CBO

An Analysis of the Navy's Fiscal Year 2020 Shipbuilding Plan

OCTOBER 2019

At a Glance

As directed by the Congress, the Navy submits an annual report with the President's budget describing the planned inventory, purchases, deliveries, and retirements of the ships in its fleet for the next 30 years. In this report, the Congressional Budget Office analyzes the Navy's fiscal year 2020 shipbuilding plan and estimates the costs of implementing it.

- **Fleet Cost.** The 2020 plan would require shipbuilding appropriations that are more than 50 percent larger than the Navy's average funding for shipbuilding over the past five years. Including nuclear refueling and all other costs associated with the Navy's shipbuilding budget, CBO estimates, the total shipbuilding budget would average $31 billion per year (in 2019 dollars), one-third more than the Navy estimates. Annual operation and support costs for the fleet over the next 30 years would grow from $60 billion today to about $90 billion by 2049.

- **Purchasing Plan.** The Navy plans to purchase 304 new ships between 2020 and 2049: 247 combat ships and 57 support ships.

- **Fleet Size.** If the Navy adhered to that purchasing plan as well as the schedule for retiring ships outlined in the 2020 plan, the inventory of ships would rise from 290 today to its goal of 355 ships in 2034 and thereafter, but would fall short of its specific goals for some types of ships.

Contents

Notes

Unless otherwise indicated, all years referred to in this document are federal fiscal years, which run from October 1 to September 30 and are designated by the calendar year in which they end; all dollar amounts reflect budget authority in 2019 dollars.

Numbers in the text and tables may not add up to totals because of rounding.

The data underlying the figures are posted with the report on CBO's website.

On the cover:

Top: The Arleigh Burke class guided missile destroyer USS *Carney* (DDG-644).
U.S. Navy photo by Mass Communication Specialist 1st Class Fred Gray IV.

Middle: The Nimitz class aircraft carrier USS *John C. Stennis* (CVN-74).
U.S. Navy photo by Mass Communication Specialist 2nd Class Anderson W. Branch.

Bottom: The Ohio class ballistic missile submarine USS *Louisiana* (SSBN-743).
U.S. Navy photo by Lieutenant Ed Early.

An Analysis of the Navy's Fiscal Year 2020 Shipbuilding Plan

Summary

The Department of Defense (DoD) submitted the Navy's 2020 shipbuilding plan to the Congress in March 2019.[1] The average annual cost of carrying out that plan, which covers fiscal years 2020 to 2049, would be $31.0 billion in 2019 dollars, the Congressional Budget Office estimates. The Navy's 2020 plan differs very little from its 2019 plan in its goal for the total inventory of battle force ships, the number and types of ships that the Navy would purchase, and the funding proposed to implement the plan. If fully carried out, the shipbuilding plan would represent the largest naval buildup since the 1980s.

The Navy Plans to Expand the Fleet to 355 Battle Force Ships

In September 2019, the Navy's fleet numbered 290 battle force ships—aircraft carriers, submarines, surface combatants, amphibious ships, combat logistics ships, and some support ships. The Navy's 2020 shipbuilding plan reflects its 2016 force structure assessment and sets a goal of building and maintaining a fleet of 355 battle force ships.[2] Toward that goal, the Navy would buy 304 ships over the 2020–2049 period: 247 combat ships and 57 combat logistics and support ships (see Table 1). If the Navy adhered to the schedule for retiring ships outlined in the 2020 plan, it would meet the goal of 355 ships in 2034 and maintain that number through at least 2049. (See Table 2 for the current composition of the fleet and the planned service life of the major types of ships.)

In testimony in spring 2019, senior Navy officials told the Congress that the Navy intends to release a new force structure assessment sometime in late 2019. Those officials stated that although the goal of 355 ships is likely to change, it is not clear by how much; it is also unclear how the large unmanned systems that the Navy wants to develop might be counted toward that goal. The current goal does not include any unmanned systems.[3] (See Box 1 for a description of the major types of ships in the Navy's fleet.)

New Ships in the Navy's Plan Would Cost an Average of $28.8 Billion per Year

CBO estimates that buying the new ships specified in the 2020 plan would cost $865 billion over 30 years, or an average of $28.8 billion per year.[4] The Navy estimates a lower cost—$660 billion over 30 years, or an average of $22.0 billion per year—$0.6 billion more per year than it estimated new-ship construction would cost under its 2019 plan.

CBO's estimates are higher than the Navy's because CBO and the Navy made different assumptions about the design and capabilities of some future ships, used different estimating methods, and treated growth in shipbuilding labor and materials costs differently. Most of the difference between the estimates stems from uncertainty about the design and capabilities of large ships whose construction would begin in 5 or 10 years—in particular, the future large surface combatant and the future attack submarine. The difference in estimates also widens over time in part because the Navy's method of developing constant-dollar estimates for most of its shipbuilding programs does not account for the faster growth in the costs of labor and materials in the shipbuilding

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1. See Department of the Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2020* (March 2019), https://go.usa.gov/xyhvK.

2. See Department of the Navy, *Executive Summary, 2016 Navy Force Structure Assessment (FSA)* (December 2016), http://tinyurl.com/zgdk5o7.

3. See Ronald O'Rourke, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, Report for Congress RL32665 (Congressional Research Service, updated September 20, 2019), https://crsreports.congress.gov/product/pdf/RL/RL32665 (3.2 MB).

4. For more information, see Congressional Budget Office, *How CBO Estimates the Costs of New Ships* (April 2018), www.cbo.gov/publication/53785.

Table 1.

The Navy's 2019 and 2020 Shipbuilding Plans

	2019 Plan (2019–2048)	2020 Plan (2020–2049)	Change From 2019 to 2020
	Number of Ships Purchased Over 30 Years		
Combat Ships			
Aircraft carriers	7	7	0
Ballistic missile submarines	12	12	0
Large payload submarines	5	5	0
Attack submarines	60	61	1
Large surface combatants	76	76	0
Small surface combatants	57	58	1
Amphibious warfare ships	28	28	0
Subtotal	245	247	2
Combat Logistics and Support Ships	56	57	1
Total	**301**	**304**	**3**
	Cost of New-Ship Construction[a] (Billions of 2019 dollars)		
Total Cost Over 30 Years			
Navy's estimate	643	660	17
CBO's estimate	817	865	48
Average Annual Cost			
Navy's estimate	21.4	22.0	0.6
CBO's estimate	27.2	28.8	1.6
Average Cost per Ship			
Navy's estimate	2.1	2.2	0.1
CBO's estimate	2.7	2.8	0.1
Memorandum:			
Average Annual Costs of All Activities Typically Funded From Budget Accounts for Ship Construction[b]			
Navy's estimate	23.4	24.1	0.7
CBO's estimate	29.4	31.0	1.6

Source: Congressional Budget Office.

a. Costs exclude funds for refueling nuclear-powered aircraft carriers and for ship conversions, construction of ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. The costs of the mission packages for littoral combat ships, which are not funded by the Navy's shipbuilding accounts, are also excluded.

b. Includes all items excluded from new-ship construction costs.

industry than in the economy as a whole (see Figure 1 on page 6). As a result, the Navy's estimate does not reflect the increase in the real (inflation-adjusted) costs of ships with today's capabilities that CBO anticipates in future purchases of such ships.

The Navy's shipbuilding plan reports only the costs of new-ship construction. It excludes other activities typically funded from the Navy's budget account for ship construction. Including nuclear refueling and all other costs associated with the Navy's shipbuilding budget would add $2.1 billion to the Navy's average annual shipbuilding costs under the 2020 plan, CBO estimates.

Shipbuilding Costs Over the Next 30 Years Would Be Twice As Much As Appropriations Over the Past 30 Years

If the Navy received the same average annual amount of funding (in constant dollars) for ship construction in each of the next 30 years that it has received over the past three decades, the service would not be able to afford its 2020 shipbuilding plan. CBO's estimate of $28.8 billion per year for new-ship construction under the plan is more than double the historical average of $13.8 billion (in 2019 dollars). CBO's estimate of $31.0 billion per year for the full cost of the plan is almost double the $16.0 billion the Navy has received in annual appropriations, on average, over the past 30 years for all activities funded by its shipbuilding account.[5]

The 30-year historical average includes the relatively small, post–Cold War shipbuilding appropriations of the 1990s. The shipbuilding budgets in the past five years have been larger. In fact, since 2013, the Congress has appropriated $1 billion to $3 billion more per year than the President's request, partly as a result of concerns that the fleet is too small to perform all the missions assigned to it (see Figure 2 on page 7). Compared with shipbuilding budgets of the past five years, the Navy's plan would still require an increase of more than 50 percent, on average. In another comparison, shipbuilding appropriations averaged $26.7 billion per year (in 2019 dollars) during the Cold War years of 1955 to 1989, a period of great power competition that could resemble the future.[6] On average, the Navy's plan would cost 16 percent more than that.

A Larger Fleet Would Cost More to Operate

Current costs to operate and support the fleet under the Navy's plan are about $60 billion per year, including direct, indirect, and overhead costs, CBO estimates.[7] As

Table 2.

The Navy's Inventory of Major Ships and Their Expected Service Life, as of September 2019

	Inventory	Service Life (Years)
Aircraft Carriers	11	50
Ballistic Missile Submarines	14	42
Guided Missile Submarines	4	42
Attack Submarines	51	33–43
Large Surface Combatants	89	35–45
Small Surface Combatants and Mine Countermeasures Ships	29	25–30
Amphibious Ships	32	40
Combat Logistics and Support Ships	60	30–45
Total	**290**	

Source: Congressional Budget Office, using data from the Department of the Navy.

the fleet increased in size, its operation and support costs would rise. Like ship construction costs, operation and support costs also increase at a rate that is faster than the economywide inflation rate. After adjusting for that increase, CBO estimates that by 2049 the 355-ship fleet would cost about $90 billion per year (in 2019 dollars) to operate and support.

## Ship Purchases and Inventories Under the 2020 Plan

The Navy's 2020 shipbuilding plan, which the Department of Defense submitted to the Congress on March 18, 2019, reflects the inventory goal of 355 battle force ships that the service set forth in its 2016 force structure assessment.[8] (For a comparison of the goals established in the four most recent force structure assessments, see Table 3 on page 8.) The Navy intends to buy 12 ships in 2020 and 43 ships from 2021 through 2024—the period covered by DoD's 2020 Future Years

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5. For an example of how large a fleet the Navy could build if funding continued at its 30-year average, see Congressional Budget Office, *Comparing a 355-Ship Fleet With Smaller Naval Forces* (March 2018), www.cbo.gov/publication/53637.

6. CBO's historical data for shipbuilding budgets begins with 1955; the year the Berlin Wall fell, 1989, is widely regarded as the end of the Cold War.

7. For a more detailed discussion of how CBO calculates operation and support costs, see Congressional Budget Office, *Costs of Building a 355-Ship Navy* (April 2017), pp. 5–7, www.cbo.gov/publication/52632, and *The U.S. Military's Force Structure: A Primer* (July 2016), www.cbo.gov/publication/51535.

8. See Department of the Navy, *Executive Summary, 2016 Navy Force Structure Assessment (FSA)* (December 2016), http://tinyurl.com/zgdk5o7. For a more extensive discussion of the history of the Navy's force structure goals, see Ronald O'Rourke, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, Report for Congress RL32665 (Congressional Research Service, updated September 20, 2019), https://crsreports.congress.gov/product/pdf/RL/RL32665 (3.2 MB).

Box 1.

Major Types of Ships in the Navy's Fleet

Nimitz Class Aircraft Carrier
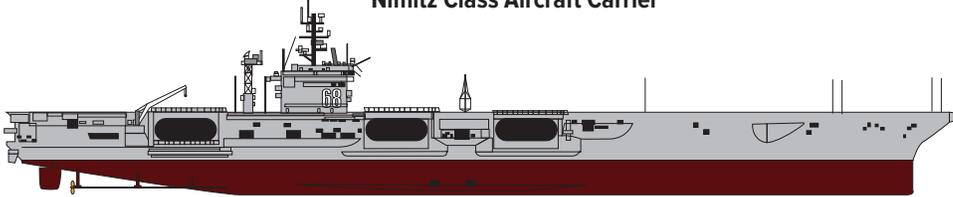
The Navy's 11 **aircraft carriers** are the heart of the battle force. Each carries an air wing of about 60 aircraft, which can attack hundreds of targets per day (based on 12 hours of flight operations) for up to a month before needing to rest. Carriers are the largest ships in the fleet, with a displacement of about 100,000 tons. (A ship's displacement is the weight of water that it displaces when floating or, for a submarine, when submerged.) Ten of the current carriers belong to the Nimitz class. The Navy commissioned the first of a new class, the *Gerald R. Ford*, in 2017.

**Ohio Class Ballistic Missile Submarine**

Strategic ballistic missile submarines are one component of the U.S. nuclear triad. Each submarine carries up to 20 Trident missiles armed with 1 to 8 nuclear warheads apiece. (Originally, they were built with 24 missile tubes, but arms control treaties now limit them to 20 operational tubes.) The Navy has 14 Ohio class ballistic missile submarines, each of which displaces about 19,000 tons when submerged. The service has 4 other submarines of that class that it converted to a conventional guided missile (SSGN) configuration. Those SSGNs carry up to 154 Tomahawk missiles as well as special operations forces.

Virginia Class Attack Submarine

Attack submarines are the Navy's premier undersea warfare and antisubmarine weapons. Since the end of the Cold War, however, they have mainly been used for covert intelligence gathering. They can also launch Tomahawk missiles at land targets, frequently in the early stages of a conflict in an effort to destroy enemy air defense systems. Of the Navy's 51 attack submarines, 31 belong to the Los Angeles class. Displacing 7,000 tons when submerged, they are less than half the size of ballistic missile submarines. Virginia class attack submarines are a little larger, at 7,800 tons.

Arleigh Burke Class Destroyer
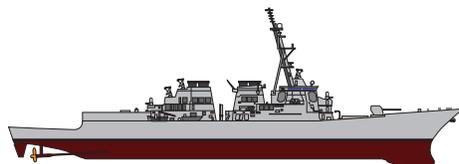
Large surface combatants, which include cruisers and destroyers, are the workhorses of the fleet. They provide ballistic missile defense for the fleet and for overseas regions. They defend aircraft carriers and amphibious warfare ships against other surface ships, aircraft, and submarines, and they perform such day-to-day missions as patrolling sea lanes, providing an overseas presence, and conducting exercises with allies. They can also launch Tomahawk missiles to strike land targets. Most of the Navy's surface combatants displace about 9,000 to 10,000 tons.

Box 1.   Continued

Major Types of Ships in the Navy's Fleet

Freedom Class Littoral Combat Ship

Small surface combatants include littoral combat ships (LCSs) and frigates. LCSs, which are built in two variants, are intended to counter mines, small boats, and diesel-electric submarines in the world's coastal regions. The Navy's new frigates, which it will begin building in 2020, are expected to be multimission ships, capable of performing many of the missions of the LCS but also carrying robust antiship capabilities as well as being able to defend against threats in the immediate area. More routinely, LCSs and frigates—like their counterparts, the large surface combatants—patrol sea lanes, provide an overseas presence, and conduct exercises with allies. They range in size from 3,000 to 4,000 tons. The Navy currently has no frigate because it retired all of its Oliver Hazard Perry frigates as of 2015.

San Antonio Class Amphibious Transport Dock

The Navy has five classes of **amphibious warfare ships**. The two classes referred to as amphibious assault ships (also known as large-deck amphibious ships or helicopter carriers) are the second-largest types of ships in the fleet, displacing between 40,000 and 45,000 tons. With capacity for about half the troops and equipment of a Marine expeditionary unit, the amphibious assault ship is the centerpiece of the amphibious ready group. In addition to troops, each ship can carry as many as 30 helicopters and 6 fixed-wing Harrier jump jets or short takeoff and landing versions of the Joint Strike Fighters (F-35Bs), or up to 20 of those fixed-wing aircraft. The other three classes are divided into two types: amphibious transport docks and dock landing ships. Two of those ships together provide the remaining transport capacity for a Marine expeditionary unit in an amphibious ready group. They range in size from 16,000 to 25,000 tons.
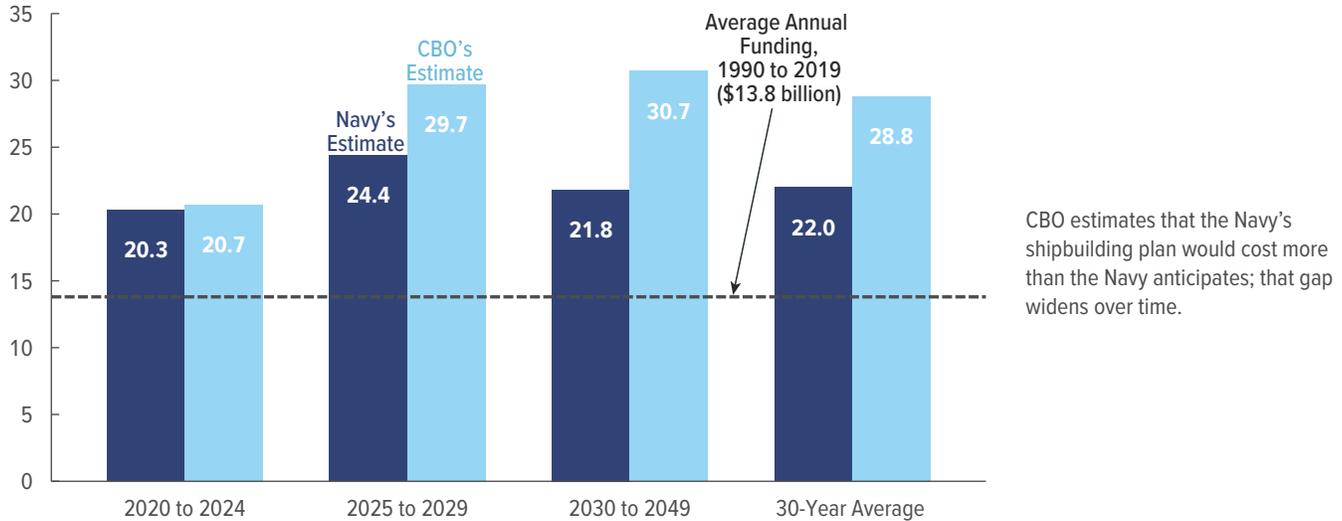
Lewis and Clark Class Dry Cargo/Ammunition Ship
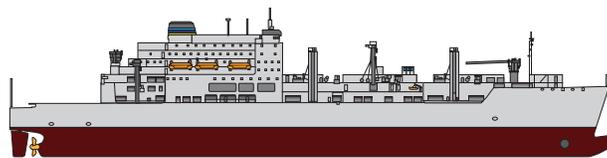
The many **combat logistics and support ships** in the Navy's fleet provide the means to resupply, repair, salvage, or tow combat ships. The most prominent of those vessels are fast combat support ships, which resupply carrier strike groups with fuel, dry cargo (such as food), and ammunition. Logistics and support ships can be as small as 2,000 tons for an oceangoing tug or as large as 50,000 tons for a fully loaded fast combat support ship.

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0    100    200    300    400    500 feet
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Figure 1.

Average Annual Costs of New-Ship Construction Under the Navy's 2020 Plan

Billions of 2019 Dollars

Source: Congressional Budget Office, using data from the Department of the Navy.

Costs of new-ship construction exclude funds for refueling nuclear-powered aircraft carriers and for ship conversions, construction of ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. The costs of the mission packages for littoral combat ships, which are not funded in the Navy's shipbuilding accounts, also are excluded.

Defense Program (see Figure 3 on page 9).[9] From 2025 through 2049, the Navy would buy an additional 249 ships, for a total of 304 ships over 30 years, or an average of about 10 ships per year. The pace of shipbuilding would be faster, on average, in the first 15 years of the plan than later on, reflecting the service's desire to increase the size of the fleet as quickly as is practical. The Navy plans to purchase ships at an average annual rate of 11 ships from 2020 to 2034 and 9 ships from 2035 to 2049.

Last year, the Navy determined that it could not reach its goal of 355 ships quickly with only the new-ship construction program outlined in the 2019 plan; as a result, it decided to extend the service life of its Arleigh Burke class destroyers to between 42 and 45 years (compared with 35 or 40 years previously) and the service life of as

many as 7 Los Angeles class attack submarines from 33 to 43 years. All of the destroyer life extensions and, thus far, two of the submarine life extensions are reflected in the Navy's 2020 plan. With those extensions, the Navy would achieve a fleet of 355 ships in 2034 and would maintain that size through the end of its shipbuilding plan in 2049 (see the bottom panel of Figure 3 on page 9). However, it would not meet the specific force structure goals for every type of ship outlined in the 2016 force structure assessment.

This report assesses the costs of implementing the 2020 plan, the plan's effects on the force structure, and the extent to which it would satisfy the Navy's specific goals for major components of the U.S. fleet. CBO did not evaluate the validity of the Navy's goals or the fleet's ability to fulfill its missions in the national military strategy.

Combat Ships
Over the next 30 years, the Navy envisions buying 247 combat ships, including aircraft carriers, submarines,

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9. Throughout this report, CBO uses the terms "purchase" and "buy" to refer to authorization by the Congress to acquire ships. The budget authority for such purchases may be provided over several years, depending on how the Congress appropriates the money for them.

large and small surface combatants, and amphibious war-fare ships. Those purchases would leave the Navy short of its inventory objectives for aircraft carriers, ballistic missile submarines, attack submarines, small surface combatants, and amphibious ships for significant segments of the 2020–2049 period (see Figure 4 on page 10). In contrast, the Navy would have an excess of large surface combatants during some of those years.

Aircraft Carriers. Under its 2020 shipbuilding plan, the Navy would purchase 7 aircraft carriers between 2020 and 2049 (see Figure 5 on page 12). One would be purchased in 2020, another in 2028, and the remainder every 4 years thereafter.[10] As part of its plan, the Navy wanted to retire the USS *Harry S. Truman* (CVN-75) at its midlife point and not refuel its nuclear reactors to save money for other, higher priorities. The Administration subsequently reversed course and announced in April 2019 that it would not retire the *Truman*. To reflect that decision, CBO's analysis in this report keeps that carrier in the fleet for its full 50-year service life. As a result, the Navy's 2020 plan, along with the decision to refuel the *Truman*, would allow the Navy to maintain a force of 11 aircraft carriers through 2039. Because of the carriers' 50-year expected service life, however, the force would fall to 10 carriers in 2040 and for most years through 2049. (To reach and sustain a force of 12 carriers, its stated goal, the Navy would need to purchase 1 ship every 3 years for the entire 30-year period.)[11]

Ballistic Missile Submarines. The 2020 shipbuilding plan calls for buying the first Columbia class ballistic missile submarine (SSBN) in 2021 to begin replacing the

Figure 2.

Requested and Appropriated Shipbuilding Budgets, 2012 to 2020

Billions of Dollars

Since 2012, the Congress has appropriated more money for ships than the President has requested.

Source: Congressional Budget Office, using various volumes of the Department of the Navy's *Highlights of the Department of the Navy Budget*.

a. The 2020 appropriation was not available at the time of publication.

current Ohio class SSBNs and for purchasing 11 more by 2036. The Navy estimates that the lead submarine would take at least 7 years to build, so the first Columbia class SSBN would be commissioned into the fleet in 2028. (It would take 2 to 3 additional years, however, before it went on its first patrol.) Subsequent submarines in the class would take about 7 years to build and test. Because the Ohio class submarines would be retired at the end of 42 to 44 years of service, the Navy's inventory of SSBNs would fall at least 1 ship short of its goal of 12 SSBNs between 2030 and 2041. From 2037 to 2040, the Navy would have only 10 SSBNs.

Attack Submarines. Under the 2020 plan, the Navy would purchase 61 attack submarines (SSNs) through 2049, 1 more than under the 2019 plan. The Navy proposes buying 3 SSNs in 2020 and then 2 per year for the next 29 years, which would not allow it to meet its inventory goal of 66 until 2048. Under the Navy's plan, which includes service life extensions for two Los Angeles class attack submarines, the number of attack submarines

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10. In the John S. McCain National Defense Authorization Act of 2019, the Congress authorized the Navy to purchase two carriers in order to save money on materials. The Navy, in its 2020 plan, treats the second of those two carriers as being authorized in 2020 (the first was authorized in 2018). To keep its analysis consistent with the Navy's plan, CBO treats those purchases the same way but recognizes that that carrier could be construed as being purchased in 2019. Thus, the purchase of 7 carriers over the 30-year period includes a carrier in 2020. If that ship was instead counted in 2019, the Navy would purchase 6 carriers over the 30-year period. For a discussion of this issue, see Ronald O'Rourke, *Navy Ford (CVN-78) Class Aircraft Carrier Program: Background and Issues for Congress*, Report for Congress RS20643 (Congressional Research Service, updated September 17, 2019), https://crsreports.congress.gov/product/pdf/RS/RS20643 (4.87 MB).
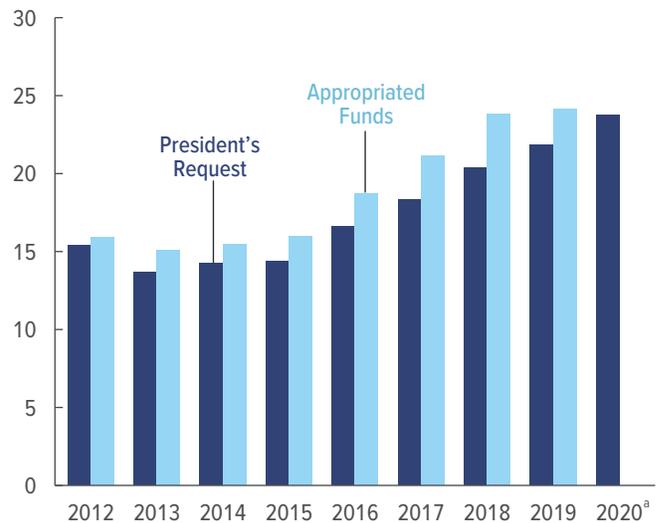
11. See Congressional Budget Office, *Costs of Building a 355-Ship Navy* (April 2017), pp. 10–11, www.cbo.gov/publication/52632.

Table 3.

The Navy's Inventory Goals As Stated in Its Force Structure Assessments, 2010 to 2016

	2010 Force Structure Assessment	2012 Force Structure Assessment	2014 Update of the 2012 Force Structure Assessment	2016 Force Structure Assessment
Aircraft Carriers	11	11	11	12
Submarines				
Ballistic missile	12	12	12	12
Attack	48	48	48	66
Guided missile	4	0	0	0
Large Surface Combatants	94	88	88	104
Small Surface Combatants and Mine Countermeasures Ships[a]	55	52	52	52
Amphibious Warfare Ships	33	33	34	38
Combat Logistics Ships	30	29	29	32
Support Ships				
Expeditionary fast transport	10	10	10	10
Other[b]	16	23	24	29
Total	**313**	**306**	**308**	**355**

Source: Congressional Budget Office, using data from the Department of the Navy.

a. Small surface combatants include frigates and littoral combat ships.

b. Includes command ships, salvage ships, ocean tugs, ocean surveillance ships, and tenders.

would decline from 52 today to a low of 42 in 2028.[12] The force would then gradually grow to 66 over the next 20 years.

If the Navy followed through with its goal of extending the service life of 5 additional Los Angeles class submarines, then the force would only fall to 45 by 2026.[13] Although refueling 5 more existing submarines would boost the force over the following 20 years, those service life extensions would not allow the Navy to meet its goal of 66 SSNs sooner than 2048, because even with a longer service life they would all be retired by 2040.

12. The decline is the result of the retirement, beginning in 2014, of Los Angeles class attack submarines (SSN-688s). Those ships, which were generally built at a rate of 3 or 4 per year during the 1970s and 1980s, are reaching the end of their 33-year service life. Under the 2020 plan, the Navy would replace them with Virginia class attack submarines (SSN-774s) and their successors at a rate of 2 per year.

13. Refueling an attack submarine (or an aircraft carrier) involves replacing the spent nuclear fuel rods in the reactor cores of nuclear-powered ships with new ones.

Large Surface Combatants. The 2020 shipbuilding plan calls for buying 76 destroyers and new large surface combatants (LSCs), the same number as in the 2019 plan. Of those ships, 15 would be based on the existing Arleigh Burke class destroyer (DDG-51) design and 61 would be a new design. Those planned purchases, along with the Navy's plan to modernize its existing cruiser force and its announcement last year that it will extend the service life of its destroyers, would allow the Navy to meet its goal of 104 large surface combatants in 2029 and stay at or above that number through 2049 (see the fourth panel of Figure 4). The 2020 plan differs from the 2019 plan in proposing to move up the start date for the Navy's future large surface combatant from 2030 to 2025 and to purchase 14 more future large surface combatants but, as a consequence, 14 fewer DDG-51 Flight III ships.

Small Surface Combatants. For small surface combatants (SSCs), the Navy has 35 littoral combat ships (LCSs) in the fleet or under construction and 11 mine countermeasures ships. Under the 2020 plan, the service would

Figure 3.

Annual Ship Purchases and Inventories Under the Navy's 2020 Plan

Number of Ships
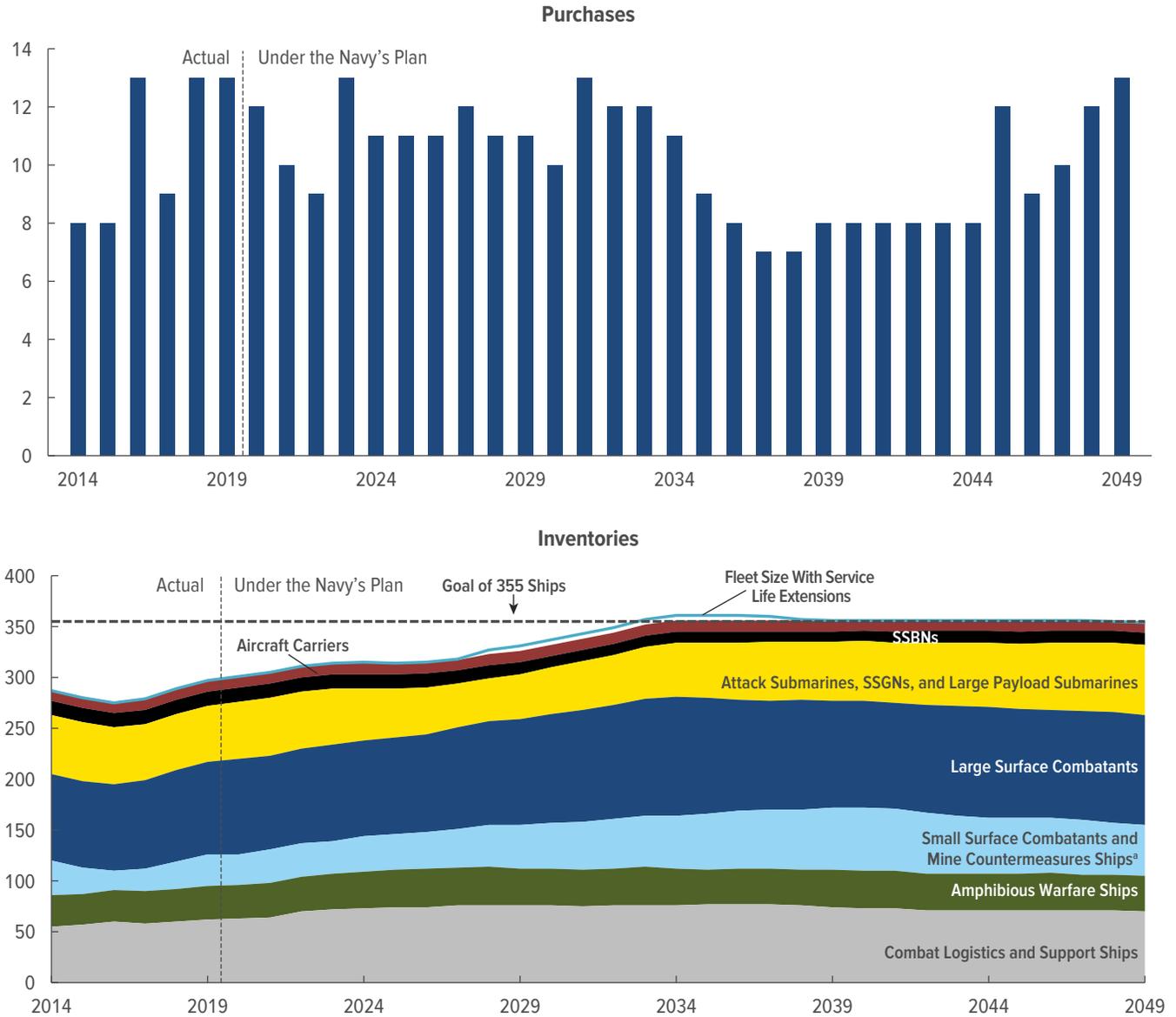
Purchases

Inventories

Source: Congressional Budget Office, using data from the Department of the Navy.

SSBNs = ballistic missile submarines; SSGNs = guided missile submarines.

a. Includes littoral combat ships, Oliver Hazard Perry FFG-7 guided missile frigates, new frigates, new small surface combatants, and Avenger class mine countermeasures ships.

purchase 20 guided missile frigates, designated FFG(X), and 38 future small surface combatants that would probably resemble a guided missile frigate. The construction plan would allow the Navy to reach its goal of 52 small

surface combatants by 2034 and to remain at or above that number through 2047 before declining slightly to 51 and 50 for the last two years of the plan.

Figure 4.

Annual Inventories Under the Navy's 2020 Plan Versus Goals for Selected Categories of Ships

Number of Ships
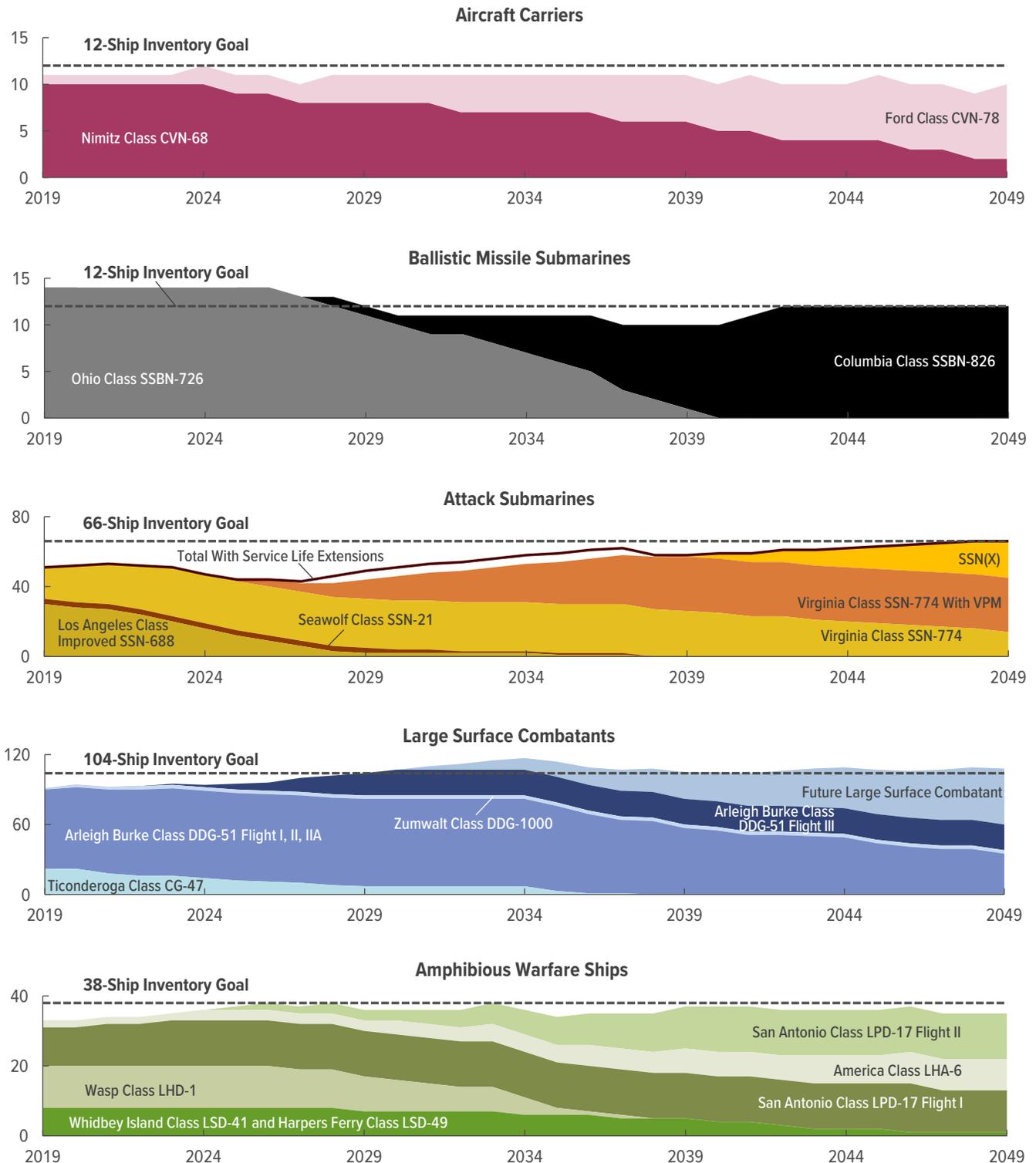
Source: Congressional Budget Office.

CG = guided missile cruiser; CVN = nuclear-powered aircraft carrier; DDG = guided missile destroyer; LHA and LHD = amphibious assault ship; LPD = amphibious transport dock; LSD = dock landing ship; SSBN = ballistic missile submarine; SSN and SSN(X) = attack submarine; VPM = Virginia payload module.

Amphibious Warfare Ships. The Navy's 2020 plan calls for buying 28 amphibious warfare ships through 2049—the same number as in the 2019 plan—and increasing the amphibious force from the current 32 ships to a high of 38 ships by 2026. The force would then fluctuate between 34 and 38 ships for the remainder of the period. Overall, the Navy would hit its target of 38 amphibious warfare ships for three years under the 2020 plan, although it would be within 2 ships of its goal for most years of the plan after 2022.

Combat Logistics and Support Ships

Under the 2020 plan, the Navy would buy 57 combat logistics and support ships in the next three decades—1 more than under the 2019 plan. Combat logistics ships include T-AKE dry cargo ships, T-AO oilers, and AOE fast combat support ships; they operate with or directly resupply combat ships that are under way. The plan calls for purchasing 16 new oilers (which provide fuel and other supplies to ships at sea) at a rate of 1 or 2 per year from 2019 through 2033 and 11 replacements for T-AKE dry cargo and ammunition ships from 2043 to 2048. Under the plan, the Navy would also purchase 30 other support ships: 11 expeditionary fast transports, 7 surveillance ships, 5 salvage/fleet tug ships, 2 command ships, 2 tenders, 1 variant of the T-AKE for the Navy's maritime prepositioning squadrons, 1 expeditionary sea base, and 1 expeditionary transfer dock replacement.

Shipbuilding Costs Under the 2020 Plan

According to the Navy's estimates, its planned purchases of new ships would cost (that is, require appropriations of) an average of $22.0 billion per year in 2019 dollars through 2049 (see Table 4)—3 percent more than the $21.4 billion average funding per year that the service estimated it would need to carry out its 2019 plan (see Figure 6 on page 14). Although the Navy did not divide its cost estimates into different time periods as it did in all previous reports, CBO's analysis retains those time periods: the near term (2020 to 2024), the midterm (2025 to 2029), and the far term (2030 to 2049).

CBO also estimated the costs of the Navy's 2020 plan, using its own cost models and assumptions to price the ships. On average, CBO's estimates of the new-ship construction costs are $6.8 billion (or 31 percent) higher per year than the Navy's estimates for the 30-year period. The differences between CBO's and the Navy's estimates increase over time: They are smallest for the near term and largest for the far term. Other activities that the

Navy would need to fund from its budget account for ship construction add $2.1 billion more per year to projected costs, bringing the total estimated annual cost for ship construction to $24.1 billion (based on the Navy's estimate of new-ship construction costs) or $31.0 billion (CBO's estimate).

The Navy's Estimates

The Navy's 2020 report discusses its future shipbuilding procurements, retirements, and inventory projections. It outlines the Navy's planned shipbuilding purchases over a 30-year period with average funding roughly equivalent to the average funding it received between 2017 and 2019. The report also emphasizes the importance of steady work for the shipbuilding industry to prevent boom and bust cycles, which could jeopardize the financial health of some shipyards and secondary suppliers as well as create uncertainty about the cost of future shipbuilding plans.[14]

New-Ship Construction Costs. According to the Navy's estimates for its 2020 plan, new-ship construction would cost an average of $20.3 billion per year over the near term. That amount excludes $228 million needed to cover cost overruns related to the construction of ships funded before 2020; that sum would be appropriated from 2020 through 2023.

According to the Navy's estimates, the average annual cost for new-ship construction would rise from $20.3 billion in the near term to $24.4 billion in the midterm (see Figure 7 on page 15). The costs for the far term, which includes 6 years in which the Navy plans to purchase Columbia class ballistic missile submarines and 14 more years at the end of the planning period, would average $21.8 billion per year—58 percent more than the $13.8 billion a year the Navy has received, on average, over the past 30 years.

Total Shipbuilding Costs. As in previous shipbuilding plans, the Navy's 2020 estimates exclude certain costs that it would need to cover with funds from its budget account for ship construction:

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14. In an appendix, the Navy offers a framework whereby, if more budgetary resources were made available, additional ships could be added to the shipbuilding plan to achieve a 355-ship fleet sooner without disrupting the shipbuilding industry. Detailed cost projections are provided in Appendix 8 of the report, a limited-distribution document that the Navy made available to CBO.

Figure 5.

Annual Ship Purchases Under the Navy's 2020 Plan, by Category

Number of Ships
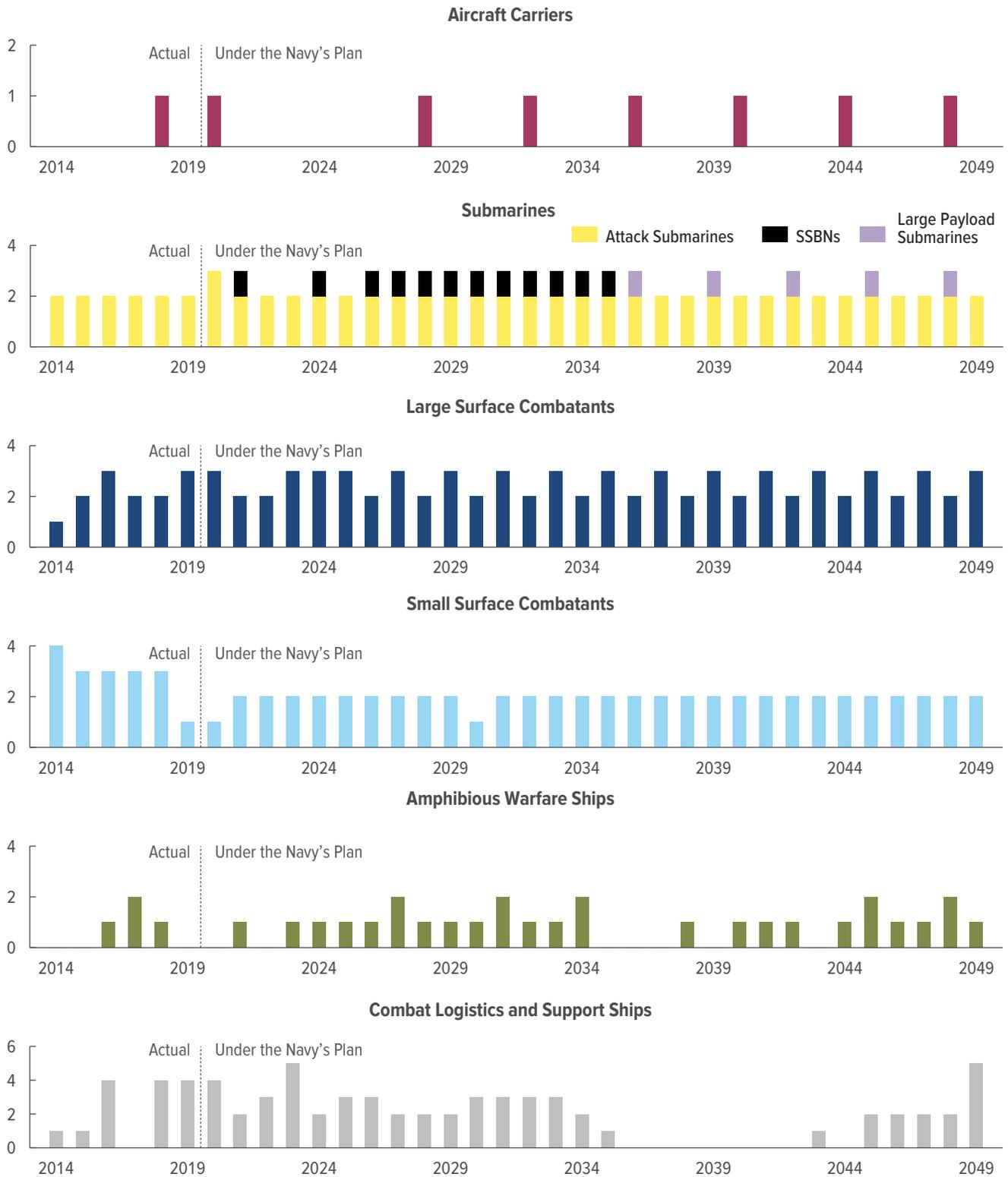
Source: Congressional Budget Office, using data from the Department of the Navy.

SSBNs = ballistic missile submarines.

Table 4.

Average Annual Shipbuilding Costs Under the Navy's 2020 Plan

	Near Term (2020–2024)	Midterm (2025–2029)	Far Term (2030–2049)	All Three Decades (2020–2049)
	Navy's Estimates (Billions of 2019 dollars)			
New-Ship Construction	20.3	24.4	21.8	22.0
New-Ship Construction and Refueling of Nuclear- Powered Aircraft Carriers[a]	21.6	26.7	22.7	23.2
New-Ship Construction, Refueling of Nuclear- Powered Aircraft Carriers, and Other Items[b]	22.7	28.1	23.5	24.1
	CBO's Estimates (Billions of 2019 dollars)			
New-Ship Construction	20.7	29.7	30.7	28.8
New-Ship Construction and Refueling of Nuclear- Powered Aircraft Carriers	21.9	31.9	31.5	30.0
New-Ship Construction, Refueling of Nuclear- Powered Aircraft Carriers, and Other Items	23.0	33.3	32.5	31.0
	Difference Between the Navy's and CBO's Estimates (Percent)			
New-Ship Construction	2	21	41	31
New-Ship Construction and Refueling of Nuclear- Powered Aircraft Carriers	2	20	39	30
New-Ship Construction, Refueling of Nuclear- Powered Aircraft Carriers, and Other Items	1	19	38	28

Source: Congressional Budget Office, using data from the Department of the Navy.

Costs are the appropriation of budget authority necessary to implement the Navy's plan.

Costs for other items include funds for ship conversions and for ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. Actual costs for the Navy's shipbuilding accounts over the past 30 years averaged about $16 billion per year (in 2019 dollars) for all items.

a. These figures include the Navy's estimates for new-ship construction and CBO's estimates for the refueling of nuclear-powered aircraft carriers.

b. These figures include the Navy's estimates both for new-ship construction and for the cost to complete ships purchased in prior years and CBO's estimates for the refueling of nuclear-powered aircraft carriers and for other items.

- The cost of refueling nuclear-powered aircraft carriers midway through their 50-year service life, CBO estimates, would add $1.2 billion per year to the Navy's estimate of the cost of implementing the 2020 plan, bringing the average cost to $23.2 billion per year through 2049.[15]

- The costs of ship conversions, construction of ships that are not part of the Navy's battle force (oceanographic survey ships, for instance), moored training ships, outfitting and postdelivery activities (including the purchase of many smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the shipyard when the ship is built), and smaller items would boost the Navy's estimate by $1.0 billion per year through 2049, CBO projects.
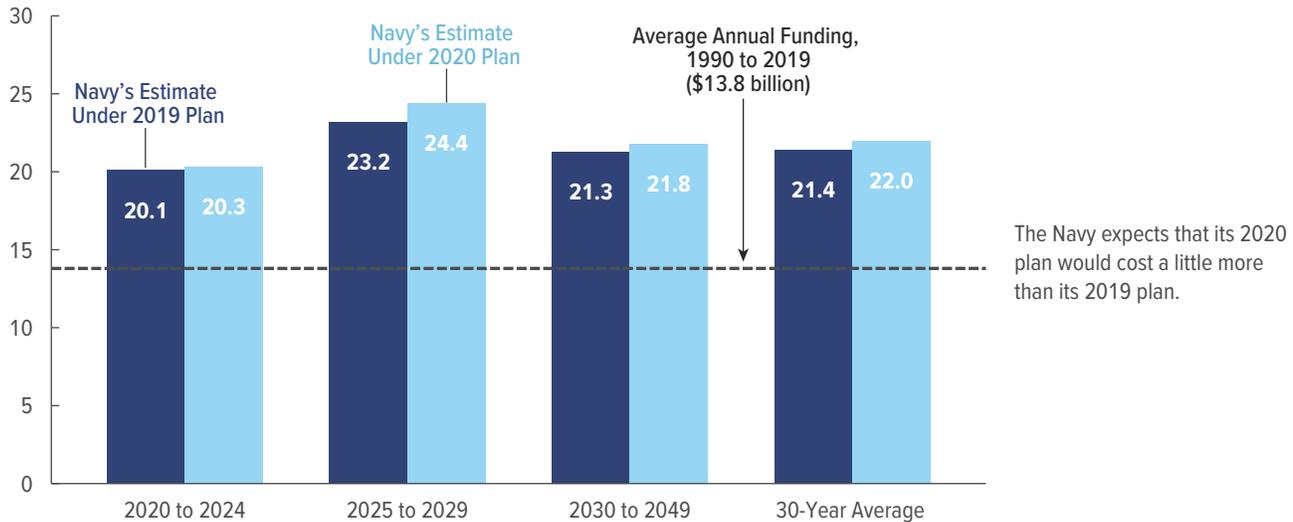
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15. In 2010, the Navy transferred funding for refueling nuclear-powered submarines from its Shipbuilding and Conversion account to three other accounts (Other Procurement, Operation and Maintenance, and Weapons Procurement) that are not used to purchase ships. Therefore, CBO did not include the refueling costs for submarines in its estimates of future shipbuilding costs, nor do the estimates include the costs for the destroyer service life extensions. For further discussion of those costs, see Congressional Budget Office, *Comparing a 355-Ship Fleet With Smaller Naval Forces* (March 2018), www.cbo.gov/publication/53637.

Figure 6.

The Navy's Estimates of the Average Annual Costs of New-Ship Construction Under Its 2019 and 2020 Plans

Billions of 2019 Dollars

Source: Congressional Budget Office, using data from the Department of the Navy.

Costs of new-ship construction exclude funds for refueling nuclear-powered aircraft carriers and for ship conversions, construction of ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. The costs of the mission packages for littoral combat ships, which are not funded in the Navy's shipbuilding accounts, also are excluded.

Adding those costs, plus the $228 million that will be spent from 2020 through 2023 to cover cost overruns, to the estimated cost of new-ship construction would boost the Navy's estimate for the 30-year cost of the 2020 shipbuilding plan to an average of $24.1 billion per year—$2.1 billion more than its estimate for new-ship construction alone. That amount is 50 percent greater than the average funding of $16.0 billion per year that the Navy has received for shipbuilding over the past three decades.

CBO's Estimates

According to CBO's estimate, the full cost of the 2020 shipbuilding plan (including construction, refueling of nuclear-powered aircraft carriers, and other items) would average $31.0 billion per year over the 2020–2049 period (see Table 4 on page 13). That amount is nearly twice as much as the average annual funding the Navy has received over the past three decades. The estimated costs vary from year to year but generally trend upward for the first half of the plan (see Figure 8). CBO
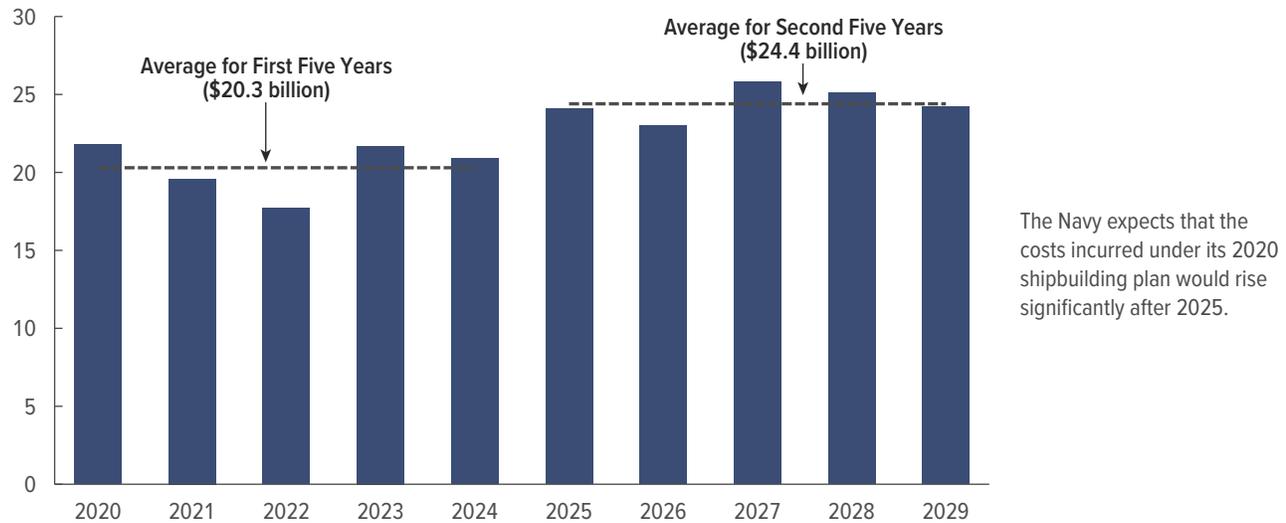
makes the following estimates for the 30-year period as a whole:

- New-ship construction would cost an average of $28.8 billion per year, 31 percent more than the Navy's estimate of $22.0 billion.

- New-ship construction plus refueling of nuclear-powered aircraft carriers would cost an average of $30.0 billion per year, 30 percent more than the $23.2 billion estimate that is based on the Navy's projection of new-ship construction costs plus CBO's estimate of the cost of refueling nuclear-powered aircraft carriers.

- All other items would add annual costs of about $1 billion, raising CBO's estimate to an average of $31.0 billion per year through 2049, 28 percent more than the $24.1 billion estimate that is based on the Navy's projection of new-ship construction costs and CBO's estimate of all other costs.

Figure 7.

The Navy's Estimates of the Costs of New-Ship Construction, 2020 to 2029

Billions of 2019 Dollars

The Navy expects that the costs incurred under its 2020 shipbuilding plan would rise significantly after 2025.

Source: Congressional Budget Office, using data from the Department of the Navy.

Costs of new-ship construction exclude funds for refueling nuclear-powered aircraft carriers and for ship conversions, construction of ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. The costs of the mission packages for littoral combat ships, which are not funded in the Navy's shipbuilding accounts, also are excluded.

CBO's estimates of the full cost of the plan are only 1 percent higher than the Navy's for the near term, which coincides with DoD's Future Years Defense Program, but they are 38 percent higher for the far term. The two sets of estimates are similar for the near term because most of the ships that the Navy plans to buy are already under construction, and their costs are reasonably well known. But CBO's and the Navy's different assumptions about the size and capabilities of future ships led to different cost estimates for the midterm and far term. In particular, two large programs—the new attack submarine and the future large surface combatant to be built in the mid-2020s and beyond—account for most of the difference between the Navy's and CBO's estimates (see pages 22–25 for details).

Operation and Support Costs

In addition to the costs of buying 304 new ships, operation and support costs for a larger fleet would be higher: More ships would require more sailors; recruiting and training those sailors would require more civilian and military positions ashore; additional ships would lead to

larger maintenance budgets; and those extra ships and crews would consume more fuel and supplies, during both training exercises and deployments.

CBO estimated operation and support costs in three categories: direct costs, indirect costs, and overhead costs. Direct costs include crew salaries, fuel, supplies, and repairs and maintenance that the crews perform. Indirect costs include expenditures for various support units and organizations that are necessary for combat units to fight effectively. Overhead costs refer to expenditures that also support combat units, such as recruiting, training, acquisition offices, maintenance, and medical care.[16] Thus, in CBO's approach to operation and support costs, the costs for combat ships are direct costs; the costs for combat logistics and support ships are counted as indirect costs.

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16. For more detail on CBO's approach to modeling operation and support costs, see Congressional Budget Office, *The U.S. Military's Force Structure: A Primer* (July 2016), www.cbo.gov/publication/51535.

Figure 8.

CBO's Estimates of Annual Shipbuilding Costs Under the Navy's 2020 Plan

Billions of 2019 Dollars

Over the next three decades, CBO estimates, the new SSBN and new attack submarine programs would push the Navy's annual shipbuilding costs well above the historical average.
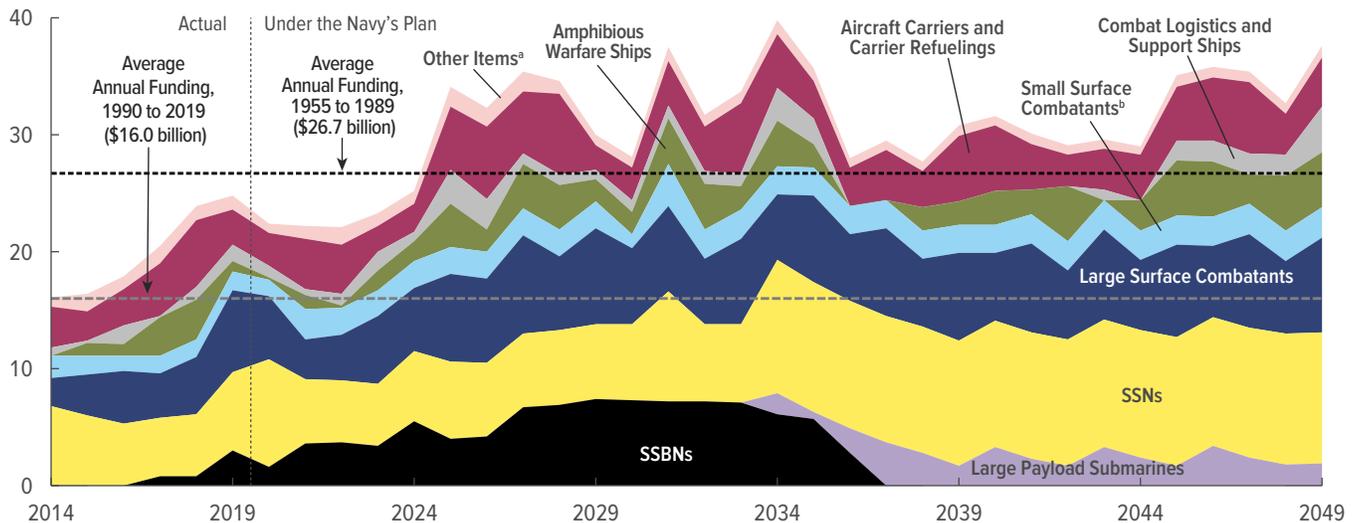
Source: Congressional Budget Office, using data from the Department of the Navy.

SSBNs = ballistic missile submarines; SSNs = attack submarines.

a. Includes ship conversions, ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items.

b. The costs of the mission packages for littoral combat ships, which are not funded in the Navy's shipbuilding accounts, are not included.

Direct costs for the combat ships in the Navy's current fleet are about $23 billion per year (see Figure 9). Those costs would rise in real terms to $36 billion per year by 2049, CBO estimates. The increase is caused in part by the larger fleet size, which would grow from 290 ships today to 355 by 2034 and beyond, and in part by the higher rate of inflation in operation and support costs than in the economy as a whole. As with ship construction, the difference between inflation in operation and support costs and inflation in the economy as a whole is included as real growth in costs, calculated in 2019 dollars. With a larger fleet, total operation and support costs would increase from about $60 billion per year today to almost $90 billion per year by 2049, CBO estimates.

The Navy's report includes an appendix on operation and support costs, but its estimates are not comparable to CBO's. The Navy calculates its estimates in nominal

dollars only and categorizes costs differently than CBO does.

Plans for Specific Ship Programs

To project the costs of implementing the Navy's 2020 shipbuilding plan, CBO estimated the cost of each of the 304 ships that the Navy intends to purchase between 2020 and 2049. For ships under construction, the estimates were based in part on the Navy's data for actual costs. For ships yet to be built, CBO based the estimates primarily on information about the cost-to-weight ratio of similar ships acquired in the past.

Specifically, CBO used the cost per thousand tons of lightship displacement, which is the weight of the water that the ship displaces without its crew, stores, ammunition, and fuel or other liquids. CBO then adjusted its estimates to incorporate the effects of rate and learning: Rate is the reduction in average overhead costs that

Figure 9.

Annual Operation and Support Costs for the Navy's Fleet Under Its 2020 Plan

Billions of 2019 Dollars
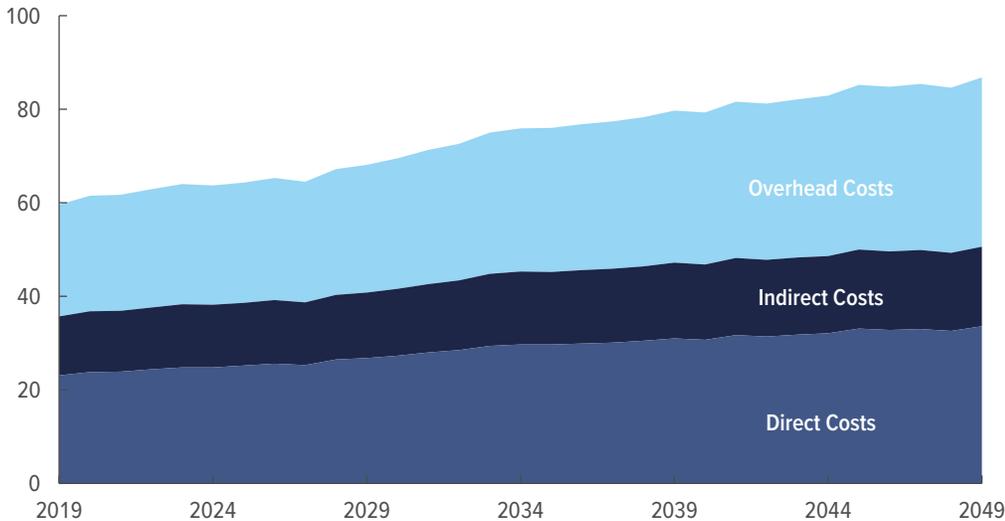
With the fleet growing to 355 ships, operating costs would grow significantly in real terms over the next 30 years.

Source: Congressional Budget Office, *The U.S. Military Force Structure: A Primer* (July 2016), www.cbo.gov/publication/51535. Data are updated for the 2020 budget.

Overhead costs refer to expenditures that support combat units, such as recruiting, training, acquisition offices, maintenance, and medical care. Indirect costs include expenditures for various support units and organizations that are necessary for combat units to fight effectively. Direct costs are the funds needed to pay crews, buy fuel and supplies, and pay for repairs and maintenance that the crews perform on the Navy's combat ships. (CBO counts the costs for combat logistics and support ships as indirect costs.)

occurs as a shipyard builds multiple ships of the same type simultaneously; learning refers to the efficiencies that shipyards gain as they produce additional units of a given type of ship. Those effects were applied to the estimated cost of the first ship of a class (the lead ship) to determine the estimated costs for all subsequent ships of that class. Thus, CBO's estimate of the cost of the lead ship of a class drove its estimate of the costs of subsequent ships of that class.[17]

For ships for which the Navy has not yet developed designs, CBO made assumptions about their likely size and capabilities. All cost estimates for specific ships exclude outfitting and postdelivery costs, which typically add at least 3 percent to a ship's cost (included as "other items" in the totals). CBO's estimates also incorporate a projection that labor and materials costs would probably

continue to grow 1.2 percent faster in the naval shipbuilding industry than in the economy as a whole, as they have for the past several decades.

Aircraft Carriers

According to the 2020 shipbuilding plan, the Navy intends to buy 7 CVN-78 Gerald R. Ford class aircraft carriers over the 2020–2049 period as part of its goal to have 12 aircraft carriers. To project those costs, CBO considered the costs of 4 carriers that have already received some or all of their funding.

The Navy's current estimate of the total cost of the USS *Gerald R. Ford*, the lead ship of the CVN-78 class, is $13.1 billion in nominal dollars appropriated over the period from 2001 to 2018. CBO used the Navy's inflation index for naval shipbuilding to convert that figure to $16.2 billion in 2019 dollars, or 25 percent more than the corresponding estimate when the ship was first

17. For an explanation of how CBO combines the different factors in its cost model, as well as a detailed example for a particular ship, see Congressional Budget Office, *How CBO Estimates the Costs of New Ships* (April 2018), www.cbo.gov/publication/53785.

authorized in 2008.[18] Neither the Navy's nor CBO's esti-mate includes the $5 billion in research and development costs that apply to the entire class.

Because construction of the lead ship is finished, CBO used the Navy's estimate for that ship to estimate the cost of successive ships in the class. But not all of the cost risk has been eliminated; in particular, the ship's power sys-tems, advanced arresting gear (the system used to recover fixed-wing aircraft landing on the ship), and weapons elevators are not yet working properly. It is not clear how much those problems will cost to fix, but current Navy estimates suggest that it will be several tens of millions of dollars or more. CBO does not have enough information to independently estimate those final repair costs.[19]

The next carrier after the CVN-78 is the CVN-79, the *John F. Kennedy*, which is expected to be completed in 2024 and deployed in 2026. Funding for the ship began in 2007, the Congress officially authorized its construction in 2013, and the planned appropriations for it were completed in 2018. The Navy estimates that the ship will cost $11.3 billion in nominal dollars (or $11.9 billion in 2019 dollars). The Navy's 2014 selected acquisition report on the CVN-79 states that "the Navy and shipbuilder have made fundamental changes in the manner in which the CVN 79 will be built to incor-porate lessons learned from CVN 78 and eliminate the key contributors to cost performance challenges realized in the construction of CVN 78."[20] Nevertheless, the Navy informed CBO that there is a greater than 60 per-cent chance that the ship's final cost will be more than the current estimate. Although CBO expects the Navy to achieve a considerable cost reduction in the CVN-79 compared with the CVN-78, as is typical with the second ship of a class, CBO's estimate is higher than the Navy's. Specifically, CBO estimates that the ship will cost $12.4 billion in nominal dollars (or $12.9 billion

in 2019 dollars), about 9 percent more than the Navy's estimate.

In 2018, the Congress authorized the third carrier of the class, the *Enterprise* (CVN-80). Appropriations for that ship began in 2016 and are expected to be complete by 2025. In 2019, the Congress authorized the Navy to purchase materials jointly for the CVN-80 and the next ship, the CVN-81, to save money by buying in greater quantity. It also authorized the Navy to change the sequencing involved in building the ships to gain greater efficiencies in their construction. Although that legis-lative action is known as a "two-carrier buy," the Navy would not be building both ships at exactly the same time. Purchasing the two ships together would accelerate the CVN-81's construction by only one year compared with buying the ships individually as envisioned in the 2019 shipbuilding plan.

In the 2020 budget, the Navy estimated that the CVN-80 would cost $12.3 billion in nominal dollars (or $11.4 billion in 2019 dollars). That represents a savings of $300 million compared with the Navy's estimate in the 2019 budget. In contrast, CBO estimates that the CVN-80 would cost $13.6 billion in nominal dollars (or $12.4 billion in 2019 dollars), about 9 percent more than the Navy's estimate. In information provided to CBO as part of the 2019 budget presentation, the Navy indicated that there was a greater than 60 percent chance that the ship's final cost will be more than it estimated; in contrast, with the 2020 budget, the Navy puts that figure at 78 percent. Thus, it is not clear whether the service's 2020 estimates incorporate savings stemming from a two-carrier buy or simply an acceptance of increased risk of future cost growth.

With respect to the CVN-81, the pattern is similar. In the 2019 budget, the Navy estimated the CVN-81 at $15.1 billion in nominal dollars. In the 2020 bud-get with the two-carrier buy, the Navy estimated the cost of the ship at $12.6 billion in nominal dollars (or $10.5 billion in 2019 dollars), for a savings of $2.5 bil-lion. However, the Navy also told CBO that there is an 80 percent chance that the final cost will be higher than the current estimate, compared with the roughly 40 percent chance indicated in the 2019 budget. CBO estimates that the CVN-81 would cost $14.4 billion in nominal dollars (or $11.9 billion in 2019 dollars), or 14 percent more than the Navy's estimate.

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18. For more information on calculating the costs of aircraft carriers, see Congressional Budget Office, *Inflation in the Costs of Building Aircraft Carriers* (April 2016), www.cbo.gov/publication/51469.

19. See, for example, David Axe, "The U.S. Navy's New Ford-Class Aircraft Carriers Have Lots of Problems," *National Interest* (February 12, 2019), https://tinyurl.com/y5q8kpjz.

20. See Defense Acquisition Management Information Retrieval, *Selected Acquisition Report (SAR): CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier, as of FY 2016 President's Budget* (Department of the Navy, December 2014), p. 29.

Overall, the Navy estimates an average cost of $12.7 billion (in 2019 dollars) for the 7 carriers (CVN-81 through CVN-87) in the 2020 shipbuilding plan. CBO's estimate is $13.0 billion per ship (see Table 5).

Submarines

Under the 2020 shipbuilding plan, submarines would consume the lion's share of shipbuilding funds over the next 30 years—more than 40 percent of the amount needed for new-ship construction (see Table 6). The Navy currently operates 14 Ohio class ballistic missile submarines, 4 Ohio class guided missile submarines (SSGNs) modified from the SSBN version, and 51 attack submarines of several classes. Over the next three decades, the Navy plans to buy 12 new SSBNs, with the first purchase occurring in 2021. In addition, the Navy wants to purchase 5 large payload submarines that are intended to replace the capability provided by the SSGNs that will be retired in the mid- to late 2020s. It also plans to buy 61 new attack submarines, including 28 Virginia class submarines that will carry more weapons than existing Virginias and 33 attack submarines of a new, advanced design. Production of those ships is set to begin in 2031.

Ballistic Missile Submarines. SSBNs, which carry Trident ballistic missiles, constitute the sea-based component of the United States' strategic nuclear triad. (The other two components are land-based intercontinental ballistic missiles and strategic bombers.) The cost of the 12 Columbia class submarines included in the 2020 shipbuilding plan is one of the most significant uncertainties in the Navy's and CBO's analyses of future shipbuilding costs. Under the 2020 plan, the first Columbia would be purchased in 2021, although advance procurement funding started in 2017 for items with long lead times. The Navy would purchase a second Columbia class submarine in 2024 and then 1 per year from 2026 to 2035 (see Figure 5 on page 12).[21]

The Navy currently estimates that the first Columbia would cost $13.4 billion in 2019 dollars and that subsequent ships would have an average cost of $6.7 billion. The total procurement cost for the 12 submarines is $87 billion (which includes appropriations

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21. For additional information, see Ronald O'Rourke, *Navy Columbia (SSBN-826) Class Ballistic Missile Submarine Program: Background and Issues for Congress*, Report for Congress R41129 (Congressional Research Service, updated September 18, 2019), https://crsreports.congress.gov/product/pdf/R/R41129 (1.6 MB).

of $4.5 billion from 2017 to 2019), or an average of $7.2 billion for each ship (see Table 5). Of that amount, $82 billion would be funded between 2020 and 2035. The Navy estimates that research and development costs would amount to $13 billion, bringing the total acquisition cost to $100 billion.

According to the Navy's estimate, the cost per thousand tons for the first Columbia would be 14 percent less than that of the first Virginia class attack submarine—an improvement that would affect costs for the entire new class of ballistic missile submarines. The Navy anticipates lower costs per thousand tons for the Columbia because it plans to recycle, to the extent possible, the design, technology, and components used for the Virginia class. Furthermore, because ballistic missile submarines like the Columbia class tend to be larger and less densely built than attack submarines like the Virginia class, the Navy maintains that they will be easier to build and thus less expensive per thousand tons. The Navy has stated, however, that there is a 50 percent chance that the cost of the first Columbia and subsequent ships of the class will exceed its estimates, and CBO's cost estimates are about 9 percent greater than the Navy's.

The costs of lead ships of new classes of submarines built in the 1970s and 1980s provide little evidence that ballistic missile submarines are cheaper per ton to build than attack submarines (see Figure 10). The first Ohio class submarine was more expensive to build than the lead ships of the two classes of attack submarines built during the same period—the Los Angeles and the Improved Los Angeles. (The design of the Improved Los Angeles included the addition of 12 vertical-launch system cells.) In addition, the average cost-to-weight ratio of the first 12 or 13 ships of the class was virtually identical for the Ohio, Los Angeles, and Improved Los Angeles classes.

Moreover, although the cost by weight of lead ships for submarines had grown substantially by the 1990s, there was still little evidence that submarine size affected the cost per thousand tons. The first Virginia class submarine, which was ordered in 1998, cost about the same per thousand tons as the first Seawolf submarine even though the Seawolf is 20 percent larger and was built nine years earlier.

CBO estimates that purchasing the first Columbia class submarine would cost $14.0 billion, $700 million more than the Navy estimates. Estimating the cost of the lead

Table 5.

Comparison of the Navy's and CBO's Estimates for the Construction of Major New Ships Under the Navy's 2020 Plan

Billions of 2019 Dollars

	Number of New Ships Purchased Under the 2020 Plan	Total Costs per Class Over the 2020–2049 Period		Average Cost per Ship Over the 2020–2049 Period		Memorandum: Average Cost per Ship Under the 2019 Plan	
		Navy's Estimates	CBO's Estimates	Navy's Estimates	CBO's Estimates	Navy's Estimates	CBO's Estimates
CVN-78 Gerald R. Ford Class Aircraft Carriers	7	87[a]	91[a]	12.7[a]	13.0[a]	12.4	12.8
SSBN-826 Columbia Class Ballistic Missile Submarines	12	82	90	7.2[b]	7.9[b]	7.3	7.7
Large Payload Submarines	5	34[c]	37[c]	7.1[c]	7.8[c]	7.2	7.8
SSN-774 Virginia Class Attack Submarines With VPM[d]	28	83	87	2.8	2.9	3.0	3.1
SSN(X) Future Attack Submarines	33	112	181	3.4	5.5	3.1	5.6
DDG-51 Flight III Arleigh Burke Class Destroyers	15	26	27	1.7	1.8	1.6	1.9
Future Large Surface Combatants	61	102	169	1.7	2.8	1.6	2.3
FFG(X) Guided Missile Frigates	20	17	23	0.9	1.2	0.8	1.1
Future Small Surface Combatants	38	28	48	0.7	1.3	0.8	1.2
LHA-6 America Class Amphibious Assault Ships	8	27	31	3.4	3.9	3.2	3.9
LPD-17 Flight II San Antonio Class Amphibious Warfare Ships	12	20	23	1.6	1.9	1.5	1.9
LPD-17 Amphibious Warfare Ship Replacements	8	13	21	1.7	2.6	2.2	2.6
T-AO-205 John Lewis Class Oilers	16	8	8	0.5	0.5	0.5	0.5
T-AKE(X) Replenishment Ship Replacements	11	7	11	0.7	0.9	0.7	0.9

Source: Congressional Budget Office, using data from the Department of the Navy.

Amounts shown in this table exclude funding for research and development.

Unlike Table 1, this table excludes 30 support ships of various types.

CVN = nuclear-powered aircraft carrier; DDG = guided missile destroyer; FFG(X) = future guided missile frigate; LHA = amphibious assault ship; LPD = amphibious transport dock; SSBN = ballistic missile submarine; SSN = attack submarine; SSN(X) = future attack submarine; T-AKE(X) = future dry cargo ship; T-AO = oiler; VPM = Virginia payload module.

a. In CBO's and the Navy's estimates for aircraft carriers, total costs per class include remaining funding for the CVN-80 but exclude some funding for the carrier the Navy plans to purchase in 2048 because that money would not be budgeted until 2050 or later. CBO's and the Navy's estimates of the average cost per ship include all funding for the CVN-81 and the 2048 carrier.

b. In CBO's and the Navy's estimates for ballistic missile submarines, total costs exclude $4.5 billion of funding appropriated before 2020 for the first ship of the class. Average ship costs, however, include the $4.5 billion for the lead ship appropriated in 2017, 2018, and 2019. Both estimates exclude the research and development costs associated with the program, which the Navy estimates to be $13 billion and CBO estimates to be between $14 billion and $18 billion.

c. In CBO's and the Navy's estimates for large payload submarines, total costs exclude some funding for the fifth ship, which would not be budgeted until 2050 or later, but average costs per ship are calculated including those amounts.

d. Under the Navy's budget, one of the submarines that would be purchased in 2020 would exclude VPM.

ship of a class with a new design is particularly difficult because of uncertainty about how much the Navy will spend on nonrecurring engineering and detailed design. Including appropriations from 2017 to 2019, CBO

estimates that, all told, 12 Columbia class submarines would cost $95 billion (of which $90 billion would occur between 2020 and 2036), or an average of $7.9 billion each—$700 million more per submarine than the Navy

estimates. That average is based on the $14.0 billion estimated cost of the lead submarine and an average cost of $7.4 billion estimated for the 2nd through 12th submarines. Research and development would cost between $14 billion and $18 billion, CBO estimates.

Overall, the Navy expects a 14 percent improvement in the cost-to-weight ratio of the Columbia class compared with the first 12 submarines in the Virginia class. Given the history of submarine construction, however, CBO is less optimistic than the Navy. CBO estimates that the Navy would realize a 6 percent improvement, stemming in part from the projected savings attributable to the concurrent production of the Columbia and Virginia class submarines.

The costs for the Columbia class submarines could be lower than the Navy and CBO project, depending on the acquisition strategy. The Navy is purchasing the submarines through the National Sea-Based Deterrence Fund, which was established by the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015 (Public Law 113-291). The Congress appropriates money for the program in the Navy's main shipbuilding account, and then DoD transfers money into the fund. The Navy could realize savings from special procurement authorities associated with that fund, such as the ability to purchase components and materials for several submarines, and possibly for other ships, at the same time.

Further savings could be considerable if, for example, lawmakers authorized the Navy to use a block-buy strategy—an approach it has used with other types of ships. A block-buy strategy allows the Navy to purchase a group of submarines over a specified period (effectively lowering the price of the ships by promising a steady stream of work for the shipyards) and to buy components and materials for the submarines in optimal amounts that minimize costs (known as economic order quantities).[22] One disadvantage of the strategy is that if

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22. For more information on block-buy and multiyear procurement authority acquisition strategies, see Ronald O'Rourke and Moshe Schwartz, *Multiyear Procurement (MYP) and Block Buy Contracting in Defense Acquisition: Background and Issues for Congress*, Report for Congress R41909 (Congressional Research Service, updated September 16, 2019), https://crsreports.congress.gov/product/pdf/R/R41909 (1.24 MB). The potential cost savings from block buys and purchasing materials in economic order quantities are not included in either the Navy's or CBO's estimate.

Table 6.

Average Annual Shipbuilding Costs, by Major Category, 1990 to 2049

	Historical, 1990–2019	CBO's Estimates Under the Navy's 2020 Plan, 2020–2049
	Average Annual Costs (Billions of 2019 dollars)	
New-Ship Construction		
Aircraft carriers	1.7	3.0
Submarines	4.1	13.2
Surface combatants	5.4	9.0
Amphibious ships	1.7	2.5
Logistics and support ships	0.8	1.1
Subtotal	13.8	28.8
Refueling of Nuclear-Powered Carriers and Submarines[a]	1.1	1.2
Other Items	1.1	1.0
Total	16.0	31.0
	Share of Average Annual Costs (Percent)	
New-Ship Construction		
Aircraft carriers	11	10
Submarines	26	43
Surface combatants	34	29
Amphibious ships	11	8
Logistics and support ships	5	4
Subtotal	86	93
Refueling of Nuclear-Powered Carriers and Submarines[a]	7	4
Other Items	7	3
Total	100	100

Source: Congressional Budget Office.

Costs for new-ship construction exclude funds for refueling nuclear-powered aircraft carriers and for ship conversions, construction of ships that are not part of the Navy's battle force (such as oceanographic survey ships) and training ships, outfitting and postdelivery activities (including the purchase of smaller tools and pieces of equipment that are needed to operate a ship but that are not necessarily provided by the manufacturing shipyard as part of ship construction), and smaller items. The costs of the mission packages for littoral combat ships, which are not funded in the Navy's shipbuilding accounts, also are excluded.

a. CBO's estimates under the Navy's 2020 plan reflect only the costs of refueling aircraft carriers. Historically, the refueling of nuclear-powered submarines was also included in the Navy's shipbuilding accounts, but the Navy transferred that funding to other accounts in 2010.

Figure 10.

Cost per Thousand Tons for Various Classes of Submarine, by Lead Ship and Class Average

Millions of 2019 Dollars

Historically, the cost per thousand tons has been about the same for attack submarines and ballistic missile submarines.
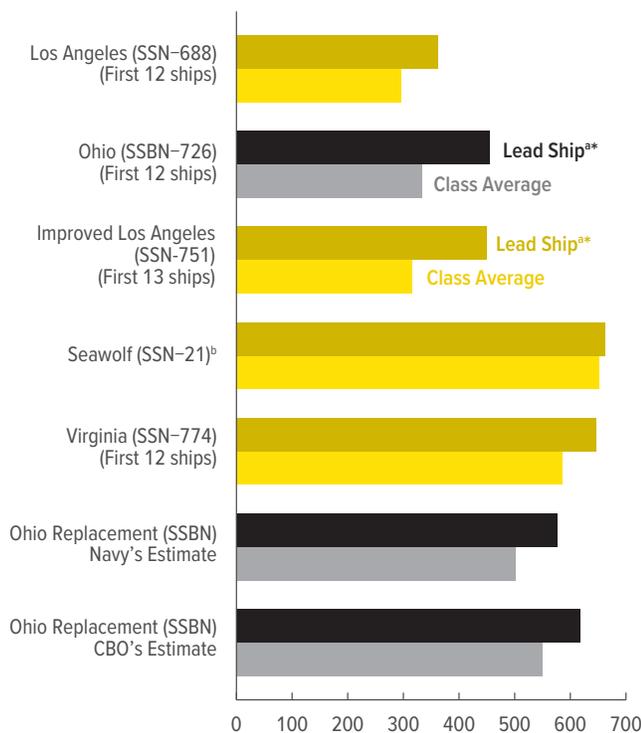
Source: Congressional Budget Office, using data from the Department of the Navy.

SSBN = ballistic missile submarine; SSN = attack submarine.

Cost per thousand tons of Condition A-1 weight is analogous to lightship displacement (the weight of the ship without its crew, stores, ammunition, and fuel or other liquids) for surface ships.

a. Data exclude costs for plans, which include nonrecurring engineering and detail design.

b. Although 29 Seawolf class submarines were planned, only 3 were built.

lawmakers later decided not to build all the submarines, materials that were purchased for the unbuilt ships might go unused. A block-buy strategy might also leave the Congress with less flexibility to change procurement plans or to purchase fewer submarines if lawmakers did not approve of how the program was progressing.

Costs for the Columbia class submarines could, however, exceed both the Navy's and CBO's estimates. The new

[*Labeling error corrected on November 5, 2019]

SSBN would be the largest submarine that the United States has ever built. It is expected to reuse some technology and components from the Virginia class submarine, but it would also include many new elements, such as an all-electric drive system, an X-stern ship control system (where the rear rudders and dive planes are shaped like an X, rather than a + as on the Ohio class), a new missile compartment, and a nuclear reactor that is designed to last the entire 42-year service life of the submarine. One production challenge that has already occurred on the new SSBN is that its missile tubes required many welds to be redone, further tightening the Columbia class schedule. Such challenges are not uncommon on lead ships, and they may indicate future difficulties. First ships of a new class often experience substantial cost growth (see Figure 11).

Large Payload Submarines. Like the 2019 plan, the 2020 plan includes a submarine that would be similar to an SSGN but would be a "large-diameter, next-generation payload-based submarine."[23] The ship would perform missions similar to those currently conducted by SSGNs and, in the future, by Virginia class ships with the Virginia payload module (VPM), as well as other missions. The first ship would be ordered in 2036, after production of the Columbia class ceased; thereafter, the Navy would purchase 1 ship every three years, for a total of 5 by 2049. The 2020 plan does not indicate the final inventory objective for these ships.

The Navy's plan provides little information about the size and capabilities of the large payload submarine. CBO's estimate reflects the assumption that it would be based on the Columbia class hull with its missile tube section reconfigured to perform whatever missions the Navy might want and that other sections of the ship would receive the necessary equipment and modifications to support the payloads the submarine might carry. The Navy estimates that the cost of the 5 ships in the plan would average $7.1 billion per ship; CBO estimates that they would cost $7.8 billion per ship.
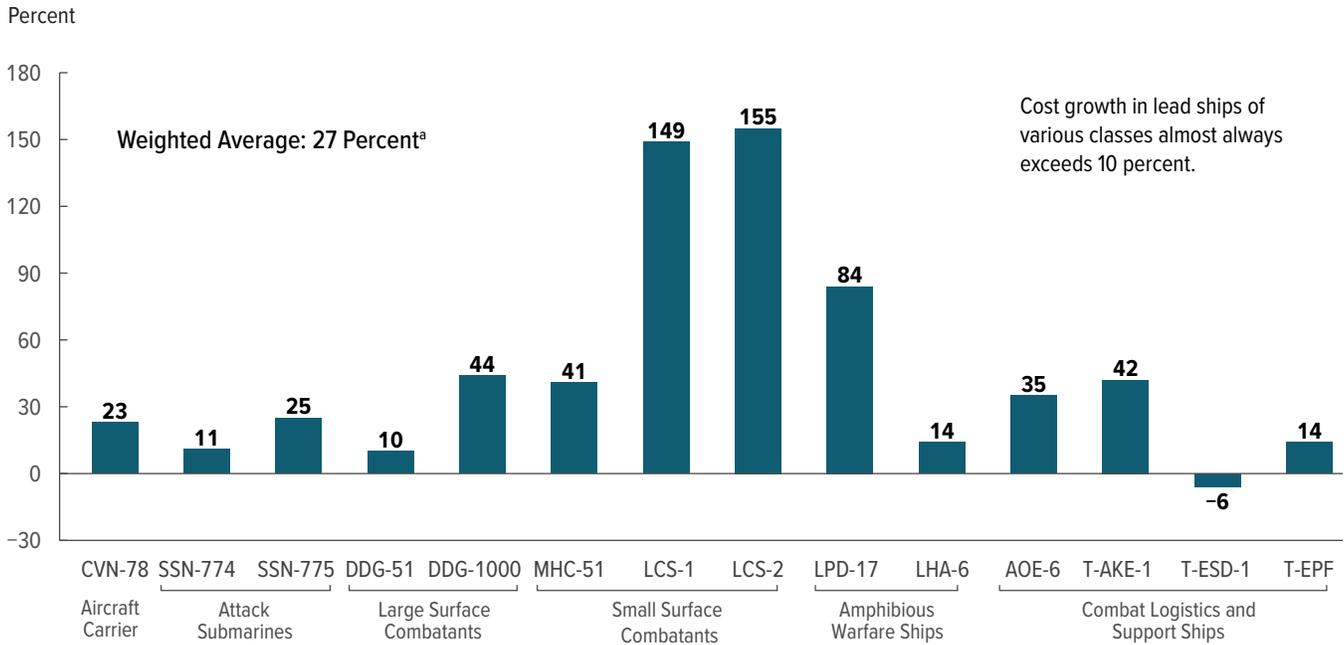
Attack Submarines. The 2020 shipbuilding plan calls for the Navy to buy 28 Virginia class attack submarines. It would purchase 3 ships in 2020 and 2 ships per year between 2021 and 2033 (except for 2031, when the Navy would purchase 1 Virginia). In 2031, the Navy

23. See Department of the Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2020* (March 2019), p. 10, https://go.usa.gov/xyhvK.

Figure 11.

Cost Growth in Lead Ships, 1985 to 2015

Percent

Weighted Average: 27 Percent[a]

Cost growth in lead ships of various classes almost always exceeds 10 percent.

Aircraft Carrier · Attack Submarines · Large Surface Combatants · Small Surface Combatants · Amphibious Warfare Ships · Combat Logistics and Support Ships

CVN-78: 23, SSN-774: 11, SSN-775: 25, DDG-51: 10, DDG-1000: 44, MHC-51: 41, LCS-1: 149, LCS-2: 155, LPD-17: 84, LHA-6: 14, AOE-6: 35, T-AKE-1: 42, T-ESD-1: −6, T-EPF: 14

Source: Congressional Budget Office, using data from the Department of the Navy.

AOE = fast combat support ship; CVN = nuclear-powered aircraft carrier; DDG = guided missile destroyer; LCS = littoral combat ship; LHA = amphibious assault ship; LPD = amphibious transport dock; MHC = coastal mine hunter; SSN = attack submarine; T-AKE = ammunition cargo ship; T-EPF = expeditionary fast transport (formerly joint high speed vessel); T-ESD = expeditionary transfer dock (formerly mobile landing platform).

For most ships, CBO calculated cost growth using the first and last mentions of a ship in the books that accompany each year's budget: *Justification of Estimates, Shipbuilding and Conversion, Navy*. For AOE-6, MHC-51, T-EPF (formerly JHSV), and DDG-51, CBO relied on information papers provided by the Navy for the final estimates and on the Budget Appendixes for the years those ships were authorized.

a. CBO calculated the weighted average by summing the initial costs for all ships in the data set and comparing that with the sum of all final costs for the ships in the data set. The unweighted average cost growth is 46 percent.

would purchase the first ship of a new class of attack submarine, designated the SSN(X). After skipping two years, it would then buy the rest of the new class at a rate of 2 per year from 2034 through 2049, for a total of 33 ships.

Unlike the Virginia class ships built in earlier years, most of the Virginias the Navy would purchase under the 2020 plan would have longer hulls to accommodate the Virginia payload module. The VPM would contain four large-diameter payload tubes, each of which could carry 7 Tomahawk missiles or other payloads such as unmanned underwater vehicles. That modification would increase the submerged displacement of the submarine by nearly 30 percent and would increase the number of the Virginia class submarine's Tomahawk-sized vertical-launch weapons from 12 to 40. (The

submarines would be armed with approximately 25 additional weapons—torpedoes and Tomahawks—in the torpedo room.) The Navy estimates that the 28 submarines scheduled to be purchased between 2020 and 2033 would cost about $83 billion; CBO estimates that cost to be $87 billion.

In contrast, CBO estimates much greater costs for the SSN(X) than the Navy does. The 2020 plan envisions a submarine that would be more capable than the Virginia in many respects but without the VPM. Specifically, the Navy indicates that the next-generation attack submarine should be faster, stealthier, and able to carry more torpedoes than the Virginia class—similar to the Seawolf class submarine. CBO therefore assumed that the SSN(X) would be a Seawolf-sized SSN, which displaces about 9,100 tons when submerged, and would have an all-new

design in keeping with the Navy's description of it as a "fast, lethal next-generation attack submarine."[24]

On the basis of those assumptions, CBO estimates that the average cost of the SSN(X) would be $5.5 billion per submarine, whereas the Navy estimates the cost at $3.4 billion per submarine. That difference amounts to $69 billion and accounts for more than a third of the difference between CBO's estimate and the Navy's estimate of shipbuilding costs under the 2020 plan. The large difference between the Navy's and CBO's estimates under the 2020 plan suggests either that the Navy's cost estimates may be optimistic in light of the SSN(X)'s proposed capabilities or that the two estimates relied on widely different assumptions about the submarine's size, capabilities, and design. As a result, the SSN(X)'s final capabilities and costs are highly uncertain.

Large Surface Combatants

The Navy's 2020 plan calls for the purchase of the same types of ships as the 2019 plan but on an accelerated schedule. Currently, the Navy's fleet has 67 DDG-51 destroyers, composed of three variants designated as Flight I, Flight II, and Flight IIA. Another 8 Flight IIAs and 7 Flight IIIs (an upgraded design) are under construction or have been authorized for construction by the Congress. Between 2020 and 2025, the Navy plans to build 15 DDG-51 Flight IIIs (see Table 5 on page 20). The first ship in that new flight was authorized in 2017. In 2025, the Navy would buy the first of 61 large surface combatants of a new class, which is intended to replace the DDG-51s. Although those new ships were designated as destroyers in the past, the Navy does not offer any description or designation of the class in its 2020 plan.

DDG-51 Flight III Destroyers. To meet combatant commanders' goal of improving future ballistic missile defense capabilities beyond those provided by existing DDG-51s—and to replace 15 Ticonderoga class cruisers when they are retired in the 2020s—the Navy is substantially modifying the design of the DDG-51 Flight IIA destroyer to create a Flight III configuration. That modification will incorporate the new Air and Missile Defense Radar (AMDR) or SPY-6, which will be larger and, recent testing indicates, nearly 100 times more powerful than the radar on current DDG-51s.[25] For the AMDR

to operate effectively in the new Flight III configuration, however, the ships must have a greater capacity to generate electrical power and cool major systems.[26]

With those improvements incorporated into the design of the Flight III and the associated increases in the ships' displacement, CBO estimates that the average cost per ship over the entire production run would be $1.8 billion—about 7 percent more than the Navy's estimate of $1.7 billion. Costs could be higher or lower than CBO's estimate, however, depending on the eventual cost and complexity of the AMDR and the associated changes to the ship's design to integrate the new radar. Completion of the first Flight III ship is several years away.

Future Large Surface Combatants. Like the Navy's 2019 shipbuilding plan, the current plan includes a future class of LSCs that is intended to replace the DDG-51 Flight I and II ships when they are retired in the late 2020s and 2030s.[27] The 2020 plan does not specify whether that new ship would be a cruiser or destroyer.

Under the 2020 plan, production of the future class of large surface combatants would start in 2025, five years sooner than under the 2019 plan. The Navy says that it would buy 61 of the new LSCs through 2049 at an average cost of $1.7 billion—the same price as the Navy's estimate for the average cost of a DDG-51 Flight III ship (but $400 million less than what the Navy estimated for the same ship under its 2017 plan three years ago). That estimate implies that the new LSC would be either a destroyer-sized ship with capabilities that represent only a modest improvement over the DDG-51 Flight III or a smaller ship with significantly improved capabilities based on new design technologies.

Navy officials have said that although the new LSC would have combat capabilities equivalent to those of the DDG-51 Flight III, it would have a larger hull,

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24. Ibid.

25. See Jason Sherman, "Navy Determines SPY-6 Radar Three Times Stronger Than Original Requirement," *Inside Defense* (May 3, 2019), https://tinyurl.com/y4zyghq7.

26. See Ronald O'Rourke, *Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress*, Report for Congress RL33745 (Congressional Research Service, updated September 19, 2019), https://crsreports.congress.gov/product/pdf/RL/RL33745 (1.8 MB), and *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress*, Report for Congress RL32109 (Congressional Research Service, updated September 17, 2019), https://crsreports.congress.gov/product/pdf/RL/RL32109 (1.4 MB).

27. Those retirement dates are based on the Navy's assumption that all DDG-51 Flight IIAs will be modernized midway through their 45-year service life.

substantially more power, more stealth characteristics, and a greater capacity to have new weapon systems and other capabilities installed in the future. Some Navy officials have indicated that the LSC would look more like the DDG-1000 Zumwalt class destroyer than an Arleigh Burke.[28]

The Navy's cost estimate for the future class of LSCs suggests that it would be based on a modified version of the existing DDG-51 Flight III ship. By contrast, in CBO's estimate the new LSC would have a largely new design and would displace 12,000 tons, or about 2,000 tons more than the DDG-51 Flight III. That represents a substantial change in CBO's estimate for the size of the ships under the 2019 plan; in CBO's previous estimate, the LSC would displace 10,000 tons. CBO's change is based in part on statements by senior Navy leaders about the features they expect the new surface combatant to have. A newly designed ship would be more expensive to build than a modified version of an existing ship. In fact, the comparison to the Zumwalt and comments last year by the Navy's Director for Surface Warfare, Admiral Ron Boxall, appear to validate CBO's assumption. He stated that although the future LSC should have capabilities that are similar to or greater than those of the DDG-51 Flight III, the Navy has "maxed out that hull footprint" and is looking at "what we need a new hull to do."[29] (Recently, some senior admirals have indicated that the Navy may delay the LSC until 2026 or later in favor of further upgrades to the Arleigh Burke class beyond the Flight III variant. It is not clear, however, whether such an upgrade would be practical or cost-effective.)[30]

Thus, CBO projects that the future LSC would cost an average of $2.8 billion, roughly 65 percent more than the Navy's projection. Over the 2020–2049 period,

CBO estimates, the Navy would need $169 billion in funding for the future LSC portion of the shipbuilding program—$67 billion more than the Navy's $102 billion estimate. That amount represents another third of the $205 billion overall difference between the Navy's and CBO's estimates for the total cost of the 2020 shipbuilding plan (see the appendix). The great uncertainty about the ultimate size and capabilities of the future class of LSCs suggests that the true cost could differ substantially from both the Navy's and CBO's estimates.

Small Surface Combatants
Under the 2020 plan, the Navy envisions building 58 small surface combatants—20 guided missile frigates and 38 future small surface combatants—by 2049. The 2016 force structure assessment set the goal for those ships at 52, and the construction rate in the 2020 plan would achieve a force of at least 52 between 2034 and 2047, before falling 1 to 2 ships short thereafter.

Guided Missile Frigates. In 2017, the Navy announced it would design and build 20 guided missile frigates, designated as FFG(X). The first ship was to be purchased in 2020 and the last ship ordered in 2030. According to the Congressional Research Service, "Although the Navy has not yet determined the design of the FFG(X), given the capabilities that the Navy wants the FFG(X) to have, the ship will likely be larger in terms of displacement, more heavily armed, and more expensive to procure than the Navy's Littoral Combat Ships."[31] Unlike the predecessor LCSs, the Navy wants the FFG(X) to have robust self-defense capabilities as well as the ability to protect another ship from air attack and to have at least 32 vertical-launch system cells, which can launch a variety of defensive and offensive weapons. To design and build the new class, the Navy is holding a full design and contract competition. Industry teams competing for the FFG(X) must have an existing design or ship or a "parent design" of another ship that can be adapted to the Navy's requirements. The four shipbuilders in the competition are using existing designs that have displacements of between 3,000 tons and almost 7,000 tons.

The Navy's cost goal for the program is currently set at $1.2 billion for the first ship of the class and an average

28. The Zumwalt is a ship that is 50 percent larger than the DDG-51, with substantially more installed power and significant stealth features. The Navy built 3 ships of the class at an average of more than $3 billion per ship, excluding nonrecurring costs.

29. See Megan Eckstein, "Navy's Next Large Surface Combatant Will Draw From DDG-51, DDG-1000—But Don't Call It a Destroyer Yet," *USNI News* (August 28, 2018), http://tinyurl.com/y7eufaeh. See also Ben Werner, "Navy: Next Large Surface Combatant Will Look a Lot Like Zumwalt," *USNI News* (June 19, 2019), https://tinyurl.com/yxdtnv9g.

30. See Joseph Trevithick, "Navy Eyes Yet Another Arleigh Burke Destroyer Variant After Warship Plans Hit Snags," *The Drive* (August 9, 2019), https://tinyurl.com/yxun9bzu.

31. See Ronald O'Rourke, *Navy Frigate (FFG[X]) Program: Background and Issues for Congress,* Report for Congress R44972 (Congressional Research Service, updated September 17, 2019), https://crsreports.congress.gov/product/pdf/R/R44972 (2.4 MB).

cost of $800 million to $950 million for the remaining 19 ships. Because the 2020 shipbuilding plan estimates an average cost of slightly more than $850 million each for all 20 ships—an amount near the lower end of the Navy's cost goal—actual costs would probably exceed the estimates. Historically, the costs of lead ships have grown by 27 percent, on average, over the Navy's initial estimates (see Figure 11 on page 23). Taking into account all publicly available information, CBO's estimate reflects an assumption that the FFG(X) would displace about 4,700 tons, or the median point of the four proposed ship designs in competition for the program contract. As a result, CBO estimates the average cost of the FFG(X)s at $1.2 billion each, for a total cost of $23 billion, compared with the Navy's estimate of $17 billion. Uncertainty about the frigate design makes that estimate difficult to determine.

Future Small Surface Combatants. Under the 2020 plan, the Navy would begin purchasing 38 next-generation ships, which it currently refers to simply as future small surface combatants, in 2031, to replace existing littoral combat ships as they retire. In light of the many changes to the LCS and FFG(X) programs and their continuing evolution, it is not clear how large the new SSC would be, what capabilities it would have, or what its full range of missions would be. The Navy estimates that the new SSCs would cost an average of $750 million each, suggesting a ship in size and capabilities that would be more equivalent to a frigate than to a littoral combat ship. CBO made the same assumption about displacement for the SSC that it did for the FFG(X), estimating an average cost of about $1.3 billion per ship. All told, CBO estimates that the new SSCs would cost $48 billion, whereas the Navy projects a cost of $28 billion.

Amphibious Warfare Ships
The Navy's inventory goal for amphibious warfare ships is 38. That proposed force would consist of 12 America class LHA or Wasp class LHD amphibious assault ships, 13 San Antonio class LPD amphibious transport docks, and 13 replacements for the Navy's LSD dock land- ing ships. To achieve that goal, the 2020 plan calls for buying 8 LHA-6s, at a rate of 1 every three or four years, starting in 2024, to replace LHD-1 class amphibious assault ships as they are retired. It also calls for purchas- ing 12 replacements for dock landing ships to replace existing LSD-41s and LSD-49s as they are retired. The program, which used to be called the LX(R), was

renamed the LPD-17 Flight II in 2018 because the Navy plans to adapt the LPD-17 hull for the mission. (The first LPD-17 Flight II was purchased in 2018.) Under the plan, the Navy would also start replacing the original LPD-17 class with a new class in 2040 and would buy 8 of the new ships by 2049.

Amphibious Assault Ships. The Navy estimates that the LHA-6 class amphibious assault ships would cost $3.4 billion each, or $200 million more per ship than the 2019 plan's estimate. Under the 2020 plan, a seven-year gap separates the last LHA-6 class ship ordered in 2017 and the next one, slated to be pur- chased in 2024, which in CBO's estimation would effectively eliminate any manufacturing learning gleaned from building the first 3 ships of the class. As a result, CBO's estimate is higher than the Navy's, at $3.9 bil- lion per ship. Both CBO and the Navy assumed that all LHA-6 class ships authorized under the 2020 plan would have well decks. (A well deck is a large floodable area in the stern of an amphibious warfare ship that allows direct launching of amphibious vehicles and craft.) The first 2 America class ships did not have well decks.

Amphibious Transport Docks. The Navy estimates that the LPD-17 Flight IIs would cost $1.6 billion each, on average, and that the lead ship would cost $1.7 billion to $1.8 billion. The Flight II is a derivative of the LPD-17, which is much larger than existing LSDs—similar to the way the DDG-51 Flight III is based on the Flight IIA of that class. (The hull and the main mechanical systems are the same, but key systems related to the ship's mission are different.) To achieve its cost goal for the LPD-17 Flight II, the Navy plans to further alter the LPD-17 design and, perhaps, to change the way it buys them: The Flight II variant would have substantially less capability than the LPD-17 class, and the Navy might use block-buy or multiyear authority to purchase the ships, although it has not yet stated an intention to do so.[32] Such authority

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32. Although multiyear procurement and block-buy authority are broadly similar acquisition strategies, they are not identical. Block-buy authority is not regulated by law, and it is more flexible (in that it is subject to less Congressional oversight) and less likely to carry cancellation penalties than multiyear procurement authority. But multiyear procurement authority allows the Navy to buy materials in large quantities for all ships covered under a given contract (and thus purchase materials in economic order quantities), whereas block-buy authority requires separate authorizations to purchase materials for more than one ship at a time.

would commit the government to buying a group of ships over several years, thereby realizing savings as a result of the predictable and steady work provided to the construction shipyard and to the vendors that provide parts and components to the shipbuilder. The authority would be similar to that provided for the Arleigh Burke class destroyers, Virginia class attack submarines, and LCSs.

CBO estimates that the LPD-17 Flight II class would cost an average of $1.9 billion per ship. The agency used the existing LPD-17 hull as the starting point for its estimate and then adjusted the ship's size to reflect the reduced capability it expects for the Flight II. CBO's estimate reflects the assumption that the Navy would ultimately use multiyear or block-buy procurement authority to purchase the ships.

In the final six years covered by its current shipbuilding plan, the Navy would purchase 8 replacements for the LPD-17 class amphibious transport docks. CBO assumes that the replacement for the LPD-17 would be the same size and have roughly the same capabilities as the existing class—an assumption that the Navy also appears to have made in its 2020 plan. The Navy estimates the average price for those ships at $1.7 billion each, or $500 million less per ship than under its 2019 plan. It is not clear why the Navy's estimate fell by 23 percent. CBO estimates that the average cost per ship would be $2.6 billion. Part of the reason for the large difference between the estimates is that CBO factors real growth in the costs of labor and materials in the shipbuilding industry into its constant-dollar estimates and the Navy does not. Because those ships would be purchased in the 2040s, the effect of that real growth, which compounds over time, would be significant.

Appendix:
The Difference Between the Navy's and CBO's Estimates for the Costs of New Ships

Each year, the Navy provides estimates of the costs of building each class of ship in its 30-year shipbuilding plan. The Congressional Budget Office also produces annual estimates. Table A-1 compares the two sets of estimates for the eight most recent 30-year plans. For the 2020 plan, two classes of ships account for two-thirds of the $205 billion difference between CBO's estimate of the total cost of the plan and the Navy's estimate: the future attack submarine and future large surface combatants. Future large surface combatants have been a significant source of estimating differences for all of the recent plans.

Table A-1.

Share of the Difference Between the Navy's and CBO's Estimates of Shipbuilding Costs, by Program

Percent

	2012 Plan	2013 Plan	2014 Plan	2015 Plan	2016 Plan	2017 Plan	2019 Plan	2020 Plan
CVN-78 Gerald R. Ford Class Aircraft Carriers	18	13	3	3	9	6	1	2
SSBN-826 Columbia Class Ballistic Missile Submarines	15	13	12	20	22	20	4	4
Large Payload Submarines	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2	2
SSN-774 Virginia Class Attack Submarines	1	1	-1	3	3	8	4	2
SSN(X) Future Attack Submarines	3	4	-3	8	2	-14	42	34
DDG-51 Flight III Arleigh Burke Class Destroyers	-7	11	7	11	12	10	4	0
Future Large Surface Combatants	41	34	58	38	29	30	20	33
LCS-1 Freedom Class Littoral Combat Ships	1	3	4	5	2	0	n.a.	n.a.
FFG(X) Guided Missile Frigates	n.a.	n.a.	n.a.	n.a.	0	0	4	3
Future Small Surface Combatants	5	4	7	0	5	18	9	10
LHA-6 America Class Amphibious Assault Ships	7	5	5	3	3	6	3	2
LPD-17 Flight II San Antonio Class Amphibious Warfare Ships	5	4	4	5	3	4	3	1
LPD-17 Amphibious Warfare Ship Replacements	n.a.	n.a.	n.a.	n.a.	5	4	2	4
T-AO-205 John Lewis Class Oilers	0	0	1	1	3	4	0	0
T-AKE(X) Replenishment Ship Replacements	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2
Other Ships	8	7	4	4	2	2	1	2
Total	100	100	100	100	100	100	100	100
Memorandum:								
Difference in Billions of Dollars[a]	74	94	76	66	58	50	170	205

Source: Congressional Budget Office.

Numbers reflect the percentage that each ship program contributes to the total difference in cost between CBO's and the Navy's estimates for each plan. Positive values indicate instances in which CBO's estimate is higher; negative values indicate instances in which the Navy's estimate is higher.

CVN = nuclear-powered aircraft carrier; DDG = guided missile destroyer; FFG(X) = future guided missile frigate; LCS = littoral combat ship; LHA = amphibious assault ship; LPD = amphibious transport dock; SSBN = ballistic missile submarine; SSN = attack submarine; SSN(X) = future attack submarine; T-AKE(X) = future dry cargo ship; T-AO = oiler; n.a. = not applicable.

a. For each plan, the difference is expressed as a percentage in constant dollars from the preceding year. For example, the difference for the 2012 plan is calculated in 2011 dollars, the difference for the 2016 plan is calculated in 2015 dollars, and so on.

List of Tables and Figures