the actual effort required to construct the ship. As a result, the Secretary of the Navy increased the cost cap in 2010, and Congress approved an additional increase to the cap in 2013. The Navy attributed the cost increases to construction cost overruns and economic inflation. Figure 3 depicts CVN 78's procurement cost growth and cost cap increases.

Figure 3: Gerald R. Ford Aircraft Carrier (CVN 78) Procurement Costs and Congressional Cap Increases



Source: GAO analysis of U.S. Navy budget data. | GAO-17-575

Recent Shipboard Testing Problems Create Cost and Schedule Uncertainty

Recent issues discovered during shipboard testing of the systems installed on the ship further delayed CVN 78's delivery date, creating added uncertainty regarding the program's ability to maintain costs under the current \$12.9 billion cost cap. Since we last reported on the status of CVN 78 in November 2014, EMALS has completed deadload testing—a key aspect of the system's test program—and the shipbuilder has positioned the ship to begin testing the ship's propulsion system in preparation for sea trials. However, other systems have experienced the following problems, which have resulted in cost and schedule uncertainty:

- **DBR**—In August 2016, program officials told us that testing for DBR had been further delayed due to problems with ship integration, specifically related to its interface with the power system. The Navy is working to resolve technical deficiencies with the volume search radar. Program officials stated that they plan to continue DBR testing during sea trials following ship delivery. However, issues with DBR may still affect CVN 78's schedule. For example, warfare and aircraft operations events scheduled for 6 weeks after ship delivery may be pushed back if DBR issues are not resolved.
- **AAG**— In May 2017, the Navy reported that shipboard testing of AAG is 85 percent complete, and the remaining testing has been deferred to post-delivery.¹⁷ The Navy is still resolving issues with emergent faults with the AAG system discovered during shipboard testing, while land-based testing with live and simulated aircraft continues. The Navy needs to resolve these issues in order to support aircraft operations during an exercise scheduled to take place 10 weeks after ship delivery.
- **Propulsion Plant**—According to the Navy, in June 2016, a transformer in one of the main turbine generators in CVN 78's propulsion plant experienced a catastrophic failure. A shipbuilder and vendor review of this incident found that the failure was likely due to a manufacturing defect in the transformer. However, a follow-on review uncovered additional problems, including issues with the voltage regulator on the main turbine generator; design and performance problems with the protection system; and excessive noise in the plant. Detailed assessments of these issues show that the voltage regulator and protection systems require design modifications. Laboratory testing of the design modifications are complete and shipboard installation is

¹⁷ The Navy reported this information after GAO-17-190SU was published.

underway, which will be followed by shipboard testing. The generator incident and the time needed to conduct the subsequent reviews have affected propulsion plant testing, but program officials believe that they are able to meet the new delivery date.

- **Advanced Weapons Elevators**—In early January 2017, the Navy reported that testing of the Advanced Weapons Elevators was 35 percent complete and that the shipbuilder would complete construction and testing of 2 of the 11 elevators by ship delivery. The Navy is working to resolve a problem with the elevator doors in order to continue with testing. In general, the elevators continue to have issues with reliability, which will affect their ability to support aircraft operations.

Program officials stated that they are considering several options to resolve problems uncovered during shipboard testing and have not fully estimated the resulting costs. Because the remaining costs have not been estimated, the current program baseline does not represent the required budget necessary to deliver the ship. Data from contract performance reports—owned and maintained by the shipbuilder—in turn no longer provide an accurate assessment of the costs at completion, as additional undefined work will be required to resolve problems identified in testing. In the likely event that additional funding is needed to complete the ship, the Navy may choose to defer more construction work or installation of mission-related systems until after ship delivery to stay within the cost cap. Finally, the delivery schedule for CVN 78 has continued to slip from its initial plan of September 2015 and was delivered in May 2017.¹⁸ Delays in delivery will result in additional costs, as the government may continue to have to pay for unanticipated construction work and unanticipated overhead costs.

¹⁸CVN 78 was delivered after GAO-17-190SU was published. GAO-17-190SU is a sensitive but unclassified version of this report.

CVN 79 Cost Estimate Is Not Reliable, with Construction Costs Likely to Exceed Cost Cap

The \$11.4 billion the Navy has budgeted to construct CVN 79 is likely insufficient, in part because the cost estimate that supports the budget is not reliable and does not address lessons learned from the experiences of the lead ship. We compared the program life-cycle cost estimate to best practices criteria as outlined in GAO's Cost Estimating and Assessment Guide.¹⁹ While the estimate was comprehensive in that it included all life-cycle costs—meaning development, procurement, and sustainment—we found several weaknesses that indicate the \$11.4 billion is not a realistic program estimate.

- First, we question the accuracy of the CVN 79 estimate because of its optimistic assessment regarding the labor hours needed to construct the ship and because the estimate did not use timely data to ensure that it reflected the costs most likely to be incurred. While Navy officials stated they have updated the cost estimate, the documentation they provided to us was only a high-level briefing chart reflecting final numbers. This documentation is not sufficient for us to gain insights into the sources or timeliness of the data—key aspects of our cost estimating best practices.
- Second, we question the credibility of the estimate because it does not sufficiently account for program risks. As a result, the cost estimate does not provide a reliable basis for program decision making, such as developing annual budgets, making requirement trade-offs, and gauging shipbuilder progress, among other things.
- Third, we found that the estimate lacked documentation and analysis to support the derived cost savings from CVN 78.

For a high-level summary of the CVN 79 cost estimate compared to GAO best practices, see appendix II.

Finally, the contractor performance reports indicate the shipbuilder has not been consistently achieving the anticipated labor efficiencies needed to meet the \$11.4 billion cost cap.

¹⁹[GAO-09-3SP](#).

Cost Estimate Is Not Accurate Because of Overly Optimistic Labor Hour Projections and Untimely Cost Data

The CVN 79 cost estimate does not address lessons learned from the experiences of the lead ship, specifically in terms of its optimistic assessment of the labor hours required to complete construction. A cost estimate is considered accurate when it is based on an assessment of the most likely costs—that is, it is neither overly conservative nor overly optimistic—and it is updated regularly to reflect the current status of the program. However, the cost estimate for CVN 79 does not fully meet GAO’s best practice standards for accuracy because: (1) it is based on a projected reduction in construction labor hours that is unprecedented in aircraft carrier construction and relies on untested efficiencies and (2) inadequate documentation existed regarding the timeliness of data to ensure that it reflected the costs most likely to be incurred. Additional information supporting the GAO conclusions in this section may be found in the sensitive version of this report, which is available upon request for official use only to those with the appropriate need-to-know.

Labor Hour Estimate Is Based on Unprecedented Reductions Compared to Prior Carrier Class Construction

The April 2015 cost estimate calculated that significantly fewer labor hours would be required to construct CVN 79 compared to CVN 78. NAVSEA 05C cost estimators attributed most of this labor hour reduction to the assumption that CVN 79 would not experience the same challenges that led to increased labor hours for CVN 78, including an immature design, and the construction and engineering challenges discussed above. The estimate also assumed reductions would result from changes in the processes to build the ship that would make construction more efficient and thus require fewer labor hours. Specific details of the CVN 79 estimate were redacted because the directorate responsible for NAVSEA contracting deemed the information to be sensitive in the context of CVN 80 contract negotiations.

After developing this cost estimate, the Navy negotiated an 18 percent reduction in the labor hours to construct CVN 79 compared to CVN 78. However, this reduction is twice the labor hour reduction from the Nimitz Class of carriers. Even if the shipbuilder did not experience the same challenges as CVN 78, a nearly 9 million labor hour reduction would be unprecedented in 50 years of aircraft carrier construction since the construction contract for CVN 68 was awarded in 1967. As shown in table 5, in 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). Specific details of the CVN 79 estimate were redacted because the directorate responsible for

NAVSEA contracting deemed the information to be sensitive with regard to CVN 80 contract negotiations.

Table 5: Number of Production Labor Hours Required to Build Aircraft Carriers

| Hull | Total labor hours (millions) | Labor hour change (millions) | Percent change | Construction contract award date |
|---------------------------|------------------------------|------------------------------|-------------------|----------------------------------|
| Nimitz Class ^a | | | | |
| CVN 68 | 34.4 | - | - | March 1967 |
| CVN 69 | 31.2 | -3.2 | -9.3% | June 1970 |
| CVN 70 | 33.7 | 2.5 | 8.0% | April 1974 |
| CVN 71 | 40.3 | 6.6 | 19.6% | September 1980 |
| CVN 72 | 38.0 | -2.3 | -5.7% | December 1982 |
| CVN 73 | 36.2 | -1.8 | -4.7% | December 1982 |
| CVN 74 | 33.2 | -3.0 | -8.3% | July 1988 |
| CVN 75 | 34.4 | 1.2 | 3.6% | July 1988 |
| CVN 76 | 39.2 | 4.8 | 13.9% | December 1994 |
| CVN 77 | 45.0 | 6.3 | 16.1% | January 2001 |
| Ford Class ^b | | | | |
| CVN 78 | 49.0 (estimated) | - | - | September 2008 |
| CVN 79 | 40.2 (estimated) | -8.8 (estimated) | -18% (negotiated) | June 2015 |

Source: GAO analysis of Navy data. | GAO-17-575

Note: Since CVN 68 and CVN 78 were the first in class for the Nimitz and Ford Classes respectively, a labor hour or percent change is not calculated.

^aNimitz Class are actual hours and include recurring planning and sourcing hours

^bFord-Class CVN 78 hours reflect NAVSEA 05C's April 2015 cost estimate. GAO calculated CVN 79 hours based on negotiated labor reductions

The planned labor hour reduction in the CVN 79 cost estimate includes a reduction as a result of several shipbuilder initiatives intended to increase efficiency. NAVSEA 05C cost estimators derived this reduction based on the shipbuilder's estimates of its efficiencies, but did not conduct any additional assessments to validate these estimates. The shipbuilder's planned efficiencies include a new build sequence aimed at completing more work earlier in the construction sequence and in the shops instead of after the ship is in the dock, as well as improvements to some shipyard construction facilities. Work completed earlier in the build process is more efficient and less costly than work done later on the ship when spaces are more difficult to maneuver within.²⁰ In addition, the shipbuilder's revised

²⁰We discuss this issue further in [GAO-13-396](#).

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. However, the new build sequence and shipyard improvements are untested and there are no historical data available to support whether the planned labor reductions can be achieved. Shipbuilder representatives told us they had not fully estimated the anticipated savings from future efficiencies. Since a complete plan to achieve the required efficiencies has not been developed, the shipbuilder is at risk of not meeting the planned \$11.4 billion budget. Specific details of the CVN 79 estimate were redacted because the directorate responsible for NAVSEA contracting deemed the information to be sensitive in the context of CVN 80 contract negotiations.

Independent DOD and Navy cost reviews also found NAVSEA 05C's labor hour estimates to be optimistic. To calculate the labor hour reduction, CAPE accounted for CVN 78 work packages that were adversely impacted by concurrency of design and construction, and material unavailability. NCCA developed two different estimates of the labor hour reduction from Nimitz-Class labor hour data, accounting for the weight of each ship. Specific details of the CAPE and NCCA estimates were redacted because the directorate responsible for NAVSEA contracting deemed the information to be sensitive.

NCCA officials stated they do not believe that CVN 79 construction will be as efficient as the program office projects. CAPE's independent cost estimate also assumed fewer construction efficiencies than the program estimate. Additionally, CAPE's review noted that challenges may arise during construction when parts are assembled at the dock and pier, and estimated that 15 percent of future work will begin late relative to the schedule. CAPE's independent cost estimate projected that CVN 79 would exceed the program's cost estimate by several hundred million dollars, with nearly all of that difference for labor costs. Similarly, NCCA noted that the shipbuilder is at risk of not achieving the entire estimated labor hour savings from CVN 78 to CVN 79, and estimated that labor costs could potentially increase by over \$100 million. Specific details of the CAPE and NCCA estimates were redacted because the directorate responsible for NAVSEA contracting deemed the information to be sensitive with regard to CVN 80 contract negotiations.

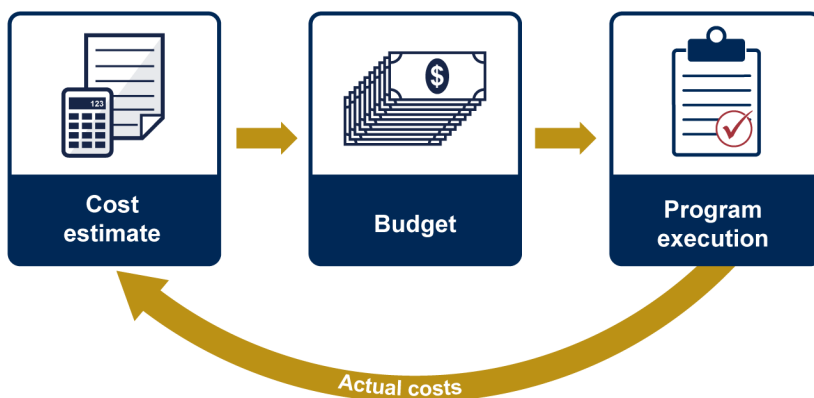
Although the CAPE and NCCA labor estimates are more conservative than the NAVSEA 05C estimate, they are still optimistic compared to historical aircraft carrier construction data. CAPE and NCCA officials told us they had limited time to prepare their reviews, in part due to delayed

access to shipbuilder labor hour data. As a result, these reviews may not have captured the full extent of potential cost risks. According to DOD and Navy cost guidance, CAPE and NCCA should have been notified at least 7 or 6 months, respectively, in advance of the program milestone event. NCCA only had 3 months to develop its cost review and officials stated they had to shorten their internal review process. In addition, NCCA officials stated they did not receive shipbuilder labor hour data. CAPE officials stated they received this data only one month prior to the estimate completion date. At the April 2015 Defense Acquisition Board review, the CAPE estimate was still in development, so the optimistic NAVSEA 05C estimate was the only complete estimate available to inform decision makers at that review. The final CAPE estimate was completed in May 2015, prior to issuance of the Acquisition Decision Memorandum in June 2015.

The Navy Did Not Demonstrate the Estimate Has Been Updated with Current Data

In its April 2015 estimate, NAVSEA 05C used an estimate of CVN 78's total labor hours at ship completion as the starting point to determine CVN 79 labor hours. Since CVN 78 had not yet been delivered, NAVSEA 05C used shipbuilder data on the actual labor hours expended and an estimate of the labor hours for the remaining work. However, some of the shipbuilder data used to calculate the distribution of production labor hours were from March 2014, which was already a year out of date at the time of the estimate. GAO's Cost Estimating and Assessment Guide advises regularly updating cost estimates as technical or program assumptions change and more data become available. The guide also recommends that the cost estimate be continually updated as actual costs begin to replace the original estimates, as shown in figure 4.

Figure 4: Cost Estimate Process



Source: GAO Cost Estimating and Assessment Guide. | GAO-17-575

GAO's Cost Estimating and Assessment Guide emphasizes that cost estimates should be realistic and timely. If an estimate is not regularly updated with actual costs, it is difficult to analyze changes, accurately estimate future costs, and provide decision makers with accurate information for assessing alternatives. Regularly updating cost estimates also allows program officials and estimators to have a track record of the estimate for comparison over time. Without a documented comparison between a current estimate—updated with actual costs—and the previous estimate, cost estimators cannot determine how different the two estimates are, and thus how well they are estimating.

While NAVSEA 05C cost estimators assert they have updated the CVN 79 cost estimate since April 2015, we are unable to validate this claim based on the documentation provided. In June 2016, we were provided with a demonstration of the cost estimating model NAVSEA 05C used to develop the CVN 79 cost estimate. However, the cost estimating model did not incorporate any updates based on new performance data. According to officials from NAVSEA 05C, the cost estimating model was updated in July and September 2016 with actual costs. However, officials were unable to provide documentation sufficient for us to verify the assumptions and sources of the estimate. This level of detail is a key component of the “accurate” characteristic for our cost best practices.

CVN 79 Cost Estimate Is Not Credible Because It Does Not Include Sufficient Risk for Program Uncertainties

To determine an estimate's credibility, cost estimators should test, among other things, the sensitivity of key elements of cost, such as labor hours and labor rates, and conduct uncertainty analyses to quantify risks.²¹ Uncertainty analysis provides the basis for adjusting estimates to reflect known facts and circumstances that could affect costs and a level of confidence in the estimate to help inform decision makers about the effects of varying levels of cost. Additionally, an independent cost estimate should be conducted by a group outside the acquiring organization to determine whether other estimating methods produce similar results. While CAPE and NCCA conducted independent cost assessments and NAVSEA 05C conducted sensitivity and risk analyses to test the validity of its estimate, our evaluation of the cost estimate shows that it may not accurately account for the risk of certain technologies and the new shipbuilder efficiencies. As a result, the amount the Navy has budgeted for CVN 79 is likely insufficient to cover program costs. Additional information supporting the GAO conclusions in this section may be found in the sensitive version of this report, which is available upon request for official use only to those with the appropriate need-to-know.

In August 2016, the Under Secretary of Defense for Acquisition, Technology, and Logistics expressed concern about CVN 78's schedule and performance and directed an independent team to review the critical technologies in order to identify and mitigate potential risks for Ford-Class follow-on ships. In December 2016, the independent review found that CVN 79 is at risk of not meeting planned efficiencies. In particular, the review found that the new radar system, which was intended to reduce cost and technical risk, is at risk of not meeting the CVN 79 schedule. The review also found that reverting to legacy systems for follow-on Ford-Class ships is impractical and would impact the ships' ability to meet key performance parameters.²²

Sensitivity Analysis Indicates CVN 79 Cost Estimate Does Not Accurately Reflect Program Uncertainties

While NAVSEA 05C conducted a sensitivity analysis to identify a range of possible costs, we found that the results of this analysis were not realistic. We reviewed some of the top cost drivers identified in the sensitivity analysis developed for NAVSEA 05C's cost estimate and how each driver

²¹See app. II for a detailed description of best practices.

²² Our assessment of the DOD independent review was conducted after GAO-17-190SU was published.

impacts the range of potential program costs. Our analysis of the results of the sensitivity analysis found that for some cost drivers, NAVSEA 05C estimated a higher likelihood that these costs would be lower than expectations (or underrun), rather than higher than expectations (or overrun)—which seems unlikely given the program uncertainties.

This is particularly evident in NAVSEA 05C's sensitivity analysis for production labor hours. As previously mentioned, we found the CVN 79 labor hour estimate to be optimistic. This optimism results in an unrealistic range of labor hours in the sensitivity analysis. Compared to historical aircraft carrier data, the minimum value represents a labor reduction which is significantly more than the largest decrease that has been observed in the past 50 years of carrier construction. The sensitivity analysis also indicates that the range for labor hour underruns is larger than the range for overruns, which is not realistic given that construction for CVN 76 and CVN 77 have required more labor hours than originally estimated. Specific details of the CVN 79 sensitivity analysis were redacted because the directorate responsible for NAVSEA contracting deemed the information to be sensitive with regard to CVN 80 contract negotiations.

In addition, the sensitivity analysis for EMALS and AAG may not accurately reflect program uncertainty. Specifically, the analysis for AAG conducted by NAVSEA 05C indicates that a cost underrun is more likely than a cost overrun. Given the significant technical issues on AAG that are still being resolved for the lead ship, this risk analysis may not accurately reflect the cost risk associated with AAG performance issues. Specific details of the CVN 79 sensitivity analysis were redacted because the directorate responsible for NAVSEA contracting deemed the information to be sensitive.

Further, NAVSEA 05C's estimate did not sufficiently account for potential changes during CVN 79 construction. NAVSEA 05C estimators only included a factor of 3 percent of the total construction cost for changes. However, 3 percent is not realistic compared to historical data from the Nimitz-Class ships. The actual change order costs for all but one carrier were greater than 3 percent, with an average cost of 5 percent. Additionally, the estimate is on the low side of cost guidance from NAVSEA for programs to budget between 3 and 5 percent of total construction costs for potential changes on its follow-on ships. Due to the uncertainty of the new technologies and build strategies, CVN 79 will likely have above average change orders that will exceed the 3 percent budget.

Risk Analysis Indicates CVN 79 Budget Will Not Cover Most Likely Costs and Has No Reserve for Cost Growth

Finally, none of the cost reviews validated the program office's anticipated savings of \$188 million from replacing the DBR with a new radar solution, known as the Enterprise Air Surveillance Radar.²³ The NCCA independent cost assessment stated that analysts could not develop a cost estimate for the radar since the program office did not provide sufficient technical details. At the time of NCCA's estimate, the Navy had not yet begun development of the Enterprise Air Surveillance Radar. In addition, NCCA pointed out that the radar program was not fully funded to the cost estimate. As a result, the Navy may need to request additional funding. The Navy awarded a contract for the radar development in August 2016. While the new radar may result in procurement cost savings, as the independent review team identified, there is risk for additional costs going forward to integrate the radar on the ship.²⁴

Based on our analysis, the CVN 79's program estimate will likely be insufficient to complete ship construction. NAVSEA 05C analysts conducted a risk analysis to identify and quantify program risks, and determined the effects of changing key cost driver assumptions and factors—important steps in creating a high quality estimate. However, NAVSEA 05C's risk analysis indicates that the point estimate of \$11.5 billion represented less than a 50 percent confidence level—the probability that costs for the program will be at or below that level. For example, a 50 percent confidence level indicates that there is an equal chance that program costs will be above or below that cost level. An estimate's confidence level is used to inform a program budget, and as additional budget is allocated to a program, there is a higher confidence that program costs will fall under the budgeted amount. Navy cost guidance recommends using the "risk adjusted mean" as the best estimate for unknown cost for the program, which usually lies between 50 and 60 percent. Additionally, GAO's Cost Estimating and Assessment Guide states that program cost estimates should be budgeted to at least the 50 confidence level. Even then, there is still a chance that the program will need additional funding because programs tend to overrun more than underrun. Thus, budgeting to the mean of the distribution or higher, which is between the 55 percent to 65 percent confidence level, is considered a best practice to guard against potential risks. Specific details of the CVN 79 risk analysis were redacted because the directorate

²³The Navy now estimates that anticipated savings will be \$143 million.

²⁴ Our assessment of the DOD independent review was conducted after GAO-17-190SU was published.

responsible for NAVSEA contracting deemed the information to be sensitive in the context of CVN 80 contract negotiations.

However, NAVSEA 05C's risk analysis indicates that the current budget does not provide margin for cost risk. We compared NAVSEA 05C's risk analysis of CVN 79's potential cost outcomes and the associated probability that such an outcome will be realized, with the typical risk-adjusted funding levels based on Navy cost guidance and GAO best practices. Specific details of the CVN 79 risk analysis were redacted because the directorate responsible for NAVSEA contracting deemed the information to be sensitive.

The National Defense Authorization Act for Fiscal Year 2016 reduced CVN 79's cost cap to \$11.4 billion and the program budget was further reduced, resulting in a confidence level well below typical risk-adjusted funding levels based on GAO's best practices and Navy guidance. As a result, the current budget for CVN 79 construction is unlikely to cover the program costs even if there are no issues or schedule delays, and therefore leaves no margin for program risk or uncertainty. The program office plans to meet the cost cap in part from anticipated savings through a two-phase delivery for CVN 79. Under this strategy, labor hours would shift to a second phase, where installation of some electronic systems (in particular the Enterprise Air Surveillance Radar) and compartments will be completed after the ship is delivered and competed among different vendors, which the Navy hopes will lower costs. The NAVSEA 05C estimate did not include any savings from the two-phased delivery approach beyond the savings identified for radar replacement, assuming that the shipbuilder would remain responsible for completing all remaining installation work. However, the NCCA independent cost assessment reviewed the two-phase approach and could not substantiate the assumption that the shift in labor hours to the second phase would decrease overall costs. As a result, it is unclear whether the two-phase approach will result in cost savings to meet the CVN 79 cost cap. Specific details of the CVN 79 risk analysis were redacted because the directorate responsible for NAVSEA contracting deemed the information to be sensitive.

Further, we found that since the cost estimate does not sufficiently account for program risks, it is likely that its confidence levels are optimistic and this ship is at an even higher risk of exceeding the budget. Based on an insufficient reflection of risk in the program office estimate and recent budget reductions, the Navy will likely need additional funding beyond the cost cap to complete CVN 79 construction. Typically, a high

confidence level means that there is a high probability that funding is available to cover costs, even if multiple risks are realized. In the case of CVN 79, this means that a high confidence level should cover the shipbuilder not meeting planned labor efficiencies, as well as any critical technologies requiring unplanned changes. We found the estimate does not realistically reflect the full potential of CVN 79 cost growth, compared to CVN 76 and CVN 77, the last two ships in the Nimitz Class, which had 6 and 17 percent cost growth respectively. Considering the cost risks associated with potential changes to CVN 79's baseline and the cost growth observed on previous carriers, it is unlikely that the confidence levels reflects the potential for CVN 79 cost growth. Since NAVSEA 05C applied a narrow risk range to the cost estimate, the confidence levels are particularly sensitive to change. However, since CVN 79 is not a low risk program, it is likely that the cost estimate does not capture all potential risks or costs.

Basis for Program Cost Estimate Is Poorly Documented

A reliable cost estimate is supported by detailed documentation that describes how it was derived and how the expected funding will be spent in order to achieve an objective. It is important that outside parties can replicate the cost estimate and understand the logic behind the estimate. The cost estimate documentation we reviewed did not describe the estimating methodologies used and estimators had to provide us with additional explanations to support the methodologies. Although production man hours are identified as the top risk variable, there is limited documentation to support the inputs behind the labor hour risk analysis. For example, the estimate for planned construction efficiencies was based on a shipbuilder estimate and had insufficient documentation and no historical data to support it. To be considered fully documented in accordance with best practices, we would expect to see data sources, methodologies, and assumptions behind the estimate. For example, for Milestone B in 2004, a 58-page document with 13 separate appendixes was produced for the Ford-Class program life-cycle cost estimate. In contrast, the primary documentation for the April 2015 program life-cycle cost estimate was a 14-page memorandum which did not include the same level of detail. Specific details of the CVN 79 cost analysis were redacted because the directorate responsible for NAVSEA contracting deemed the information to be sensitive with regard to CVN 80 contract negotiations.

Poorly documented cost estimates can cause a program's credibility to suffer because the documentation cannot explain the rationale of the methodology or the calculations underlying the cost elements. Therefore,

estimates that lack sufficient documentation are not useful for updates or information sharing and can hinder understanding and proper use. Furthermore, without adequate documentation, analysts unfamiliar with the program will not be able to replicate the estimate because they will not understand the logic behind it. Documentation is essential for validating and defending a cost estimate. That is, without a well-documented cost estimate, one cannot present a convincing argument of an estimate's validity, or answer decision makers' and oversight groups' probing questions.

Current CVN 79 Construction Performance Suggests Cost Estimate May Not Be Achieved

Shipbuilder representatives told us that they are still working to define some of the future efficiencies that will help them meet the planned reduction in labor hours. As of January 2016, the shipbuilder had primarily made progress on structural and component fabrication assembly work, which represents only 15 percent of total labor. The largest labor category, ship assembly, which is 45 percent of total labor, was only 5 percent complete, so it is uncertain whether shipbuilder performance will continue to progress similarly as more ship assembly work is completed. CAPE noted in its May 2015 independent cost estimate that although the CVN 79 construction preparation contract was performing well at the time, ship assembly is a key cost driver for the remainder of the construction contract. Since efficiencies will be implemented for specific phases of work, achieving efficiencies to date does not ensure that the shipbuilder can achieve future efficiencies.

Our analysis of contract performance reports shows the shipbuilder is not achieving the estimated labor efficiencies and cost performance—as illustrated by the cost performance index, which indicates a steady decline in performance. The cost performance index measures the ratio of work performed to actual costs for work performed.

A cost performance index of less than 1 is unfavorable, because work is being performed less efficiently than planned; a value greater than 1 is favorable, implying that work is being performed more efficiently than planned. Cost performance can be expressed in dollars: 0.9 means that for every dollar spent, the program has received 90 cents worth of completed work. Calculating the cost performance of the prior 6 months provides an average measure of recent shipbuilder performance. Our analysis found recent drops from the established baseline in both monthly cost performance and the cost performance of the prior 6 months. The first shipbuilder performance report for the new construction contract was provided in October 2015, so a 6-month cost performance average could

not be calculated until March 2016. Additional information supporting the GAO conclusions in this section may be found in the sensitive version of this report, which is available upon request for official use only to those with the appropriate need-to-know.

Shipbuilder contract performance reports identify several labor categories, such as sheet metal, insulation, and piping, where completed work has cost more than planned. In some of these categories, the shipbuilder may not realistically be able to improve labor efficiencies and complete certain work within the budget. Independent analysis from the Navy's Supervisor of Shipbuilding also found that overall construction labor cost performance has been slowly degrading.²⁵ The shipbuilder must complete future work more efficiently and below budget in order to compensate for recent performance issues. If current shipbuilder performance trends continue, CVN 79 is at risk of not being completed within the \$11.4 billion cost cap.

Ford Class Oversight Mechanisms Provide Limited Insight into Ship Costs

Current reporting mechanisms, such as budget requests and the SAR, provide limited insight into the overall Ford-Class program and individual ship costs. Because the Navy has designated the entire Ford-Class program as a single major defense acquisition program, independent cost reviews have been infrequent and are not conducted for each ship before the Navy must request funding for ship construction. As a result, individual ships have received a significant portion of funding with limited information on program costs. Additionally, annual acquisition reports to Congress provide only aggregate program cost for all three ships currently in the class, a practice that diminishes transparency into individual ship costs. As a result of unreliable cost estimates and limited acquisition reporting, Congress has limited ability to oversee one of the most expensive programs in the defense portfolio.

²⁵Navy's Supervisor of Shipbuilding is the Navy's primary on-site representative at the private shipyards that build Navy ships, and is tasked with overseeing the shipbuilder's production processes.

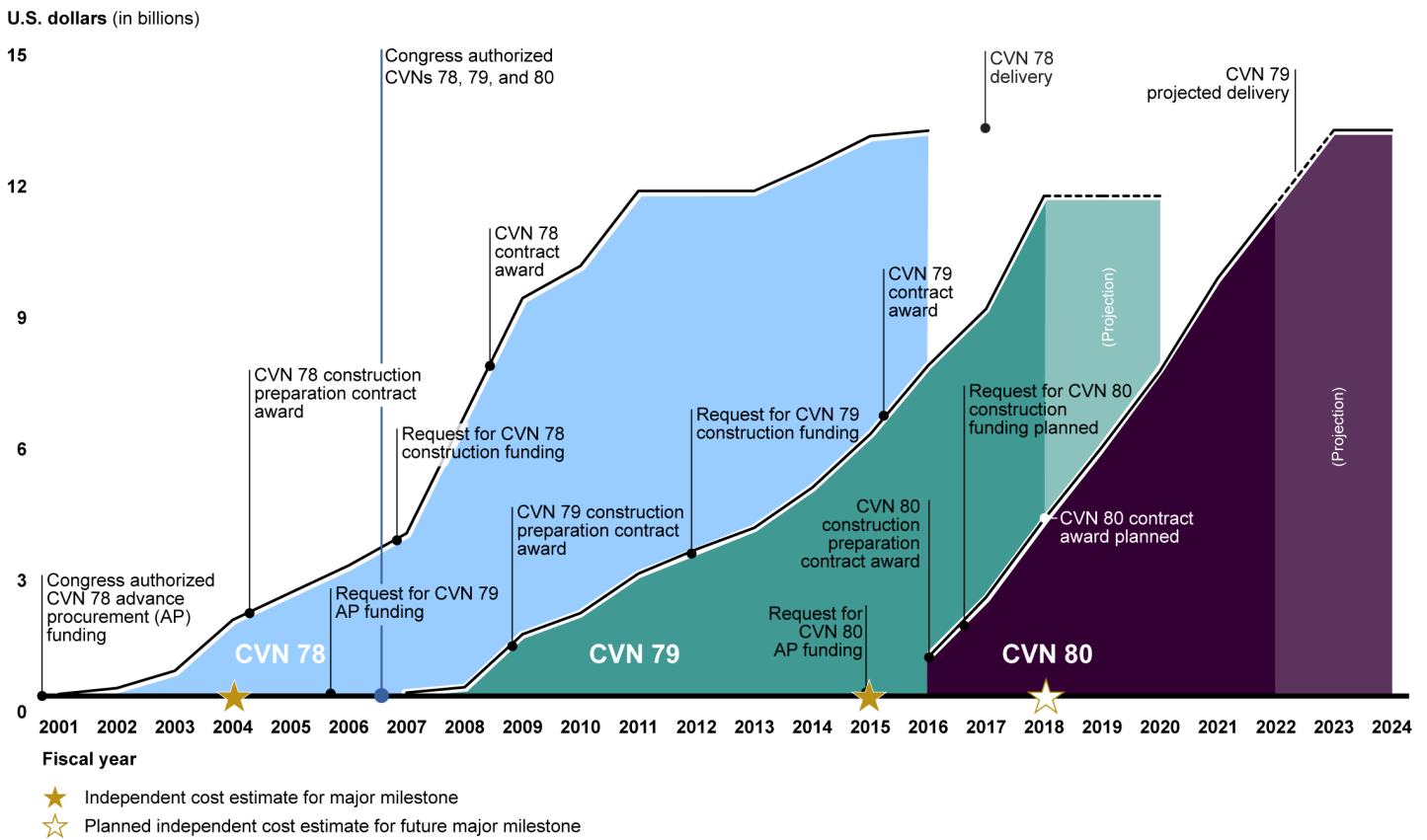
Significant Funding Decisions Are Made Prior to Attaining Independent Cost Estimates

Because the entire Ford-Class program is considered a single major defense acquisition program, the Navy requested and received a significant portion of funding for each of the first three Ford-Class ships without an independent cost estimate to confirm the credibility of program estimates.²⁶ An independent cost estimate is important because it provides an unbiased assessment of whether a program's estimate is reasonable. DOD acquisition policy and federal statute state that independent cost estimates for major defense acquisition programs are conducted at milestone events. In the case of the Ford-Class program, although each individual ship exceeds the \$2.79 billion procurement cost threshold to be designated a major defense acquisition program, DOD considers the entire Ford-Class program—rather than each individual ship—as a major defense acquisition program. Therefore, independent cost estimates are not required for each individual ship and CAPE only developed independent cost estimates to support milestone events in 2004 and 2015 for the Ford-Class program as a whole.

Figure 5 shows that the independent cost estimates have trailed behind the Navy's funding requests and Congress's authorization of advance procurement and construction funding.

²⁶A major defense acquisition program is an acquisition program that is estimated by the defense acquisition executive to require an eventual total expenditure for research, development, test, and evaluation of more than \$480 million (in fiscal year 2014 constant dollars) or for procurement of more than \$2.79 billion (in fiscal year 2014 constant dollars), or that is designated as a major defense acquisition program by the milestone decision authority. Department of Defense Instruction 5000.02, Operation of the Defense Acquisition System Encl. 1, Table 1 (Jan. 7, 2015).

Figure 5: Ford Class Funding and Major Milestones and Independent Cost Estimates



CAPE developed its first independent cost estimate for CVN 78 in 2004 in support of the program’s Milestone B decision. However, at this point the program had already received \$1.7 billion in advance procurement funding. For CVN 79, an independent cost estimate was not developed until May 2015 to support the Ford-Class program’s originally planned Milestone C. This occurred after the CVN 79 construction preparation contract was awarded and \$6.0 billion of procurement funding had been received. As a result, no independent cost estimates were conducted during the 11-year period between these milestones. Program officials stated that CAPE reviewed NAVSEA 05C’s estimate in 2007 and 2010; however, CAPE did not develop an independent cost estimate during those reviews to provide decision makers with an alternative estimate. During that time, the program received \$15.1 billion in procurement funding. In particular, there was no current independent cost estimate to inform the Department of Navy’s President’s budget request for

construction of CVN 78 in 2007, and no independent cost estimate prior to the budget request for construction of CVN 79 in 2012. Additionally, there was no independent cost review of CVN 79 before Congress raised the program cost cap from \$8.1 billion to \$11.5 billion in 2013.²⁷

No independent cost estimate to date has included CVN 80, and before an independent cost estimate for CVN 80 is developed, the Navy will have received nearly \$2.2 billion in advance procurement funding. According to guidance, CAPE will be required to develop an independent cost estimate, to include costs for CVN 80, for the Ford-Class program Milestone C now scheduled for fiscal year 2018. The Joint Explanatory Statement accompanying the National Defense Authorization Act for Fiscal Year 2016 required the Navy to assess the merits associated with using economic order quantity procurement with CVN 80 and CVN 81 and the Navy has estimated savings of \$1.3 billion by pursuing this strategy.²⁸ However, since there will be no future milestone events for the program after the Milestone C scheduled for fiscal year 2018, CAPE will not be required to develop independent cost estimates for any follow-on ships in the class after CVN 80—including CVN 81, which may soon be added to the acquisition program baseline.

If each individual carrier were designated a separate major defense acquisition program, each ship would have its own milestone events.²⁹ The Navy could align these milestones to correspond with major funding decisions—for example, prior to budget requests for advanced procurement funding, or prior to requesting funding to begin ship construction—and CAPE would develop independent cost estimates prior to these major milestones. Similarly, NCCA would also develop more frequent independent cost assessments that focus on each individual carrier. NCCA officials stated they have only conducted one review of the

²⁷National Defense Authorization Act for Fiscal Year 2014, Pub. L. No. 113-66, § 121 (2013).

²⁸Economic order quantity procurement can decrease costs by buying in economically efficient quantities.

²⁹Previous GAO reports recommended that major upgrades be designated major defense acquisition programs or subprograms in order to improve program oversight. See GAO, *F-35 Joint Strike Fighter: Continued Oversight Needed as Program Plans to Begin Development of New Capabilities*, [GAO-16-390](#) (Washington, D.C.: Apr. 14, 2016); and *Arleigh Burke Destroyers: Delaying Procurement of DDG 51 Flight III Ships Would Allow Time to Increase Design Knowledge*, [GAO-16-613](#) (Washington, D.C.: Aug. 4, 2016).

Ford-Class program since it began in 2000.³⁰ In comparison, Air Force instruction requires the Air Force Cost Analysis Agency to conduct annual independent cost assessments of all major defense acquisition programs.

In February 2005, we recommended, and DOD concurred, that an independent review should occur with every acquisition of every aircraft carrier.³¹ But DOD has not implemented this recommendation, as demonstrated by the fact that no independent estimate was conducted prior to the start of CVN 79 construction and the request for construction funding. Given the fact that CVN 78's costs have increased \$2.4 billion and CVN 79 faces cost increases as well, more realism in the budget requests would help inform Congress about expected costs to the taxpayer for the Ford Class.

Program Selected
Acquisition Reports
Obscure Individual Ship
Cost Growth

The Navy totals Ford-Class performance measures for all three Ford-Class ships in the SAR, a practice that diminishes transparency and encumbers oversight efforts. The SAR is a statutorily-mandated, comprehensive acquisition summary required for major defense acquisition programs.³² DOD submits SARs to Congress for program oversight purposes. The SAR for the Ford Class is prepared in accordance with the current Ford-Class acquisition program baseline—which is approved for three ships (CVN 78 to CVN 80). As a result, the Navy reports combined average unit costs for the three ships annually, rather than preparing separate reports for individual ships. The program office noted that costs for non-recurring engineering and EMALS apply to the entire Ford-Class program and cannot be easily allocated to individual ships. While this is true, most costs are for ship procurement, which is budgeted specifically for each ship. Reporting combined average unit costs obscures individual ship cost growth and does not provide insight into cost performance against the specific cost caps Congress has mandated for each ship.

Further, this practice is in contrast to Nimitz-Class ships, which were reported by individual hull in the SAR, with the exception of CVN 72 and

³⁰NCCA was not required to review the Ford-Class program prior to 2009, so 2015 was the first opportunity to conduct an independent cost assessment for a milestone event.

³¹GAO, *Defense Acquisitions: Improved Management Practices Could Help Minimize Cost Growth in Navy Shipbuilding Programs*, [GAO-05-183](#) (Washington, D.C.: Feb. 28, 2005).

³²10 U.S.C. § 2432.

CVN 73, and CVN 74 and CVN 75, which were procured under single contracts. Navy officials could not provide an explanation for why SAR reporting changed.

The effect of the current practice of reporting combined average unit costs for the three Ford-Class ships is clear when considering the Navy's reported procurement costs for the class. The 2015 SAR reported a decline in the base year program and average procurement unit costs for the class, when actual costs for CVN 78 have increased.³³ This reported decline is driven by a decrease in the estimated costs for CVN 80. However, since an independent cost estimate for CVN 80 has not yet been developed, it is possible that the anticipated ship savings have not been accurately estimated and will not compensate for cost growth in CVN 78 and CVN 79.

Principle 15 in Standards for Internal Control in the Federal Government states that management should externally communicate the necessary quality information to achieve the entity's objectives.³⁴ As a result of the combined Ford-Class reporting, program managers are not externally communicating the necessary quality information to achieve their program's objective. Reporting the program cost by hull for the Ford-Class program would allow for enhanced oversight—which is necessary given the magnitude of the investment required for each ship. It would also allow Congress more visibility into the cost performance of each ship against the legislated cost caps.

Additionally, cost and funding summaries for individual ships would allow more transparency into the cost trade-offs of each ship.³⁵ Federal standards for internal control note that the information program managers communicate to overseers, namely Congress, should include significant matters relating to risks, changes, or issues that affect the program's internal control system. Internal control standards further note that managers should select appropriate methods of communication for external parties. Further, while the statute governing the SAR does not

³³Program and average procurement unit costs in the SAR are reported in fiscal year 2000 constant dollars.

³⁴GAO, *Standards for Internal Control in the Federal Government*, [GAO-14-704G](#) (Washington, D.C. Sept. 10, 2014).

³⁵GAO has ongoing work regarding Navy decisions to defer shipbuilding work to the post-delivery and outfitting phase, including work deferral for CVN 78.

require reporting on individual aircraft carriers, it requires that the SAR provide information that the congressional defense committees need to perform their oversight functions. Reporting cost and funding information by individual hull would provide more transparency on cost tradeoffs and cost drivers, which would improve the committees' ability to perform oversight.³⁶ Reporting ship costs individually in the SAR would also allow program managers to separately baseline, track, and manage each ship's cost. Without this more granular level of reporting, Congress and DOD cannot determine the amount and cause of cost growth for each ship.

Conclusions

The experiences of the Ford-Class program are well known. We have reported for many years on the program's challenges that contributed to nearly \$2.4 billion in cost growth for the lead ship. Even as construction of CVN 78 was just getting underway in 2007, we noted key risks in the Ford-Class carrier program and pointed out the optimism in the cost estimate. CVN 79's cost estimate appears to suffer from similar optimism, indicating that lessons were not learned from the lead ship in this regard. NAVSEA 05C's CVN 79 estimate is not realistic, as it does not accurately capture actual program risks. As a result, CVN 79 is likely to experience cost growth beyond the congressionally mandated cost cap and will require additional program funding. Congress designed the cost cap in order to encourage the program to adhere to its cost estimate. However, the cost cap for CVN 79 was established without the input from a program cost estimate. Consequently, instead of the program cost estimate informing the cost cap, the cost cap informed the program cost estimate. Developing a new CVN 79 cost estimate would allow the program to have a more realistic budget that accurately reflects current shipbuilder performance.

Further, the infrequent independent cost estimates result in Congress being asked to commit billions of dollars to the program before key information is available. As a result, individual ships receive billions of dollars in funding before a realistic cost is determined, at which point there are fewer opportunities to identify cost efficiencies or potential tradeoffs. More frequent independent cost reviews would identify risks for program cost growth sooner, allowing actions to be taken.

³⁶When DOD makes a change in the content of a SAR (as would be the case if DOD started reporting information by individual ship for the Ford Class), the statute governing the SAR requires DOD to submit a notice of the change to the Committees on Armed Services of the Senate and House of Representatives. 10 U.S.C. § 2432.

Finally, although each individual ship far exceeds the threshold for being a major defense acquisition program, the entire Ford Class, rather than each ship, is considered a major defense acquisition program, and thus there is less oversight over individual ships as a result of infrequent independent cost reviews and consolidated SAR reporting. Reporting cost and funding summaries in the SAR individually for each ship would allow Congress insight into individual ship cost growth and any tradeoffs that are made to stay within cost caps. Additional information on ship costs would allow for the Navy and Congress to develop a realistic acquisition strategy and budget for the Ford-Class program.

Recommendations for Executive Action

We recommend the Secretary of Defense direct the Secretary of the Navy to take the following three actions:

- To ensure the Milestone Decision Authority has an accurate and credible cost estimate for the Milestone C program review, NAVSEA 05C should update the cost estimate for CVN 79 as part of the Ford-Class program life-cycle cost estimate. This estimate should be prepared in accordance with cost estimating best practices and include current shipbuilder performance data.
 - NCCA should review the new CVN 79 cost estimate as part of the planned independent cost assessment.
 - Further, the Secretary of Defense should direct the CAPE to include the new CVN 79 cost estimate as part of the planned independent cost estimate, which should form the basis of the program budget request. If the independent cost estimate for CVN 79 should exceed the cost cap, the Navy should submit to Congress a request to revise the cost cap.
- Starting with CVN 80, NAVSEA 05C should develop program life-cycle cost estimates for each individual ship in the Ford-Class program baseline.
 - Development of these estimates should be provided at milestone reviews that should be aligned with major aircraft carrier funding events. In particular, for CVN 80, a program life-cycle cost estimate should be developed prior to the request for ship construction funding.
 - For all ships in the class after CVN 80, a program life-cycle cost estimate should be aligned with milestone reviews that correspond with the receipt of any advance procurement funding and the first year of the request for ship construction funding. These estimates

should be prepared in accordance with best practices and updated regularly with actual cost data.

- The Secretary of Defense should further direct the CAPE to develop independent cost estimates for these ships prior to the listed events.
- The Secretary of the Navy should direct NCCA to conduct independent cost assessments for these ships prior to the listed events.
- To improve insight into cost changes for individual ships in the Ford Class, the program office should prepare cost summary and funding summary sections for each individual ship in the class as part of the SAR for the overall Ford-Class program.

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 concurred with much of the report. DOD agreed that an accurate cost estimate for CVN 79 is essential to support the Milestone C review for the program, but did not concur with revising the cost cap should the CVN 79 cost estimate exceed the current cost cap, stating that it will use the cost estimate to determine whether the current cost cap is at risk and if additional cost mitigation strategies are needed. While we understand that the program would want to evaluate and balance the cost risks, we continue to believe that the cost cap is meant to reflect the program's baseline. If the department chooses not to request that Congress update the cost cap, then the cost cap is driving the cost estimate and not vice versa, increasing the likelihood that the cost estimate will not reflect realistic assumptions, such as regarding the number of labor hours needed to construct the ships. We will review the updated CVN 79 cost estimate to determine whether it accurately reflects likely program costs.

DOD agreed to develop program life-cycle cost estimates for each individual ship according to our recommended timelines. However, DOD stated that it will not be able to meet the timeline for CVN 80 since the request for ship construction funding has already been submitted and the first program life-cycle cost estimate is still being prepared to support the program review in fiscal year 2018. DOD stated it will follow our recommendation for all subsequent ships.

In response to agency comments, we revised one of our draft recommendations, specifically regarding reporting in the SAR. DOD informed us that submitting a separate SAR report for each individual ship

would result in duplicative information. We subsequently revised the recommendation to focus on cost and funding data for each ship within the overall Ford Class SAR. We believe this change will improve the transparency of individual ship costs without imposing burdensome or duplicative reporting requirements. DOD noted that the department currently provides progress reports to Congress on costs for CVN 78 and CVN 79. While true, the SAR is the primary statutorily required means for DOD to report on program status. And as our report notes, at present the SAR does not include any cost information on individual ships. Grouping costs of all Ford-Class ships together does not provide Congress with an adequate level of insight to monitor this approximately \$40 billion program. Further, the current progress reports do not include CVN 80. Our recommendation would ensure that Congress receives insight into the costs of each existing and planned Ford Class ship.

In addition, DOD provided technical comments that were incorporated as appropriate.

We are sending copies of this report to the appropriate 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. GAO staff who made key contributions to this report are listed in appendix IV.



Michele Mackin
Managing Director
Acquisition and Sourcing Management

Appendix I: Scope and Methodology

This report assesses cost drivers for the lead ship in the Ford Class, the quality of the Navy's Ford-Class cost estimates, and the cost insights provided by Ford-Class reports. The scope of our work primarily focused on the Gerald R. Ford (CVN 78) and the John F. Kennedy (CVN 79), as a complete cost estimate has not yet been established for the Enterprise (CVN 80). Specifically, we assessed (1) the drivers of CVN 78 cost growth; (2) the extent to which the CVN 79 cost estimate is reliable and addresses known cost risks from the performance of the lead ship; and (3) the extent to which oversight mechanisms—including annual budget requests and selected acquisition reports—provide insight into total ship costs and budget execution.

To identify the drivers of CVN 78 cost growth and what, if any, challenges remained for the lead ship as it approached delivery, we reviewed an Office of the Under Secretary of Defense memorandum to the Secretary of the Navy, Navy memorandums to members of Congress, and program office briefings to Congress. In addition, we analyzed Navy budget submissions. We also relied on our prior work evaluating the Ford-Class program 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 officials from the Program Executive Office, Aircraft Carriers.

To assess the reliability of CVN 79's cost estimate, we determined the extent to which the estimate was consistent with best practices as identified in GAO's Cost Estimating and Assessment Guide.² We examined documents supporting the cost estimate, such as the CVN 79 estimate brief, memorandum, and other documents that contain cost, schedule, and risk information, as well as relevant Department of Defense (DOD) and Navy policies. We met with Navy personnel responsible for developing the cost estimate to understand the processes used by the cost estimators, to clarify information, and to allow the program to provide additional documentation to support the estimate. Because we did not have direct access to the CVN 79 cost model, we observed portions of the model during a presentation and discussion with Navy cost

¹GAO, *Ford Class Aircraft Carrier: Poor Outcomes Are the Predictable Consequences of the Prevalent Acquisition Culture*, [GAO-16-84T](#) (Washington, D.C.: Oct. 1, 2015). See Related GAO Products at the end of this report for a complete list of prior reports on the Ford-Class program.

²GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, [GAO-09-3SP](#) (Washington, D.C.: Mar. 2, 2009).

estimators. Finally, we examined Navy cost estimating guidance to determine whether the Navy complied with the guidance in developing the CVN 79 estimate. In addition, to inform our analysis of how well the CVN 79 cost estimate addresses known cost risks from the performance of CVN 78, we relied on our prior work evaluating the Ford-Class program.³ To further corroborate documentary evidence and gather additional information in support of our review, we conducted interviews with relevant DOD and Navy officials responsible for developing and updating the Ford-Class cost estimates, such as the Office of Cost Assessment and Program Evaluation; Naval Center for Cost Analysis; Naval Sea Systems Command's Cost Engineering and Industrial Analysis Group; Program Executive Office, Aircraft Carriers; CVN 78 and 79 program offices; Aircraft Launch and Recovery program office; and the Program Executive Office, Integrated Warfare Systems.

To determine how oversight mechanisms provide insight into Ford-Class ship costs and budget execution, we examined Navy budget requests and Selected Acquisition Reports (SAR), to assess the transparency of cost information. We reviewed the budget requests and the SARs to identify cost information. 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 and CVN 79 program offices; and the Naval Sea Systems Command's Cost Engineering and Industrial Analysis Group. We also held discussions with officials from the Office of the Assistant Secretary of the Navy Financial Management and Comptroller and the Congressional Budget Office.

We conducted this performance audit from December 2015 to March 2017 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

³GAO, *Ford-Class Aircraft Carrier: Congress Should Consider Revising Cost Cap Legislation to Include All Construction Costs*, [GAO-15-22](#) (Washington, D.C.: November 20, 2014); *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).

that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Assessment of CVN 79 Cost Estimate

Summary of the GAO Methodology Used to Perform Cost Estimating Analysis

The GAO Cost Estimating and Assessment Guide ([GAO-09-3SP](#)) was used as criteria in this analysis¹. For this guide, GAO cost experts assessed measures consistently applied by cost-estimating organizations throughout the federal government and industry and considered best practices for the development of reliable cost estimates. We analyzed the cost estimating practices used by the Navy against these best practices. For our reporting needs, we collapsed these best practices into four general characteristics for sound cost estimating, which include: well-documented, comprehensive, accurate, and credible. The cost estimating analysis was also based on interviews with Navy officials and the Navy's written responses regarding their implementation of the 12-step cost-estimating process.

GAO High-Level Analysis

After reviewing documentation the Navy submitted for its cost estimate, conducting numerous interviews, and reviewing relevant sources, we determined that the CVN 79 cost estimate substantially met one and partially met three of the four characteristics of a reliable cost estimate, shown in table 6. We determined the overall assessment rating by assigning each individual rating a number: Not Met = 1, Minimally Met = 2, Partially Met = 3, Substantially Met = 4, and Met = 5. Then, we took the average of the individual assessment ratings to determine the overall rating for each of the four characteristics. The resulting average becomes the Overall Assessment as follows: Not Met = 1.0 to 1.4, Minimally Met = 1.5 to 2.4, Partially Met = 2.5 to 3.4, Substantially Met = 3.5 to 4.4, and Met = 4.5 to 5.0. A cost estimate is considered reliable if the overall assessment ratings for each of the four characteristics are substantially or fully met. If any of the characteristics are not met, minimally met, or partially met, then the cost estimate does not fully reflect the characteristics of a high-quality estimate and cannot be considered reliable.

See table 6 for a high level summary of each best practice and the reasons for the overall scoring.

¹GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, [GAO-09-3SP](#) (Washington, D.C.: March 2009)

Table 6: Summary Assessment of Navy's Cost Estimate Compared to Best Practices

| Characteristic | Overall assessment ^a | Best practice | Individual assessment |
|-----------------|---------------------------------|--|-----------------------|
| Comprehensive | Substantially met | The cost estimate includes all life-cycle costs. | Met |
| | | The cost estimate completely defines the program, reflects the current schedule, and is technically reasonable. | Substantially met |
| | | The cost estimate work breakdown structure is product-oriented, traceable to the statement of work/objective, and at an appropriate level of detail to ensure that cost elements are neither omitted nor double-counted. | Substantially met |
| | | The estimate documents all cost-influencing ground rules and assumptions. | Partially met |
| Well-documented | Partially met | The documentation should capture the source data used, the reliability of the data, and how the data were normalized. | Partially met |
| | | The documentation describes in sufficient detail the calculations performed and the estimating methodology used to derive each element's cost. | Minimally met |
| | | The documentation describes step by step how the estimate was developed so that a cost analyst unfamiliar with the program could understand what was done and replicate it. | Minimally met |
| | | The documentation discusses the technical baseline description and the data in the baseline is consistent with the estimate. | Met |
| | | The documentation provides evidence that the cost estimate was reviewed and accepted by management. | Partially met |
| Accurate | Partially met | The cost estimate results are unbiased, not overly conservative or optimistic, and based on an assessment of most likely costs. | Partially met |
| | | The estimate has been adjusted properly for inflation. | Partially met |
| | | The estimate contains few, if any, minor mistakes. | Minimally met |
| | | The cost estimate is regularly updated to reflect significant changes in the program so that it is always reflecting current status. | Minimally met |
| | | Variances between planned and actual costs are documented, explained, and reviewed. | Minimally met |
| | | The estimate is based on a historical record of cost estimating and actual experiences from other comparable programs. | Partially met |
| | | The estimating technique for each cost element was used appropriately. | Partially met |

Appendix II: Assessment of CVN 79 Cost Estimate

| Characteristic | Overall assessment^a | Best practice | Individual assessment |
|-----------------------|---------------------------------------|--|------------------------------|
| Credible | Partially met | The cost estimate includes a sensitivity analysis that identifies a range of possible costs based on varying major assumptions, parameters, and data inputs. | Partially met |
| | | A risk and uncertainty analysis was conducted that quantified the imperfectly understood risks and identified the effects of changing key cost driver assumptions and factors. | Partially met |
| | | Major cost elements were cross-checked to see whether results were similar. | Minimally met |
| | | An independent cost estimate was conducted by a group outside the acquiring organization to determine whether other estimating methods produce similar results. | Partially met |

Source: GAO analysis of Navy's data. | GAO-17-575

^aNot Met - Navy provided no evidence that satisfies any of the criterion, Minimally Met – Navy provided evidence that satisfies a small portion of the criterion, Partially Met – Navy provided evidence that satisfies about half of the criterion, Substantially Met – Navy provided evidence that satisfies a large portion of the criterion, and Met – Navy provided complete evidence that satisfies the entire criterion.

Appendix III: Comments from the Department of Defense



ACQUISITION,
TECHNOLOGY,
AND LOGISTICS

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

FEB - 7 2017

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 letter serves as the Department of Defense (DoD) response to the Government Accountability Office (GAO) Draft Report, GAO-17-190, "FORD CLASS AIRCRAFT CARRIER: Follow-On Ships Need More Frequent and Accurate Cost Estimates to Avoid Pitfalls of Lead Ship," dated December 13, 2016 (GAO Code 100517). The Department acknowledges receipt of the draft report and notes that it contains three recommendations for DoD action as a result of your review.

The Department partially concurs with recommendations one and two, but does not concur with recommendation three for the reasons stated in the enclosure.

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

Sincerely,

A handwritten signature in blue ink, appearing to read "J MacStravic".

James A. MacStravic
Performing the Duties of the
Under Secretary of Defense
for Acquisition, Technology,
and Logistics

Enclosure:
As stated

**GAO DRAFT REPORT DATED DECEMBER 13, 2016
GAO-17-190 (GAO CODE 100517)**

**“FORD CLASS AIRCRAFT CARRIER: FOLLOW ON SHIPS NEED MORE
FREQUENT AND ACCURATE COST ESTIMATES TO AVOID PITFALLS
OF LEAD SHIP”**

**DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATIONS**

RECOMMENDATION 1: To ensure the Milestone Decision Authority has an accurate and credible cost estimate for the Milestone C program review, NAVSEA 05C should update the cost estimate for CVN 79 as part of the Ford Class program life-cycle cost estimate. This estimate should be prepared in accordance with cost estimating best practices and include current shipbuilder performance data. The Naval Center for Cost Analysis (NCCA) should review the new CVN 79 cost estimate as part of the planned independent cost assessment. Further, the Secretary of Defense should direct the Office of Cost Assessment and Program Evaluation (CAPE) to include the new CVN 79 cost estimate as part of the planned independent cost estimate, which should form the basis of the program budget request. If the independent cost estimate for CVN 79 should exceed the cost cap, the Navy should submit to Congress a request to revise the cost cap.

DoD RESPONSE: Partial Concur. The Department agrees that an accurate cost estimate for CVN 79, prepared by NAVSEA 05C and supported by a review by NCCA, is essential to support the Milestone C review for the program. The Department fully intends to have CAPE perform an independent cost estimate for the program, to include an update of the CVN 79 cost estimate. The CAPE independent cost estimate will also inform the Milestone C review. The Department does not concur with revising the cost cap should the CVN 79 independent cost estimate exceed the current cost cap, as it would be premature to do so. Rather, the Navy will use the independent cost estimate to determine whether the execution within the cost cap is at risk and whether additional mitigation strategies are needed to ensure CVN 79 is delivered at or below the cost cap. The Department will continue to comply with Public Laws 109-364, 113-66, and 114-92 regarding cost cap adjustments. For reference purposes, this item will be identified as GAO-17-190-01.

RECOMMENDATION 2: Starting with CVN 80, NAVSEA 05C should develop program life-cycle cost estimates for each individual ship in the Ford Class program baseline. Development of these estimates should be provided at milestone reviews that should be aligned with major aircraft carrier funding events. In particular, for CVN 80, a program life-cycle cost estimate should be developed prior to the request for ship construction funding. For all ships in the class after CVN 80, a program life-cycle cost estimate should be aligned with milestone reviews that correspond with the receipt of any advance procurement funding and the first year of the request for ship construction funding. These estimates should be prepared in accordance with best practices and updated regularly with actual cost data. The Secretary of Defense should

ENCLOSURE

further direct CAPE to develop independent cost estimates for these ships prior to the listed events. The Secretary of the Navy should direct NCCA to conduct independent cost assessments for these ships prior to the listed events.

DoD RESPONSE: Partial Concur. The Department agrees with the GAO recommendation and will conform to the development of program life cycle cost estimates for each individual ship in the GERALD R. FORD Class beginning with CVN 80 at the timelines recommended by GAO, with one exception. The Department will not be able to meet the GAO recommended timeline for a program life cycle cost estimate prior to the initial request for ship construction funding for CVN 80. The request for CVN 80 ship construction funding will be included in the President's Budget Request for Fiscal Year (FY) 2018. The first CVN 80 program life cycle cost estimate prepared by the Navy and supported by an independent review by NCCA, and the first CAPE independent cost estimate for that ship will be completed prior to the CVN 80 Construction Defense Acquisition Board Interim Program Review scheduled for the first quarter of FY 2018. The Department will be able to follow the GAO recommended timelines for preparation and timing of individual ship program life cycle cost estimates for all ships in the GERALD R. FORD Class that follow CVN 80. For reference purposes, this item will be identified as GAO-17-190-02.

RECOMMENDATION 3: To improve insight into cost changes for individual ships in the Ford Class, program office should prepare a separate SAR for each individual ship in the class, in addition to the Selected Acquisition Report (SAR) for the overall Ford Class program.

DoD RESPONSE: Non-Concur. The Department disagrees that insight into cost changes at the individual ship level is lacking. Since 2011, the Department has provided to the congressional defense committees monthly progress reports on the cost of CVN 78 and, since 2014, quarterly progress reports on the cost of CVN 79. The Department also disagrees that a separate SAR should be prepared for each individual ship in the Class in addition to the SAR for the overall program. The current SAR includes two subprograms as required by section 221 of the National Defense Authorization Act for FY 2012. The two subprograms include the Electromagnetic Aircraft Launch System as one subprogram and the remainder of the ship as the second subprogram, with each subprogram aggregated across the three ships in the program. In order to meet the requirements of section 221 as well as this new recommendation from GAO, it would require eight separate SAR sections covering the individual ships broken out by the two subprograms, plus the full program broken out by the two subprograms. Much of the data in these SARs would be unnecessary duplication. Given the monthly and quarterly cost reporting that already occurs, there would be no new information provided in an annual SAR covering each ship. Until otherwise directed, the Department intends to continue reporting in the following manner: annual SARs with the two required subprograms legislated by Congress, monthly reporting to the defense committees on the costs for CVN 78, and quarterly reporting on the costs for CVN 79. For reference purposes, this item will be identified as GAO-17-190-03.

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Appendix IV: GAO Contact and Staff Acknowledgments

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Staff Acknowledgments

In addition to the contact named above, key contributors to this report were Diana Moldafsky, Assistant Director; Jessica E. Karnis; Juana S. Collymore; Burns C. Eckert; Marcia Fernandez; Laura Greifner; Kristine Hassinger; Karen Richey; and Roxanna Sun.

Related GAO Products

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Defense Acquisitions: Assessments of Selected Weapon Programs. [GAO-16-329SP](#). Washington, D.C.: March 31, 2016.

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