Congressional Budget Office
Nonpartisan Analysis for the U.S. Congress

Maintenance Delays for Conventional Navy Ships

DECEMBER | 2025

At a Glance

The Navy has experienced chronic delays and labor overruns in maintenance on its large conventional ships (that is, ships that are not nuclear-powered). Those delays can affect deployment schedules and limit the operational readiness of the Navy's fleet. In this report, the Congressional Budget Office analyzes maintenance events for two types of such ships—destroyers and amphibious warfare ships—from October 2010 to September 2024.

Maintenance for large conventional combat ships often takes longer than expected. CBO projects that DDG-51 class destroyers will spend an average of nine years, or more than a quarter of their planned service life, out of the fleet for maintenance. That is more than twice as long as estimated in their 2012 class maintenance plans.

Schedules for overhauls underestimate their duration, and changes to those schedules have not closed the gap. Maintenance events often take 20 percent to 100 percent longer than estimated in the Navy's final schedules for those events. The Navy has raised its estimates, but the delays have continued to increase—especially for older ships, which have longer scheduled overhauls.

Maintenance delays are driven by many factors. Several likely causes of maintenance delays were reported by representatives of the Navy, the private shipyards that maintain the Navy's conventional ships, or both:

- The aging of the fleet,
- Late inspections and contract awards,
- Unexpected additional work and contract negotiations,
- Delays in obtaining parts and materials,
- Poor integration of modernization (which is performed separately by contractors) with maintenance work, and
- Contract incentives that emphasize keeping costs low over completing work on time—although some Navy officials disagreed with that characterization.

In previous analyses, CBO found that capacity constraints at Navy shipyards had led to delays in nuclear ship maintenance. CBO did not identify capacity constraints as a driver of delays in maintenance for conventional ships.

Contents

Summary 5
How Large Are Maintenance Delays and Labor Overruns? 5
How Large Are Maintenance Delays for DDG-51s? 7
What Are the Causes and Consequences of Maintenance Delays and Labor Overruns? 7

Chapter 1: Maintenance Delays and Labor Overruns for Large Conventional Combat Ships 9
Maintenance Events in the Navy's Data 9
How the Navy Estimates Durations and Labor for Maintenance Events 11
How CBO Measured the Performance of Maintenance Events 12
Limitations of CBO's Analysis 14

Chapter 2: Maintenance Delays and Labor Overruns for DDG-51 Class Guided Missile Destroyers 15
The DDG-51 Fleet and Its Class Maintenance Plans 15
Trends in Budgets for Destroyer Maintenance 17
Delays and Labor Overruns for DDG-51s' Docking Maintenance Events 17
Delays and Labor Overruns for DDG-51s' Nondocking Maintenance Events 22
DDG-51s' Total Duration of Maintenance Over Their Service Life 24

Chapter 3: The Causes and Consequences of Maintenance Delays 27
Causes of Steadily Increasing Durations and Labor Use 27
Causes of Unexpected Delays and Labor Overruns 29
Consequences of Maintenance Delays 35

Appendix A: Maintenance Delays and Labor Overruns for Amphibious Ships 37

Appendix B: Maintenance Data From Naval Sea Systems Command 41

Appendix C: Projecting Total Duration and Labor for Unfinished Overhauls 43

List of Tables and Figures 49

About This Document 50

Notes About This Report

All years referred to in this report are federal fiscal years, which run from October 1 to September 30 and are designated by the calendar year in which they end.

Throughout this report, the terms "overhaul" and "maintenance event" are used to encompass all periods of depot maintenance. Depot maintenance is the most intensive type of maintenance and makes a ship unavailable for training and operations. For details, see Department of Defense, "DoD Maintenance of Military Materiel," DoD Instruction 4151.18 (August 30, 2024), https://tinyurl.com/4xsdswk4; and 10 U.S.C. § 2460.

The Navy separates the maintenance of nuclear and conventional (petroleum-fueled) ships. Most maintenance for conventional ships is performed under contract at private shipyards. By contrast, most maintenance for nuclear-powered ships is performed at Navy shipyards. In an earlier report, the Congressional Budget Office analyzed significant delays that the Navy's four shipyards have experienced in completing maintenance on its submarines (which are nuclear-powered). See Congressional Budget Office, *The Capacity of the Navy's Shipyards to Maintain Its Submarines* (March 2021), www.cbo.gov/publication/57026.

Shortly before this report was published, CBO received an update from the Navy that included data for fiscal year 2025. Processing the new data will take time, but a preliminary review indicates that the 2025 data are generally consistent with the data from 2011 to 2024 on which CBO's analysis was based.

On the cover: The amphibious transport dock ship USS *San Diego* (LPD-22) at the BAE Systems shipyard in San Diego. Photo by R. Derek Trunkey.

Maintenance Delays for Conventional Navy Ships

Summary

The Navy's operational readiness depends on reliably estimating the time and resources needed to complete routine maintenance events. An overhaul of a ship that takes longer than expected can disrupt the training and deployment schedules for that ship and others. If maintenance events often take longer than planned, the Navy has fewer ships that it can deploy—and thus, in effect, a smaller fleet. For more than a decade, the Navy has experienced long delays and labor overruns in completing maintenance events for many of its ships.

In this report, the Congressional Budget Office examines delays and labor overruns in maintenance events for destroyers and amphibious warfare ships—two types of large conventional (that is, non-nuclear-powered) combat ships—from October 2010 to September 2024.[1] At the end of that period, the Navy had 108 such ships in its 296-ship battle force. The maintenance for conventional ships is mostly conducted in private shipyards, unlike the maintenance of nuclear-powered ships, which CBO has analyzed in previous reports.[2]

The Navy's maintenance approach varies by ship class. Each class of ships has a maintenance plan that specifies when overhauls will occur during a ship's service life and provides estimates of the time and labor needed for those overhauls. The Navy then updates and refines those estimates in schedules it prepares for each overhaul. CBO compared the performance of overhauls—their durations and labor use—with estimates from ships' class plans, when available, and the Navy's first and last schedules.[3]

CBO found that over fiscal years 2011 to 2024, those overhauls generally took longer and required more labor than the Navy had estimated in the ships' class plans or in the overhauls' schedules. Over their lifetimes, the Navy's destroyers will be out of the fleet for maintenance more than twice as long as estimated in their class plans, CBO projects.

This report begins with an analysis of maintenance for the Navy's overall fleet of large conventional combat ships. It then focuses on Arleigh Burke class (DDG-51) guided missile destroyers, which make up about two-thirds of the fleet and accounted for a similar share of the overhauls CBO analyzed. The report concludes with a discussion of likely reasons for, and consequences of, the fleet's maintenance delays and labor overruns.

How Large Are Maintenance Delays and Labor Overruns?

CBO analyzed data from Naval Sea Systems Command (NAVSEA) to measure delays and labor overruns in 225 maintenance events for destroyers and 89 for amphibious warfare ships that occurred between 2011 and 2024 (see Table S-1). CBO focused on depot maintenance events—overhauls that take ships out of service for major repairs or upgrades—that were performed in the United States.

For each overhaul, about two years before work on the ship begins, the Navy develops a first schedule and a labor estimate based on the ship's unique needs and circumstances.[4] The schedule is revised several times as the start of the overhaul approaches. Inspections of the ship, to determine its condition and identify likely maintenance issues, are a part of that process.

1. This report does not examine cruisers, which are also large conventional combat ships, or small conventional combat ships.

2. Congressional Budget Office, *The Capacity of the Navy's Shipyards to Maintain Its Submarines* (March 2021), www.cbo.gov/publication/57026, and *Costs of Submarine Maintenance at Public and Private Shipyards* (April 2019), www.cbo.gov/publication/55032.

3. CBO used the 2012 class maintenance plans for DDG-51 destroyers, provided by the Navy. Naval Sea Systems Command, *Technical Foundation Paper for DDG 51 Class Type Commander Notionals* (February 2012). No other class plans were provided to CBO.

4. Government Accountability Office, *Navy Ship Maintenance: Evaluating Pilot Program Outcomes Could Inform Decisions to Address Persistent Schedule Challenges*, GAO-20-370 (May 2020), p. 28, www.gao.gov/products/gao-20-370.

Table S-1.

Average Maintenance Delays and Labor Overruns Relative to Estimates in the Navy's Last Schedules, by Ship Type, 2011 to 2024

Ship type	Number of maintenance events	Realized delays (percent)[a]	Realized labor overruns (percent)[a]
Destroyers (DDG-51s)	225	26	8
Amphibious assault ships (LHD-1s)	31	27	11
Amphibious transport docks (LPD-17s)	29	45	31
Dock landing ships (LSD-41s and LSD-49s)	29	62	40
All ships in sample	**314**	**33**	**16**

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

See Figure 1-1 on page 10 for descriptions of ship types.

CBO excluded overhauls that were conducted outside of the United States, had no recorded start date, or were not included in a ship's class maintenance plan (when available).

a. Realized outcomes reflect both actual outcomes and outcomes that CBO projected for the 25 maintenance events (roughly 8 percent of the total) that were not yet complete as of September 30, 2024. (For details about CBO's projection methods, see Appendix C.) Many of those unfinished overhauls were already behind schedule or estimated by the Navy to be longer than average; excluding them or treating their durations and labor use as of that date as final outcomes would make estimates of the average duration and labor use for all ships artificially low.

CBO compared the first and last schedules for each overhaul with its actual performance, using the Navy's measures of duration (total time in the shipyard, in calendar days) and labor (measured in days of labor, each equal to one worker's eight-hour shift).[5]

For all types of overhauls, CBO found that, on average, the estimated durations in the Navy's schedules were longer than the estimates in the ships' class plans, and the realized durations were longer than the estimates in the Navy's schedules.[6] Depending on the type of ship, maintenance events for large conventional combat ships took about 30 percent to 60 percent longer, on average, than estimated in the last schedules for the events. Class plans and first schedules were less accurate than last schedules.

The average number of days of labor needed for maintenance events exceeded estimates in the Navy's last schedules by 8 percent to 40 percent, depending on the type of ship and the type of overhaul. Those overruns were about half as large as the average delays, possibly because work paused while shipyards were awaiting parts, inspections, or approvals by the Navy (so that the duration of overhauls increased without a proportional increase in labor).

The duration of maintenance events varied considerably among individual ships, types of ships, and types of overhauls. For example, 4 percent of overhauls for destroyers finished in the time estimated in their class plans, and 5 percent took more than five times as long as the class plans estimated. The shortest overhaul lasted about 60 days and the longest about 2,300 days (or 6.3 years). CBO focused on average performance, but that variance highlights the difficulty in projecting the performance of any particular overhaul.

The time and labor needed for maintenance events have increased significantly since 2011. Despite the Navy's efforts to adjust its estimates, delays and labor overruns have persisted.

5. The Navy records many schedule revisions for each overhaul, labeled W, W', W", X, Y, and Z in its data. The dates when the schedules were created were not provided to CBO and can vary in relation to an overhaul's start date. For example, the last schedule (labeled Y or "Definitization/Award") could be recorded one to six months before an overhaul begins. Schedules are sometimes revised, or "rebaselined," after work begins. Those rebaselined schedules then become the primary metric of shipyards' timeliness. CBO did not have access to rebaselined schedules, so it used the last schedule the Navy issued before the ship entered the shipyard.

6. CBO uses the term "realized" to refer to both actual outcomes for completed overhauls and projected outcomes for overhauls that were still underway at the end of September 2024. Omitting those unfinished overhauls would have skewed the results, understating overhauls' average durations and labor use. For more details, see Appendix C.

How Large Are Maintenance Delays for DDG-51s?

All types of overhauls for destroyers took longer, on average, than estimated in the Navy's class plans or schedules, despite growing maintenance budgets for those ships (see Figure S-1). The estimated duration of overhauls for DDG-51s was about 20 percent longer in the first schedule than in the class plan, and the realized duration of overhauls was about 60 percent longer than estimated in the first schedule.

Together, those delays suggest that, on average, destroyers will spend more than 9 years away from the fleet in maintenance over their planned 35- or 40-year service lives—more than twice as long as estimated in their 2012 class plans. Lengthening the lives of the ships would allow them to spend more time with the fleet but would also require additional maintenance.

What Are the Causes and Consequences of Maintenance Delays and Labor Overruns?

CBO spoke to representatives of private shipyards and the Navy to identify possible reasons for maintenance delays and labor overruns. The most commonly mentioned reasons were the following:

- **Aging ships.** The average age of destroyers increased from 10 in 2011 to 20 in 2024. The same types of overhauls take longer for older ships, but the Navy's class plans made little or no adjustments to the estimated durations of overhauls to account for ships' age. In addition, more destroyers have reached the midpoint of their lives, when longer and more extensive overhauls occur. Older ships also need more modernization and are more likely to need unplanned work.
- **Postponed maintenance.** Postponing overhauls, or postponing some maintenance work to the next overhaul, can lead to longer overhauls because more needed work has built up.
- **Late inspections and contract awards.** Inspections of ships that occur too close to the start of a maintenance event can lead to delays in finalizing contracts, which can, in turn, lead to delays in obtaining parts and materials for the overhaul and in hiring workers to conduct it.
- **Unexpected increases in the scope of work.** When ships require work that was not included in the awarded maintenance contract, shipyards must spend additional time deciding whether to include the work in the current overhaul, negotiating the price for the work, pausing and restarting related work, and waiting for any needed parts to arrive.
- **Delays in obtaining parts and materials.** Before an overhaul begins, the necessary parts and materials must be ordered. Some parts can take months or years to acquire and often arrive later than expected. During the coronavirus pandemic, supply-chain challenges further increased delays.
- **Poor integration of modernization work.** Maintenance overhauls often coincide with modernization work, which involves adding new systems or capabilities to a ship. However, such work is defined in a separate contract and is not usually conducted by the shipyard that performs maintenance. Coordination between modernization contractors and shipyards has been problematic, causing delays.
- **Contract incentives that encourage low costs over timely completion.** Experts told CBO that the Navy's current approach to contracts emphasizes low costs, unlike an earlier approach that emphasized long-term continuity and encouraged shipyards' efficiency. Some industry and Navy representatives said the change in approach may have contributed to delays, though other Navy representatives disagreed.

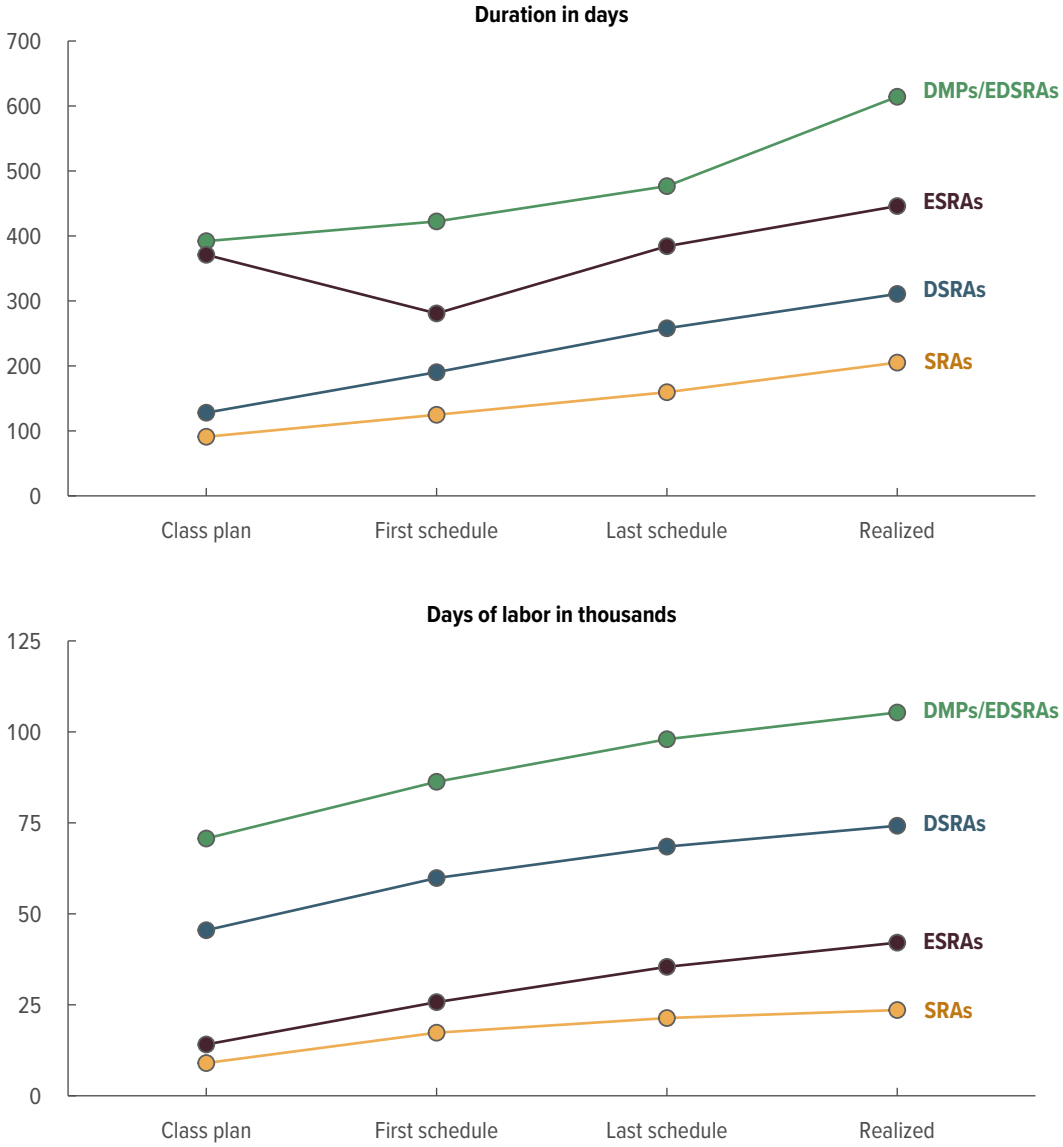
Some of those causes of delays and labor overruns are temporary or outside of the Navy's control, such as supply-chain disruptions. Others reflect choices the Navy has made to accommodate financial or operational priorities: skipped or shortened ship inspections, delayed maintenance, small inventories of parts, and contracts that incentivize low costs over timeliness.

The effects of maintenance delays on the Navy can be measured in different ways. A common approach is to describe the effect on the Navy's fleet readiness—that is, the number of ships the Navy can deploy at any one time. Chronic delays effectively result in a smaller fleet available for operations and training.

Another approach is to infer the value of the services forgone when a ship is not in the fleet. Given the cost of purchasing and operating a DDG-51 class destroyer, CBO infers that the value to the Navy of an available day for a destroyer is about $600,000. That high

Figure S-1.

Average Estimated and Realized Durations and Days of Labor for DDG-51s' Maintenance Events



Overhauls for DDG-51 destroyers took 20 percent to 150 percent longer, on average, than the Navy had estimated in the ships' 2012 class plans and also took longer than estimated in the Navy's schedules. The days of labor exceeded estimates from the ships' class plans, but those overruns were generally smaller in percentage terms.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

This figure presents outcomes for the 225 DDG-51 overhauls included in Table S-1 on page 6.

Realized outcomes reflect both actual outcomes and outcomes that CBO projected for the small number of maintenance events that were unfinished as of September 30, 2024. For details about CBO's projection methods, see Appendix C.

DDG-51 = guided missile destroyer; DMP = depot modernization period; DSRA = docking selected restricted availability; EDSRA = extended docking selected restricted availability; ESRA = extended selected restricted availability; SRA = selected restricted availability.

value applies to both current and future availability, which highlights the difficult trade-off between keeping a ship in the fleet to support high-priority operations and taking it out of the fleet to maintain it.

Policies and practices that reduced maintenance delays could be considered efficient if they cost less than the value of the additional availability they provided.

Chapter 1: Maintenance Delays and Labor Overruns for Large Conventional Combat Ships

In September 2024, the Navy's 296-ship fleet included 229 combat ships performing various missions. Of those combat ships, 151 were conventional ships. (The rest were submarines and aircraft carriers, which are powered by nuclear energy.) The most common types of conventional combat ships carry some of the nation's most advanced weapon systems and patrol international waters. Regular maintenance and modernization work on those ships must be balanced with the fleet's deployments. Delays in maintenance or repairs, however, can reduce the Navy's operational readiness and the number of ships the Navy can put to sea.

The Congressional Budget Office analyzed the duration of maintenance events and the amount of labor they used for four types of large conventional combat ships: Arleigh Burke class guided missile destroyers (DDG-51s), amphibious assault ships (LHDs), amphibious transport docks (LPDs), and dock landing ships (LSDs; see Figure 1-1).[1] Zumwalt class guided missile destroyers (DDG-1000s) and the newest class of amphibious assault ships (LHAs) were not included in the analysis because there were few maintenance events for those ships in the data.

CBO found that from 2011 to 2024, delays in maintenance events were common among all the classes of ships it examined, and those delays did not get smaller over time. The realized durations of overhauls exceeded the Navy's last estimates by about 20 percent to 60 percent, on average, depending on the class of ship and the type of maintenance event. The Navy's first estimates were even less accurate. Labor overruns in maintenance events were also common, although they were smaller in percentage terms than the delays.

This chapter describes maintenance delays and labor overruns for all four classes of ships CBO examined. For a more detailed analysis of maintenance outcomes for the DDG-51 class destroyer—the most numerous class of ship in the Navy's fleet—see Chapter 2. For an analysis of outcomes for the amphibious ship classes, see Appendix A.

Maintenance Events in the Navy's Data

The Navy provided CBO with data on maintenance events for conventional ships. The data included about 700 overhauls that began between 2011 and 2024; CBO excluded overhauls that were conducted outside of the United States, had no recorded start date, or were not included in a ship's class plan (if the class plan was available). (See Appendix B for more details about CBO's dataset.) CBO compared the duration of a maintenance event and the labor it used with up to three estimates the Navy made before the event: those from the 2012 class plan (for destroyers), the first schedule for the overhaul, and the last update to that schedule before the ship entered the shipyard.

Some overhauls that started during the period covered by the Navy's dataset had not yet finished by September 2024, when that period ended. Many of those unfinished overhauls started within a year or so of September 2024, but others had been underway for several years and were already behind schedule—some significantly so. Omitting those unfinished overhauls from the analysis would make the average delays and labor overruns appear smaller than they really are.

1. For more information about those ships, see Congressional Budget Office, *An Analysis of the Navy's 2025 Shipbuilding Plan* (January 2025), www.cbo.gov/publication/60732. See also Ronald O'Rourke, *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress*, Report RL32109, version 284 (Congressional Research Service, December 5, 2025), www.congress.gov/crs-product/RL32109, and *Navy LPD-17 Flight II and LHA Amphibious Ship Programs: Background and Issues for Congress*, Report R43543, version 150 (Congressional Research Service, March 21, 2025), www.congress.gov/crs-product/R43543.

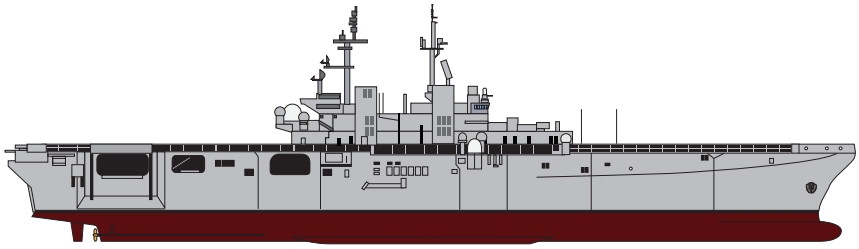
Figure 1-1.

Classes of Large Conventional Combat Ships

DDG-51 class destroyers are the most common surface combatants and are the workhorses of the Navy's fleet. Some provide ballistic missile defense for the fleet and for overseas regions. They defend aircraft carriers and amphibious warfare ships against other surface ships, aircraft, and submarines, and they perform such day-to-day missions as patrolling sea lanes, providing an overseas presence, and conducting exercises with allies. They can also launch Tomahawk missiles at land targets. The DDG-51 class destroyers displace about 9,000 tons.

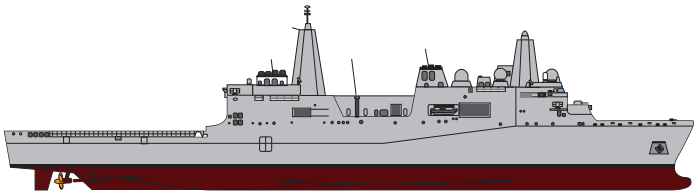
DDG-51 Arleigh Burke Class Destroyer

LHA and LHD class amphibious assault ships are the second-largest types of combat ships in the fleet, displacing 40,000 to 45,000 tons. They are equipped with full-length flight decks to support the operation of helicopters and short take-off/vertical landing aircraft, such as the F-35B. The ships are capable of transporting about half the number of marines for an expeditionary unit and, in most cases, are outfitted with well decks, or internal bays that can be flooded to deploy and recover landing craft or amphibious vehicles directly from the ship.



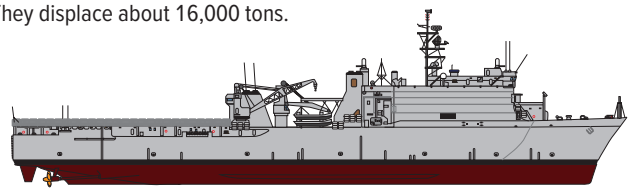
LHD-1 Wasp Class Amphibious Assault Ship

LPD-17 class amphibious transport docks represent a modern and versatile class of amphibious warfare ships. These ships can deploy helicopters, landing craft, and ground vehicles, supporting a wide range of expeditionary missions. They also have enhanced aviation capabilities, including a hangar. They displace about 25,000 tons.

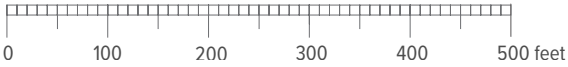


LPD-17 San Antonio Class Amphibious Transport Dock Ship

The **LSD-41 and LSD-49 classes of dock landing ships** are designed to transport and launch amphibious craft and vehicles. Although primarily focused on seaborne deployment, they are also equipped with a flight deck to support helicopter operations. They displace about 16,000 tons.



LSD-41 Whidbey Island Class Dock Landing Ship



Data source: Congressional Budget Office.

Displacement measures the amount of water that a ship displaces when carrying its crew, stores, cargo, ammunition, fuel, and other liquids. It is commonly used as a general proxy for the capability of a ship.

That distortion would be even more pronounced in estimates of trends: Overhauls conducted in recent years would appear to have shorter delays because the unfinished overhauls experiencing long delays would be omitted.

CBO therefore included the unfinished overhauls in its analysis. CBO projected the duration of unfinished overhauls on the basis of the Navy's experiences with each class since 2011.[2] (For more information about CBO's approach to handling unfinished overhauls, see the discussion later in this chapter and Appendix C.) CBO refers to the combined actual and projected outcomes as *realized* durations and *realized* labor.

How the Navy Estimates Durations and Labor for Maintenance Events

The Navy produces several estimates for each planned maintenance event, starting with the class plan developed before a new class of ships enters the fleet and ending with a final schedule prepared several months before a ship enters the shipyard.[3]

Class Plan Estimates

As a new class of ships starts to enter the fleet, the Navy develops a maintenance plan based on a technical assessment of the ships' components and their expected service life. That plan includes estimates of the total amount of time the ship will need to be in the shipyard for each maintenance event and the days of labor needed to complete the work. It also specifies the ages at which a ship should undergo particular maintenance events.

All class plans include a combination of short maintenance events and longer maintenance events. Some types of maintenance require the ship to be in a dry dock (to change the main drive shaft, for example). Events that require docking or include more modernization tend to be longer than events that do not.

For destroyers, CBO used the class plans from 2012 as a measure of the maintenance requirements that the Navy originally anticipated early in the ships' service life.[4] Class plans were not available for the other ships CBO analyzed or from other years.

Maintenance Schedule Estimates

Because a ship's maintenance needs may differ from what was estimated in the class plan, the Navy makes a series of revisions to the schedule for each overhaul before it begins. Those revisions are based on assessments of the condition of a ship, taking into account the ship's prior maintenance and modernization and the results of its inspections. CBO focused on the first and last schedules for each overhaul: the first because it indicates the Navy's initial plans for that specific ship, and the last because it is the one used for the contract award.[5]

The first schedule is prepared about two years before an overhaul begins (see Figure 1-2). First schedules are largely based on technical estimates from the class plan, but they also account for ship-specific needs identified in a prior maintenance event or by the crew. Maintenance concerns identified in an assessment of the ship are used to develop revised estimates of the work to be undertaken and the time and labor needed to accomplish it. The work package for an overhaul is typically finalized about one year before the overhaul starts, but additional updates to the schedule occur.

The last update occurs just before the maintenance contract is awarded—roughly four to six months before the maintenance event is supposed to begin (sometimes less). The last schedule is intended to be informed by a thorough inspection and should be the most reliable estimate of the total time and labor needed for an overhaul because it reflects the most recent assessment of the ship before the overhaul begins and the Navy's decisions about what maintenance and modernization tasks to include. The Navy aims to award all contracts at least four months before the overhaul's start date. However, CBO was told

2. Other methods could also address that bias, such as grouping overhauls by the year they finished rather than by the year they started, making an estimate of when the overhauls would finish on the basis of details about their current status (information not available to CBO), or assessing overhauls that began in a particular year only after they all were completed.

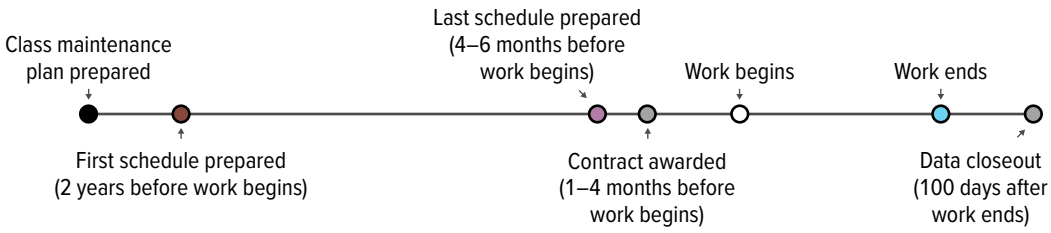
3. CBO used the 2012 class maintenance plans for DDG-51 destroyers, provided by the Navy. Naval Sea Systems Command, *Technical Foundation Paper for DDG 51 Class Type Commander Notionals* (February 2012).

4. Naval Sea Systems Command, *Technical Foundation Paper for DDG 51 Class Type Commander Notionals* (February 2012).

5. The Navy records many schedule revisions for each overhaul, labeled W, W', W", X, Y, and Z in the NAVSEA data. The dates when the schedules were created were not provided and could vary in relation to an overhaul's start date. For example, the last schedule (labeled Y or "Definitization/Award") could be recorded one to six months before an overhaul began. (Z is the actual, or "closeout," performance.)

Figure 1-2.

Notional Timeline for Planning and Executing a Maintenance Event



The first schedule for a maintenance event is produced about two years in advance. The last schedule, ideally produced at least six months before the event, reflects a series of revisions to account for the ship's unique maintenance challenges.

Data source: Congressional Budget Office.

by shipyards that contracts are sometimes awarded only one or two months before a maintenance event starts.

How CBO Measured the Performance of Maintenance Events

CBO analyzed the Navy's performance of maintenance events by measuring how those events' durations and labor use compared with the Navy's estimates.

Comparing Estimated and Realized Durations of Maintenance Events

CBO compared each maintenance event's realized duration (from the start of work to completion, measured in calendar days) against estimates from the ship's class plan (when available), the first schedule, and the last schedule.[6]

CBO found that the Navy experienced a wide range of delays in maintenance for its large surface ships. On average, the realized duration of maintenance events exceeded estimates in the first schedules by 40 percent to 200 percent—with that range reflecting different classes of ships and different types of maintenance events. Delays in relation to the last schedules were also common: The total duration of maintenance events exceeded those estimates by about 15 percent to 60 percent, on average, depending on the type of ship and the type of maintenance event.

Looking at trends over the past 14 years, CBO found that the Navy appears to be responding to those delays. Estimates of the time and labor needed for upcoming overhauls in the Navy's first and last schedules have slowly increased to better match the actual durations and labor use of completed overhauls. However, the gap between the realized durations and the Navy's last estimates has not gotten smaller, CBO found, because the realized durations have increased.

Comparing Estimated and Realized Days of Labor

The Navy uses historical data and consults with representatives of the private shipyards that maintain its ships to estimate the amount of labor needed to complete maintenance events. Shipyards include estimates of the total days of labor and labor costs in their bids to conduct a maintenance event. A typical maintenance event can use thousands or even hundreds of thousands of days of labor. Significant increases in the amount of labor for a maintenance event will raise the cost of the event and can increase its duration.

CBO found that for all ship classes, estimates of the days of labor needed to complete maintenance events were too low, on average, in the Navy's first and last schedules,

6. CBO used the 2012 class maintenance plans for DDG-51 destroyers, provided by the Navy. Naval Sea Systems Command, *Technical Foundation Paper for DDG 51 Class Type Commander Notionals* (February 2012).

Table 1-1.

Finished and Unfinished Maintenance Events for Large Conventional Combat Ships

Fiscal year overhaul started	Number of overhauls started	Number of overhauls finished	Number of overhauls unfinished	Percentage of overhauls unfinished
2011	29	29	0	0
2012	26	26	0	0
2013	29	29	0	0
2014	30	30	0	0
2015	22	22	0	0
2016	25	25	0	0
2017	24	24	0	0
2018	20	20	0	0
2019	15	15	0	0
2020	24	24	0	0
2021	21	21	0	0
2022	15	14	1	7
2023	18	10	8	44
2024	16	0	16	100
2011–2024	**314**	**289**	**25**	**8**

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

This table shows the number of maintenance events that started in each fiscal year and the number and percentage of those overhauls that were finished and unfinished as of September 30, 2024. This table presents outcomes for the same 314 overhauls as Table S-1 on page 6.

as well as in the ships' class plans (when those were available). In percentage terms, however, labor overruns were smaller than schedule delays.

Accounting for Unfinished Maintenance Events

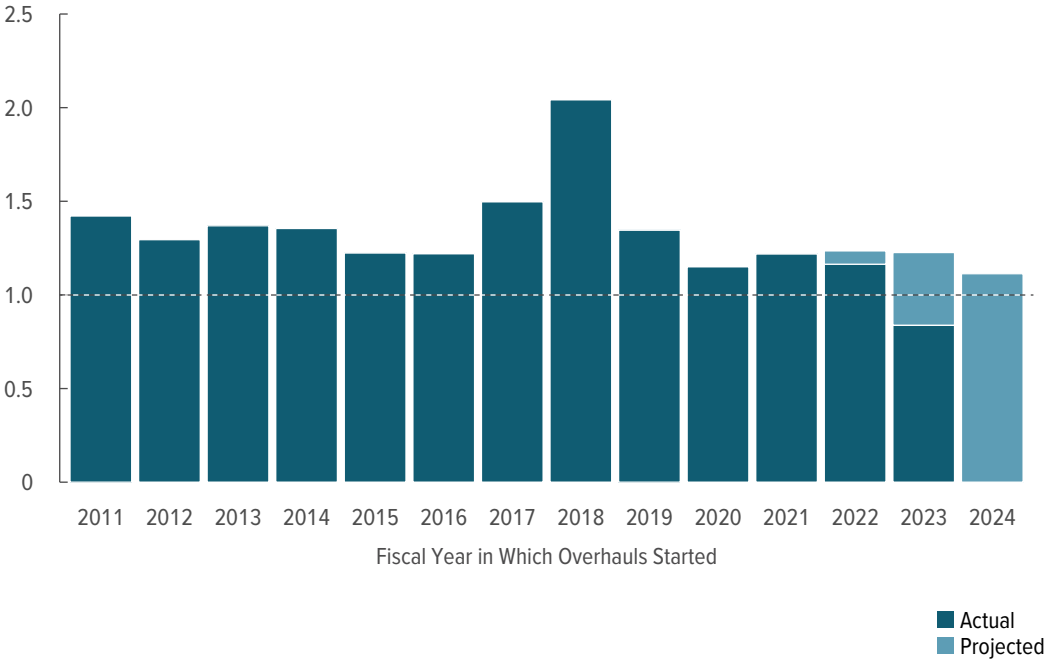
Several of the overhauls that the Navy started before the end of September 2024 were still underway at that point (see Table 1-1). Incomplete overhauls complicate the analysis, especially examinations of recent trends. Excluding those observations may lead to underestimates of delays and labor overruns. For example, one overhaul that began in 2022 for LHD-2, the USS *Essex*, remained unfinished at the end of September 2024, at which point it had already taken 863 days, or 71 percent longer than estimated in the Navy's last schedule. Excluding that overhaul would skew the results, driving down the average duration. Similarly, including incomplete overhauls but counting their durations and days of labor only up to the last month of the data (September 2024) would understate delays and, possibly, labor overruns.

To prevent those distortions, CBO used a technique from a branch of statistics known as survival analysis to project the time and labor that would be needed to complete the unfinished overhauls. (For more details, see Appendix C.) Drawing on the Navy's experiences with overhauls for each ship class since 2011, CBO created a model that projected the duration of maintenance events on the basis of the type of maintenance being performed, the class of ship, and the ship's age. CBO then projected the total days of labor by estimating that they would increase in proportion to the length of overhauls.

The survival analysis model projects that some unfinished overhauls would be completed after the dates estimated in the Navy's schedules. Likewise, some unfinished overhauls would experience labor overruns in relation to the schedules' estimates. Those projections allowed CBO to better gauge the extent of the Navy's maintenance delays and labor overruns over time, especially in recent years. The estimated magnitudes of delays and labor overruns increase, on average, when the unfinished maintenance events are included (see Figure 1-3). Without them, maintenance performance appears to have improved in 2022 and 2023 compared with 2021. However, when accounting for the projected durations of unfinished overhauls, CBO found that performance was about the same in those years.

Figure 1-3.

Ratio of Average Realized Durations of Overhauls for Large Conventional Ships to Average Estimates in the Navy's Last Schedules, by Fiscal Year in Which Overhauls Started



In every fiscal year since 2011, the average realized durations of overhauls have exceeded the average estimates in the Navy's last schedules. Those delays have ranged from 10 percent to 100 percent of the last schedules' estimates.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

This figure presents outcomes for the same 314 overhauls as Table S-1 on page 6.

A ratio greater than 1 indicates that, on average, overhauls that started in a given year took longer than estimated in the Navy's last schedules.

Realized outcomes reflect both actual outcomes and outcomes that CBO projected for maintenance events that were unfinished as of September 30, 2024. For details about CBO's projection methods, see Appendix C.

Limitations of CBO's Analysis

The data received from the Navy for this report were generally of high quality, but CBO identified some potential errors in the coding of specific maintenance events. For example, some recurring docking events were coded as the first for a ship but occurred many years later than the class plan specified, suggesting that they were actually the second or third such event.

The data also did not provide reasons for delays. CBO interviewed officials from the Navy and private shipyards to identify possible causes, but that method did not allow for a quantitative analysis of the magnitudes of their effects or the improvements that specific solutions could provide. CBO also could not assess how the effects of specific causes of delays have changed over time. In some cases, experts interviewed by the agency disagreed about which causes contributed the most to delays.

Chapter 2: Maintenance Delays and Labor Overruns for DDG-51 Class Guided Missile Destroyers

The Congressional Budget Office performed a detailed analysis of maintenance delays and labor overruns for Arleigh Burke class guided missile destroyers, or DDG-51s. That class of ships is the most numerous in the Navy's fleet and accounted for the largest number of maintenance events in the Naval Sea Systems Command data provided to CBO—225 docking and nondocking overhauls that started in fiscal years 2011 to 2024 and were performed in the United States.[1] (Docking overhauls require ships to be docked in a dry dock and are usually longer than nondocking overhauls; both types of overhauls are conducted at shipyards.)

The NAVSEA data contained information about five types of maintenance events, which the Navy refers to as "availabilities."[2] CBO analyzed each type of maintenance event in the data:

- Docking selected restricted availability (DSRA), a shorter docking event;
- Extended docking selected restricted availability (EDSRA), a longer docking event;
- Depot modernization period (DMP), a long docking event that includes a sizable modernization component;
- Selected restricted availability (SRA), a shorter nondocking event; and
- Extended selected restricted availability (ESRA), a longer nondocking event.

Overall, CBO's dataset included 47 DSRAs, 19 EDSRAs, 18 DMPs, 132 SRAs, and 9 ESRAs. (CBO excluded maintenance events that occurred in foreign shipyards, had no recorded start date, or were not included in a ship's class plan.) CBO grouped DMPs and EDSRAs together in its analysis because they had the same duration in the DDG-51s' class maintenance plans and occur at about the same point in the life of a destroyer.

CBO found that, on average, DDG-51s' overhauls took 26 percent longer than estimated in the Navy's last schedules and used 8 percent more labor (see Table 2-1). Both the longest overhauls (DMPs and EDSRAs) and the shortest overhauls (SRAs) had the largest delays in percentage terms, averaging 29 percent.

For most types of overhauls, delays in relation to the last schedule were relatively large, but labor overruns were smaller. ESRAs were the exception: They had the largest labor overruns but the shortest delays.

CBO observed two general trends from 2011 to 2024. First, the amounts of time and labor needed for DDG-51s' maintenance events were typically greater than estimated in the ships' class plans—and the magnitude of delays and labor overruns increased for most types of overhauls. Second, the magnitude of delays (measured by the gap between the last schedules' estimates and the realized outcomes) did not improve for most types of overhauls, despite increases in the Navy's estimates. (See Chapter 3 for a discussion of the possible causes of delays.)

The DDG-51 Fleet and Its Class Maintenance Plans

The DDG-51s perform a variety of missions for the Navy, including ballistic missile defense, fleet air defense, land attacks, and overseas presence. The DDG-51 fleet largely consists of three variants: 21 Flight Is, 7 Flight IIs,

1. See Appendix B for more details about the data provided to CBO by the Navy.
2. The Navy's terminology for maintenance, repairs, modernization, and overhauls is complex and sometimes counterintuitive. Thus, CBO uses the terms "overhaul" and "maintenance event" to encompass all periods of maintenance that make a ship unavailable for training and operations.

Table 2-1.

Realized Performance of DDG-51s' Maintenance Events Relative to Estimates in the Navy's Last Schedules, 2011 to 2024

		Duration			Labor		
Type of overhaul	Number of observations	Average estimate in last schedule (days)	Average realized amount (days)	Ratio of estimated to realized amounts[a]	Average estimate in last schedule (thousands of days)[b]	Average realized amount (thousands of days)[b]	Ratio of estimated to realized amounts[a]
DMP or EDSRA	37	477	614	1.29	98	105	1.08
DSRA	47	260	311	1.20	68	74	1.08
ESRA	9	384	446	1.16	35	42	1.19
SRA	132	165	212	1.29	22	24	1.08
All overhauls	**225**	**244**	**308**	**1.26**	**45**	**49**	**1.08**

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

This table presents outcomes for the 225 DDG-51 overhauls included in Table S-1 on page 6.

DMP = depot modernization period; DSRA = docking selected restricted availability; EDSRA = extended docking selected restricted availability; ESRA = extended selected restricted availability; SRA = selected restricted availability.

a. This value is the ratio of the average realized outcome for the fleet to the average estimate in the last schedules—not the average of individual ships' performance ratios. The former provides a broader measure of fleetwide performance, whereas the latter more accurately reflects the typical delay per ship. CBO used both metrics in its analysis.

b. One day of labor is equal to an eight-hour shift for one worker.

and 45 Flight IIAs. The Navy currently has one Flight III ship and is building more.

The average age of the Flight I ships at the end of September 2024 was 29 years. Flight Is were originally planned to have a service life of 35 years, but by November 2024, the Navy had extended the service lives of several Flight Is.[3] Flight II ships have an average age of 25 years and a planned service life of 35 years. Whether additional Flight Is or Flight IIs can have their service lives extended will be determined on a ship-by-ship basis as they approach 35 years of age. The average age of Flight IIA ships at the end of September 2024 was 15 years, out of an expected service life of 40 years. (Some Flight IIAs are still being delivered.)

In the 2012 class maintenance plans for DDG-51s, Navy planners anticipated four docking overhauls and eight nondocking overhauls throughout a ship's service life.[4] Altogether, those events were estimated in the class plans to take more than four years of a ship's total service life (for an example, see Figure 2-1), although they often take twice that long. Docking events tend to involve extensive maintenance on large components of a ship—for example, tank repair, corrosion control on hard-to-reach areas, and engine overhauls. Nondocking maintenance events, most of which are SRAs, are typically shorter than maintenance events that require docking and occur more often throughout a ship's life.

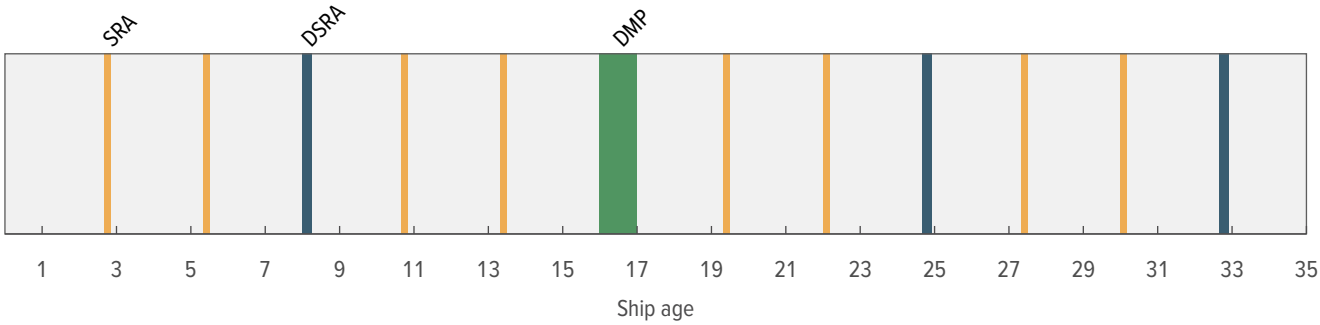
In addition to maintenance activities, which are the focus of this report, the Navy regularly conducts modernization activities during an overhaul to upgrade the combat systems and weapons on its ships. Those upgrades could be completed during a docking maintenance event but might lengthen its duration. Perhaps the most consequential upgrade will be a Navy program to retrofit a version of the SPY-6 radar and associated

3. Justin Katz, "U.S. Navy to Extend Service Lives of 12 Destroyers," *Breaking Defense* (October 31, 2024), https://tinyurl.com/4ezuf8u5.

4. Naval Sea Systems Command, *Technical Foundation Paper for DDG 51 Class Type Commander Notionals* (February 2012). Class plans are updated over the life of the ship to reflect lessons from maintenance performance. Nevertheless, the 2012 class plans serve as useful benchmarks as to what was expected early in the DDG-51s' service life. No other class plans were provided to CBO.

Figure 2-1.

Class Plan for Maintenance Events During the Service Life of DDG-51 Flight IIA Variants



The 2012 class plan for DDG-51 Flight IIA ships included four docking maintenance events and eight nondocking maintenance events. Together, those overhauls were estimated to take about 4 years (or 12 percent) of the ships' planned 35-year service life.

Data source: Congressional Budget Office, using the 2012 class maintenance plans for DDG-51 ships provided by the Navy.

The 2012 class plan for Flight I and Flight II ships was similar to the plan for the Flight IIA variants, except that the DMP was replaced with an EDSRA and, for Flight I ships, the first SRA after that EDSRA was replaced with an ESRA. The EDSRA and the DMP were the same length, whereas the ESRA was longer than an SRA.

DDG-51 = guided missile destroyer; DMP = depot modernization period; DSRA = docking selected restricted availability; EDSRA = extended docking selected restricted availability; ESRA = extended selected restricted availability; SRA = selected restricted availability.

combat system developed for Flight III ships onto some Flight IIA ships. That program will provide the Flight IIAs with a far more powerful radar than the SPY-1 they currently carry, though it will still be smaller and less capable than the SPY-6 on the Flight IIIs. The Navy plans to make that improvement to 28 of the newest Flight IIAs, at an estimated cost of $17 billion over 17 years. Those upgrades will probably be made during regularly scheduled maintenance events; the Navy has not released information about whether they are expected to increase the Flight IIAs' time in the shipyard.

Trends in Budgets for Destroyer Maintenance

From 2009 to 2024, both the total funding for destroyer maintenance and the funding per destroyer increased substantially.[5] Over that period, total funding for destroyer maintenance increased by 400 percent in real terms (that is, after removing the effects of inflation), from $0.4 billion to $2.2 billion in 2024 dollars. The number of destroyers in the fleet also increased, but by much less—about 25 percent. The net result of those two trends is that maintenance funding per destroyer grew by over 300 percent (see Figure 2-2).

In 2024, the Navy spent an average of $28 million per destroyer on maintenance. The increased spending reflects, in part, the longer durations and greater labor use of DDG-51 overhauls. Spending also increased because the Navy saw a need for additional maintenance on its ships.

Delays and Labor Overruns for DDG-51s' Docking Maintenance Events

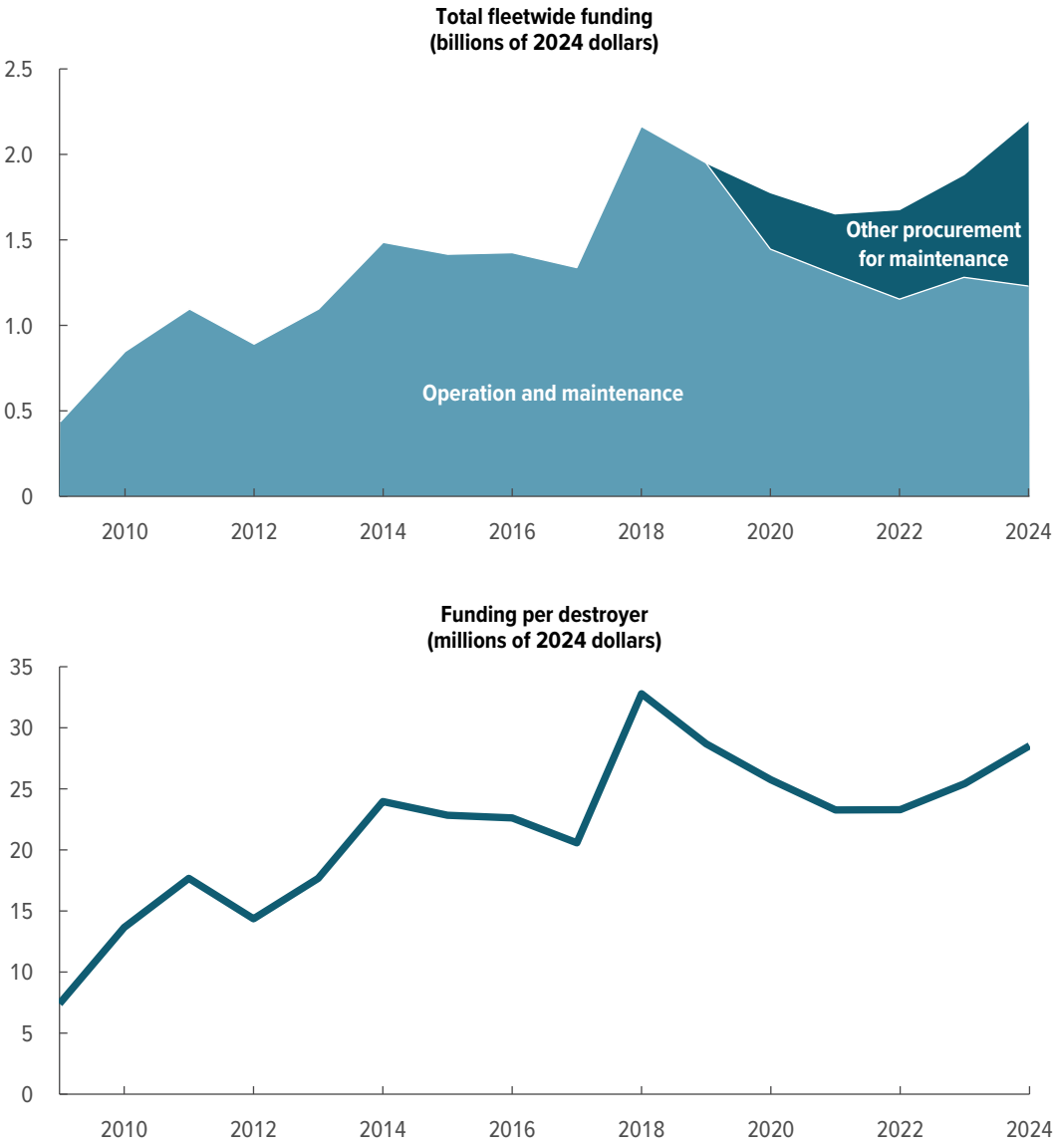
Docking overhauls are long, intensive maintenance periods in a ship's service life. Maintenance work during those events may include repairs to the hull structure, electrical systems, and propulsion systems. CBO examined the durations and labor use of three types of docking events the Navy conducted from 2011 to 2024—DSRAs, DMPs, and EDSRAs—and trends in the performance of those events over that period. CBO analyzed DSRAs separately from DMPs and EDSRAs, which are generally longer and more labor-intensive.

All but one of the DSRAs for DDG-51s since 2011 have taken longer and have used more labor than anticipated in the ships' 2012 class plans. Most have taken two to four times as long as the class plans estimated (see Figure 2-3, top panel). The durations of the longer docking overhauls—DMPs and EDSRAs—were closer to the class plans' estimates, on average (see Figure 2-3,

5. That time period is slightly different from the period over which overhauls in CBO's dataset occurred but gives context to the availability of maintenance funds.

Figure 2-2.

Maintenance Funding for DDG-51s, by Fiscal Year



Over fiscal years 2009 to 2024, total maintenance funding for destroyers grew by 400 percent. During that time, the fleet grew by 25 percent, from 59 ships to 74 ships, and a larger share of the fleet entered the part of their service life when ships receive additional maintenance. As a result, the maintenance funding per destroyer is much higher than it was in 2009.

Data source: Congressional Budget Office, using data from the Navy. See www.cbo.gov/publication/61507#data.

DDG-51 = guided missile destroyer.

bottom panel). A few of those longer overhauls were unfinished by the end of September 2024. CBO projected the time to complete those unfinished overhauls on the basis of the time each ship had already spent in the shipyard.

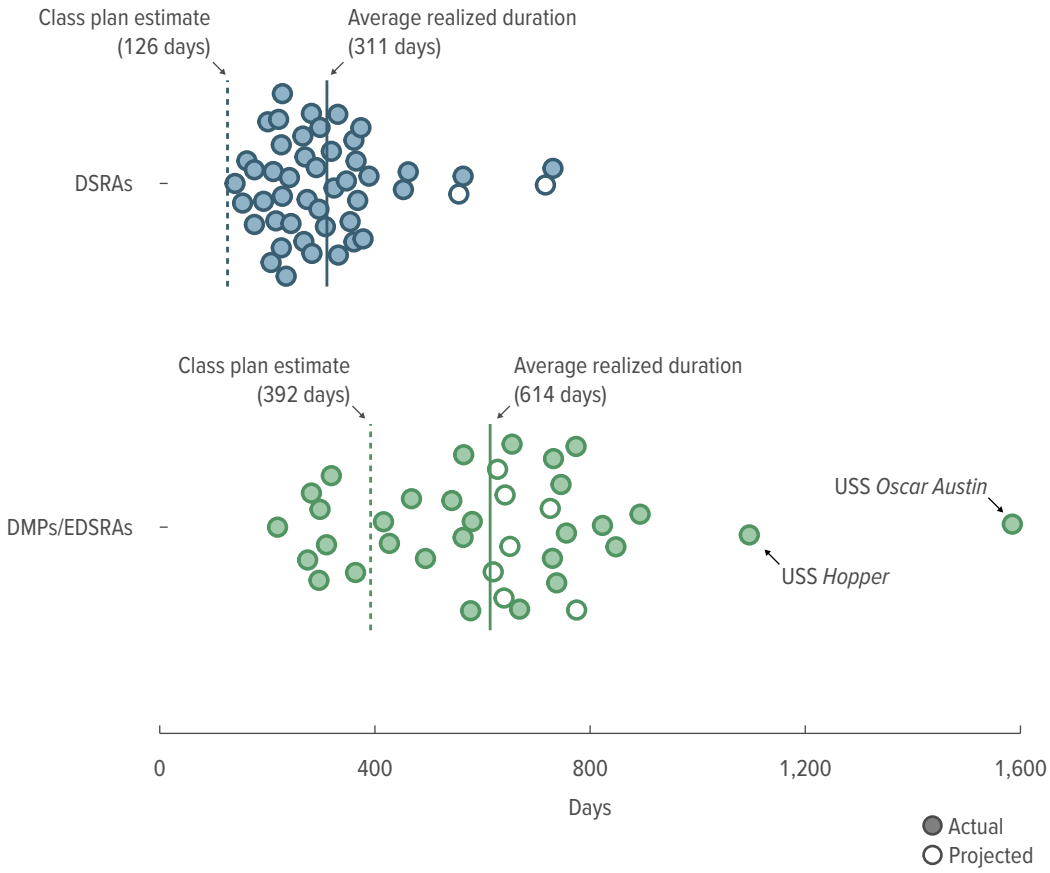
The durations and labor use of docking overhauls varied widely. Performance was especially varied for DMPs and EDSRAs, which involve more modernization and more extensive repairs. In the following discussions, CBO focuses on the average realized performance of overhauls for clarity.

DSRAs' Performance

The 47 DSRAs undertaken since the start of fiscal year 2011 took, on average, about two and a half times as long to complete as the estimate of 126 days in the ships' 2012 class plans. Estimates of duration in the Navy's first and last schedules, which were issued after the ships

Figure 2-3.

Realized Durations of DDG-51s' Docking Maintenance Events



DDG-51s' 2012 class plans underestimated the time needed to complete most docking overhauls. The projected durations of unfinished DMPs and EDSRAs are close to the average actual durations of such overhauls. But two unfinished DSRAs are projected to take much longer than average because the ships are older and have already been in the yard for longer than expected.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

Realized outcomes reflect both actual outcomes and outcomes that CBO projected for maintenance events that were unfinished as of September 30, 2024. For details about CBO's projection methods, see Appendix C.

DDG-51 = guided missile destroyer; DMP = depot modernization period; DSRA = docking selected restricted availability; EDSRA = extended docking selected restricted availability.

were assessed for individual maintenance concerns, were closer to those realized amounts. Over the fiscal year 2011–2024 period, realized overhauls lasted 63 percent longer than estimated in the first schedules, on average, and 20 percent longer than estimated in the last schedules (see Figure 2-4).

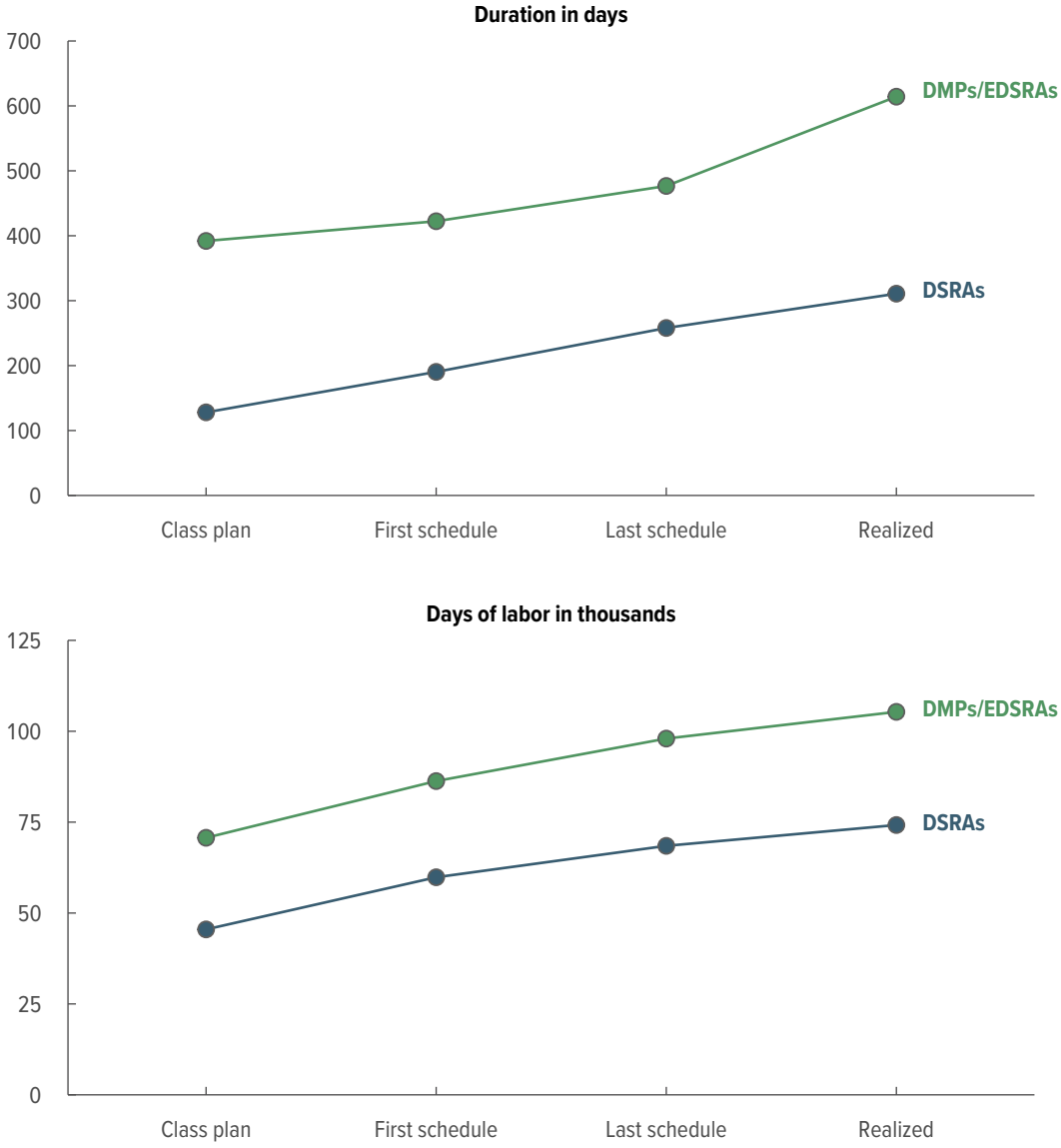
DSRAs also took more labor to complete than anticipated in the ships' class plans. The DDG-51s' class maintenance plans estimated that, on average, 46,000 days of labor would be needed to complete a DSRA. CBO found that the average number of days of labor to complete a DSRA was 74,000—a 60 percent overrun relative to the class plans. The Navy's last schedules were much more accurate: On average, their estimates of labor were only 8 percent lower than the realized amounts.

DMPs' and EDSRAs' Performance

DMPs were scheduled in the 2012 class plans to occur once in a ship's service life, when the ship was 16 years old. Because they include modernization work to update weapon systems in addition to maintenance, DMPs were estimated to last, on average, 56 weeks in the class plans. (By comparison, DSRAs were estimated to average 18 weeks.) EDSRAs were also estimated to take 56 weeks because they involve more maintenance than a standard

Figure 2-4.

Average Estimated and Realized Durations and Days of Labor for DDG-51s' Docking Maintenance Events



On average, the realized durations of DDG-51s' docking overhauls exceeded estimates in the ships' class plans and the Navy's first and last schedules. The last schedules were more accurate but still underestimated the duration of docking events—sometimes by sizable margins.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

This figure presents outcomes for the 84 docking overhauls (DMPs, DSRAs, and EDSRAs) for DDG-51s included in Table 2-1 on page 16.

Realized outcomes reflect both actual outcomes and outcomes that CBO projected for maintenance events that were unfinished as of September 30, 2024. For details about CBO's projection methods, see Appendix C.

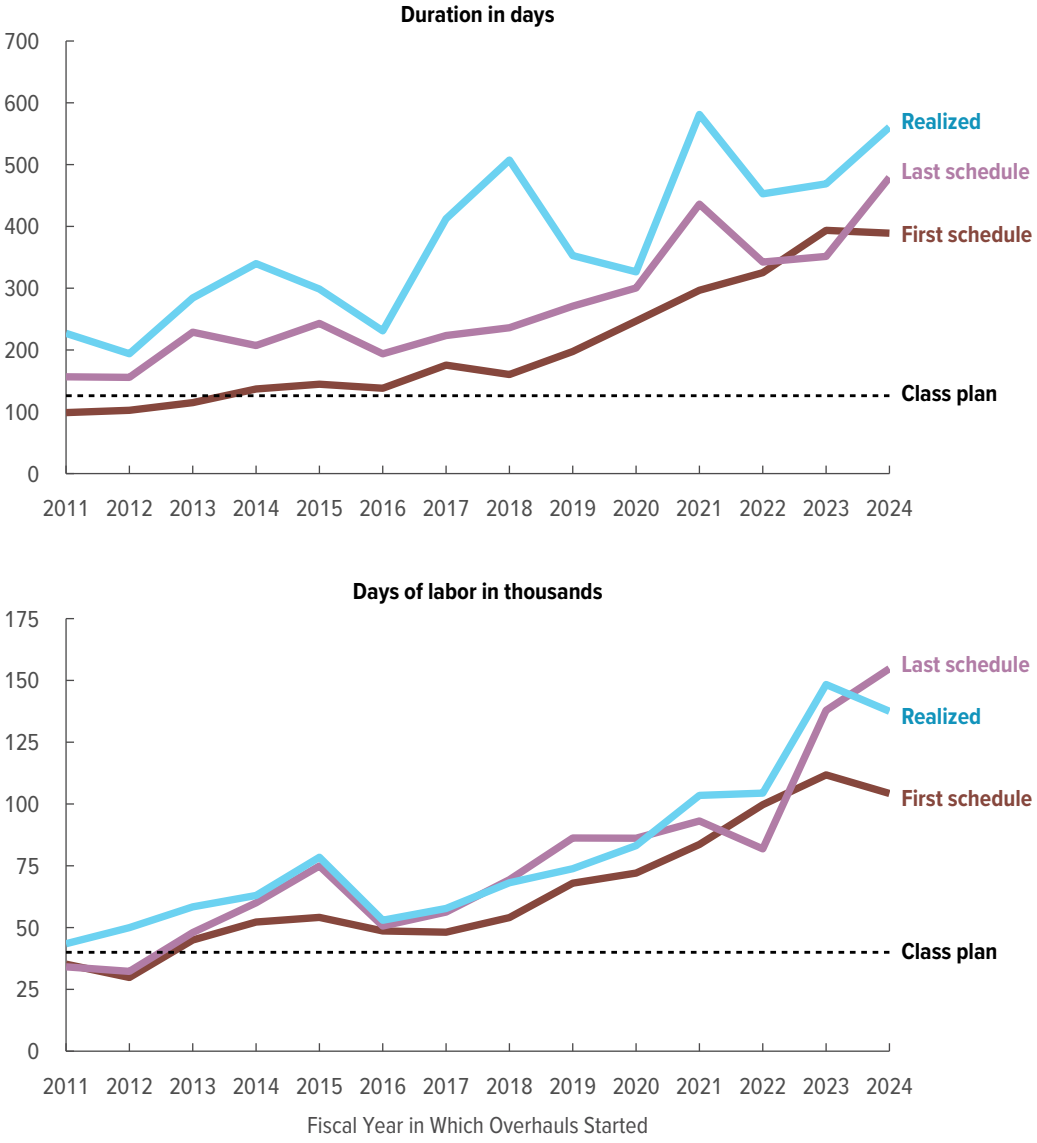
DDG-51 = guided missile destroyer; DMP = depot modernization period; DSRA = docking selected restricted availability; EDSRA = extended docking selected restricted availability.

DSRA. For that reason, CBO combined DMPs and EDSRAs in its analysis.

Although the class plans had a much longer duration estimate for DMPs and EDSRAs than for DSRAs, the realized performance for DSRAs was worse, proportionally, in relation to the class plan estimate. On average, DMPs and EDSRAs took 60 percent longer than estimated in the class plans. By comparison, DSRAs took more than twice as long as estimated in the class plans.

Figure 2-5.

Average Estimated and Realized Durations and Days of Labor for DDG-51s' DSRAs, by Fiscal Year in Which Overhauls Started



The average amounts of time and labor needed to complete a DSRA for a DDG-51 destroyer have grown substantially since 2011. Although estimates of the events' durations in the Navy's first and last schedules have increased, they have remained below the realized durations. The Navy's estimates of labor have also risen and have been more accurate.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

This figure presents outcomes for the 47 DSRAs included in Table 2-1 on page 16.

Realized outcomes reflect both actual outcomes and outcomes that CBO projected for maintenance events that were unfinished as of September 30, 2024. For details about CBO's projection methods, see Appendix C.

DDG-51 = guided missile destroyer; DSRA = docking selected restricted availability.

More labor is also required to complete the more technical DMPs and EDSRAs. Accordingly, the class plans' estimates of labor are larger for DMPs and EDSRAs (71,000 days and 79,000 days, respectively) than for DSRAs (45,000 days). Again, although the realized days of labor for DMPs and EDSRAs exceeded the estimates in the class plans, those overruns were smaller, proportionally, than the labor overruns for DSRAs.

Trends in the Navy's Estimates for Docking Events

The gap between the Navy's estimates and the actual time and labor needed for DSRAs has grown since 2011. Although the Navy has responded to that trend by raising its estimates, the estimates of duration have not closed the gap.

From 2011 to 2024, estimates of the duration of DSRAs in the Navy's first and last schedules increased, on average, by about 330 percent and 170 percent, respectively (see Figure 2-5). Estimates of labor in the Navy's first and last schedules also increased significantly over that period. In general, the last schedules' estimates of labor have gotten much closer to the realized amounts, but the gap between the first schedules' estimates and the realized amounts has grown in recent years.

For DMPs and EDSRAs, the story is somewhat different. Like DSRAs, those events are taking more time and requiring more labor than they did in 2011; in fact, the increases in their durations and labor use have been greater. Nevertheless, the Navy's estimates of the time and labor needed for those events have become more accurate than its estimates for DSRAs.

Delays and Labor Overruns for DDG-51s' Nondocking Maintenance Events

Nondocking maintenance events are interspersed between docking periods. The DDG-51s' 2012 class plans recommended that ships complete two nondocking SRAs about three years apart before each docking overhaul. Each SRA should take 91 days, according to the class plans. Maintenance work in those SRAs is limited to systems above the waterline or inside the ship. Typical activities include preservation of the ship's exterior, repairs to the propulsion system, and repairs to or replacements of nonskid surfaces on flight decks.

DDG-51 Flight I and Flight II ships may also undergo an ESRA later in their service life (sometimes in place of a DMP or DSRA), typically at around 19 years. ESRAs are significantly longer maintenance events than SRAs—estimated to take 371 days in the ships' 2012 class plans—and include lengthier repairs to or replacements of ships' auxiliary systems, such as air conditioning and sonar, as well as modernization efforts. CBO analyzed ESRAs separately from SRAs to account for those differences.

SRAs' Performance

Since 2011, SRAs have taken longer to complete than estimated in the Navy's schedules. The average realized duration of the 132 SRAs CBO analyzed was 212 days, more than double the class plans' estimate of 91 days and 29 percent longer than the average estimate in the events' last schedules (see Figure 2-6).

SRAs also faced labor overruns, using nearly three times the amount of labor estimated in the class plans, on average. However, estimates of labor in the last schedules for SRAs were much more accurate—only 8 percent below the realized amounts, on average.

ESRAs' Performance

On average, ESRAs lasted only 20 percent longer than estimated in the DDG-51s' class plans and only 16 percent longer than estimated in the Navy's last schedules.

ESRAs had the largest labor overruns of all the maintenance events for the DDG-51 class that CBO analyzed, using 20 percent more labor than estimated in the last schedules. That large increase may be a result of the age of the ships. (For details about the effects of aging ships on the performance of maintenance events, see Chapter 3.)

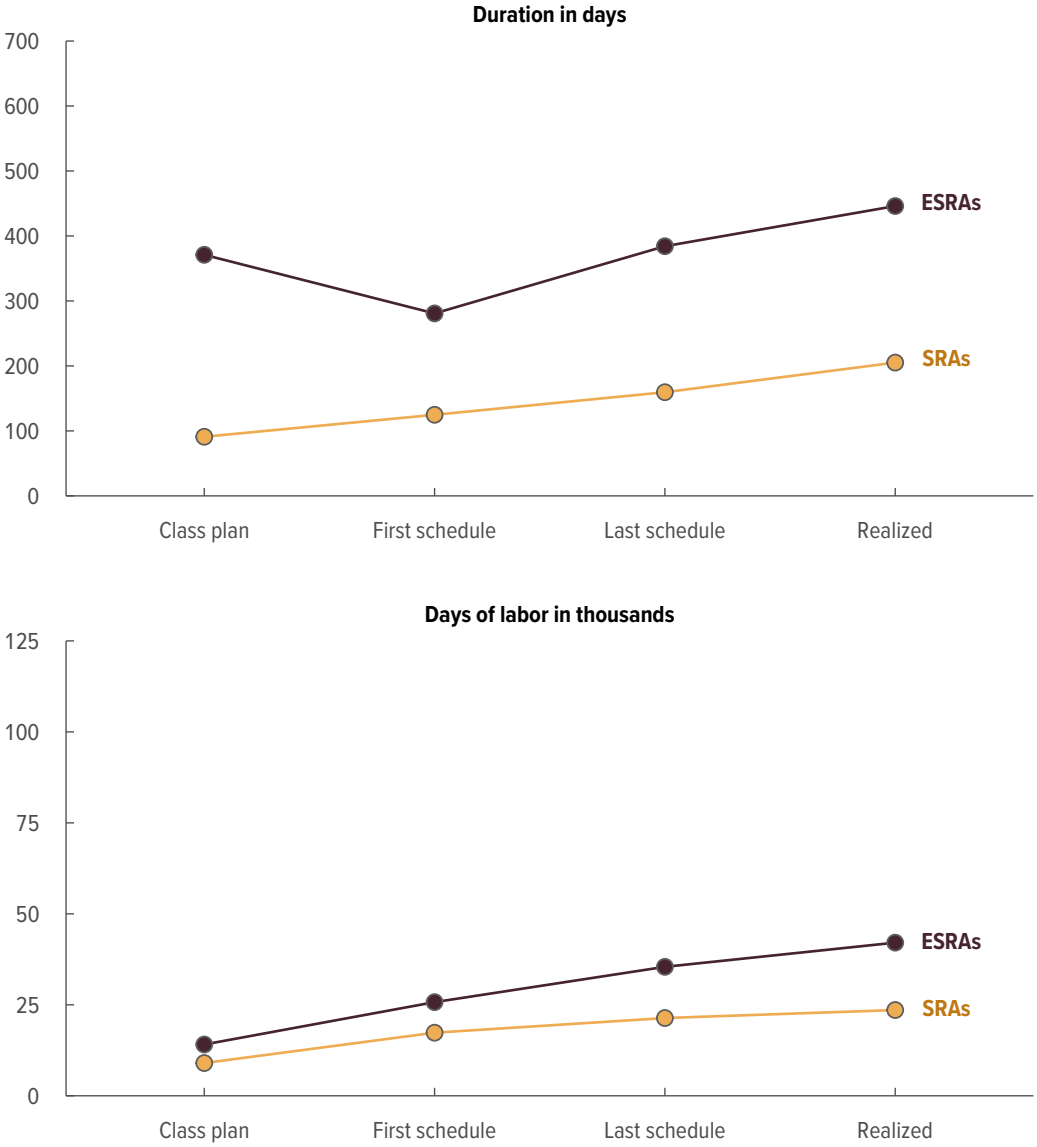
Trends in the Navy's Estimates for Nondocking Events

CBO's analysis of nondocking events focused on SRAs because ESRAs were in the class plan only for Flight Is, and there were not many of them in the NAVSEA data. The Navy routinely underestimated the duration of nondocking maintenance events for DDG-51s that started between 2011 and 2024, a period when the realized duration of those events was rising. During those years, the Navy gradually increased its estimates of duration in the events' first and last schedules.

The average realized durations of SRAs increased from 2011 to 2024, rising from 117 days to 349 days, although the variability was high (see Figure 2-7, top panel). Over that period, the Navy's first and last schedule estimates also increased, but on average they did not become more accurate. For example, the average estimate of duration in the Navy's last schedules increased from 74 days in 2011 to 249 days in 2024. Those estimates were more accurate, on average, than the estimates in the Navy's first schedules but still did not narrow the gap with realized durations in most years.

Figure 2-6.

Average Estimated and Realized Durations and Days of Labor for DDG-51s' Nondocking Maintenance Events



On average, DDG-51s' class plans and first and last schedules underestimated the labor needed for nondocking overhauls, but the estimates of labor were much more accurate than the estimates of duration.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

This figure presents outcomes for the 141 nondocking overhauls (SRAs and ESRAs) for DDG-51s included in Table 2-1 on page 16.

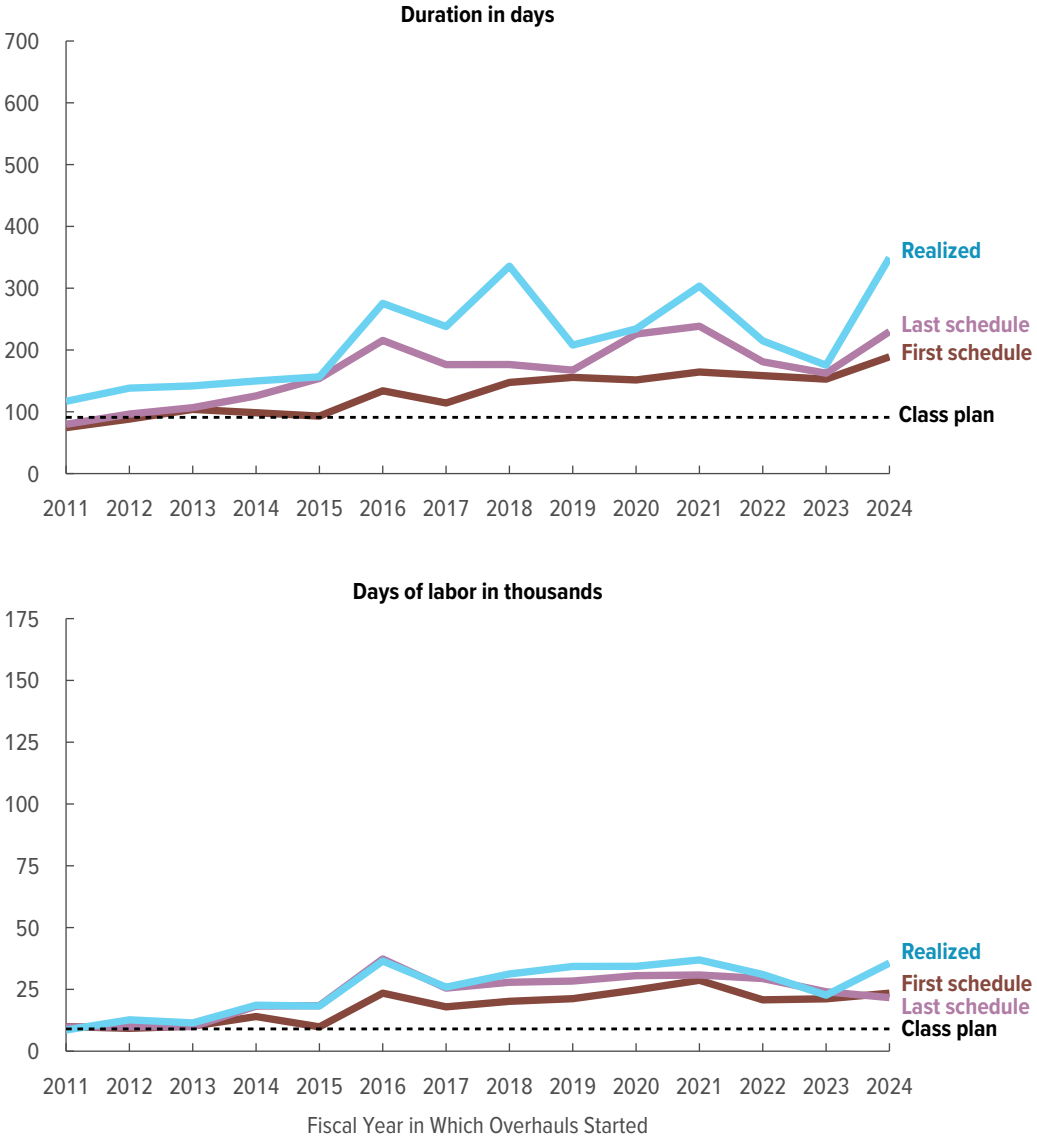
Realized outcomes reflect both actual outcomes and outcomes that CBO projected for maintenance events that were unfinished as of September 30, 2024. For details about CBO's projection methods, see Appendix C.

DDG-51 = guided missile destroyer; ESRA = extended selected restricted availability; SRA = selected restricted availability.

The amount of labor used to complete nondocking maintenance events also increased from 2011 to 2024. For overhauls that started in 2011, realized amounts of labor were close to the estimates in the class plans. After a few years, though, the realized labor began to outstrip the class plans' estimates. Estimates of labor rose in the Navy's last schedules and remained close to the realized amounts through 2017. Since then, however, the last schedules have underestimated nondocking events' labor use in most years.

Figure 2-7.

Estimated and Realized Durations for DDG-51s' SRAs, by Fiscal Year in Which Overhauls Started



From 2011 to 2024, as SRAs grew longer, the Navy increased its estimates of their duration in its first and last schedules—but not enough to close the gap in most years.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

Realized outcomes reflect both actual outcomes and outcomes that CBO projected for maintenance events that were unfinished as of September 30, 2024. For details about CBO's projection methods, see Appendix C.

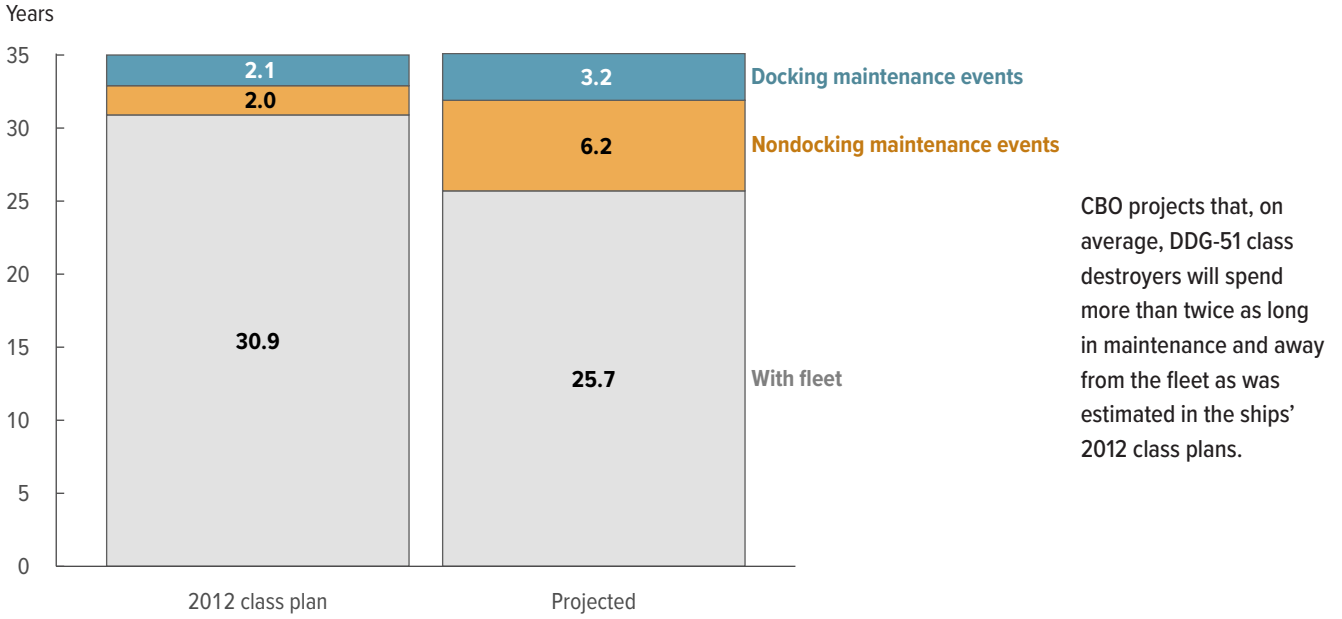
DDG-51 = guided missile destroyer; SRA = selected restricted availability.

DDG-51s' Total Duration of Maintenance Over Their Service Life

The delays in maintenance events that the Navy is experiencing with its ships can affect how much time the ships spend in the fleet over their service life. The 2012 class plans for DDG-51 destroyers indicated that the ships should spend 12 percent of their life in shipyard maintenance. For example, the class plan for the Flight I and Flight II DDG-51s included four docking maintenance events and eight nondocking maintenance events over a service life of 35 years, for a total of about four years of shipyard maintenance: two years in docking maintenance

Figure 2-8.

Projected Years of DDG-51s' Service Life Spent in Maintenance and With the Fleet



Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

Docking events in the 2012 class plan for Flight IIA ships were a DMP and three DSRAs; nondocking events were eight SRAs (see Figure 2-1 on page 17). The 2012 class plan for Flight I and Flight II ships was similar, except that the DMP was replaced with an EDSRA and, for Flight I ships, the first SRA after that EDSRA was replaced with an ESRA. The EDSRA and the DMP were the same length, whereas the ESRA was longer than an SRA.

DDG-51 = guided missile destroyer; DMP = depot modernization period; DSRA = docking selected restricted availability; SRA = selected restricted availability.

events and another two years in nondocking maintenance events (see Figure 2-1 on page 17). Class plans for later flights of DDG-51s specified slightly different schedules and maintenance events, but the ships' estimated time in maintenance was about the same.

Actual experience indicates that DDG-51s are spending a much larger fraction of their service life in maintenance at shipyards. Using data on different ships in different parts of their lives, CBO projected what the DDG-51 fleet's maintenance experience is likely to be over its service life. CBO projects that DDG-51 destroyers will spend more than nine years (or 27 percent of their planned service life) in maintenance, on average: three years in docking maintenance events and six years in nondocking maintenance events (see Figure 2-8). In that case, DDG-51s would be out of the fleet for maintenance more than twice as long as the Navy originally estimated.[6]

The Navy may be able to extend the service life of some DDG-51s. For example, the Navy recently certified that several ships can remain in the force for five additional years and that extensions of other ships' service lives will be considered on a case-by-case basis. But extending a ship's service life often requires additional maintenance or longer maintenance events.

6. That projection applies only to DDG-51 Flight I, Flight II, and Flight IIA destroyers. Flight III destroyers are just entering the fleet and had no maintenance events in CBO's dataset. Flight IIIs share many components with the earlier ships but also have many new combat systems, so it is not yet clear how their maintenance outcomes will compare.

Chapter 3: The Causes and Consequences of Maintenance Delays

The Congressional Budget Office's analysis of data on maintenance events for DDG-51 class destroyers from fiscal year 2011 to fiscal year 2024 suggests that the Navy is experiencing two types of delays in relation to the ships' class plans. Both types of delays have several possible causes—with consequences for the fleet's readiness and costs.

The first type of delay is a steady increase in the time and labor needed to complete *expected* tasks in maintenance events. Those delays are reflected in the rising estimates in the Navy's first and last schedules for those events. One cause of such delays is the aging of the ships. Older destroyers often need more time and labor for maintenance events than their 2012 class plans estimated. For example, selected restricted availability periods for the DDG-51 class have grown longer as the ships have aged, but the class plans assigned the same duration for all SRAs regardless of the ships' age. The relatively common practice of postponing maintenance may also play a role in overhauls' steadily lengthening durations.

The second type of delay is an *unexpected* increase in the time or labor needed for a maintenance event once a ship is in the shipyard. Those unexpected delays have contributed directly to the enduring gaps between the estimates in the Navy's last schedules and the realized performance of all types of maintenance events since 2011. CBO's analysis suggests that such unplanned work accounted for about one-third of the gap. Other factors accounted for the rest.

CBO met with representatives from Naval Sea Systems Command, the Navy's regional maintenance centers, ship operators, and private shipyards to discuss general causes of maintenance delays and issues specific to the DDG-51 class. Many of the reasons cited for maintenance delays among destroyers were also applicable to other conventional ships in the Navy's fleet: late contract awards, increases in the scope of work, budget shortages at the end of fiscal years, delayed parts and materials, poor integration of intensive modernization with maintenance work, and fixed-price contracts that give shipyards more incentives to keep costs low than to complete tasks on time.[1]

Causes of Steadily Increasing Durations and Labor Use

One of the most consistent findings from CBO's analysis of the DDG-51 fleet is that the realized duration and labor use of both docking and nondocking events have steadily increased over time. There are several possible reasons for that pattern. The most likely causes are the aging of the DDG-51 fleet and postponed maintenance events. Heavier-than-expected use, systemic maintenance issues, and the shorter-than-expected service life of important parts could also play a role.

Aging of the DDG-51 Fleet

The average age of the DDG-51 fleet has increased over time, which is a key cause of the steady increases in their maintenance events' durations and labor use. The average age of ships in the DDG-51 fleet was 10 years in 2011 and 20 years in 2024.[2] Older ships undergoing an overhaul may need both more maintenance and more modernization. (CBO cannot distinguish those effects because labor for maintenance and labor for modernization are not reported separately in the Navy's data.)

The performance of some types of events has been particularly affected by the aging of the fleet:

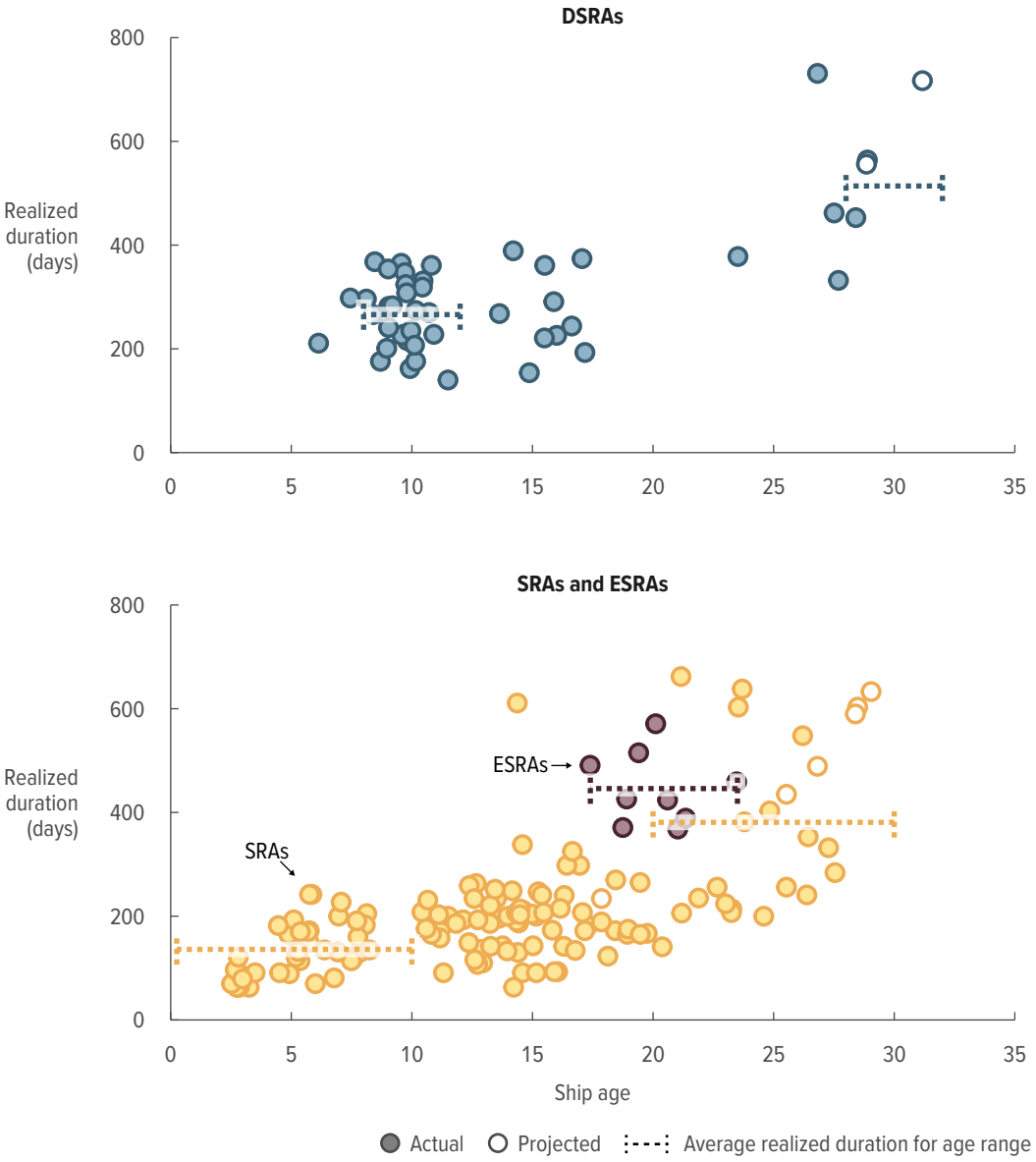
- The duration of a docking selected restricted availability period for a 10-year-old destroyer averages about 250 days; for a 30-year-old destroyer, it averages about 500 days (see Figure 3-1, top panel).

1. CBO's analysis was primarily focused on the causes of delays, not labor overruns, whose causes are more difficult to determine. The Navy estimates how much labor different tasks will require, and the winning bidder allocates labor to those tasks.

2. There are probably other causes of longer overhauls that are correlated with age that CBO could not account for.

Figure 3-1.

Realized Durations of Selected Maintenance Events for DDG-51s, by Ships' Age



Maintenance events for DDG-51s have taken longer, on average, for older ships. The durations of those events have also varied more as the ships have aged.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

Realized outcomes reflect both actual outcomes and outcomes that CBO projected for maintenance events that were unfinished as of September 30, 2024. The projected duration of an unfinished overhaul depends not only on the ship's age but on how long the overhaul has already been underway. For more details about CBO's projection methods, see Appendix C.

DDG-51 = guided missile destroyer; DSRA = docking selected restricted availability; ESRA = extended selected restricted availability; SRA = selected restricted availability.

- Similarly, the average duration of an SRA is three times as long for destroyers in their 20s as it is for destroyers in their first 10 years of service (see Figure 3-1, bottom panel).
- For older ships, the average duration of SRAs has lengthened so much that it is now close to the average duration of extended selected restricted availability periods. ESRAs are only about 20 percent longer than SRAs for destroyers in their 20s, even though the DDG-51s' class plans estimated that ESRAs would take four times longer. Older ships have also experienced much more variation in their SRAs' durations.

The aging of ships has had a less pronounced effect on the duration of other maintenance events. The durations of depot modernization periods and extended docking selected restricted availability periods are highly variable, but, on average, both types of maintenance events last about 100 days (or 20 percent) longer for ships over age 20 than for ships under age 20. That less pronounced effect may reflect the relatively short range of ages over which such maintenance events are conducted or variability in the work they involve.

Many factors may explain why aging ships are more likely to experience delays in maintenance events, but three were identified by representatives of shipyards in conversations with CBO: postponed maintenance, unanticipated work, and corrosion. The first two factors are discussed later in this chapter. The corrosive marine environment and the stresses of operations at sea lead to wear and tear on ships that tends to accumulate and create more maintenance issues over time. However, the class plans for DDG-51 destroyers did not account for that increased wear and tear.

Postponed Maintenance

Another cause of maintenance events' steadily rising durations and labor use may be past decisions by the Navy to delay the start of those events. For example, many of the first and third DSRAs and the DMPs or EDSRAs for the DDG-51 class occurred several years after the start dates established in the class plans (see Figure 3-2). The Navy may delay the start of maintenance events because it has found that maintenance can be postponed without affecting current or future readiness, because it needs to keep a ship in the fleet longer to meet deployment goals, or because its maintenance budget has insufficient funding.

If a maintenance event is postponed for either of the latter two reasons, the next event could take longer than estimated because more work will be needed to return the ship to duty. Even more time and labor will be needed if postponing the overhaul increases wear and tear on the ship or causes damage to its other systems—much as postponing repairs to a house's leaking roof can cause water damage that would not have occurred if the roof had been repaired on time.

A related cause of maintenance events' longer durations and greater labor use may be the practice of postponing work identified during one overhaul until the next overhaul. As the length and cost of maintenance events have increased, the Navy has sometimes opted to delay some work rather than keep ships out of the fleet. The Navy's flexibility to include unexpected work in ongoing maintenance contracts may also be limited. But delaying such work can worsen the condition of ships in subsequent maintenance events, increasing the events' durations and labor requirements. In fact, some Navy officials and shipyard representatives told CBO that the increased durations and labor use of overhauls for older ships are likely due in part to the accumulated effects of postponed maintenance.

Other Possible Causes

Other factors may explain the steady increase in overhauls' durations and labor use since 2011. Both could increase over time if ships are used more, or more intensively, than was estimated in their class plan. CBO does not have data to assess either of those possible causes.

Overhauls' durations and labor use could also increase if a class of ships develops a recurring maintenance issue that is not accounted for in the class plan. For example, some critical components may wear out sooner than expected. If specific types of unexpected work are common in multiple ships of a class (as repairs to corroding propeller shafts were in DDG-51s), those tasks are added to the Navy's list of regular tasks and incorporated into its first and last schedules, increasing the Navy's estimates of duration and labor for future maintenance events.

Causes of Unexpected Delays and Labor Overruns

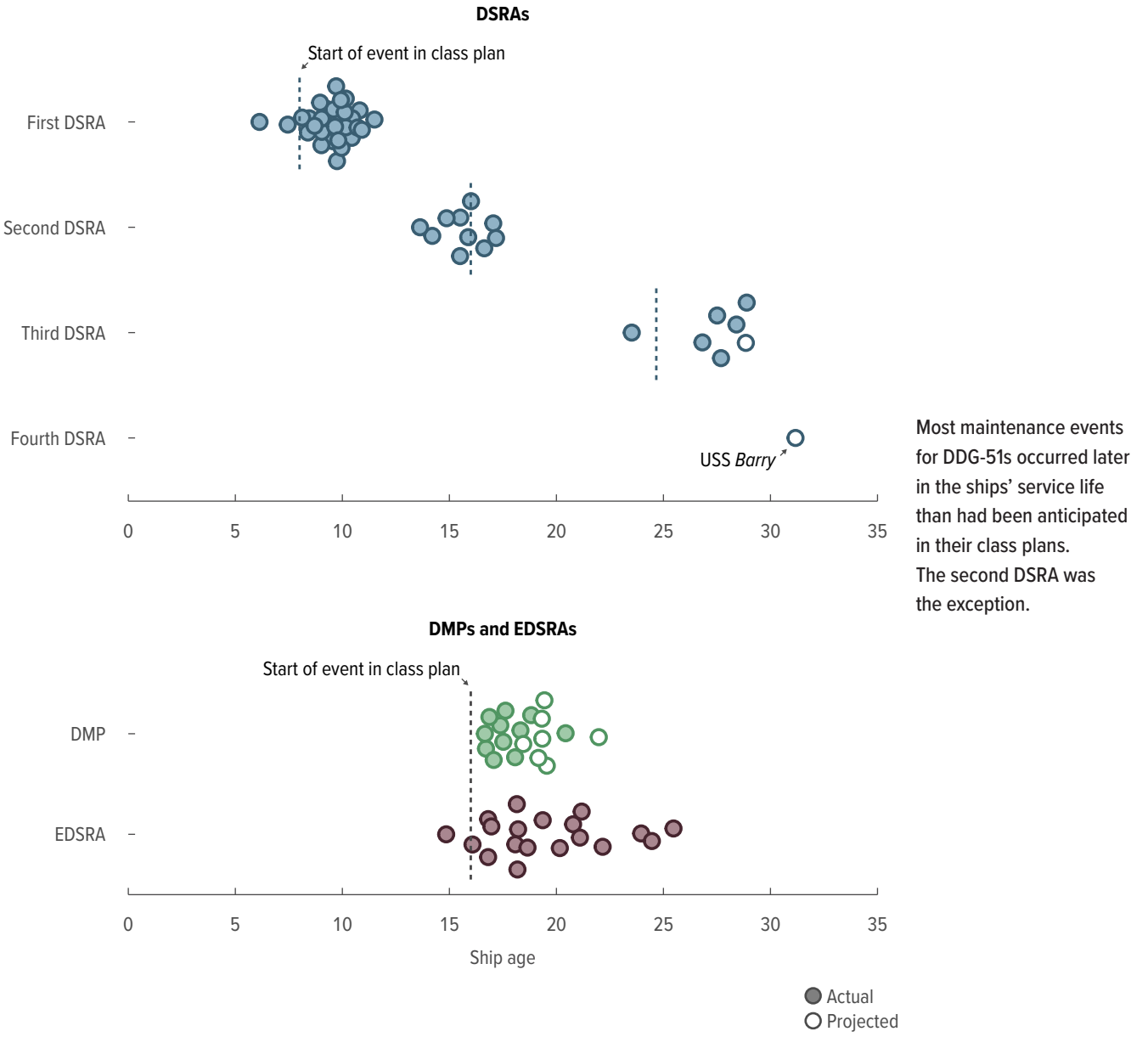
Despite the Navy's efforts to adjust its schedules, unexpected delays and labor overruns have persisted and, in some cases, have grown. There are many possible reasons for that pattern, including late inspections and contract awards, unexpected increases in the scope of work, budget shortages, delays in obtaining parts and materials, poor integration of modernization work, and misaligned contract incentives. Some of the reasons for delays in completing maintenance are temporary or outside of the Navy's control. However, the Navy has at least partial control over other causes of delays.

Late Inspections and Contract Awards

Maintenance events are meant to be informed by detailed inspections and assessments of ships, including their structure and mechanical, electrical, and other systems. But inspections that occur too close to the start of

Figure 3-2.

Ages of DDG-51s at the Start of Docking Events



Most maintenance events for DDG-51s occurred later in the ships' service life than had been anticipated in their class plans. The second DSRA was the exception.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

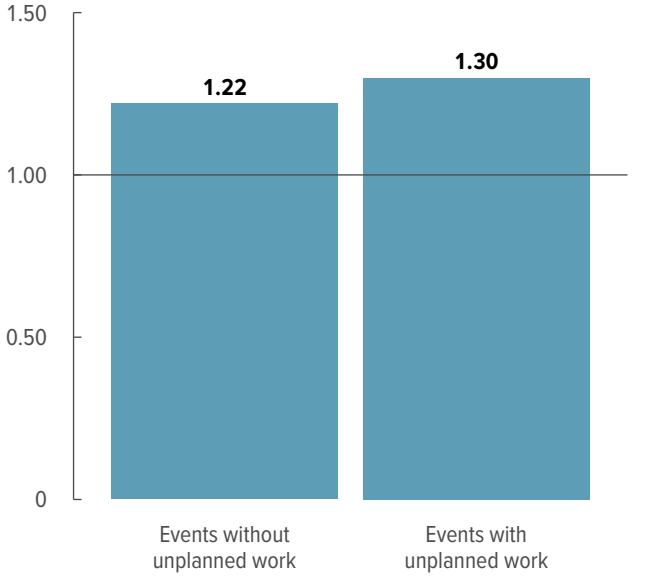
DDG-51 = guided missile destroyer; DMP = depot modernization period; DSRA = docking selected restricted availability; EDSRA = extended docking selected restricted availability.

a maintenance event can lead to delays in finalizing contracts, which can, in turn, lead to delays in getting the parts and materials needed for the overhaul. Late inspections can also delay the hiring of workers to conduct the overhaul. Both of those factors can increase the duration of an overhaul. Missed inspections can cause increases in the scope of work.

The work package for an overhaul is supposed to be complete about a year before the overhaul starts so that the Navy can solicit bids, and the last schedule is prepared about the same time the contract is awarded. The Navy's goal (as of 2020) is to award maintenance contracts at least 120 days before work begins, but shipyards told CBO that the Navy has not yet met that

Figure 3-3.

Average Ratio of the Realized Duration of DDG-51s' Maintenance Events to Estimates in the Navy's Last Schedules, With and Without Unplanned Work



Maintenance events often took longer than estimated in the Navy's last schedules, regardless of whether they involved unplanned work. On average, maintenance events lasted 30 percent longer than estimated in the last schedule if they involved unplanned work and 22 percent longer if they did not.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

A ratio greater than 1 indicates that, on average, overhauls that started in a given year took longer than estimated in the Navy's last schedules. CBO determined whether events involved unplanned work by comparing the realized days of labor to complete an overhaul with the Navy's last estimate for that event. CBO focused on labor because increases in duration may be related to other factors, such as delays in getting parts or negotiating contracts.

Some overhauls in the first column may have included unplanned work that did not cause the total amount of labor to exceed the estimate in the Navy's last schedule.

Realized outcomes reflect both actual outcomes and outcomes that CBO projected for maintenance events that were unfinished as of September 30, 2024. For details about CBO's projection methods, see Appendix C.

DDG-51 = guided missile destroyer.

goal. A shorter window gives shipyards less time to order parts or hire workers, increasing the risk of delays. (That issue is discussed below.) Shipyard representatives told CBO that timely contract awards are critical for ensuring that the necessary parts, materials, and labor are available when work starts.

The Navy has identified the timing of contract awards as an area for improvement. Navy officials told CBO that over the past several years, the average time between a contract award and the start of a maintenance event increased from 30 days to about 100 days, with roughly half of all overhauls meeting the 120-day goal. The Navy has reported additional improvements in the past year, although that extends beyond the period analyzed by CBO.

Unexpected Increases in the Scope of Work

Navy officials and shipyard representatives said that the primary driver of schedule delays and labor overruns was an unplanned increase in the scope of work in ongoing contracts.[3] In the Navy's terminology, unplanned work may be either "new work," meaning additional tasks identified after the work package for a maintenance event is completed, or "growth work," meaning planned tasks that take longer than expected. CBO does not have enough information about the overhauls it examined to distinguish those concepts.

CBO's analysis indicates that maintenance events that started between 2011 and 2024 and involved new or growth work took nearly 30 percent longer, on average, than estimated in the Navy's last schedules. Maintenance events without unplanned work exceeded the estimates in the Navy's last schedules by more than 20 percent (see Figure 3-3). That pattern suggests that, although unplanned work did not fully explain the delays in maintenance events, it lengthened those delays by about one-third. CBO does not have data on which tasks were added to or removed from specific overhauls, so those top-line results may be masking a more nuanced situation.

Traditionally, when unplanned work is identified, the shipyard submits an estimate of the time and cost to complete it, and a Navy engineer assesses the issue and recommends a maintenance strategy. Once the Navy and the shipyard agree on the scope of the work, they negotiate the cost of the additional tasks. Finalizing changes in the contract can take days or weeks, depending on the size of the project and the number of engineers involved. In the meantime, the workers in the shipyard may stop work on the ship or shift to other projects.

3. Navy experts told CBO that unplanned work is especially likely to delay the completion of a maintenance event if it is identified when the event is more than 40 percent complete.

The total delay that results from unplanned work includes the time spent in each of those stages, along with the time it takes to complete the additional work. Related work may also be delayed if it occurs later in the sequence of jobs. Shipyard representatives told CBO that negotiations with customers such as the Military Sealift Command, the Coast Guard, and private shipping companies take less time than similar negotiations with the Navy.

In 2018, to reduce delays from those negotiations, the Navy created an expedited process to approve small-dollar ($25,000 or less) changes to maintenance contracts. Shipyards now receive a predetermined sum of $7,144 to address a small-dollar maintenance concern.[4] That payment is meant to reflect the average cost of small-dollar changes. If a repair costs more than $7,144, a shipyard will lose money. If the repair costs less than $7,144, a shipyard can keep the difference. The Navy assumes that, on average, a shipyard will break even on small-dollar repairs. According to Navy and shipyard officials, the new process has reduced the average time to change a contract from weeks to days in recent years but has raised questions at some shipyards about whether the fixed payment is large enough to meet average costs. Other initiatives to streamline contract changes are underway, but CBO has limited information about them.

Unexpected increases in the scope of work can arise for a variety of reasons, including unforeseen problems in a ship class, skipped or shortened inspections of a ship before a contract for a maintenance event is awarded, or postponed maintenance tasks.

Unforeseen Problems in a Class. The 2012 class maintenance plans for DDG-51 destroyers outline specific tasks to improve a ship's structural integrity and mechanical or electrical systems in each maintenance event. Navy officials use engineering assessments and data from previous overhauls to estimate DDG-51s' maintenance needs; however, unforeseen work may be necessary.

For example, a common cause of new work identified during destroyers' maintenance periods was excessive corrosion on the underwater propulsion shaft. Once DDG-51s were out of the water for docking events, maintenance workers found that the shaft had corroded faster than the Navy's engineers had estimated. Instead of lasting for the life of the ship, the shaft needed to be replaced halfway through a ship's expected service life. Addressing that issue added time and labor to the ships' DMP. Initially, that increase in the scope of work was unexpected; for later ships, it was incorporated into the work package that shipyards bid on. Other common types of unplanned work for the DDG-51 class have been caused by excessive corrosion in tanks and smokestacks.

Skipped or Shortened Inspections. Navy officials have opportunities to identify possible problems with a ship through inspections and include them as items in the work package for a maintenance event. Some important inspections occur more than a year before the event, when officials assess a ship's condition by closely examining its structure and systems to better define the work that needs to be done. However, those assessments are resource-intensive and may require a deployed ship to be taken out of service while its engines and tanks are evaluated.

Navy officials told CBO that assessments are sometimes skipped or shortened (and therefore less thorough) in favor of ongoing missions. Those decisions allow the Navy to prioritize current operations but may increase ships' later maintenance requirements and time away from the fleet. Cutting back on inspections may also give the Navy and the shipyards less insight into the amount of work needed to complete an overhaul on time.

Postponed Maintenance Tasks. Another reason for increases in the scope of work mentioned by Navy and industry experts was the Navy's increasing tendency to postpone maintenance in response to schedule or budget constraints. Postponing maintenance tasks may shorten the current overhaul but lengthen the next one by increasing the amount of work—both expected and unexpected—that it requires.

Budget Shortages

Some experts from the Navy and private shipyards indicated that occasional budget shortages can lengthen negotiations related to unplanned work or a pause in work. In a 2015 report, the RAND Corporation found that the Navy's funding for DDG-51s' maintenance and modernization activities fell short of the amounts recommended by engineers in the class plans.[5]

4. Government Accountability Office, *Navy Ship Maintenance: Evaluating Pilot Program Outcomes Could Inform Decisions to Address Persistent Schedule Challenges*, GAO-20-370 (May 2020), p. 25, www.gao.gov/products/gao-20-370.

5. Robert W. Button and others, *Assessment of Surface Ship Maintenance Requirements* (RAND Corporation, 2015), pp. 1–57, www.rand.org/pubs/research_reports/RR1155.html.

However, Navy officials told CBO that, for destroyers, shortages of maintenance funds caused delays only occasionally and only at the end of a fiscal year. In those cases, some tasks in a maintenance event would be delayed until the following fiscal year, which could increase the event's duration.

Starting in 2020, to help the Navy manage such delays, Congress shifted some maintenance funding from the Navy's operation and maintenance account (from which funds must be obligated within one fiscal year) to its other procurement account (from which funds can be obligated over more than one year; see Figure 2-2 on page 18). That shift has given the Navy more flexibility to reallocate funding from one fiscal year to another or from one account to another if an overhaul takes longer than expected or its start is delayed. All of the Navy and shipyard officials CBO met with said that that change has helped to reduce some delays.

Delays in Obtaining Parts and Materials

Another cause of delays during routine maintenance events is the extra time it can take to receive all the needed parts and materials, including government furnished material (GFM) or long lead time material (LLTM)—items that take months or years to fabricate and send to the shipyard. Delays in the process of awarding the contract or problems in the supply chain can slow the delivery of those items. Unplanned work identified after the ship enters the shipyard can also require unexpected GFM and LLTM.

Although the Navy has a process to order GFM and LLTM after a contract is awarded, the deliveries of those materials may still be delayed, thus delaying the completion of maintenance events. In some cases, work on a ship has stopped until the missing parts arrived. Shipyard representatives told CBO that in the past, they had maintained a pool of spare parts that they could use when GFM was late, but that practice ended when the Navy started using fixed-price contracts for each maintenance event (an issue that is discussed below). Shipyards are reluctant to invest in spare parts that they may not immediately use if they do not have a guarantee that they will be reimbursed by the Navy.

Shipyards often award subcontracts to small businesses to provide metals or parts for maintenance overhauls, and those small businesses have been vulnerable to supply-chain challenges. The coronavirus pandemic exacerbated those challenges. Representatives from most shipyards told CBO that during the pandemic, the lead time required to fabricate and ship parts increased because small-business subcontractors were more susceptible to labor and supply disruptions. Delays in obtaining GFM and LLTM may persist if small businesses continue to face staffing and production challenges.

The Navy has reported that in recent years, shipyards' delays in obtaining parts have decreased. According to information provided to CBO by the Navy, since 2020, about 90 percent of parts have been available for amphibious ships before an overhaul starts, and about 95 percent have been available for other surface ships. That accounting does not indicate whether the remaining parts were critical for meeting the overhauls' schedules.

Poor Integration of Modernization Work

During some maintenance periods, the Navy had planned for modernization work on a ship's electronics, radar, or weapon systems to be completed concurrently with routine maintenance tasks. However, Navy officials and shipyard representatives told CBO that completing both types of work simultaneously was challenging and often led to delays. One Navy official told CBO that it was a key driver of delays and labor overruns.

One reason for those challenges is that contracts for maintenance and contracts for modernization are separate and originate in two different Navy organizations. The scope of modernization work during an overhaul is outlined in a modernization contract between Naval Sea Systems Command and an alteration installation team (AIT), which may include an equipment manufacturer or other specialist, whereas maintenance contracts are often between regional maintenance centers and private shipyards. Until recently, although maintenance contracts had to be awarded at least 120 days before the start of a maintenance event, modernization contracts did not. As a result, shipyard representatives explained, it was difficult to develop a maintenance schedule around an AIT's modernization workload. To improve the situation, in January 2022, the Navy mandated that modernization contracts also be awarded at least 120 days before the start of a maintenance event. Moreover, AITs are required to submit an integrated schedule to the shipyard performing the maintenance event 85 days before the overhaul starts.

Shipyard representatives told CBO that they were encouraged by the Navy's efforts to better integrate

modernization activities into maintenance periods but were skeptical about how that integration would be achieved. First, AITs and modernization contracts will still not be overseen by the same organizations that govern maintenance events. That separation in responsibility makes the coordination of maintenance and modernization events difficult. Second, shipyard representatives said that AITs were less experienced at drafting integrated schedules than the maintenance shipyards. Some shipyards had to delay maintenance work because AITs were behind on their work schedule or lacked the parts required to complete a project.

Issues With Contract Incentives

From 2004 to 2015, the Navy designed most of its maintenance contracts for large surface ships using a *multiyear cost-plus* structure: It awarded a private shipyard all of the maintenance events for a single ship over a multiyear period and allowed the shipyard to request additional funds if the labor exceeded the Navy's estimates. Many shipyard representatives told CBO that the predictability created by that style of contracts helped them to more accurately estimate their future workloads and labor needs. Shipyard workers also gained technical experience with specific ships and ship classes because ships returned to the same yard over multiple years.

The Navy officials who spoke with CBO did not share the shipyard managers' enthusiasm for multiyear cost-plus contracts. One official told CBO that it was a challenge to regulate cost-plus contracts because the scope of work was more difficult to determine. Maintenance costs often increased as unplanned work was identified and addressed.

Starting in 2015, the Navy replaced most cost-plus contracts with *single-event, fixed-price* agreements.[6] The new contracts more explicitly define the work to be completed and do not reimburse shipyards for extra work unless the Navy and the shipyard agree on a contract change. Each overhaul is bid on separately, so a ship may go to a different yard for each overhaul. The use of single-event, fixed-price contracts had an immediate impact on the likelihood of a particular shipyard's receiving a contract award. More shipyards competed for and bid on maintenance events, which reduced costs, according to the Navy; however, delays and labor overruns have persisted and have even worsened.[7] CBO was unable to analyze whether the change in the Navy's contracting approach affected delays and labor overruns because other aspects of the Navy's fleet, funding, and operations were changing at the same time.

Some shipyard representatives told CBO that fixed-price contracts have reduced their ability to invest in facility improvements, to stock LLTM, or to hire additional long-term workers because they do not know if they will win future Navy contracts. Moreover, shipyards must maintain a greater variety of ships and ship classes to qualify to bid on fixed-price contracts. That may reduce a shipyard's ability to specialize in a particular ship class, leading to duration increases and labor overruns as shipyard maintainers work on ship classes they are unfamiliar with.

In the Navy's view, capacity constraints at shipyards, not issues with contracts, have caused some delays. Capacity constraints *have* caused delays at private shipyards that build new ships and at Navy shipyards that maintain nuclear-powered ships.[8] However, in interviews with CBO, representatives of the private shipyards maintaining the Navy's conventional ships said that, if anything, they have had excess capacity. Some representatives said that their workload in recent years had been lower than expected, in part because work had been moved or delayed or because more shipyards were bidding on overhauls. In some cases, they had unused capacity (empty dry docks and not enough maintenance events to bid on) and had laid off workers or considered retiring their dry docks.[9] So, in the shipyards' view, the delays are due to causes other than capacity constraints.

6. Government Accountability Office, *Navy Ship Maintenance: Action Needed to Maximize New Contracting Strategy's Potential Benefits*, GAO-17-54 (November 2016), www.gao.gov/products/gao-17-54.

7. Megan Eckstein, "GAO: Navy Seeing Improvements in Surface Ship Maintenance Costs, but Schedule Is Still an Issue," *USNI News* (May 13, 2020), https://tinyurl.com/y2wrdpvu; and Government Accountability Office, *Navy Ship Maintenance: Evaluating Pilot Program Outcomes Could Inform Decisions to Address Persistent Schedule Challenges,* GAO-20-370 (May 2020), www.gao.gov/products/gao-20-370.

8. See Congressional Budget Office, *An Analysis of the Navy's 2025 Shipbuilding Plan* (January 2025), www.cbo.gov/publication/60732, and *The Capacity of the Navy's Shipyards to Maintain Its Submarines* (March 2021), www.cbo.gov/publication/57026.

9. Government Accountability Office, *Shipbuilding and Repair: Navy Needs a Strategic Approach for Private Sector Industrial Base Investments*, GAO-25-106286 (February 2025), www.gao.gov/products/gao-25-106286; and Gary Robbins, "Struggling for Contracts, BAE Systems Cuts More Jobs at San Diego Shipyard in Big Downturn," *San Diego Union-Tribune* (updated March 1, 2024), https://tinyurl.com/hhkpbp8f.

Consequences of Maintenance Delays

There are different ways to measure the effects of maintenance delays on the Navy. A common approach is to describe the effect on the Navy's fleet readiness—that is, the number of ships that the Navy can deploy at any one time. Another approach is to infer the value of the services forgone when a ship is not in the fleet. CBO inferred that value from the cost of purchasing and operating the ships.

Fleet Readiness

Persistent delays in routine maintenance events mean that fewer ships are available to perform the Navy's missions.[10] For a ship to be ready for operations, it must not be in maintenance or awaiting maintenance, and the crew must be trained.[11] If all maintenance on DDG-51s were performed according to the schedule laid out in the 2012 class plans, those ships would be with the fleet over 80 percent of the time. Although some of that time with the fleet would be spent in small maintenance events, and crews would need time to train after large maintenance events, well over half of the fleet would be deployable at any given time. By comparison, at some points in recent years, only about one-third of the ships were available for operations.[12]

The Navy has announced a new goal to increase its overall fleet readiness so that about half of its surface ships (including destroyers) are deployable and ready for operations, but progress toward that goal has been slow.[13] The Navy's own recent assessments indicate little or no progress in improving the readiness of the fleet.[14] However, the precise effects of the maintenance delays are not clear because the Navy has not released estimates of the costs of those delays in the form of lost ship life, lower readiness, forgone missions, or other disruptions.

Inferred Cost

CBO inferred the cost of DDG-51s' missed days in the fleet by quantifying the value of the ships' availability to the Navy. CBO computed the average cost per day by dividing the lifetime cost of a destroyer, including the costs for its procurement, crews, and operation and maintenance, by the amount of time Navy planners had expected the destroyer to be available for operations in its class plan.[15]

Because the Navy has chosen to pay those costs to procure its DDG-51s and keep them operating (and is currently choosing to purchase additional destroyers at higher cost), the value to the Navy of a destroyer's availability must be at least as large as that computed cost per day. Thus, shortening a maintenance event by one day should be worth at least that much to the Navy. (The Navy has stopped production early for some types of ships, such as the DDG-1000, and has retired others many years ahead of schedule, such as the littoral combat ship, which suggests that the costs of purchasing and operating them were greater than the value they provide.)

CBO inferred that the value of a destroyer's availability for one day is at least $600,000. That high opportunity cost suggests that the Navy is faced with difficult decisions. It can postpone maintenance now to support current high-value operations, but doing so can lead to more lost availability later (which also has high value). CBO cannot determine with the available data how such decisions may have affected the Navy's total spending or the total time its ships will spend in maintenance.

10. Government Accountability Office, *Navy Ship Maintenance: Actions Needed to Monitor and Address the Performance of Intermediate Maintenance Periods*, GAO-22-104510 (February 2022), www.gao.gov/products/gao-22-104510, and *Navy Maintenance: Persistent and Substantial Ship and Submarine Maintenance Delays Hinder Efforts to Rebuild Readiness*, GAO-20-257T (December 2019), www.gao.gov/products/gao-20-257t.

11. For an example of efforts to promote such readiness, see Megan Eckstein, "Seeking 75 Ships Ready for Combat, Navy Turns to New Readiness Orgs," *Defense News* (January 9, 2024), https://tinyurl.com/3s3h44zd.

12. Government Accountability Office, *Navy Ship Maintenance: Actions Needed to Monitor and Address the Performance of Intermediate Maintenance Periods*, GAO-22-104510 (February 2022), www.gao.gov/products/gao-22-104510, and *Navy Maintenance: Persistent and Substantial Ship and Submarine Maintenance Delays Hinder Efforts to Rebuild Readiness*, GAO-20-257T (December 2019), www.gao.gov/products/gao-20-257t.

13. Gidget Fuentes, "SWO Boss: 75-Warship Readiness Goal Remains a Work in Progress," *USNI News* (updated August 14, 2024), https://tinyurl.com/2cxa8ay5.

14. Geoff Ziezulewicz, "Fleet's Material Condition Keeps Getting Worse, New INSURV Report Says," *Navy Times* (June 2, 2023), https://tinyurl.com/5n7r9bty; and Department of the Navy, Board of Inspection and Survey, *INSURV Annual Report* (March 1, 2023), https://tinyurl.com/4mx8ppsh.

15. To compute that average cost, CBO converted the lifetime costs and benefits of destroyers into present values and calculated the ratio of the present-value costs and benefits. For more information about that technique, see Edward G. Keating and Elvira N. Loredo, *Valuing Programmed Depot Maintenance Speed: An Analysis of F-15 PDM* (RAND Corporation, 2006), www.rand.org/pubs/technical_reports/TR377.html.

Appendix A: Maintenance Delays and Labor Overruns for Amphibious Ships

The Congressional Budget Office analyzed the maintenance experiences of two common types of ships that had sufficient sample sizes in the data provided by the Navy: destroyers and amphibious warfare ships. Arleigh Burke destroyers make up the largest class in the Navy's fleet and account for most of the docking and nondocking maintenance events in the data, but the amphibious ships—amphibious assault ships (LHDs), amphibious transport docks (LPDs), and both classes of dock landing ships (LSDs)—have experienced similar maintenance delays and labor overruns. This appendix presents CBO's findings for those amphibious ships.

CBO used the same analytical approach for amphibious ships as it did for destroyers, including making projections of the durations and labor use of overhauls that were still ongoing at the end of fiscal year 2024. (See Appendix C for details about CBO's projection methods.) CBO did not analyze maintenance events for the Navy's newest class of amphibious assault ships (LHAs) because there were too few observations of those ships in the data. CBO also did not make comparisons with the class plans for amphibious ships because it was unable to obtain those plans from the Navy. CBO focused primarily on the last schedule because it is the most common point of reference for measuring delays in a maintenance event.

LHDs' Maintenance Events

On average, LHDs' maintenance events took longer to complete and required more labor than was estimated in the Navy's first and last schedules for those events. Nevertheless, in percentage terms, LHDs had the smallest delays and labor overruns among the three classes of amphibious ships that CBO analyzed.

The durations of LHDs' maintenance events exceeded estimates in the Navy's last schedules by an average of 90 days, or 27 percent. Estimates of labor use in the last schedules were more accurate than estimates of duration for all three types of amphibious ships. For LHDs, the labor estimate in the last schedule fell short of the realized days of labor by an average of 16,000 days, or 11 percent (see Figure A-1).

LPDs' Maintenance Events

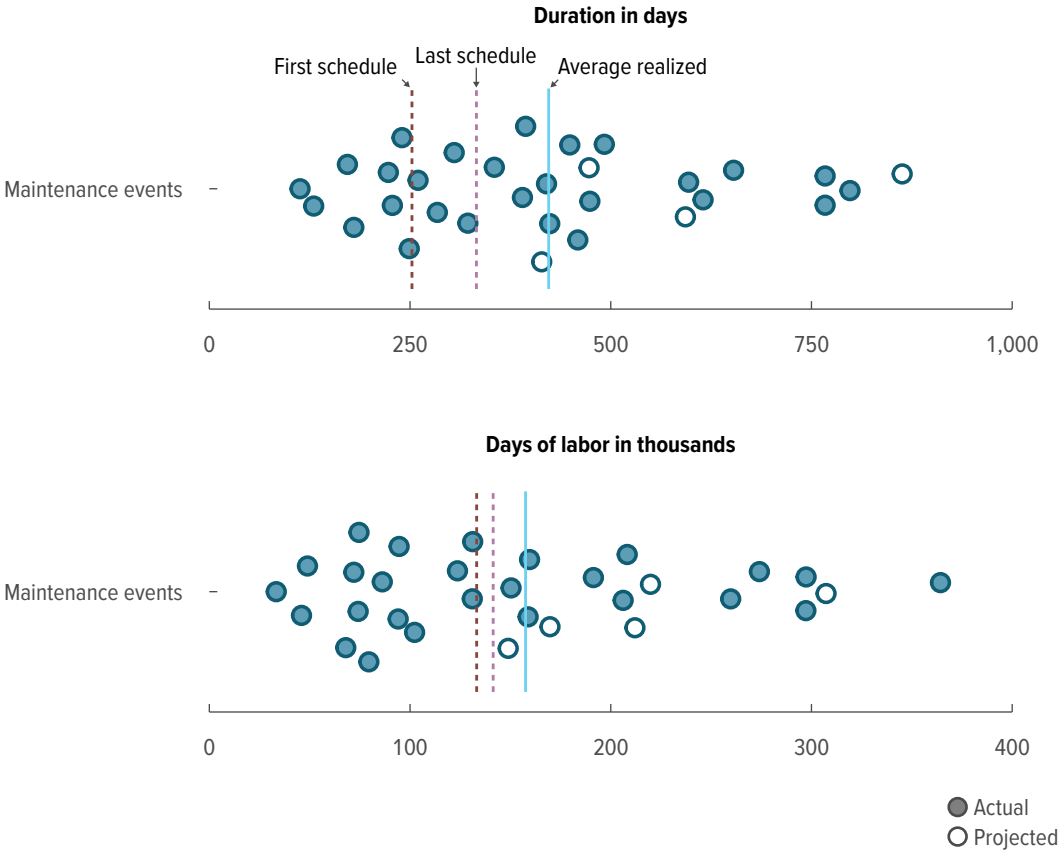
On average, the realized duration of LPDs' maintenance events exceeded the estimates in the Navy's last schedules by 142 days, or 45 percent (see Figure A-2). The last schedules' estimates of labor use were more accurate in percentage terms, understating the labor used to complete an overhaul by an average of 21,000 days, or 31 percent.

LSDs' Maintenance Events

On average, the realized durations and days of labor for LSDs' maintenance events exceeded the estimates in the Navy's first and last schedules. (For this analysis, CBO combined events for LSD-41 class and LSD-49 class ships.) The realized durations exceeded the estimates in the last schedules by an average of 213 days, or 62 percent (see Figure A-3). The realized days of labor exceeded the estimates in the last schedules by an average of 39,000 days, or 40 percent. Those delays and labor overruns were the largest among the amphibious ship classes.

Figure A-1.

Durations and Days of Labor for LHDs' Maintenance Events



The performance of maintenance for LHDs was similar to that for DDG-51s in terms of percentage delays and labor overruns relative to estimates in the Navy's schedules.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

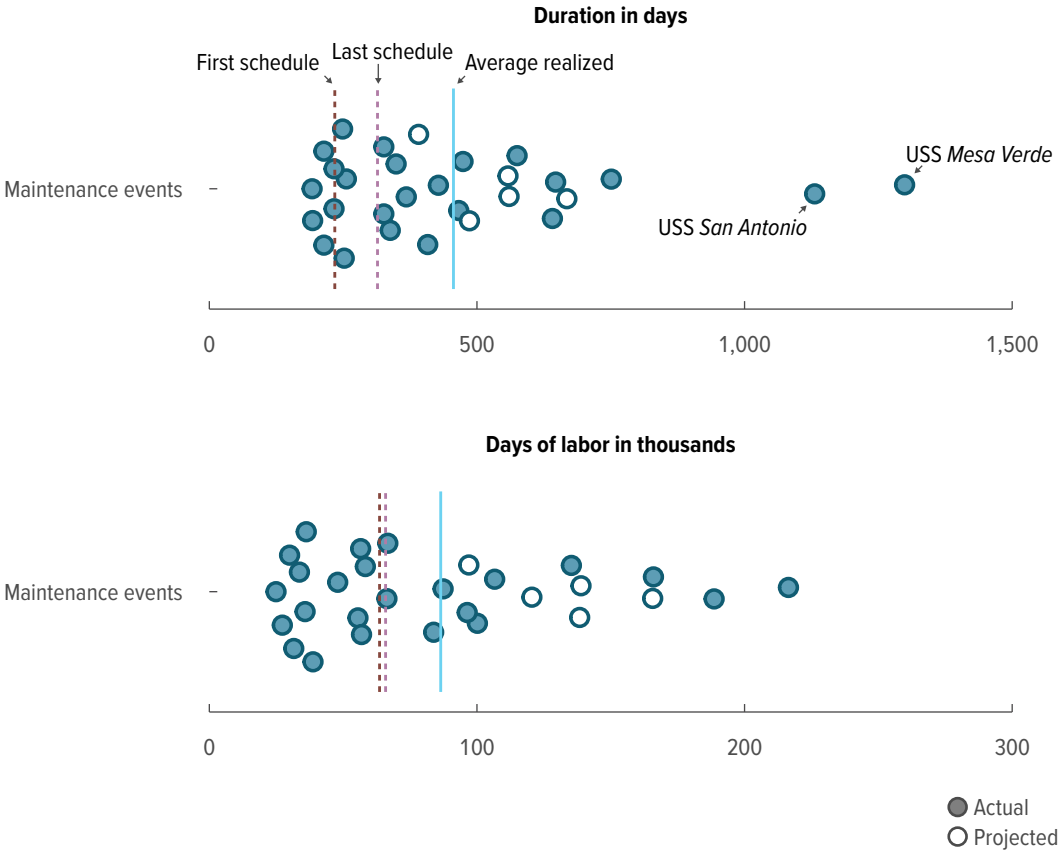
This figure presents realized (actual or projected) outcomes for the 31 LHD overhauls included in Table S-1 on page 6. Four overhauls had not been completed and did not have final values for their duration or labor use in the data. One other overhaul had been completed but did not have a final value for labor use. For details about CBO's projection methods for overhauls that had not been completed, see Appendix C.

CBO grouped different types of overhauls together for amphibious ships because of small sample sizes and other data anomalies, such as unusual overhaul types. That explains the wide spread in durations and days of labor.

DDG-51 = guided missile destroyer; LHD = amphibious assault ship.

Figure A-2.

Durations and Days of Labor for LPDs' Maintenance Events



Amphibious ships tend to be larger and older than destroyers, and therefore their overhauls take longer—sometimes over three years.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

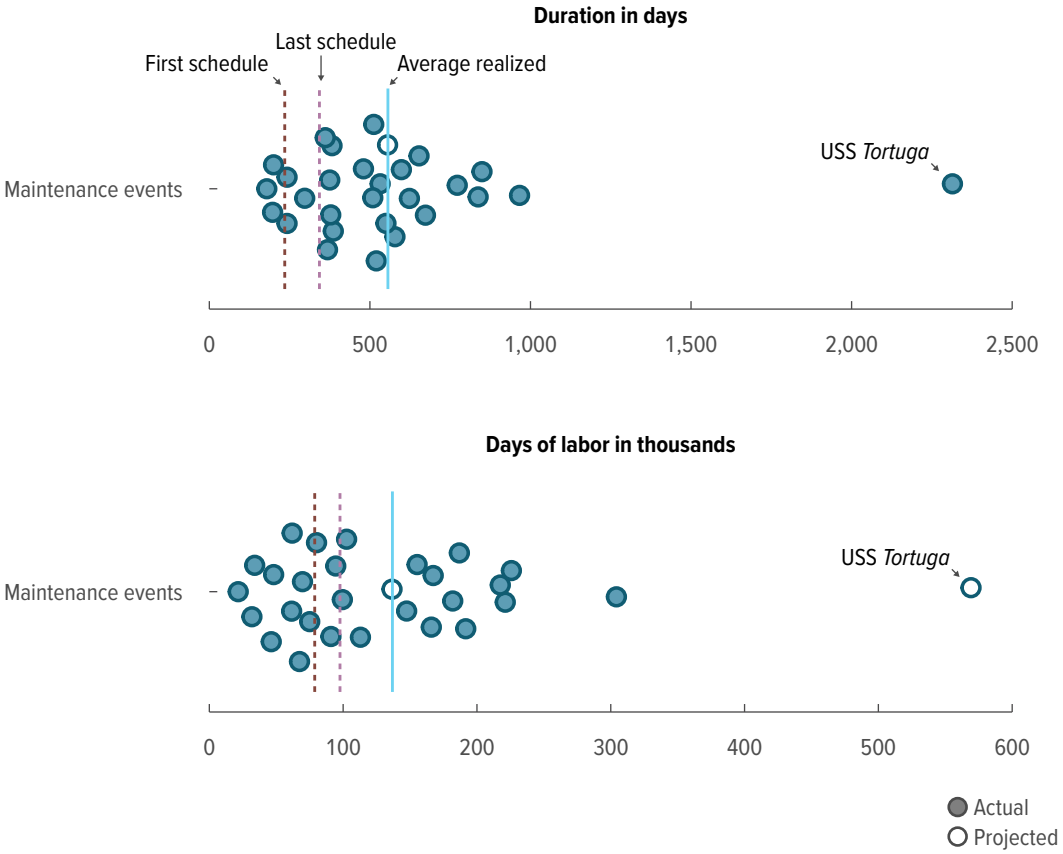
This figure presents realized (actual or projected) outcomes for the 29 LPD overhauls included in Table S-1 on page 6. Five overhauls had not been completed and did not have final values for their duration or labor use in the data. For details about CBO's projection methods for overhauls that had not been completed, see Appendix C.

CBO grouped different types of overhauls together for amphibious ships because of small sample sizes and other data anomalies, such as unusual overhaul types. That explains the wide spread in durations and days of labor.

LPD = amphibious transport dock.

Figure A-3.

Durations and Days of Labor for LSDs' Maintenance Events



LSDs are even older than LPDs. Maintenance events for LSDs have taken as long as six years; they also tend to use more labor.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

This figure presents realized (actual or projected) outcomes for the 29 LSD overhauls included in Table S-1 on page 6. One overhaul had not been completed and did not have final values for its duration or labor use in the data. Another overhaul had been completed but did not have a final value for labor use. For details about CBO's projection methods for overhauls that had not been completed, see Appendix C.

CBO grouped different types of overhauls together for amphibious ships because of small sample sizes and other data anomalies, such as unusual overhaul types. That explains the wide spread in durations and days of labor.

LSD = dock landing ship.

Appendix B: Maintenance Data From Naval Sea Systems Command

Naval Sea Systems Command (NAVSEA) provided the Congressional Budget Office with data on 657 maintenance events that began between fiscal year 2011 and fiscal year 2024, covering eleven types of conventionally powered surface ships (see Table B-1). This appendix describes the information captured by the full dataset and explains how CBO used and filtered the data in its analysis.

Of the eleven ship types covered by the NAVSEA data, CBO focused on large combat surface ships because of their importance to the Navy. Within that subset, CBO analyzed the two most common types of large ships: destroyers and amphibious warfare ships. Arleigh Burke class destroyers (DDG-51s) are the most numerous class in the fleet, but the amphibious ships—amphibious assault ships (LHDs), amphibious transport docks (LPDs), and dock landing ships (LSDs)—have experienced similar delays and labor overruns and are also important to Navy and Marine Corps operations. CBO did not analyze Zumwalt class destroyers (DDG-1000s) or the Navy's newest class of amphibious assault ships (LHAs) because there were few maintenance events for those ships in the data.

Overhauls documented in the NAVSEA data were completed in the United States and in foreign shipyards located in Spain, Japan, and Bahrain. Maintenance events in foreign shipyards often adhere to different procedures, accounting methods, and timelines than those completed in the United States. The cost of maintenance in foreign countries may also be different, depending on labor market conditions and use agreements. For those reasons, CBO restricted the maintenance events it analyzed to those completed in shipyards in the United States.

The Navy estimates the time and labor needed to complete a maintenance event in class-specific maintenance plans and ship-specific assessments made before the event begins. Class maintenance plans were available only for destroyers. The data that CBO used included the start and end dates and days of labor for each maintenance event, as well as estimates from the various schedules the Navy prepared before that event. The data also contained partial information about the durations and labor use of ship overhauls that had not been completed as of September 30, 2024, the final date in the data.

Table B-1.

Maintenance Events From 2011 to 2024 in NAVSEA's Data, by Ship Type

Ship type	Number of overhauls
Destroyers (DDG-51s and DDG-1000s)	324
Amphibious assault ships (LHD-1s and LHA-6s)	42
Amphibious transport docks (LPD-4s and LPD-17s)	44
Dock landing ships (LSD-41s and LSD-49s)	38
Cruisers (CG-47s)	74
Mine countermeasures ships (MCMs)	53
Patrol ships (PCs)	32
Frigates (FFGs)	26
Littoral combat ships (LCS-1s and LCS-2s)	13
Command ships (LCCs)	11
Total	**657**

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

This table lists *all* overhauls in the data provided by the Navy that had started as of September 30, 2024, including overhauls that were excluded from CBO's analysis: those that were performed at foreign shipyards, were unusual, or involved classes of ships with too few overhauls for analysis or classes other than destroyers or amphibious ships. It excludes 44 planned overhauls that were listed in the data but had not started as of September 30, 2024.

NAVSEA = Naval Sea Systems Command.

Appendix C: Projecting Total Duration and Labor for Unfinished Overhauls

Naval Sea Systems Command (NAVSEA) provided the Congressional Budget Office with data on the time and labor associated with ship overhauls performed in fiscal years 2011 to 2024. Many multiyear overhauls that started in the past few years were unfinished when NAVSEA provided those data to CBO. The NAVSEA data recorded estimates from the Navy's first and last schedules for those unfinished overhauls, but not their total durations or labor use.

Either excluding or including those unfinished overhauls in the analysis of maintenance performance would change the results. For example, excluding unfinished overhauls that were already delayed would cause the percentage of overhauls completed on time to seem higher than it really was. The results would be similarly distorted if CBO included the unfinished overhauls and treated their observed durations and labor levels on the last day in the data as final.

To avoid such bias, CBO projected the total time and labor that would ultimately be associated with the still-in-progress overhauls. By construction, those projections were greater than the observed durations and days of labor for the same overhauls as of September 30, 2024. This appendix describes how CBO determined how much greater the projected totals should be.

Survival Analysis

CBO used a technique called survival analysis to project the total duration (and then estimate the associated labor) for unfinished overhauls in the NAVSEA data. Survival analysis is a branch of statistics and econometrics concerned with modeling the time until an event of interest occurs. In economics and related social sciences, it is often used to analyze durations—such as the length of unemployment spells, time to default on a loan, or the duration of a business cycle phase. The key feature of survival data is that the event of interest may not have occurred for all subjects within the observation period.[1]

This method allowed CBO to more accurately describe the performance of all maintenance events that began between 2011 and 2024, especially those that began in more recent years and were more likely to be unfinished.

In all, CBO used this technique to project durations and then days of labor for 25 unfinished maintenance events for guided missile destroyers (DDG-51s), amphibious assault ships (LHDs), amphibious transport docks (LPDs), and dock landing ships (LSDs) out of a total of 326 events that CBO analyzed for those ships (see Table C-1).[2] For each unfinished overhaul, CBO used data on the type of ship, the ship's age, and the durations and days of labor for completed overhauls to project the total duration and days of labor.

Survival Analysis Analogies

Projections of lifespan and time to failure are well-studied topics. The field of survival analysis, which typically measures the efficacy of drugs or projects lifespans for health insurance coverage, has developed many models that can include the effects of multiple factors on those and other outcomes. For example, life expectancy can be projected on the basis of a person's age—a baby has a life expectancy of 78 years, whereas an adult who has lived to 65 is expected to live to 85—but additional factors such as sex or level of education can affect those projections.

A survival model can also be used to project the total duration (duration so far plus a projection of remaining duration) of unfinished ship maintenance events (see Table C-2). In that approach, a ship that is just entering the shipyard for a maintenance event is expected to remain for the average duration for that type of event. But the longer the ship is in the yard, the longer the maintenance event is likely to take. Accounting for factors such as the age of the ship can also affect the projected duration—older ships tend to require more work, for example.

1. Jeffrey M. Wooldridge, *Econometric Analysis of Cross-Section and Panel Data*, 2nd ed. (MIT Press, 2010), Chapter 22.

2. Another event in the data had a final value for its duration but not its labor.

Table C-1.

Projected Total Durations and Days of Labor for Maintenance Events That Were Unfinished as of September 30, 2024

Ship class and hull number[a]	Type of maintenance event	Ship's age at start of event[b]	Start date of event	Days in shipyard as of September 30, 2024	Projections	
					Duration (days)	Labor (thousands of days)
DDG-51 class						
DDG-52	DSRA	31.2	02/05/24	239	717	153
DDG-60	SRA	29.0	06/03/24	120	633	57
DDG-61	DSRA	28.8	02/26/24	218	556	122
DDG-63	SRA	28.5	04/08/24	176	603	55
DDG-64	SRA	28.4	06/24/24	99	590	53
DDG-70	SRA	26.8	05/27/24	127	489	46
DDG-73	SRA	25.5	03/04/24	211	435	42
DDG-82	DMP	22.0	01/23/23	617	775	125
DDG-90	DMP	19.3	02/06/23	603	726	120
DDG-91	DMP	19.6	02/05/24	239	640	111
DDG-93	DMP	19.4	12/04/23	302	642	111
DDG-94	DMP	18.4	07/17/23	442	651	112
DDG-95	DMP	19.2	01/15/24	260	620	109
DDG-97	DMP	19.3	09/23/24	8	628	110
DDG-99	SRA	17.9	04/15/24	169	234	26
LHD-1 class						
LHD-2	DSRA	29.7	06/06/22	848	863	307
LHD-3	DSRA	29.5	04/17/23	533	593	212
LHD-5	DSRA	26.5	04/01/24	183	414	149
LHD-6	DPMA	20.3	11/05/18	615	615[c]	220
LHD-8	SRA	13.8	08/21/23	407	473	170
LPD-17 class						
LPD-19	SRA	16.4	05/06/24	148	391	97
LPD-23	DSRA	10.2	07/24/23	435	486	121
LPD-24	DSRA	10.0	04/17/23	533	560	139
LPD-26	SRA	7.1	11/13/23	323	558	138
LPD-27	SRA	5.0	12/14/22	657	668	166
LSD-41 class						
LSD-46	MODPRD	27.2	01/08/18	2,314	2,314[c]	569
LSD-49 class						
LSD-50	DSRA	28.8	07/22/24	71	555	137

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

DMP = depot modernization period; DSRA = docking selected restricted availability; MODPRD = modernization period; SRA = selected restricted availability.

a. See Figure 1-1 on page 10 for descriptions of ship classes. The combination of letters and numbers in a ship class designates the type of ship and the first hull number of the class—for example, DDG-51 is a guided missile destroyer (DDG), and its lead ship is number 51.

b. Ships' age is measured from their commissioning date.

c. CBO classified an overhaul as finished if it had a final, or "closeout," duration and a total for days of labor in the dataset. Two unfinished overhauls had a closeout duration but not total days of labor. For these overhauls, CBO treated the closeout duration as the actual duration and projected the days of labor.

Table C-2.

An Analogy Between Projections of Life Expectancy and the Duration of Ship Maintenance Events

Projecting life expectancy	Projecting ship maintenance duration
A survival model can be used to estimate people's life expectancies without observing everyone's entire lifetime. At birth, a person's life expectancy in the United States is 78 years.	A survival model can be used to estimate when ongoing maintenance events will finish. Before a maintenance event begins, the Navy estimates how long it will last. For example, the average duration of a DSRA for a DDG-51 is 11 months.
Accounting for how long a person has already lived increases the accuracy of those estimates. Conditional on reaching a certain age, that person's life expectancy increases. For example, at age 65, a person's life expectancy is 85 years.	Including those unfinished events in performance analyses will reduce bias. The longer a maintenance event runs, the longer its total duration is likely to be. For example, after a ship has been in the yard for one year, it is projected to stay for six additional months.
Demographic characteristics such as sex and ethnicity may affect lifespan estimates and can be included in the model. For example, once men reach the age of 65, their life expectancy is 83, while women's is 86.	Accounting for additional explanatory variables such as ships' age and the type of maintenance event can improve the accuracy of the projections. For example, the estimated duration of a DSRA increases with the age of the ship.

Data source: Congressional Budget Office, using data from the National Center for Health Statistics.

DDG-51 = guided missile destroyer; DSRA = docking selected restricted availability.

Applying Survival Analysis to Ship Overhauls

CBO used a logistic survival model to project the total duration of maintenance events. In that model, CBO projected the probability that an overhaul would be completed on each day the ship was undergoing maintenance. That required structuring the data so that each day before an overhaul finished was counted as unfinished and only the day that the ship actually finished was counted as finished. For example, if a ship completed its overhaul on day 232, CBO created 231 observations with a "finished" indicator variable equal to 0, and the observation for day 232 had the indicator variable set to 1. Unfinished overhauls received a 0 for all of the days the ship was observed in the dataset.

Once the data were structured in that way, CBO used a logistic function to model the probability that an overhaul finished on any particular day. The logit model is a type of binary response model used in econometrics to model the probability that a binary dependent variable equals 1, conditional on a set of explanatory variables. It is based on the logistic distribution and is particularly suited to situations in which the dependent variable can take only two values—commonly coded as 0 and 1.[3]

Combining the probabilities of completion for each day of a maintenance event produces an estimate of its total duration. That estimate depends on how long the overhaul has already been ongoing, among other factors. The model also accounts for a ship's age. The equation CBO used was as follows:

$$\ln\left(\frac{h}{1-h}\right) = \beta_0 + \beta_1 \times (\text{Duration}) + \beta_2 \times (\text{Duration})^2 + \beta_3 \times (\text{Age of Ship at Start of Overhaul})$$

In that equation, h is an overhaul's probability of completion on a given day and β_0 to β_3 are the parameters to be calculated.[4] The equation means that the log of the odds of the overhaul's completion is a quadratic function of the duration of the overhaul so far and a linear function of the ship's age at the start of the overhaul.

Logit Results

CBO used that model to project the probability that an ongoing maintenance event would finish on any particular day, given the time elapsed so far and the ship's age. Those probabilities were then summed to project the additional time that the ship would spend in the ongoing event. CBO used separate models for each ship type; for DDG-51s, CBO used separate models for each type of overhaul. For an example of the results from the model for docking selected restricted availabilities (DSRAs) for DDG-51s, see Table C-3.

One way to visualize the model's results is with a survival curve applied to ships of different ages; for an illustration of such survival curves, see Figure C-1. That figure presents the model's results for two hypothetical groups of destroyers undergoing a DSRA: 10-year-old

3. Jeffrey M. Wooldridge, *Econometric Analysis of Cross-Section and Panel Data*, 2nd ed. (MIT Press, 2010), Chapter 15.

4. That functional form is from G. S. Maddala, *Introduction to Econometrics*, 2nd ed. (Prentice Hall, 1992), p. 328.

Table C-3.

Logit Survival Coefficients for the Duration of DDGs' DSRAs

		95 percent confidence interval	
	Coefficient	Lower bound	Upper bound
β_0 for constant	-8.71*	-10.54	-6.87
β_1 for days in yard	0.0271*	0.0168	0.0373
β_2 for days in yard squared	-0.000024*	-0.000038	-0.00001
β_3 for ship's age at start of overhaul	-0.129*	-0.188	-0.07

Source: Congressional Budget Office. See www.cbo.gov/publication/61507#data.

DDG-51 = guided missile destroyer; DSRA = docking selected restricted availability.

The asterisks in the table indicate statistical significance at the 95 percent confidence level ($p < 0.05$). The p value is the probability of observing a coefficient at least as large as the one listed in the table if the true coefficient is zero (assuming that all of the model's other conditions are met).

DDG-51s and 20-year-old DDG-51s. On day 1, all of the overhauls in both groups are unfinished. On day 100, 98 percent of overhauls for the 10-year-old ships and 99 percent of those for the 20-year-old ships are unfinished. The model makes clear that as time in the yard increases, older ships tend to take longer to service: On day 300, overhauls remain unfinished for 32 percent of the 10-year-old ships and 72 percent of the 20-year-old ships (see Figure 3-1 on page 28).

Survival Model Projections

CBO's main goal for the survival analysis was to project when the unfinished overhauls would finish (see Table C-1 on page 44). As an example, two DSRAs for DDG-51s in the data provided by NAVSEA had not finished when the data were extracted at the end of September 2024. The equation above and the coefficients in Table C-3 can be used to project the end date and total duration of those overhauls.

DDG-52, the USS *Barry*, started its most recent DSRA on February 5, 2024, and had been in the yard for 239 days as of the end of September. The ship was 31 years old when the overhaul started and was the oldest DDG-51 starting an overhaul in the data (see Figure 3-1 on page 28, in which that overhaul is the rightmost open circle). Given the destroyer's age and the number of days it had already spent in the shipyard, CBO's model projected that the overhaul would finish at 717 days. That is larger than the estimate of 530 days in the Navy's last schedule, but both are above average.

The other ship that had not finished its DSRA was DDG-61, the USS *Ramage*. It started that overhaul on February 26, 2024; was 29 years old when the overhaul started; and had been in the shipyard for 218 days as of the end of September. CBO's model projected that the overhaul would finish at 556 days; the Navy's last schedule estimated that it would finish at 466 days. In either case, the duration would be well above the average for DSRAs (see Figure C-2).

Many of the finished overhauls were completed when the ships were relatively new—about 10 years old. But many of the unfinished overhauls, including those two DSRAs, started when the ships were older. Older ships tend to take longer in overhauls; thus, CBO's model projects that those DSRAs will have longer durations (see Figure 3-1 on page 28).

Estimating Missing Values for Days of Labor

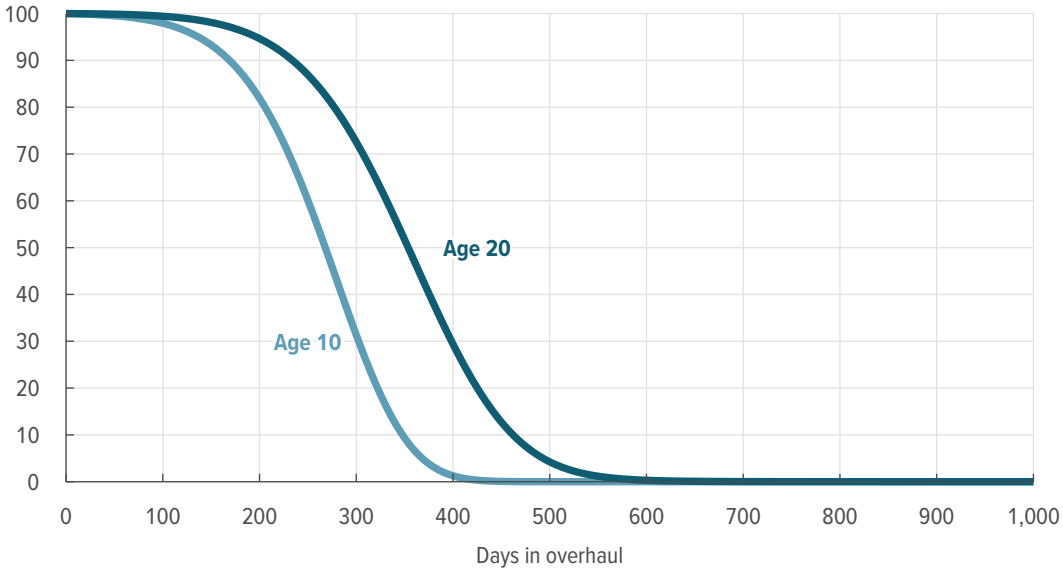
CBO also created a labor model to project the number of days of labor required to complete unfinished overhauls. A day of labor is one eight-hour shift for one worker. CBO modeled days of labor as a linear function of total duration (in calendar days) with a constant and a slope. The general formula is as follows:

$$\text{Days of Labor} = \beta_0 + \beta_1 \times \text{Duration} + \varepsilon$$

The calculated effect of a one-day increase in a DSRA's duration was 194 days of labor (see Table C-4). To project the total days of labor for unfinished docking events, CBO multiplied its projection of the total duration from the survival model by the coefficient of the number of days of labor in the labor model (also adding the constant). For example, the survival model projected that the unfinished DSRA for the USS *Ramage* would finish in 556 days. The labor model projected that it would require 122,000 days of labor.

Figure C-1.

Projected Survival Curves for 10- and 20-Year-Old DDG-51s Undergoing a DSRA



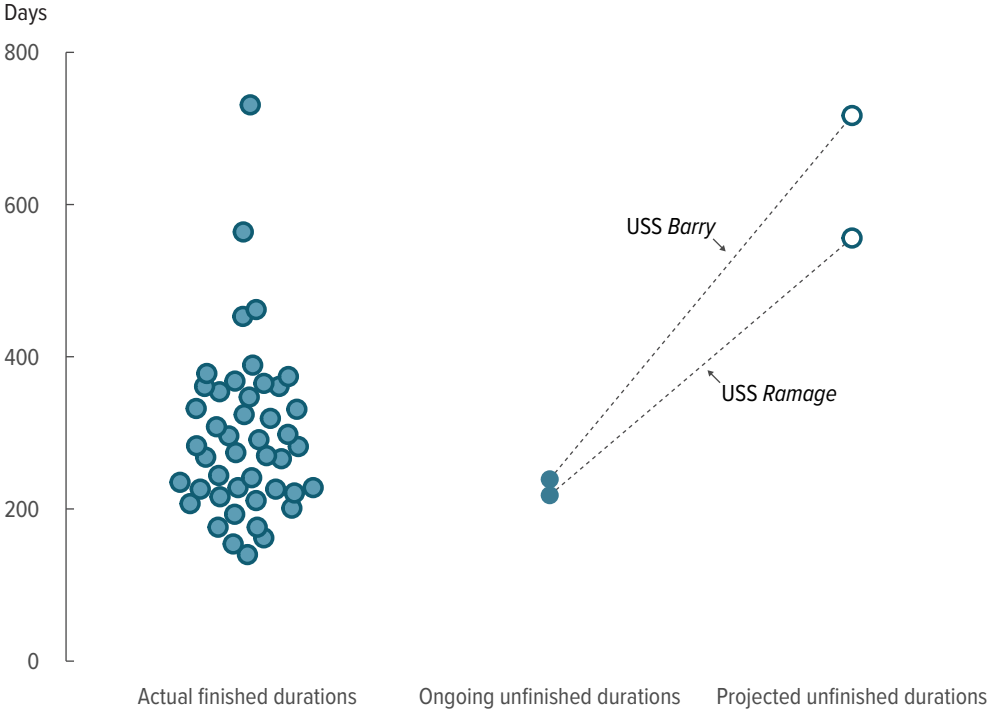
Overhauls tend to take longer for older DDG-51s than for newer DDG-51s.

Data source: Congressional Budget Office. See www.cbo.gov/publication/61507#data.

DDG-51 = guided missile destroyer; DSRA = docking selected restricted availability.

Figure C-2.

Actual Durations of Finished DSRAs and Ongoing and Projected Durations of Unfinished DSRAs for DDG-51s as of September 30, 2024



CBO projects that yet-to-be-completed DSRAs for DDG-51s will have above-average durations.

Data source: Congressional Budget Office, using data from Naval Sea Systems Command. See www.cbo.gov/publication/61507#data.

DDG-51 = guided missile destroyer; DSRA = docking selected restricted availability.

Table C-4.

Ordinary Least Squares Coefficients for Days of Labor for DDGs' Docking Events

		95 percent confidence interval	
	Coefficient	Lower bound	Upper bound
β_0 for constant	13,834.80	-4,349.90	32,019.40
β_1 for duration, in days	194.3*	136.7	251.9

Source: Congressional Budget Office. See www.cbo.gov/publication/61507#data.

The asterisk in the table indicates statistical significance at the 95 percent confidence level ($p < 0.05$) The p value is the probability of observing a coefficient at least as large as the one listed in the table if the true coefficient is zero (assuming that all of the model's other conditions are met).

DDG-51 = guided missile destroyer.

List of Tables and Figures

Tables

S-1. Average Maintenance Delays and Labor Overruns Relative to Estimates in the Navy's Last Schedules, by Ship Type, 2011 to 2024 6

1-1. Finished and Unfinished Maintenance Events for Large Conventional Combat Ships 13

2-1. Realized Performance of DDG-51s' Maintenance Events Relative to Estimates in the Navy's Last Schedules, 2011 to 2024 16

B-1. Maintenance Events From 2011 to 2024 in NAVSEA's Data, by Ship Type 41

C-1. Projected Total Durations and Days of Labor for Maintenance Events That Were Unfinished as of September 30, 2024 44

C-2. An Analogy Between Projections of Life Expectancy and the Duration of Ship Maintenance Events 45

C-3. Logit Survival Coefficients for the Duration of DDGs' DSRAs 46

C-4. Ordinary Least Squares Coefficients for Days of Labor for DDGs' Docking Events 48

Figures

S-1. Average Estimated and Realized Durations and Days of Labor for DDG-51s' Maintenance Events 8

1-1. Classes of Large Conventional Combat Ships 10

1-2. Notional Timeline for Planning and Executing a Maintenance Event 12

1-3. Ratio of Average Realized Durations of Overhauls for Large Conventional Ships to Average Estimates in the Navy's Last Schedules, by Fiscal Year in Which Overhauls Started 14

2-1. Class Plan for Maintenance Events During the Service Life of DDG-51 Flight IIA Variants 17

2-2. Maintenance Funding for DDG-51s, by Fiscal Year 18

2-3. Realized Durations of DDG-51s' Docking Maintenance Events 19

2-4. Average Estimated and Realized Durations and Days of Labor for DDG-51s' Docking Maintenance Events 20

2-5. Average Estimated and Realized Durations and Days of Labor for DDG-51s' DSRAs, by Fiscal Year in Which Overhauls Started 21

2-6. Average Estimated and Realized Durations and Days of Labor for DDG-51s' Nondocking Maintenance Events 23

2-7. Estimated and Realized Durations for DDG-51s' SRAs, by Fiscal Year in Which Overhauls Started 24

2-8. Projected Years of DDG-51s' Service Life Spent in Maintenance and With the Fleet 25

3-1. Realized Durations of Selected Maintenance Events for DDG-51s, by Ships' Age 28

3-2. Ages of DDG-51s at the Start of Docking Events 30

3-3. Average Ratio of the Realized Duration of DDG-51s' Maintenance Events to Estimates in the Navy's Last Schedules, With and Without Unplanned Work 31

A-1. Durations and Days of Labor for LHDs' Maintenance Events 38

A-2. Durations and Days of Labor for LPDs' Maintenance Events 39

A-3. Durations and Days of Labor for LSDs' Maintenance Events 40

C-1. Projected Survival Curves for 10- and 20-Year-Old DDG-51s Undergoing a DSRA 47

C-2. Actual Durations of Finished DSRAs and Ongoing and Projected Durations of Unfinished DSRAs for DDG-51s as of September 30, 2024 47

About This Document

This report was requested by the former Chairmen and Ranking Members of the Subcommittee on Readiness and the Subcommittee on Seapower and Projection Forces of the House Committee on Armed Services. In keeping with the Congressional Budget Office's mandate to provide objective, impartial analysis, the report makes no recommendations.

R. Derek Trunkey, Nikhil Bhandarkar (formerly of CBO), Kathryn McGinnis (formerly of CBO), and Eric J. Labs prepared the report with guidance from David Mosher and Edward G. Keating. Justin Falk, Ron Gecan, and Julie Topoleski provided considerable assistance. Evan Herrnstadt, William Ma, Noah Meyerson, Molly Sherlock, and Chad Shirley offered comments.

Brent Boning of CNA Corporation, Vice Admiral James P. Downey and other staff of Naval Sea Systems Command (NAVSEA), Bradley Martin of the RAND Corporation, and Vice Admiral Thomas Moore (formerly of NAVSEA) provided comments on an earlier draft. The assistance of external reviewers implies no responsibility for the final product; that responsibility rests solely with CBO.

Jeffrey Kling reviewed the report. Christine Browne edited it, and Casey Labrack created the graphics and prepared the text for publication. The report is available at www.cbo.gov/publication/61507.

CBO seeks feedback to make its work as useful as possible. Please send comments to communications@cbo.gov.

Phillip L. Swagel
Director
December 2025