United States Government Accountability Office

Navy Shipbuilding

Past Performance Provides Valuable Lessons for Future Investments

Accessible Version

June 2018 | A Report to Congressional Committees | GAO-18-238SP

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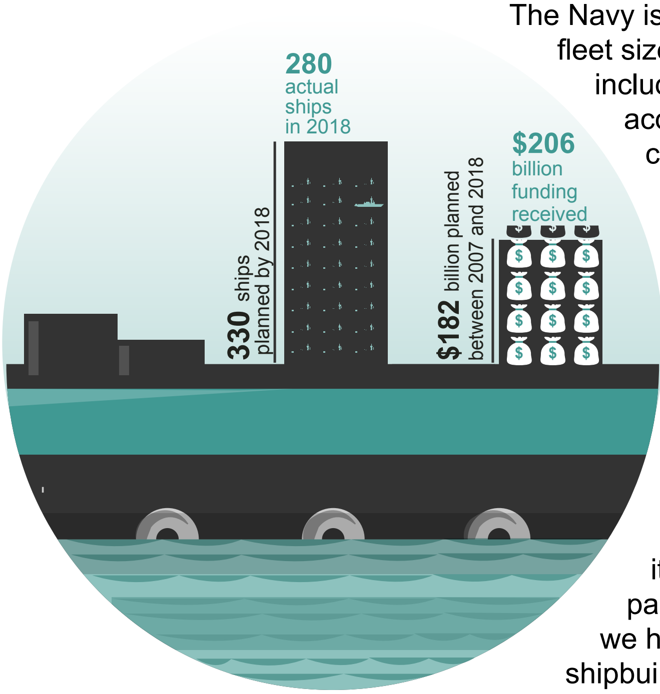
Cover photo source: LCS 8. U.S. Navy photo by Electronics Technician First Class Adam Ross. | GAO-18-238SP

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

June 6, 2018

Congressional Committees,

Challenges in meeting shipbuilding cost, schedule, and performance goals have resulted in a less-capable and smaller fleet today than the Navy planned over 10 years ago. While the Navy is continuing to accept delivery of ships, it has received $24 billion more in funding than originally planned but has 50 fewer ships in its inventory today, as compared to the goals it first established in its 2007 long-range shipbuilding plan. Cost growth has contributed to the erosion of the Navy's buying power with ship costs exceeding estimates by over $11 billion during this time frame. Additionally, the Navy's shipbuilding programs have had years of construction delays and, even when the ships eventually reached the fleet, they often fell short of quality and performance expectations. Congress and the Department of Defense have mandated or implemented various reform efforts that have led to some improvements, but poor outcomes tend to persist in shipbuilding programs.



Source: GAO analysis of Navy documentation. | GAO-18-238SP

The Navy is now planning for the most significant fleet size increase in over 30 years, which includes some costly and complex acquisitions, such as the Columbia class ballistic missile submarine and a new class of guided missile frigates. In its long-range shipbuilding plan accompanying the fiscal year 2019 budget, the Navy estimated that it needs over $200 billion during the next 10 years to sustain a Navy fleet with more than 300 ships and begin working toward its ultimate goal of achieving a 355-ship fleet. As it embarks upon this plan, the Navy has an opportunity to improve its shipbuilding approach and avoid past difficulties. Over the last 10 years, we have issued 26 reports, identified shipbuilding best practices, testified before Congress on several occasions, and made 67

NOTE: In the figure above, the planned funding amounts and ship counts are from the Navy's 2007 Long-Range Shipbuilding Plan. The current vessel count is from the Navy's Vessel Register and the funding received represents the Navy shipbuilding and conversion appropriations. All funding numbers are in fiscal year 2018 dollars.

recommendations to help the Navy improve shipbuilding outcomes. The Department of Defense and the Navy have implemented 29 of our recommendations and have agreed with the principles of GAO's identified best practices. In many cases, however, the Navy has not taken steps based upon these best practices. This product summarizes our key observations and identifies common challenges that shipbuilding programs have faced over the past decade to help the Navy deliver better outcomes for the sailor and the taxpayer going forward.

This special product, which is divided into two sections, presents an overview of our work on shipbuilding programs over the past decade. The first section summarizes the Navy's acquisition outcomes for ship classes built during the last 10 years—meaning the difference between the planned versus actual cost, schedule, quality, and performance results for these ships. The second section discusses GAO-identified best practices for addressing risks inherent in shipbuilding and compares these practices to the Navy's approach for addressing risk. To identify common issues across the Navy's shipbuilding portfolio and challenges within specific programs, we examined our past findings and recommendations on Navy shipbuilding and acquisition best practices. We also updated analyses from prior work to include current data on funding, cost, schedule, and other shipbuilding metrics. We provided the report to Navy officials for review and incorporated their comments, as appropriate. More detailed information on our objectives, scope, and methodology for the works cited in this report can be found in the related reports and in appendix I of this report. In addition, definitions of key terms and concepts that we use throughout this report can be found in appendix II.

We prepared this report from June 2017 to June 2018 under the authority of the Comptroller General in light of planned increases in ship acquisitions. We conducted the work upon which this product is based 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.

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Ship Classes Built During the Last 10 Years

Littoral Combat Ship, Freedom (LCS 1) and Independence (LCS 2) variants

Mine countermeasures, antisubmarine warfare, and surface warfare using mission packages comprised of systems launched from the ship

Source: LCS 1. U.S. Navy photo by Mass Communication Specialist 2nd Class Nathan Laird; LCS 2. U.S. Navy photo by Mass Communication Specialist 1st Class Ace Rheaume. | GAO-18-238SP

Arleigh Burke Class Guided Missile Destroyer (DDG 51)

Offensive and defensive operations against air, surface, and subsurface threats

Source: DDG 112. U.S. Navy photo courtesy of General Dynamics Bath Iron Works. | GAO-18-238SP

Zumwalt Class Destroyer (DDG 1000)

Offensive surface strike (mission recently changed—previously land attack)

Source: DDG 1000. U.S. Navy photo courtesy of General Dynamics Bath Iron Works. | GAO-18-238SP

America Class Amphibious Assault Ship (LHA 6)

Ship-to-shore movement of Marines with aviation assets and landing craft

Source: LHA 6. U.S. Marine Corps Photo by Lance Cpl. Dana Beesley. | GAO-18-238SP

San Antonio Class Amphibious Transport Dock (LPD 17)

Embark, transport, and land Marine forces

Source: LPD 17. U.S. Navy photo by Mass Communication Specialist 2nd Class Katrina Parker. | GAO-18-238SP

Source: GAO analysis of Navy information. | GAO-18-238SP


Source: SSN 786. U.S. Navy photo courtesy of General Dynamics Electric Boat. | GAO-18-238SP

Virginia Class Submarine (SSN 774)
Multi-mission attack


Source: CVN 78. U.S. Navy photo by Erik Hildebrandt. | GAO-18-238SP

Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)
Independent, sustained aviation operations


Source: T-EPF 3. U.S. Navy photo by Chief Mass Communication Specialist Christopher E. Tucker. | GAO-18-238SP

Expeditionary Fast Transport (EPF)
High-speed personnel and cargo transport


Source: T-ESD 2. U.S. Navy photo. | GAO-18-238SP

Expeditionary Transfer Dock / Expeditionary Sea Base (ESD/ESB)
Logistics movement from ship to shore


Source: T-AKE 7. U.S. Navy photo by Mass Communication Specialist Seaman Jose Madrigal. | GAO-18-238SP

Lewis and Clark Class Dry Cargo / Ammunition Ship (T-AKE)
Cargo and ammunition replenishment

Source: GAO analysis of Navy information. | GAO-18-238SP

Forthcoming Navy Ship Classes

(1) Columbia Class Submarine (SSBN 826): strategic deterrence; planned to start construction in 2021

(2) Guided Missile Frigate (FFG(X)): anti-submarine and anti-air warfare among other missions; planned to begin detail design in 2020

(3) San Antonio Class Amphibious Transport Dock Flight II (LPD 17 Flight II): embark, transport and land Marine forces; planned to begin construction in 2020

(4) Arleigh Burke Class Guided Missile Destroyer Flight III (DDG 51 Flight III): offensive and defensive operations against air, surface, and subsurface threats; planned to start construction in 2018

(5) John Lewis Class Oiler (T-AO 205): oil, food, and cargo delivery to Navy ships at sea; started construction in 2016

SHIPBUILDING OUTCOMES

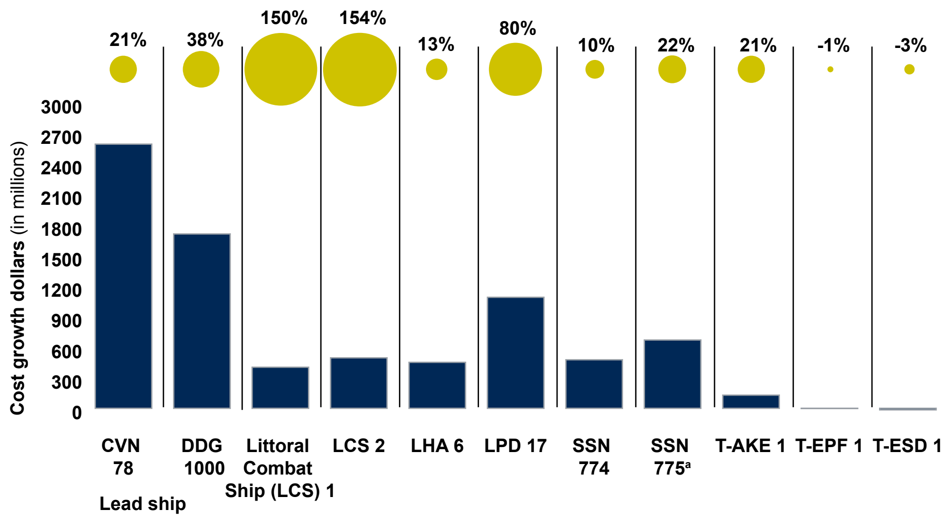
Navy Ships Cost Billions More and Take Years Longer to Build Than Planned While Often Falling Short of Quality and Performance Expectations

Source: LPD 17. U.S. Navy photo by Mass Communication Specialist 2nd Class Katrina Parker. | GAO-18-238SP

Navy shipbuilding programs under construction during the last 10 years have often not achieved their cost, schedule, quality, and performance goals. While poor outcomes are more acute with the first ships of the class, follow-on ships also often do not meet expected outcomes.

01.
Navy Lead Ships Consistently Cost More Than Initially Budgeted

Overall, Navy lead ships cost a total of $8 billion more to construct than initially budgeted for the 11 most recently delivered lead ships. Although the magnitude of cost growth varied significantly among programs, nearly all of the Navy's recent lead ships have experienced cost growth, including three lead ships that have exceeded their initial budgets by 80 percent or more. Only 2 of the 11 lead ships we reviewed were delivered below their initial budget.



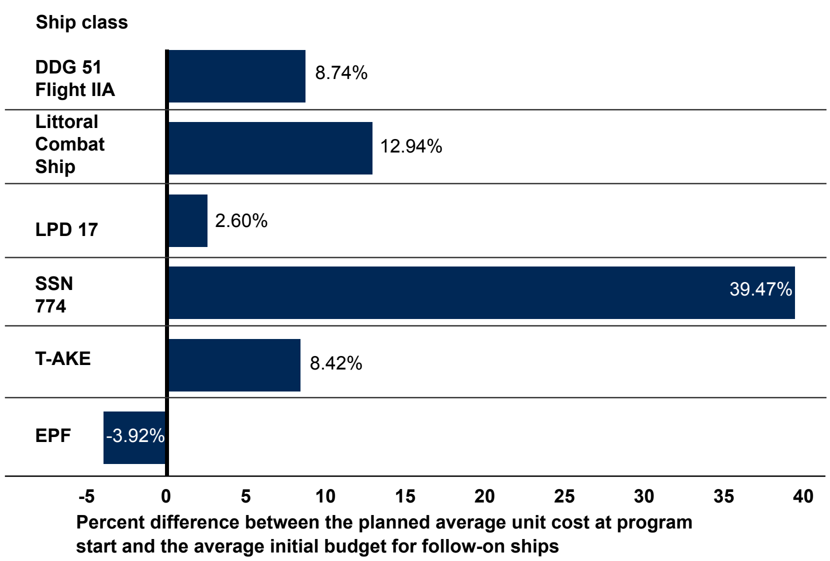
[a]SSN 775 is the second Virginia class submarine, but was the first hull delivered by Newport News shipyard. SSN 774, the lead ship of the class, was delivered by Electric Boat shipyard.

Source: GAO analysis of Navy documentation. | GAO-18-238SP

NOTE: Cost growth is measured as the difference between the initial cost estimate reflected in the Navy's budget request documents prior to ship construction (year in which the Navy requested authorization for the ship from Congress) and the cost estimate reflected in the Navy's fiscal year 2018 budget request documents or the actual cost. All cost estimates and cost growth calculations are in fiscal year 2018 dollars.

Related GAO reports: GAO-05-183, GAO-07-866, GAO-07-943T, GAO-08-804, GAO-10-523, GAO-13-396, GAO-15-22, and GAO-16-84T.

02.
Follow-on Ships Also Cost More Than Initially Estimated



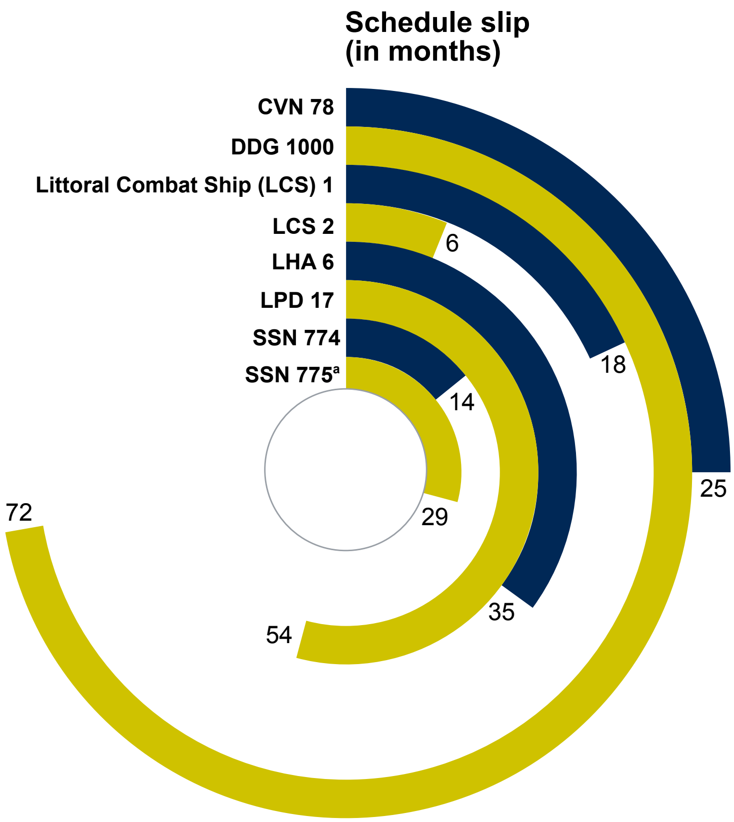
Source: GAO analysis of Navy documentation. | GAO-18-238SP

Follow-on ships have less cost growth than lead ships, as the Navy and its shipbuilders learn lessons from constructing the lead ship. Nonetheless, the requested budgets for follow-on ships have generally still been higher than the Navy's initial planned cost per ship for the class. Furthermore, beyond the growth in average ship cost portrayed in the figure, since 2007, the Navy has also received $3 billion in total subsequent funding to finish all follow-on ships.

NOTE: Percent cost difference of follow-on ships is calculated by comparing the Navy's initial average procurement unit cost at program start in its Selected Acquisition Report against the average initial cost estimate in the Navy's budget request for all follow-on ships in each class. All cost estimates and cost growth calculations are in fiscal year 2018 dollars. Increases in follow-on ship costs could be due to adding upgraded capabilities, but data accounts for increases in quantities.

Related GAO reports: GAO-05-183, GAO-07-943T, GAO-08-804, GAO-10-523, GAO-13-396, GAO-13-530, GAO-15-22, and GAO-17-575.

03.
Navy Ships Regularly Fall Short of Program Schedule Expectations



Source: GAO analysis of Navy documentation. | GAO-18-238SP

We have found that schedule delays are common in Navy shipbuilding programs. All 8 of the lead ships we have reviewed were provided to the fleet behind schedule, and more than half of these ships were delayed by more than 2 years.

[a]SSN 775 is the second Virginia class submarine, but was the first hull delivered by Newport News shipyard. SSN 774, the lead ship of the class, was delivered by Electric Boat shipyard.

NOTE: Schedule delays are measured as the difference between the obligation work limiting date (OWLD) reflected in the Navy's budget request documents prior to ship construction (year in which the Navy requested authorization for the ship from Congress) and the OWLD reflected in the Navy's fiscal year 2018 budget request documents or the actual date. In this report, we refer to OWLD as the date the ship is provided to the fleet. This graphic only includes lead ships that report obligation work limiting dates or an equivalent milestone.

The Navy has also experienced significant schedule delays with follow-on ships. Most significantly, deliveries of almost all LCS under contract (LCS 5-28) have been delayed by several months, and, in some cases, a year or longer. Additionally, four of the most recently constructed LPD 17 class ships were each delivered 15 to 20 months behind schedule.

The average follow-on Freedom variant LCS is 16 months late.

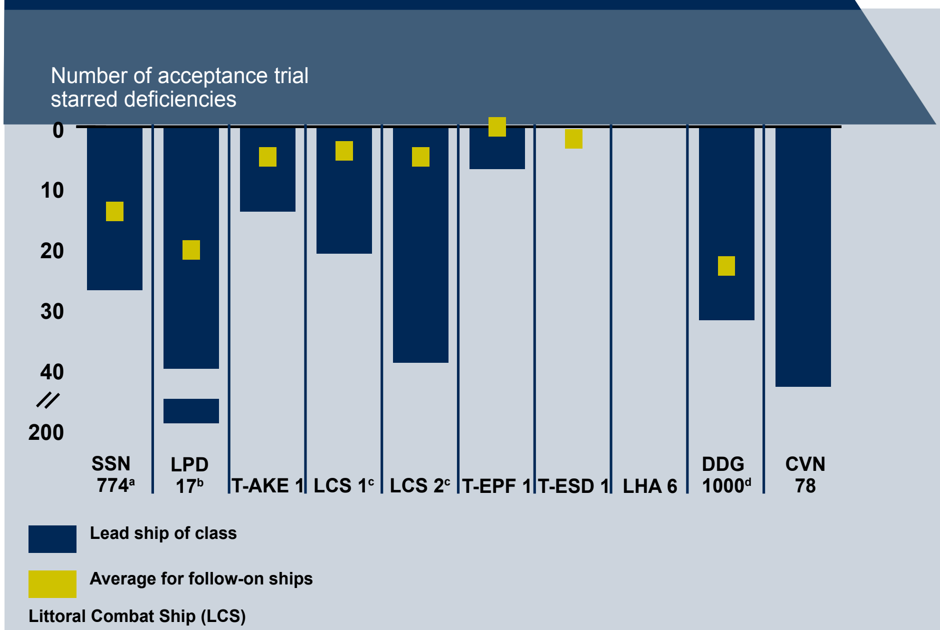
The average follow-on Independence variant LCS is 14 months late.

Source: LCS 1. U.S. Navy photo by Mass Communication Specialist 2nd Class Nathan Laird; LCS 2. U.S. Navy photo by Mass Communication Specialist 1st Class Ace Rheaume. | GAO-18-238SP

Related GAO reports: GAO-07-943T, GAO-08-804, GAO-10-523, GAO-13-396, GAO-14-827, GAO-16-84T, GAO-17-211, and GAO-17-323.

04.
Navy Accepts Ships with Deficiencies and Incomplete Work

Navy policy calls for starred deficiencies to be corrected or waived by the Navy prior to delivery; most are waived and not corrected before delivery



Source: GAO analysis of Navy information. | GAO-18-238SP

NOTE: Lead ships are presented in chronological order by delivery date, with CVN 78 being the most recent. The Navy's Back to Basics quality improvement initiative began in 2009. The Navy accepted delivery of LCS 2 and all subsequent lead ships after this initiative began.

[a]The count of starred deficiencies for Virginia-class submarines delivered before 2015 includes some deficiencies for which the Chief of Naval Operations provided class-wide permanent waivers in 2015, according to a senior Board of Inspection and Survey (INSURV) official. The Chief of Naval Operations directed INSURV not to document deficiencies covered by these permanent waivers as starred deficiencies. There are approximately a dozen of these permanent waivers for select Virginia class submarines. The permanent waiver significantly reduced the number of starred deficiencies for SSN 785 and follow-on submarines.

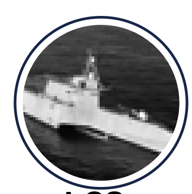
[b]LPD 17 was incomplete when the Navy conducted acceptance trials.

[c]LCS 1 and LCS 2 were incomplete when the Navy conducted acceptance trials.

[d]The DDG 1000 acceptance trial only included the hull, mechanical, and electrical portions of the ship. Combat systems will be assessed in a separate trial.

We have found that the Navy routinely accepts delivery of ships with large numbers of uncorrected deficiencies, including starred deficiencies, which are the most serious deficiencies for operational or safety reasons. The Navy's practice is in conflict with its policy, which states that ships and submarines will be fully mission capable in the sense that all contractual responsibilities must be resolved prior to delivery, except for a few requirements that cannot be met until after delivery—such as ship outfitting. The Navy identifies starred deficiencies just prior to delivery during acceptance trials and it frequently does not correct them before delivery. In 2009, after several cases of poor ship quality, the Navy began taking steps to improve oversight of ship construction by establishing an initiative to focus on efficiency and quality during ship construction. Since then, the Navy has generally reduced the number of uncorrected deficiencies at the time of ship delivery, particularly for follow-on ships. Nevertheless, we have found that the Navy continues to accept ships with uncorrected starred deficiencies. For instance, in 2017, we found that 90 percent of acceptance trial starred deficiencies were not corrected prior to delivery for the eight ships we reviewed. Although the Navy works to resolve many defects in the post-delivery period, we have found in a number of cases that ships were then provided to the fleet with outstanding issues. We have made recommendations to improve quality but the Navy did not agree with or implement most of these recommendations.

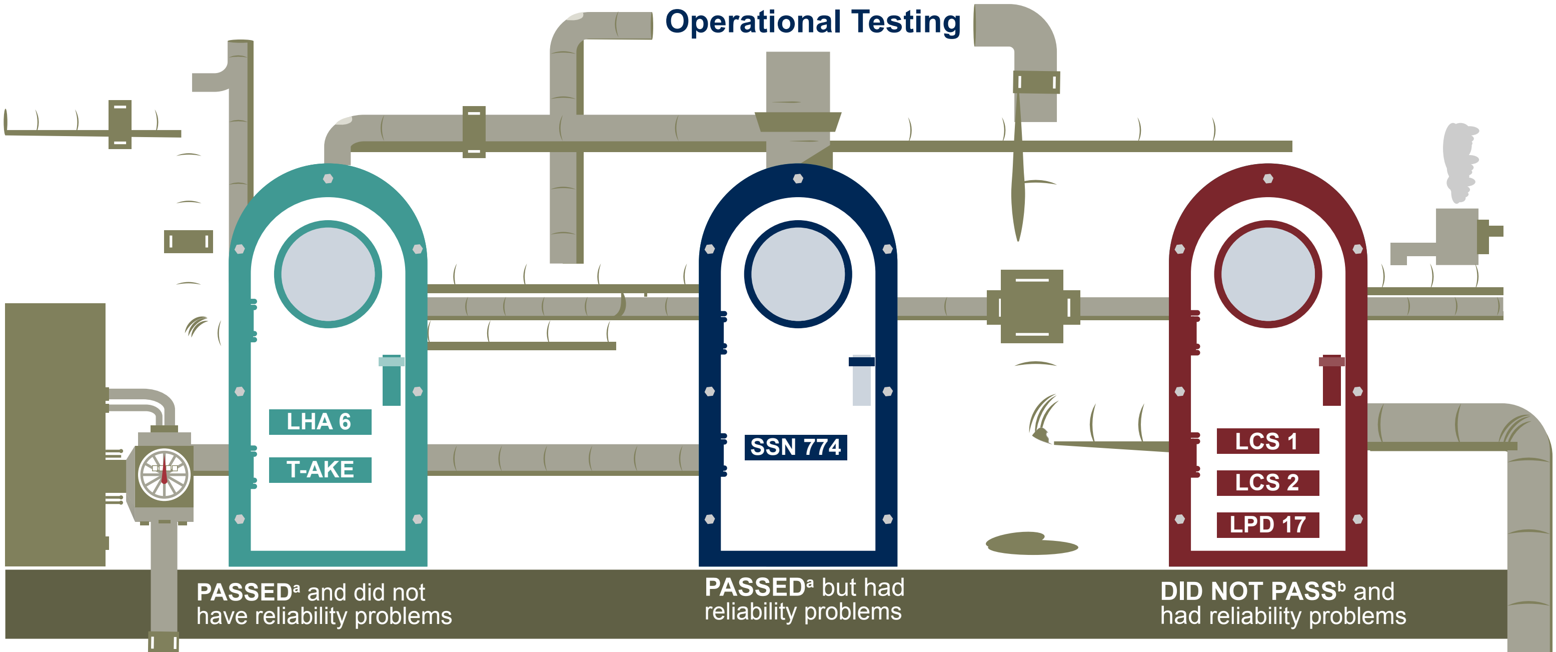
One open starred deficiency on an LCS concerned a radar system that did not work properly, which could have resulted in unintended countermeasure launches. This deficiency was not corrected until nearly 4 months after the ship was provided to the fleet.



LCS

Related GAO reports: GAO-07-943T, GAO-08-804, GAO-10-523, GAO-14-122, GAO-14-827, GAO-15-22, and GAO-17-418.

05.
Navy Ships Do Not Consistently Meet Performance Expectations



[a]Passed - operationally effective and suitable

[b]Did not pass - not operationally effective and/or not operationally suitable

Littoral Combat Ship (LCS)

Source: GAO analysis of Navy information. | GAO-18-238SP

Of the six ship classes that went through operational testing during the last 10 years, only half—SSN 774, T-AKE, and LHA 6—passed testing on the first attempt, meaning the ships were found to be operationally effective and suitable. Testers use operational effectiveness—whether or not a ship can perform its mission—and operational suitability—the capacity to logistically support a ship class—to assess basic ship performance.

Testing revealed that four of the six ship classes had significant reliability issues—meaning key pieces of equipment failed more frequently than desired. Even though reliability problems may not result in a ship class failing operational testing, such unreliable systems—when provided to the fleet without correction—can consume limited resources, inhibit performance, and add to sailors' workloads.

LCS

We have reported extensively on performance failures identified during testing of the LCS seaframes and mission packages, including:

- **The Freedom variant falls far short of its range requirement of 3,500 nautical miles at 14 knots.**
- **The Independence variant cannot meet the speed requirement of 40-50 knots.**
- **Both LCS variants have only demonstrated requirements for surface warfare at a reduced capability. In addition, the mine countermeasures package failed developmental testing, resulting in significant delays to provide this capability to the fleet.**

LPD 17

Testing revealed significant reliability issues and, after delivery to the fleet, several LPD 17 class ships experienced catastrophic propulsion system failures, issues with the engineering control system, and electrical distribution system problems including total loss of electrical power. The Navy stood up a team in 2008 that fixed the class's initial reliability problems, but, 10 years later, this team continues to work through many issues. Fleet engineers, operators, and other officials who work with LPD 17 class ships told us that they continue to have significant concerns about the quality of the ships.

Related GAO reports: GAO-08-804, GAO-10-523, GAO-13-530, GAO-13-396, GAO-14-749, GAO-15-22, GAO-16-201, and GAO-17-418.

SHIP BUILDING RISK

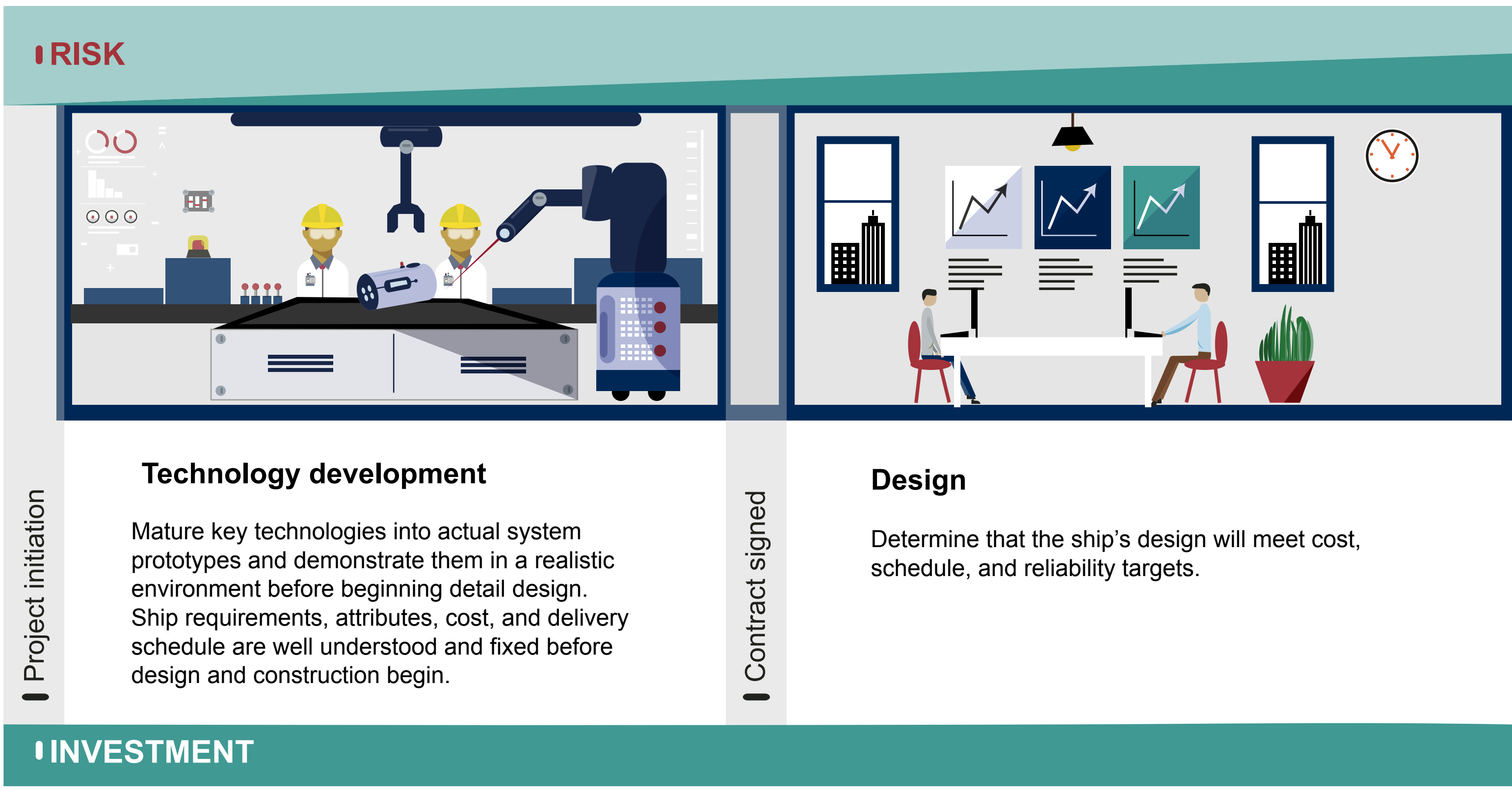
The Navy Accepts Significant Risk in Its Programs—an Approach Enabled by Process Weaknesses and Unclear Policy

Source: DDG 112. U.S. Navy photo courtesy of General Dynamics Bath Iron Works. | GAO-18-238SP

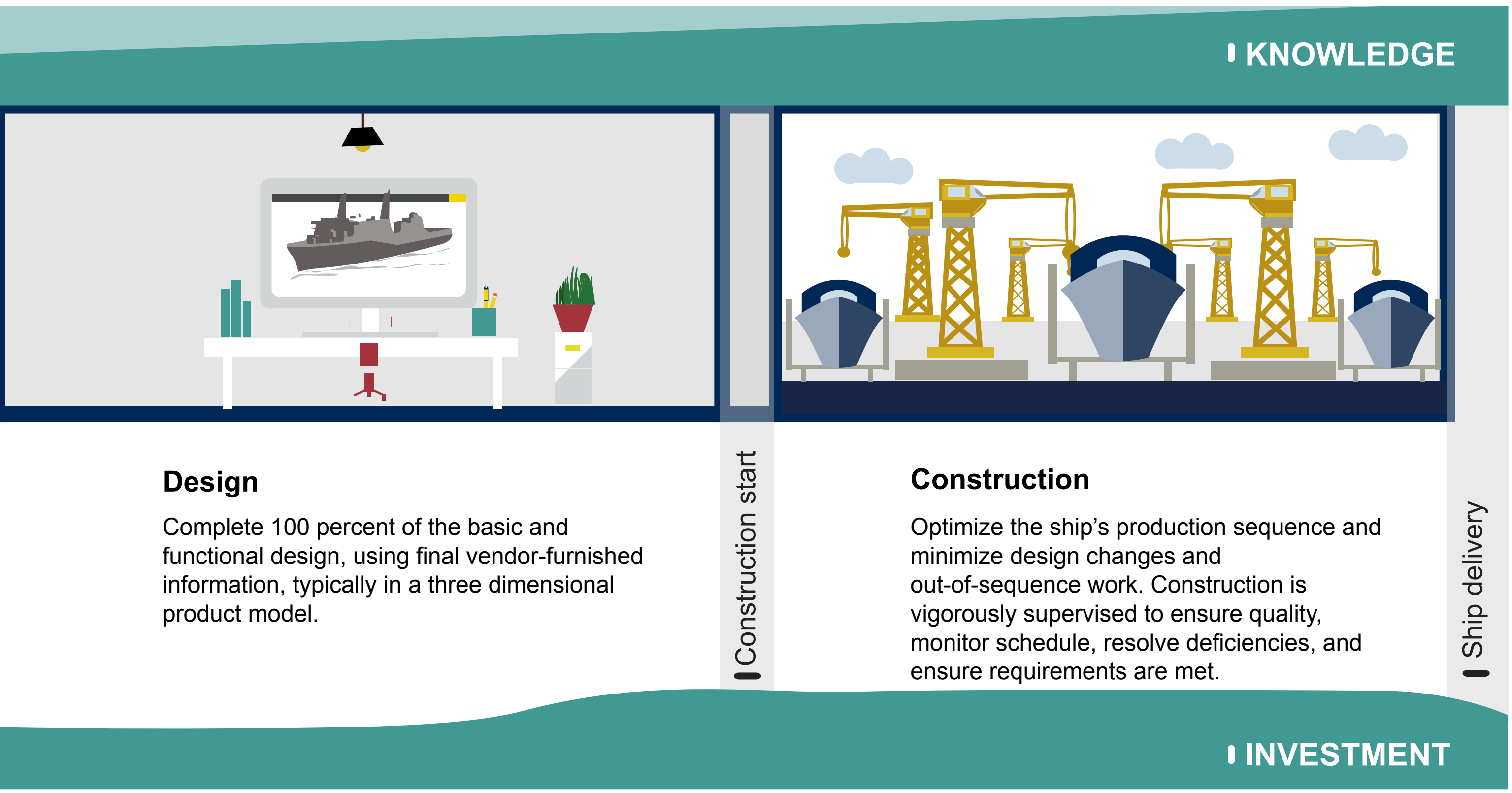
For shipbuilding programs to succeed, they must be based on a sound business case. However, for the Navy's shipbuilding programs, there is an imbalance between the resources planned to execute these programs and the capabilities the Navy seeks to acquire. This imbalance forms during the pursuit to fund lead ship construction, when competitive pressures to get funding for the program are high and many aspects of the program remain unknown. During this process, the Navy often initiates shipbuilding programs with weak business cases that over-promise the capability the Navy can deliver within the planned costs and schedule. As ship construction progresses and these initial business cases predictably begin to erode, Navy shipbuilding programs come under pressure to control growing costs and schedules, often by changing planned quality and performance goals. By the time these pressures are realized and acted upon, multiple ships are often under construction, resulting in disruptions throughout the ship class. Over time, this approach reduces the Navy's buying power and the likelihood of achieving fleet goals.

06.
Successful Shipbuilding Programs Supplant Risk with Knowledge

In its simplest form, an acquisition business case should balance the concept selected to satisfy warfighter needs and the resources—technologies, design knowledge, funding, and time—needed to transform the concept into a product—in this case, a ship. We frequently report on the benefits of establishing a solid, executable business case in our work examining acquisition best practices. In 2009, based on our analysis of several leading buyers and builders of large, complex commercial ships, we identified best practices that could be adapted by the Navy. We found that successful shipbuilding programs have sound business cases, starting with the lead ship, built on attaining critical levels of knowledge at key points in the shipbuilding process before significant investments are made, as shown in the figure below. Although there are differences between Navy and commercial shipbuilding—in particular, the Navy usually integrates weapons and advanced information systems into its ships—the attainment of knowledge is crucial to success in both endeavors.



Source: GAO depiction of notional shipbuilding process. | GAO-18-238SP



Executable business cases use realistic cost and schedule targets to meet the warfighter's performance and quality expectations by balancing inherent uncertainties in acquisition programs. To do this, a solid business case provides for the resources necessary to mitigate challenges, such as immature technologies and design requirements. The greater the potential for these uncertainties to occur, the more time and money should be factored into the business case to address them. In the commercial sector, successful shipbuilding programs progressively reduced uncertainty and risk by accumulating knowledge over time—prior to making investments in the lead ship—resulting in ships delivered on schedule, within budget, and that perform as expected.

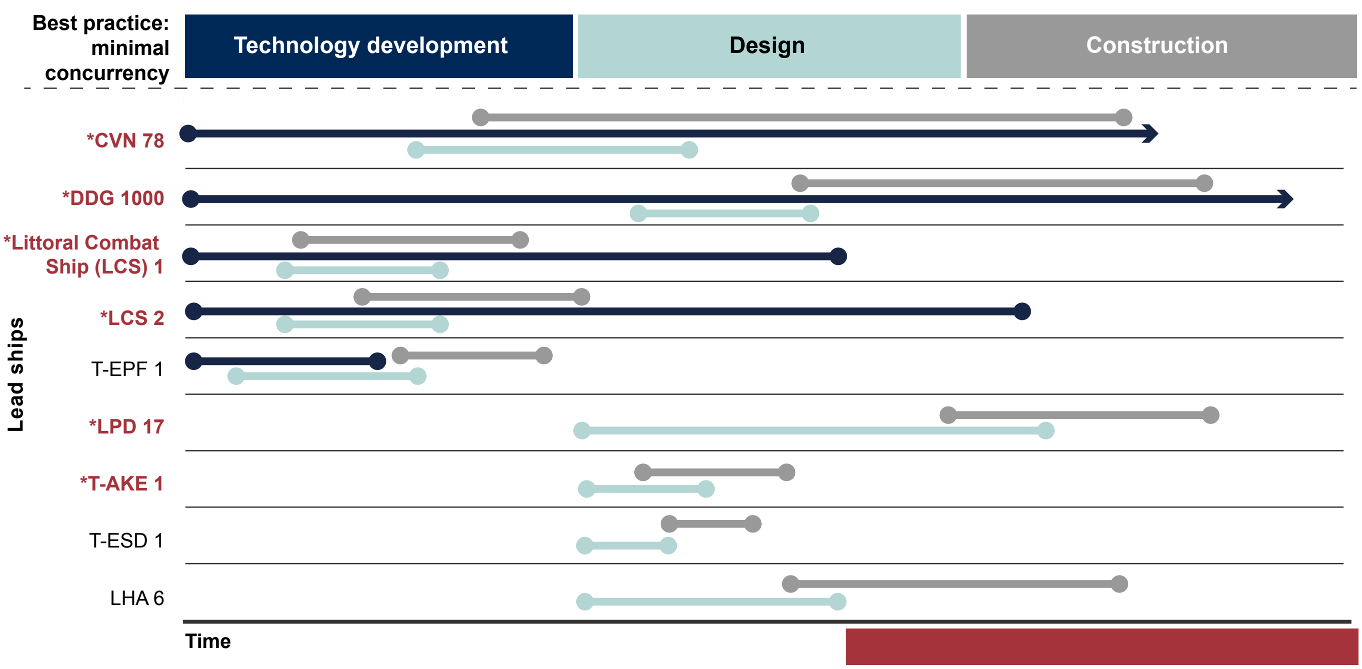
Related GAO reports: GAO-04-386SP, GAO-07-943T, and GAO-09-322.

07.
Proceeding with Programs before Gaining Sufficient Knowledge

The Navy has agreed in principle that knowledge should be attained prior to key milestones to better ensure ships are built to agreed-upon cost, schedule, quality, and performance standards. But, contrary to shipbuilding best practices, the Navy often proceeds with shipbuilding programs absent an executable business case. Instead of gradually building knowledge over time and sequentially moving through the three main phases of the shipbuilding process, the Navy's shipbuilding programs often experience significant overlap—known as concurrency—between the technology development, design, and construction phases of the acquisition.

Concurrency in shipbuilding programs can frequently result in the opposite of its intended results. Instead of recovering schedule losses, concurrency typically results in cost growth and schedule delays. If technologies are not mature before the ship is designed, there will likely be design changes later in the shipbuilding process when the technical requirements become more well-defined. Moreover, if design changes are made after construction is already underway, the shipbuilder will likely have to complete out-of-sequence construction and redo completed work to implement the changes. This additional work during construction, driven primarily by overlapping technology development and ship design efforts, has led to poor acquisition outcomes.

Most Navy lead ships we reviewed proceeded into construction before completing technology development and ship design. In fact, four shipbuilding programs that identified critical technologies for development had significant overlap among the development, design, and construction phases over the course of several years. We have found that the programs with the greatest amount of overlap between shipbuilding phases often have some of the highest cost and schedule growth, as well as quality and performance issues. Further, when concurrency continues for extended periods, these shipbuilding programs tend to have a large number of changes that disrupt multiple ships in the class.



Source: GAO analysis of Navy information. | GAO-18-238SP

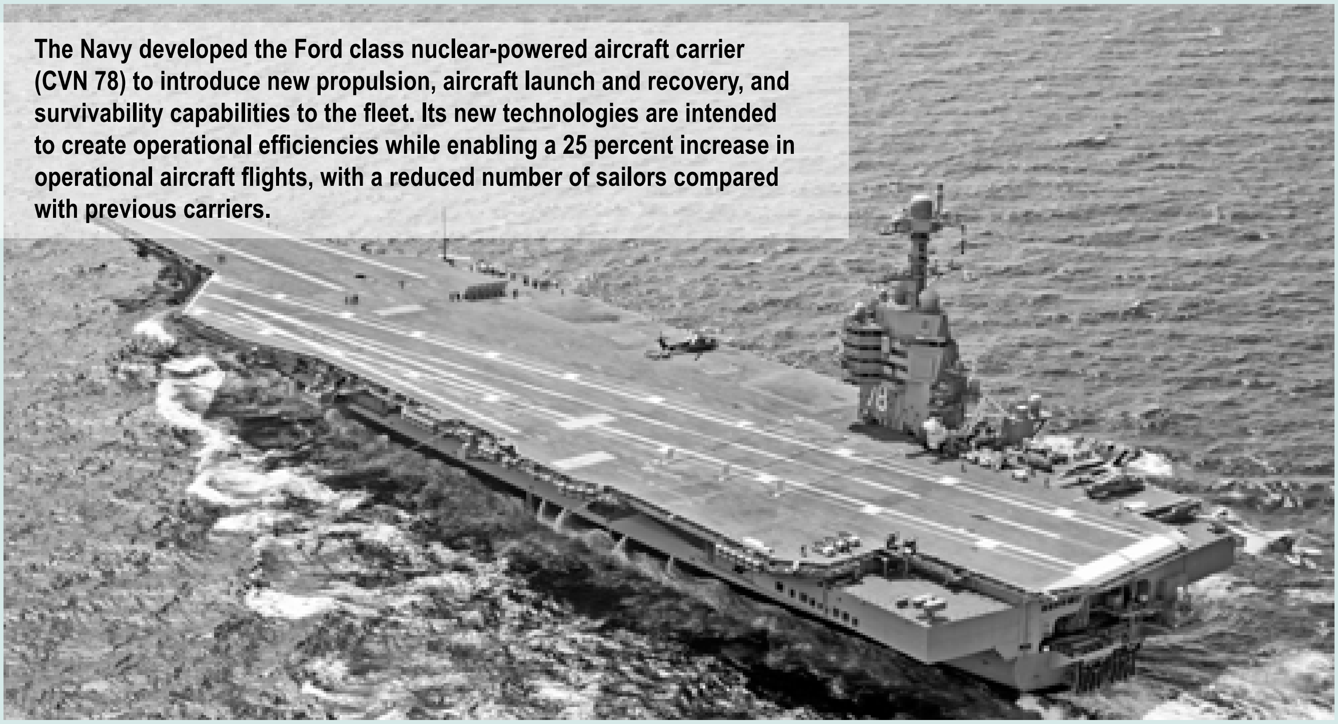
NOTE: For ships that do not have a technology development bar in the graphic above, the Navy did not identify critical technologies for development. While the LPD 17 program included the development of new or modified key ship systems that could have been considered critical technologies, some of which were incorporated after the start of construction, the program was initiated before DOD began specifically tracking critical technologies.

Related GAO reports: GAO-07-943T, GAO-08-1061T, GAO-09-322, GAO-13-530, GAO-16-84T, GAO-16-356, GAO-16-613, and GAO-17-323.

CASE STUDY:

A Weak Business Case for the Ford Class Aircraft Carrier Led to Poor Outcomes

The Navy developed the Ford class nuclear-powered aircraft carrier (CVN 78) to introduce new propulsion, aircraft launch and recovery, and survivability capabilities to the fleet. Its new technologies are intended to create operational efficiencies while enabling a 25 percent increase in operational aircraft flights, with a reduced number of sailors compared with previous carriers.



Source: CVN 78. U.S. Navy photo by Erik Hildebrandt. | GAO-18-238SP

In August 2007, we found that, at its inception, the business case for CVN 78 was predicated on unrealistic cost and schedule estimates that did not sufficiently account for risks associated with the development of the Ford class's 13 critical technologies and construction of the lead carrier. Lead ships typically have challenging technology development and construction efforts and, therefore, require more funding and labor hours to construct than follow-on ships. Nevertheless, the Navy estimated fewer labor hours to construct the lead ship of the Ford class than the last two aircraft carriers of the previous Nimitz class. Shipbuilding challenges were exacerbated by the Navy's decision to proceed with ship construction while continuing to develop critical technologies, such as aircraft launch and recovery systems, radar, and weapons elevators, resulting in design changes and construction disruptions that led to cost and schedule growth.

The Navy took delivery of CVN 78 in May 2017, but the carrier will not be ready to deploy until 2022 as significant development, construction, and testing continues. Despite more than 15 years of development, reliability and performance shortfalls with several of the carrier's key technologies persist—such as with the aircraft landing system. Currently, CVN 78 costs over $2 billion more than estimated and the Navy accepted delivery of the carrier over 2 years late, yet still before it was complete. Since 2007, we have made several recommendations to improve the Navy's approach to acquiring its aircraft carriers—including improving cost estimates and testing—but the Navy has not implemented many of them.

The business case for the first follow-on ship, CVN 79, has similar weaknesses. We recently found that the Navy developed a cost estimate for this carrier that did not include sufficient risk factors or accurately account for program uncertainty. For example, the Navy is unlikely to achieve planned construction efficiencies and is still developing technology necessary to meet requirements. Therefore, costs for CVN 79 are likely to exceed the $11.4 billion estimate.

Related GAO reports: GAO-07-866, GAO-07-943T, GAO-13-396, GAO-15-22, GAO-16-84T, GAO-17-418, and GAO-17-575.

08.
Navy Is Increasing Knowledge for Some Programs

The Navy has taken some actions to improve knowledge and reduce risk prior to key milestones. Building a ship class, however, is a complex and lengthy endeavor that can span several decades. Thus, it could take many years to see the outcomes of the actions the Navy has taken to implement improved practices from reform efforts and policy changes. Further, some reform efforts, such as reducing technology risk and increasing design stability, cannot be fully integrated into existing ship classes; therefore, any improvements based on these reforms will only be known once new classes begin construction in the early 2020s, according to the Navy's most recent shipbuilding plan.

Reducing Technology Development Risk: The Navy has taken steps to reduce technical risk in a few forthcoming ship classes by limiting the number of technologies to be developed and—in some cases—maturing them prior to entering the design and construction phases, in line with GAO-identified best practices. This approach represents a significant change from the high-risk approach undertaken by the CVN 78 and DDG 1000 programs, in which the Navy undertook development of numerous new technologies, and could help improve the Navy's shipbuilding business cases going forward.

Increasing Design Stability before Construction: Some recent shipbuilding programs have reflected a more purposeful focus on finishing design prior to construction, an approach that aligns with GAO-identified best practices for shipbuilding. For example, the Columbia class submarine program is aiming for a higher percentage design completion at the start of construction than many of the Navy's other shipbuilding programs. The Navy is also reducing design risk and increasing the likelihood of completing design before ship construction by utilizing existing designs more frequently.

FFG(X)

The Navy originally planned to accelerate its new frigate program and limit competition to only the two shipyards building LCS variant ships. We recommended that the Navy delay procurement plans until cost estimates were completed and the Navy attained more knowledge about design and testing. The Navy has recently delayed the program by one year to achieve additional knowledge and is now planning on conducting a full and open competition.

Source: FFG(X). U.S. Navy. | GAO-18-238SP

T-AO 205

The T-AO 205 John Lewis Class Fleet Replenishment Oiler reported its critical technologies were fully mature in October 2014, almost 2 years before it awarded a contract for the design and construction of the first ships in the class.

Source: T-AO 205 rendering. General Dynamics NASSCO. | GAO-18-238SP

DDG 51

Although we have reported on some issues with the Navy's acquisition strategy for Flight III of the DDG 51 class, the Navy has taken steps to increase knowledge at key points, in line with our identified best practices for shipbuilding. For example, the Navy limited technology development for the new flight of DDG 51 class destroyers by focusing on four systems needed to incorporate an upgraded radar onto the ships and modifying existing technologies. The Navy also plans to complete design efforts before beginning construction.

Source: DDG 112. U.S. Navy photo courtesy of General Dynamics Bath Iron Works. | GAO-18-238SP

Related GAO reports: GAO-07-866, GAO-08-804, GAO-09-322, GAO-16-329SP, GAO-16-613, GAO-17-333SP, and GAO-18-158.

09.
Funding and Acquisition Processes Do Not Align

Due to the dynamics of weapon system budgeting, the effort necessary to secure funding for a shipbuilding program sometimes runs counter to the process of attaining sufficient knowledge. At the time the Navy requests funding from Congress to construct a new ship, the Navy often promises high-performing ships with ambitious schedules at an affordable cost. This leads to the weak business cases we have observed because the funding process incentivizes the creation of optimistic cost, schedule, and performance goals prior to developing the knowledge necessary to understand the resources required to execute the program. In other words, the requirements, technologies, and cost estimates for a shipbuilding program—essential to the development of a sound business case—may not be well understood at the time the Navy makes its funding request to construct a ship, or later when Congress makes the funding decision. Once the ship is funded and construction progresses, the gap between the over-promised ship and the reality of the shipbuilding effort becomes evident, which creates pressure as costs and schedules grow beyond initial estimates.

The Navy has also requested that Congress authorize it to purchase multiple ships at once—through multi-year procurement authority and authority it refers to as block buy—before it had robust knowledge about the program's costs. According to the Navy, purchasing multiple ships at the same time can help save money. However, doing so without requisite knowledge of the technology, design, and construction efforts could result in the Navy taking on the risk of cost growth across multiple ships, potentially negating anticipated savings.

At the time the Navy requested funding for the construction of CVN 78 in 2007 it had already received a total of $3.7 billion in advance procurement funding for the program. The program used these funds to initiate design activities, purchase long-lead materials, and build 13 percent of the ship's construction units. However, at that time the program had considerable unknowns—technologies were immature and cost estimates unreliable. Similarly, when the Navy requested authorization to construct CVN 79, it had already received nearly $3.3 billion toward construction efforts for the carrier, even though the Navy still had an incomplete understanding of the costs required to construct and deliver the lead ship. In these scenarios, the government has a limited ability to walk away from the investment once it is underway, even when ships fall short of expectations.

CVN 78

Source: CVN 78. U.S. Navy photo by Erik Hildebrandt. | GAO-18-238SP

DDG 51

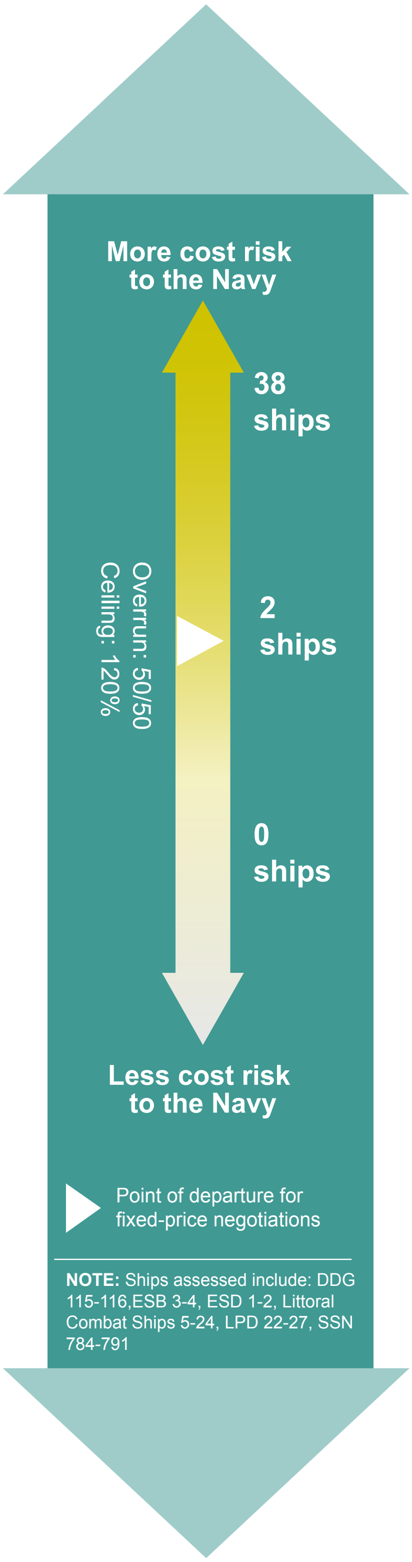
LCS

Source: DDG 112. U.S. Navy photo courtesy of General Dynamics Bath Iron Works; LCS 2. U.S. Navy photo by Mass Communication Specialist 1st Class Ace Rheaume. | GAO-18-238SP

In the case of DDG 51 Flight III, the Navy asked Congress for and received multi-year procurement authority to procure nearly half of the ships before the flight met the criteria for requesting this authority. In particular, detail design was not complete and cost estimates were not informed by any Flight III construction history. In the case of the LCS, the Navy asked for and received what the Navy refers to as block buy authority from Congress to commit to up to 20 ships with limited knowledge about the resources required to execute the program. Our analysis of the LCS contracts found that a block buy approach could affect Congress's funding flexibility. For example, the LCS block buy contracts provide that a failure to fully fund a purchase in a given year would make the contract subject to renegotiation, which provides a disincentive to the Navy or Congress to take any action that might disrupt the program.

Related GAO reports: GAO-08-804, GAO-13-530, GAO-16-84T, GAO-16-356, GAO-16-613, GAO-17-262T, GAO-17-323, and GAO-17-575.

10.
Navy Pays for Majority of Cost Increases and Deficiencies



Source: GAO analysis of Navy information. | GAO-18-238SP

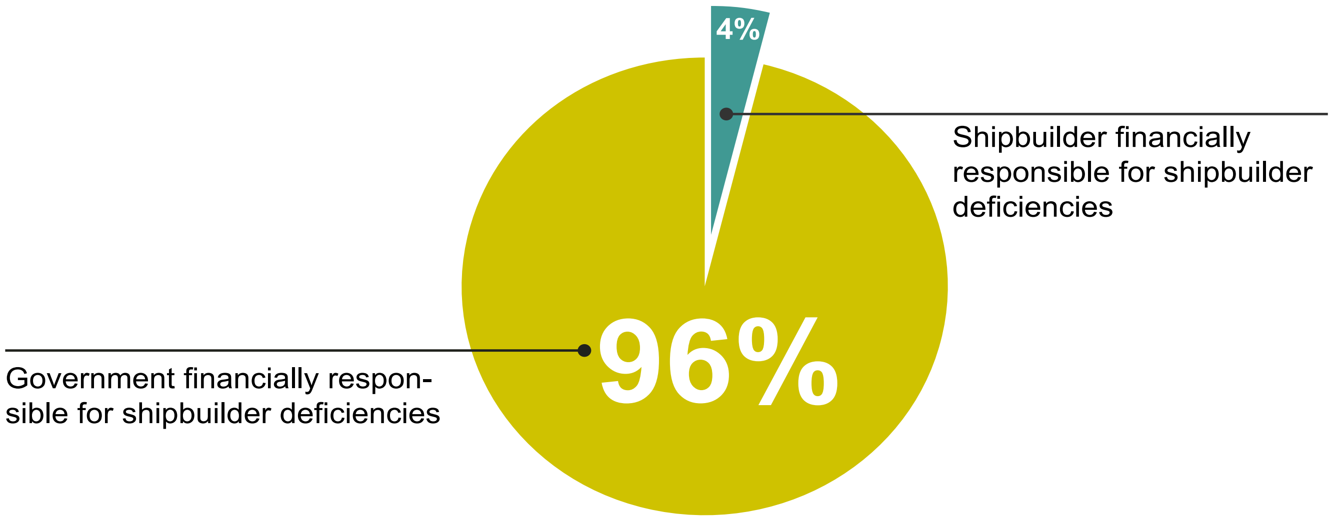
Once funding is secured, the Navy negotiates contract terms that align with the program's optimistic cost expectations, while addressing any lingering uncertainties regarding the effort necessary to build the ship. During negotiations, the Navy must navigate a unique industrial base that is characterized by a symbiotic relationship between the Navy and a limited number of shipyards. Taken together, these factors limit the government's ability to negotiate favorable contract terms and the Navy absorbs the preponderance of risk for cost overruns, schedule delays, and quality deficiencies.

Absorbing the Majority of Cost Risk in Its Construction Contracts: The Navy has generally used cost-reimbursement contracts for lead ships and fixed-price incentive contracts for follow-on ships.

The Navy negotiated cost-reimbursement contracts for construction of the first ships in the CVN 78, LPD 17, LCS, DDG 1000, and SSN 774 ship classes because it did not have a complete understanding of the effort needed to construct these ships at the time of contract award. Under cost-reimbursement contracts, the Navy generally reimburses the shipbuilder for its allowable incurred costs, and the shipbuilder agrees to use its best efforts to perform the work within the estimated cost. These types of contracts may be appropriate for developmental projects, such as cutting-edge weapon system research and testing. However, when these types of contracts are used for ship construction, the Navy assumes more cost risk because the shipbuilder is reimbursed for its allowable incurred costs within the cost ceiling regardless of whether the shipbuilder produces a complete end item. For example, since the Navy awarded the two lead LCS as cost reimbursement type contracts, the prime contractors were only required to give their best efforts to deliver complete ships. After incurring 150 percent cost growth, the Navy took delivery of two deficient and incomplete ships.

Fixed-price incentive contracts are typically more effective than cost-reimbursement contracts in terms of controlling cost risk to the government. When using fixed-price incentive contracts, the Navy and the shipbuilder share the risk of cost overruns up to a maximum price (ceiling), above which the shipbuilder generally absorbs all additional costs. However, there is significant technical risk and cost uncertainty even for follow-on ships, particularly when the lead ship is not yet finished at the time of follow-on ship contract award. To account for unresolved risks, we found that the Navy structured its fixed-price incentive contract elements to assume more responsibility for cost growth than Department of Defense guidance recommends. When the structure of the contract elements results in the government bearing a greater amount of the cost risk, the effectiveness of fixed-price incentive contracts in motivating the shipbuilder to control costs may be weakened. We have previously found that the Navy often relied upon contract structures that left a higher level of risk with the Navy, often because an incomplete understanding of the effort needed to complete the ship translated into uncertainty about costs. For example, we found that fixed-price incentive contracts awarded for follow-on ships in the LPD 17 and LCS classes contained unrealistic cost targets that did not accommodate the high degree of unresolved technical risks in the programs, resulting in the Navy paying the maximum costs (under the contract's price ceiling) for half of the delivered ships we reviewed. In addition to the fixed-price incentive cost elements, which are intended to incentivize the shipbuilder, we also found that the Navy included over $700 million in additional incentives for the contracts we reviewed. The Navy agreed with our recommendation to assess the extent to which such added incentives improve shipbuilder performance. The Navy is in the process of taking action on this and other issues.

Paying to Correct Shipbuilder-Responsible Deficiencies: Although fixed-price incentive contracts can be more effective than cost-reimbursement contracts at controlling cost risk to the government, the Navy's fixed-price incentive contracts do not necessarily ensure that it receives a deficiency-free ship at delivery. We found that the Navy structures shipbuilding contracts so that it pays shipbuilders to build ships as part of the construction process and then pays the same shipbuilders a second time to repair the ship when construction defects are discovered. For example, on LPD 25, the ship's exterior hull paint began to peel shortly after delivery. The Navy determined that the shipbuilder had not adequately prepared the surface of the ship prior to applying a second coat of paint. The shipbuilder re-painted the vessel but the Navy paid for the work. Navy officials stated that this approach reduces the overall cost of purchasing ships because the government agrees to absorb the greater burden of paying for repairs; however, the Navy had no analysis that proved this point. As a result of our work, the Navy has improved some of its practices, such as no longer paying cost plus profit to the shipbuilders for correcting some shipbuilder-responsible deficiencies after delivery, but has not fully addressed this issue.



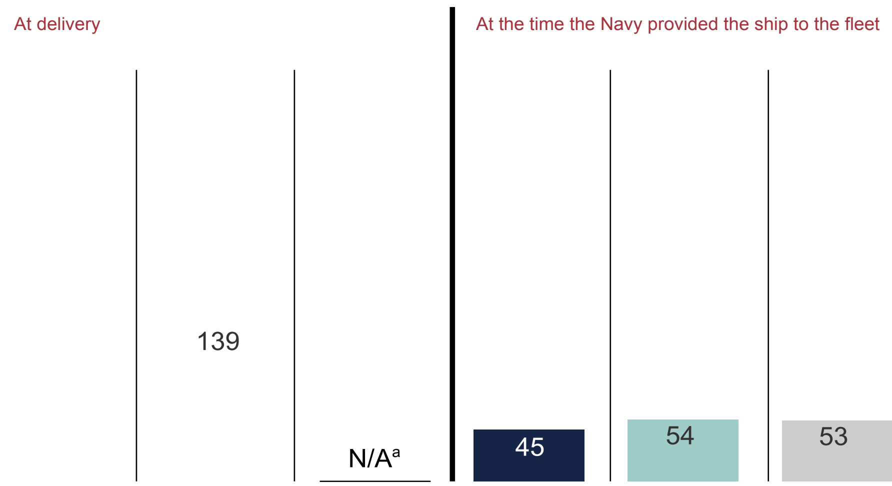
Source: GAO analysis of Navy information. | GAO-18-238SP

Related GAO reports: GAO-09-322, GAO-16-71, and GAO-17-211.

11. Navy Deviates from Inspection and Test Procedures

We found that the Navy has accepted delivery of ships in an incomplete or deficient state in an attempt to minimize the cost and schedule growth when a weak business case begins to break down. While this approach helps the Navy manage short-term cost and schedule pressures, it can short-change the quality assurance process and create problems that carry forward through the post-delivery period—even into fleet operations.

Number of quality problems/defects



Significant construction deficiencies
Systems not meeting minimal functional standard
Significant deficiencies in mission-essential equipment
a This information is not evaluated at delivery

Source: GAO analysis of Navy data. | GAO-18-238SP

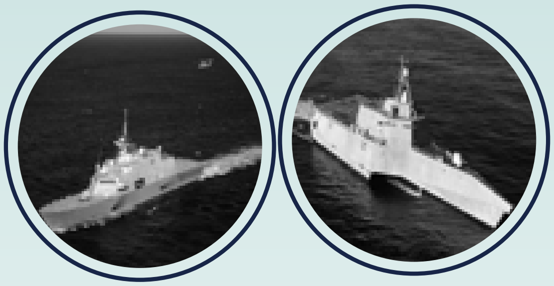
NOTE: Selected lead and follow-on ships included in this analysis: LHA 6, LCS 3, LCS 4, DDG 112, LPD 25, and SSN 782

Accepting Delivery of Incomplete Ships: The Navy often takes delivery of incomplete ships in an effort to alleviate some of the pressures caused by unrealistic cost and schedule estimates, since shipbuilding cost and schedule are often measured until delivery. Navy program offices can do so because the Navy's ship delivery policy, while providing that ships should be defect-free and mission-capable, lacks clarity regarding what constitutes a defect and by when defects should be corrected. Without a clear policy, Navy program offices define their own standards and timelines for quality and completeness, which are not always consistent. This practice results in the Navy accepting delivery of incomplete ships that frequently require up to a year or more of additional construction-related work in the post-delivery period, before the ships are eventually provided to the fleet for operations. Even after this additional work period, in all cases we reviewed, Navy ships continued to have deficiencies when provided to the fleet. When this happens, fleet operations can be negatively impacted and the fleet often becomes responsible for funding and scheduling the correction of lingering deficiencies, which creates a maintenance backlog from the first day of service and can disrupt operational schedules. As a result, we have recommended in multiple reports that the Navy should clarify its ship delivery policy to define what constitutes a complete ship and by when this should be achieved. The Navy agreed that complete ships should be provided to the fleet but disagreed that its ship delivery policy is unclear and results in ships being provided to the fleet with outstanding deficiencies and quality challenges.

For some lead ships—LCS 1, LCS 2, CVN 78, and LPD 17—the Navy did not initially plan to accept delivery of incomplete ships but chose to do so after encountering major challenges during construction. For these ships, the Navy prioritized concerns about increasing costs and schedule delays over having the contractor complete all construction work before delivery. In other cases, such as DDG 1000 and LHA 6, the Navy planned to accept incomplete ships by intentionally deferring some construction to the post-delivery period. According to Navy program officials, the Navy primarily accepts delivery of incomplete ships to mitigate cascading delays to other ships in the shipyard, which could increase costs. For the follow-on

The Navy accepted delivery of LCS 1 and LCS 2 in incomplete, deficient condition, while deferring significant portions of required ship inspections until after delivery.

The Navy declared initial operational capability for both LCS variants even though Department of Defense testers found the ships to be not suitable for operations.



LCS 1 LCS 2

Source: LCS 1. U.S. Navy photo by Mass Communication Specialist 2nd Class Nathan Laird; LCS 2. U.S. Navy photo by Mass Communication Specialist 1st Class Ace Rheaume. | GAO-18-238SP

The Navy did not establish clear deadlines for resolving deficiencies identified during the limited inspections, so corrections were allowed to lag and the fleet inherited unresolved starred deficiencies on both ships.

The Navy sought but did not receive waivers for LCS survivability testing, which verifies a ship's ability to avoid, withstand, or recover from damage.

ships in the DDG 1000 class and CVN 79, the Navy similarly plans to finish these ships after delivery, which may reduce near-term cost pressures and allow the Navy more time for technology development, but initially results in accepting delivery of incomplete vessels.

Limiting Ship Inspections:

We have found in several cases that the Navy has taken steps to limit ship inspections outlined in the Navy's ship delivery policy. These inspections are intended to ensure the Navy is accepting delivery of a ship that meets expectations for mission capability. In certain cases, the Navy has reduced the amount of the ship inspected prior to delivery, while in other cases, the Navy has taken delivery of ships that have not been inspected at all. The Navy also limits inspections of portions of ships by deferring some construction work until after the ship is delivered and inspections are complete. This approach enables the Navy to better maintain its delivery schedule, but often results in providing ships to the fleet that are not complete or have significant deficiencies. The Navy stated that its current inspection processes balance cost and schedule constraints against quality goals in its shipbuilding programs.

Reducing Test Requirements:

By attempting to reduce the scope of or seeking waivers for key tests, shipbuilding programs can save money in the short term and speed up when ships are provided to the fleet. For example, the Navy may limit operational testing of DDG 51 Flight III with its new radar and combat system upgrade. However, this practice undermines Department of Defense and Navy processes for verifying that ships meet performance expectations. Further, when ships fall short of requirements, there is no process to ensure that the Navy makes corrections to meet performance expectations in the longer term.

Related GAO reports: GAO-07-943T, GAO-13-396, GAO-14-122, GAO-14-827, GAO-15-22, GAO-15-503, GAO-16-201, and GAO-17-418.

12.
Inconsistent and Unclear Reporting

The Navy is required to provide Congress and other decision makers with key information to help inform funding and oversight decisions throughout the acquisition process. However, without consistent and meaningful information about cost, schedule, and capability expectations, decision makers may not have full insight into the Navy's progress toward ship completion or could be surprised to learn of complications that may require additional funding. Incomplete or inaccurate information enables the Navy to carry forward unchecked risk in its programs for longer periods of time than recommended by Department of Defense guidance and GAO-identified best practices.

Reporting Inconsistent and Incomplete Information about Technology Development: In some cases, the Navy has not consistently identified critical technologies in accordance with GAO-identified best practices, including reporting technologies to be more mature than testing had demonstrated. Without fully acknowledging all technical risk, programs can undermine the oversight mechanisms intended to ensure these risks are addressed prior to key ship milestones, such as the start of construction.

Reporting Unclear Information to Congress: We have identified areas where the Navy can improve the timeliness and content of its Selected Acquisition Reports—normally an annual report provided to Congress with key information about each Navy shipbuilding program—to better inform congressional oversight. First, we found that the Navy had not established separate reporting requirements for major shipbuilding efforts, such as new flights of ships, which represent major technology or design changes within an existing class, or for individual aircraft carriers. Second, we found that the Navy did not clearly and consistently communicate its programs' progress toward achieving capability and completeness in its Selected Acquisition Reports. Specifically, we found that the Navy's reporting of initial operational capability was often based on meeting certain schedule milestones rather than demonstrating capabilities through successful completion of operational testing. Further, we found that the Navy took delivery of ships in varying states of completeness; thus, the Navy's reporting of delivery was not a reliable measure of ship completion.

Due to these reporting weaknesses, Congress may be unable to ensure that programs address risks prior to receiving funding and moving forward with the ship acquisition. We made a number of recommendations to improve the Navy's reporting; the Navy agreed with some of them and is in the process of making changes, but disagreed with others, such as reporting on individual aircraft carriers.


LCS

The Navy reported that a key LCS minehunting system was mature before developmental testing was complete. Following developmental testing, the Navy endeavored to improve key components of this system before eventually abandoning it.

Source: LCS 1. U.S. Navy photo by Mass Communication Specialist 2nd Class Nathan Laird. | GAO-18-238SP


SSBN 826

We recently found that the Navy did not follow GAO-identified best practices for identifying critical technologies, thereby under-reporting the technical risk facing the SSBN 826 program. Congress has since required additional and more frequent reporting requirements for the program, including information on technology development, design progress, and reliability.

Source: SSBN 826 rendering. General Dynamics Electric Boat. | GAO-18-238SP


CVN 78

The Navy's Selected Acquisition Reports for CVN 78 provide aggregate program cost data, instead of the cost for each carrier. This practice limits transparency into individual ship costs, which are expected to be in excess of $11 billion per carrier.

Source: CVN 78. U.S. Navy photo by Erik Hildebrandt. | GAO-18-238SP


DDG 1000

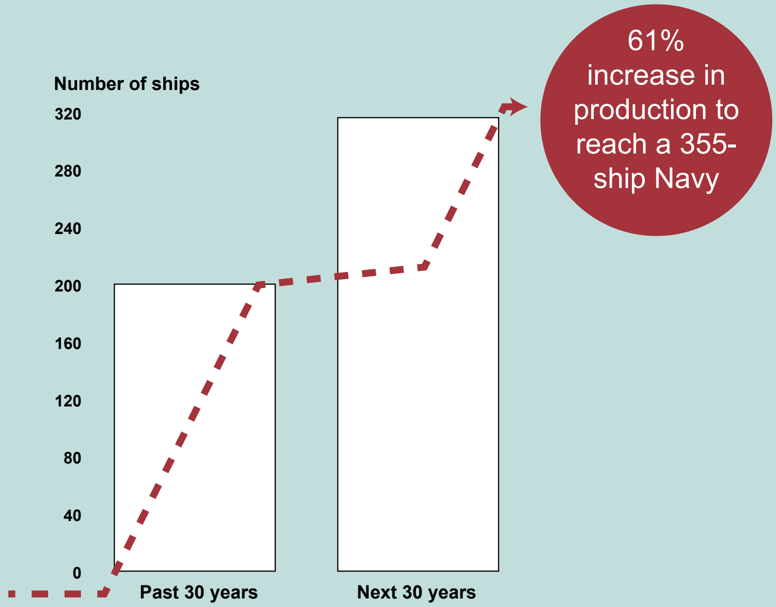
The Navy initially reported April 2016 as the planned delivery date for DDG 1000's hull, but this date did not account for work needed to complete the ship's combat systems. In 2017, Congress directed the Navy to adjust DDG 1000's delivery date to reflect the date on which the Navy determines the vessel is assembled and complete. As such, the Navy changed the delivery date of DDG 1000 by approximately 2 years and subsequently revised its reporting of the delivery dates for the follow-on ships in the class.

Source: DDG 1000. U.S. Navy photo courtesy of General Dynamics Bath Iron Works. | GAO-18-238SP

Related GAO reports: GAO-12-113, GAO-13-530, GAO-15-22, GAO-16-613, GAO-17-418, GAO-17-575, and GAO-18-158.

Next Steps:
Opportunities for Future Improvement

The Navy's tendency to proceed with shipbuilding programs before it has the requisite knowledge has resulted in the Navy not achieving its stated goals. The Navy's approach and the poor acquisition outcomes that followed—cost growth, schedule delays, quality issues, and performance shortfalls—have prevented the Navy from purchasing ships in the quantities and with the capabilities it planned, and have put its long-range plans at risk.



Source: GAO analysis of Navy information. | GAO-18-238SP

The Navy will continue to face daunting acquisition challenges over the next decade as it begins a long-term effort to significantly increase the size of its fleet. Though the Navy has started to make some improvements, its current approach to shipbuilding leaves it at risk of continually losing buying power and jeopardizes its ability to achieve its long-range shipbuilding goals. To the extent that the Navy's ability to achieve a more modern and larger fleet relies on building new ship classes, such as the Columbia class submarine and the new guided missile frigate, it is particularly important that the Navy takes steps to improve the business cases of its new programs before starting construction. Achieving requisite knowledge before starting construction is not a simple goal given the other factors that influence shipbuilding decisions. If we think of the Navy's shipbuilding acquisition processes as merely "broken," then some targeted repairs should easily fix it. However, the challenge is greater than that, as the risks associated with building ships are implicitly accepted as the cost of getting these ships to the fleet as quickly as possible.

The key to overcoming the cycle of cost growth, schedule delays, and capability shortfalls in shipbuilding programs is for decision makers within the Department of Defense, the Navy, and Congress to demand that programs be supported by executable business cases. Only when decision makers embrace this more disciplined approach to buying ships will acquisition outcomes improve and the needs of the fleet be consistently met.

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

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

Michele Mackin
Managing Director, Contracting and National Security Acquisitions

Shelby S. Oakley
Director, Contracting and National Security Acquisitions

List of Congressional Committees

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

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

The Honorable Kay Granger
Chairwoman
The Honorable Peter J. Visclosky
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Objective, Scope, and Methodology

To identify common issues across the Navy's shipbuilding portfolio and challenges within specific programs, we reviewed and summarized our past findings and recommendations on Navy shipbuilding and acquisition best practices. Detailed information about how we arrived at these findings and recommendations is contained in the objectives, scope, and methodology section of each of our prior reports and testimonies. A list of our prior reports and testimonies is provided at the end of this report.

To develop the graphics presented in this report, we updated analyses from our prior work to include current data on funding, cost, schedule, and other shipbuilding metrics, where appropriate. The methodology used to compile each graphic is described below.

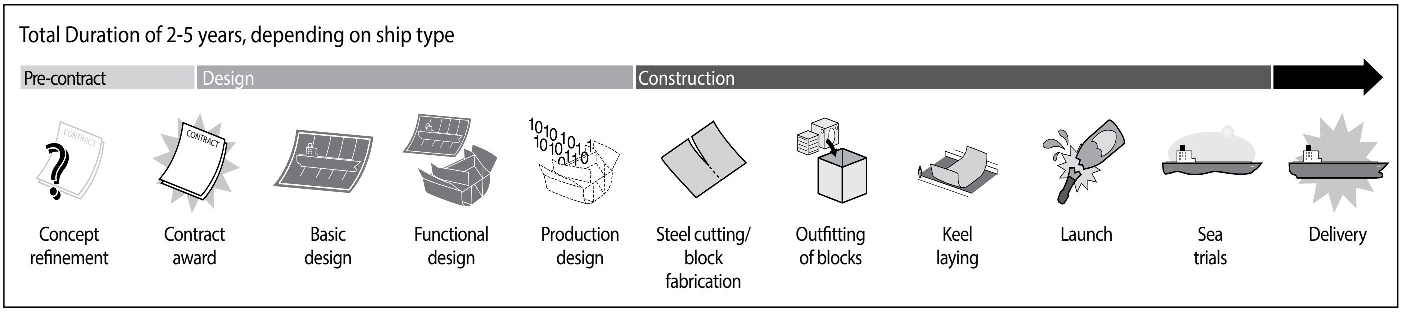
- **Comparison of fleet size and funding plans in 2007 and 2018 (page 1):** To assess the Navy's fleet size plans versus its inventory, we reviewed the Navy's 2007 long-range shipbuilding plan and compared it with the Navy's vessel register as of January 2, 2018. We then compared the funding estimates in the Navy's 2007 long-range shipbuilding plan with the Navy's shipbuilding and conversion appropriations from 2007 to 2018. All funding estimates and calculations are in constant fiscal year 2018 dollars.
- **Lead ship cost growth (page 8):** Cost growth is measured as the difference between the cost estimate reflected in the Navy's budget request documents prior to ship construction (year in which the Navy requested authorization for the ship from Congress) and the cost estimate reflected in the Navy's fiscal year 2018 budget request documents or the actual cost. All cost estimates and cost growth calculations are in constant fiscal year 2018 dollars. We assessed lead ships from ship classes that were under construction at some point during the past 10 years.
- **Follow-on ship cost estimates (page 8):** Percent cost difference of follow-on ships is measured by comparing the Navy's initial average procurement unit cost at program start in its Selected Acquisition Report against the average of the initial cost estimate in the Navy's budget request (year in which the Navy requested authorization for the ship from Congress) for all follow-on ships in each class. All cost estimates and calculations are in constant fiscal year 2018 dollars. We assessed ship classes with five or more follow-on ships under construction at some point during the past 10 years.
- **Lead ship schedule delays (page 9):** Schedule delays are measured as the difference between the planned obligation work limiting date reflected in the Navy's budget request documents prior to ship construction (year in which the Navy requested authorization for the ship from Congress) and the obligation work limiting date reported in the Navy's fiscal year 2018 budget documents or the actual date. In this report, we refer to the obligation work limiting date as the date a ship is provided to the fleet. We assessed lead ships from ship classes that were under construction at some point during the past 10 years.
- **LCS follow-on ship schedule delays (page 9):** To assess LCS follow-on ship schedule delays, we compared the actual or currently planned delivery date for LCS 5 – 28 to the original delivery dates. With respect to LCS 5 through 24, the original delivery dates are described in the original versions of the block buy contracts. With respect to LCS 25 through 28, the original delivery dates are described in the block buy contract modifications adding these ships. Data on current delivery dates are drawn from Navy contracting and budget documents.

- **Starred deficiencies for lead and follow-on ships (page 10):** To determine the number of starred deficiencies prior to delivery for lead and follow-on ships in selected classes, we reviewed acceptance trial reports and annual trials reports from the Navy Board of Inspection and Survey. The number of starred deficiencies is presented for each lead ship, alongside the average number of starred deficiencies for follow-on ships in the class that completed acceptance trials before the end of fiscal year 2017.
- **Performance of Navy ship classes (page 11):** We reviewed the Navy's operational test reports and the Department of Defense's corresponding reviews for each ship class tested during the past 10 years. We then documented the Navy's determination of whether or not the ship was found to be operationally suitable and operationally effective during the initial operational test as well as whether or not the ship met its reliability targets.
- **Lead ship technology development, design, and construction concurrency (page 16):** Concurrency is measured as the extent to which there is overlap between two or more of the three main phases of the shipbuilding process—technology development, design, and construction. The technology development phase extends from program start until all critical technologies are mature (i.e., at Technology Readiness Level 7). The design phase extends from the beginning of contract design through the completion of detail design. The construction phase begins with the start of fabrication and ends with ship delivery. We assessed lead ships from ship classes that were under construction during the past 10 years.
- **Navy contracting mechanisms (page 20 and 21):** To identify how Navy contracts distribute risk between the government and the shipbuilder, we reviewed the contract terms and other contract file documentation for a non-generalizable sample of six fixed-price incentive contracts for the detail design and construction of 40 ships in five different shipbuilding programs. To identify the extent to which the Navy's guarantee mechanism reduces the government's exposure to additional costs, we analyzed the costs to repair deficiencies after delivery for five Navy case studies. To determine the amount paid by the Navy for the correction of deficiencies, we examined each ship's contract and calculated the amount paid in accordance with the contract.
- **Deficiencies corrected during the post-delivery period for selected ships (page 22):** To determine the extent to which deficiencies were corrected during the post-delivery period for a selection of lead and follow-on ships delivered in the past 5 years, we compared deficiency counts at the time of ship delivery and at the obligation work limiting date, which we refer to in this report as the date the ship was provided to the fleet. The quality and completeness metrics in the deficiency analysis include: (1) unresolved starred and Part I trial deficiencies, (2) incomplete shipboard system certifications, and (3) open casualty reports.

We prepared this report from June 2017 to June 2018 under the authority of the Comptroller General in light of planned increases in ship acquisitions. We conducted the work upon which this product is based in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Key Terms and Concepts

Key Shipbuilding Events
notional shipbuilding process (concept refinement to delivery):

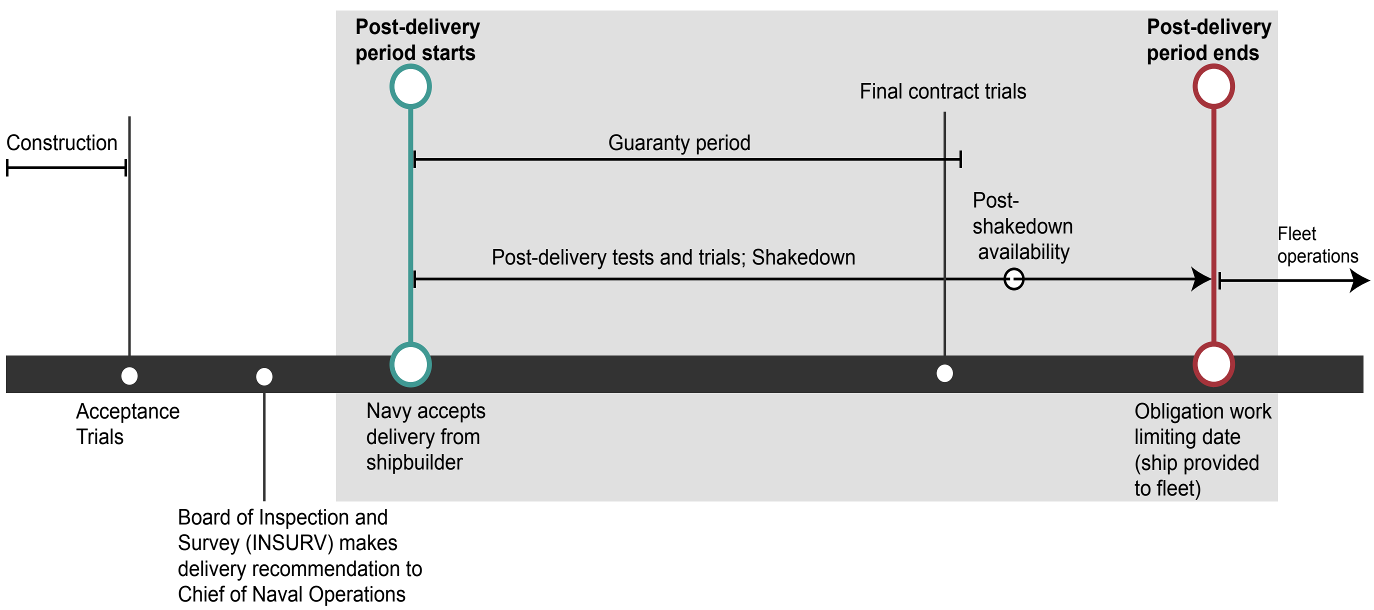


Source: GAO. | GAO-18-238SP

acceptance trials and starred deficiencies: Navy inspectors conduct sea trials for new construction ships to determine if there are any deficiencies. During these trials, Navy inspectors identify starred deficiencies, which are those deficiencies that significantly degrade a ship's ability to perform an assigned primary or secondary mission or prevent the crew from living on board in a safe manner. Typically, these trials are held prior to accepting delivery of a ship.

delivery (from shipbuilder): The Navy takes custody of a new construction ship from the shipbuilder at preliminary acceptance, which is also commonly known as delivery.

post-delivery period: The period of time after a ship is delivered from the shipbuilder but before it enters the fleet, during which the Navy completes a variety of tests, trials, and construction-related work on the ship. Major events of the post-delivery period are shown below.



Source: GAO analysis of OPNAVINST 4700.8K | GAO-18-238SP

obligation work limiting date: The date when full financial responsibility for maintaining and operating a ship is transferred from the acquisition command to the operational fleet. In this report, we refer to the obligation work limiting date as when the ship is provided to the fleet.

operational test and evaluation: A period of testing to characterize the performance of a ship under realistic operational conditions during a discrete period of time. Testers may also use actual mission performance data and data from fleet exercises in making their assessments. In conducting operational testing, testers make a determination regarding the ship's operational effectiveness and suitability:

- For operational effectiveness, testers determine whether or not a ship can perform its missions when operated by the ship's crew.
- For operational suitability, testers determine whether or not the Navy can logistically support the ship in the field, with consideration given to interoperability, safety, and reliability, among other attributes. Interoperability measures the extent to which information systems and other equipment work with other Navy systems, and other U.S. government agencies, such as the Coast Guard. Reliability measures the probability that the system will perform without failure for a certain period of time and in certain conditions.

Contracting Approaches

multi-year procurement: Multi-year contracting is a special contracting method to purchase known requirements for up to 5 years without having to exercise a contract option for each year after the first year if a set of statutory criteria is met. To meet the statutory criteria for requesting multi-year procurement authority, programs must demonstrate that they will achieve significant savings, have a realistic cost estimate, have a stable need for items, have a stable design, have stable funding, and support national security.

block buy contracting: The Navy also uses a procurement approach it calls block buy contracting. Unlike multi-year procurement authority, block buy contracting does not have permanent statutory criteria and, therefore, can be used in different ways. For instance, the Navy used this approach to purchase 20 LCS under two contracts with annual contingencies for funding. In this case, if the Navy did not receive the annual appropriation, the contract(s) could be re-negotiated.

Other Shipbuilding Terms

knowledge-based framework: The knowledge-based acquisition framework captures GAO-identified best practices and operates under the general principle that acquisition programs should attain knowledge and reduce risk before achieving key milestones, such as completing a ship's design before building it. In short, the knowledge-based framework encourages (1) developing technologies and matching resources with capabilities before contract award and ship design, and (2) completing ship design prior to starting construction on the lead ship.

lead and follow-on ships: A lead ship is the first ship of a particular set of ships, typically grouped as a class. Follow-on ships refer to the remaining ships in a class.

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Shelby S. Oakley at (202) 512-4841 or oakleys@gao.gov.

Staff Acknowledgments

In addition to the contact above, the following staff members made key contributions to this report: Diana Moldafsky, Assistant Director; Laurier Fish; Paul Francis; Laura Greifner; Kristine Hassinger; Jessica Karnis; Brendan K. Orino; Kya Palomaki; Jillian Schofield; Robin Wilson; and Marie Ahearn. Our shipbuilding body of work has been supported by many staff members who are acknowledged in the reports listed at the end of this product.

Related GAO Products

Navy Shipbuilding Reports

Columbia Class Submarine: Immature Technologies Present Risks to Achieving Cost, Schedule, and Performance Goals. GAO-18-158. Washington, D.C.: December 21, 2017.

Navy Shipbuilding: Policy Changes Needed to Improve the Post-Delivery Process and Ship Quality. GAO-17-418. Washington, D.C.: July 13, 2017.

Ford-Class Aircraft Carrier: Follow-On Ships Need More Frequent and Accurate Cost Estimates to Avoid Pitfalls of Lead Ship. GAO-17-575. Washington, D.C.: June 13, 2017.

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