Congressional Budget Office

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The Cost of the Navy's New Frigate

On April 30, 2020, the Navy awarded Fincantieri Marinette Marine a contract to build the Navy's new surface combatant, a guided missile frigate long designated as FFG(X).[1] The contract guarantees that Fincantieri will build the lead ship (the first ship designed for a class) and gives the Navy options to build as many as nine additional ships. In this report, the Congressional Budget Office examines the potential costs if the Navy exercises all of those options.

- CBO estimates the cost of the 10 FFG(X) ships would be $12.3 billion in 2020 (inflation-adjusted) dollars, about $1.2 billion per ship, on the basis of its own weight-based cost model. That amount is 40 percent more than the Navy's estimate.
- The Navy estimates that the 10 ships would cost $8.7 billion in 2020 dollars, an average of $870 million per ship.
- If the Navy's estimate turns out to be accurate, the FFG(X) would be the least expensive surface combatant program of the past 50 years (measured in cost per thousand tons when the ship is mostly empty), even in comparison to much less capable ships.

Several factors support the Navy's estimate:

- The FFG(X) is based on a design that has been in production for many years.
- Little if any new technology is being developed for it.
- The contractor is an experienced builder of small surface combatants.
- An independent estimate within the Department of Defense (DoD) was lower than the Navy's estimate.

Other factors suggest the Navy's estimate is too low:

- The costs of all surface combatants since 1970, as measured per thousand tons, were higher.
- Historically the Navy has almost always underestimated the cost of the lead ship, and a more expensive lead ship generally results in higher costs for the follow-on ships.
- Even when major parts of the ship's estimated cost are known, as they were for the Arleigh Burke destroyer, costs have turned out to be higher than initially estimated.
- Compared with the design on which it is based, the FFG(X) will be more densely built and will have somewhat more complex weapon systems.

1. Navy Secretary Kenneth Braithwaite announced on October 7, 2020, that the first FFG(X) would be named USS *Constellation* and carry the designation FFG-62.

Notes: All years referred to in this report are federal fiscal years, which run from October 1 to September 30 and are designated by the calendar year in which they end. Unless this report indicates otherwise, all costs are expressed in 2020 dollars. Numbers in the text, tables, and figures may not add up to totals because of rounding.

In addition, although the Navy's contract with Fincantieri is for a fixed price, which limits the government's financial liability, that fixed-price contract does not guarantee that costs will not increase for three reasons:

- The terms of the Navy's contract permit the ship's contract price to be increased under certain circumstances.
- The Navy could make changes to the ship's design during construction that would increase costs, as it did, for example, in the littoral combat ship (LCS) program.
- If costs rise enough to threaten the financial viability of the shipbuilder, the Navy may opt to cover some of those higher costs rather than experience a disruption in a shipbuilding program that it considers essential.

Background

After a yearlong competition among four shipbuilders, the Navy selected Fincantieri Marinette Marine to build the lead ship and up to nine more ships of the FFG(X) class of guided missile frigates. (A frigate is a small warship designed to conduct a variety of missions, including antisubmarine warfare, anti-ship warfare, and air defense, among other activities.) The 10 ships would be procured between 2020 and 2025. Currently, the Navy plans to buy a total of 20 FFG(X) frigates and expects to hold a future competition to select the builder of the second 10 ships.

The Navy considers frigates to be small surface combatants, in contrast to its large surface combatants (cruisers and destroyers, of which the Navy currently has 91 in service).[2] Since the earliest days of the republic, the Navy has been composed of smaller and larger ships with different levels of armaments that are capable of performing a variety of missions. The last frigate the Navy operated was the FFG-7 Oliver Hazard Perry class. The Navy procured 51 Perry class ships for itself; another 20 were built for or by foreign countries. The Navy's last Perry class ship was retired in 2015.

The Navy also has 22 LCSs, another type of small surface combatant, and the Congress has authorized the construction and purchase of 13 more. The new LCSs are being built in two variants: the Freedom class steel monohull, by Lockheed Martin and Marinette Marine in Marinette, Wisconsin, and the Independence class aluminum trimaran, by Austal in Mobile, Alabama. LCSs differ from frigates in that they are equipped to perform a single primary mission, such as antisubmarine warfare or mine countermeasures, at a time. They are not designed to be multimission warships, as cruisers, destroyers, and frigates are.[3]

The FFG(X)'s design is based on the FREMM, a multipurpose frigate that was built for the French and Italian navies (FREMM is its acronym in the French and Italian languages). Modeling one ship's design after another ship is known as the parent-design approach. Fincantieri's design for the FFG(X) is modeled on the Italian version of the FREMM, the Bergamini class frigate.

By current global standards, the FFG(X) will be large for a frigate. Its full-load displacement—a key measure of ship size that calculates the amount of water the ship displaces when it is completed and puts to sea on missions—is about 7,300 tons, compared with 9,100 tons for the DDG-51 Flight IIA Arleigh Burke class destroyer, 4,100 tons for the Perry class frigate (the larger LAMPS Mark III variant), and 3,400 tons for the Freedom class LCS (see Table 1).[4]

2. For more information on the different types of ships in the Navy's fleet, see Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2020 Shipbuilding Plan* (October 2019), pp. 4–5, www.cbo.gov/publication/55685.

3. For more information on the Navy's surface combatant programs, see Ronald O'Rourke, *Navy Frigate (FFG[X]) Program: Background and Issues for Congress,* Report for Congress R44972, version 61 (Congressional Research Service, July 28, 2020), https://go.usa.gov/xGG2G; *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress,* Report for Congress RL32109, version 234 (Congressional Research Service, July 28, 2020), https://go.usa.gov/xGG26; and *Littoral Combat Ship (LCS) Program: Background and Issues for Congress*, Report for Congress RL33741, version 257 (Congressional Research Service, December 17, 2019), https://go.usa.gov/xGGT4.

4. The combination of letters and numbers designates the type of ship and the first hull number of the class. For example, DD-963 is a destroyer (DD) and its lead ship is number 963. DDG refers to a guided missile destroyer, CG to a guided missile cruiser, and FFG to a guided missile frigate. LAMPS is the acronym for light airborne multipurpose system, which was a sensor system carried by SH-60 helicopters used in antisubmarine and antisurface ship warfare.

Table 1.

Characteristics of the Navy's Surface Combatants, 1970 to 2020

	Spruance DD-963	Oliver Hazard Perry FFG-7	Ticonderoga CG-47	Arleigh Burke DDG-51	DDG-51 Flight IIA	Freedom LCS-1	Independence LCS-2	Zumwalt DDG-1000	DDG-51 Flight III	FFG(X)
Authorized	1970	1973	1978	1985	1994	2005	2006	2007	2017	2020
Displacement (Long tons)										
Full-load	7,800[a]	4,100	9,466	8,315	9,140	3,427	3,138	15,656	9,714	7,291
Lightship	5,826[a]	3,210	7,000	6,624	7,033	2,748	2,377	13,539	7,597	6,014
Dimensions (Feet)										
Length	563	455	567	510	510	387	418	610	510	496
Beam	55	45	55	59	59	58	104	81	59	65
Draft	21	22	32	31	31	14	14	28	31	23
Crew										
Officers	19	16	27	23	32	9[b]	9[b]	16	41	24
Enlisted	315	202	298	247	282	41[b]	41[b]	116	318	176
VLS Cells (Number)	0/61[c]	0	122	90	96	0	0	80	96	32
Antiair Warfare Capability	Minimal self-defense	Minimal self-defense	Fleet air and missile defense	Fleet air defense	Fleet air and missile defense	Minimal self-defense	Minimal self-defense	Ship self-defense	Fleet air and missile defense	Fleet air defense
Service Life (Years)	30	30	35	35	40	25	25	35	40	25

Sources: Congressional Budget Office, using data from the Department of the Navy; Norman Polmar, *The Naval Institute Guide to the Ships and Aircraft of the U.S. Fleet*, 19th ed. (U.S. Naval Institute Press, 2013); and Norman Friedman, *U.S. Destroyers: An Illustrated Design History*, revised ed. (U.S. Naval Institute Press, 2004).

Lightship displacement is the weight of the water displaced by the ship when it is mostly empty or without its crew, stores, ammunition, or fuel or other liquids. Full-load displacement is the weight of the ship with all of those items included.

CG = guided missile cruiser; DD = destroyer; DDG = guided missile destroyer; FFG = guided missile frigate; LCS = littoral combat ship; NSC = national security cutter; VLS = vertical launch system.

a. Ship's weight is based on the original design.

b. Does not include mission package crews, which would add 15 to 24 personnel.

c. The Spruance-class destroyer did not have VLS cells when it was built in the 1970s. Sixty-one cells were added to each ship in the 1980s.

CBO's Cost Estimate to Procure and Operate the FFG(X)

CBO independently estimated the costs of the FFG(X) program, both to procure the ships and to operate and support those ships over the course of their expected service life. The agency examined other surface combatant programs to develop a weight-based estimate of the costs for the first 10 FFG(X) ships as well as for the 10 ships the Navy plans to purchase in the future. CBO relied on the operating-cost model it used for other ships to develop its estimate of the operation and support costs for the 20 FFG(X) ships over their anticipated 25-year life.

Procurement Cost

Using three other surface combatants—the Arleigh Burke Flight III, the LCS-3 (the second ship of the Freedom class LCS), and the DD-963 Spruance—as analogies, CBO estimates the cost of procuring the lead FFG(X) to be $1.6 billion, or 40 percent more than the Navy's estimate. CBO estimates the average cost of the first 10 ships of the program would be about $1.2 billion per ship, or a total of $12.3 billion, which is also about 40 percent more than the Navy's estimate. Those 10 ships would cost $205 million for every thousand

tons of lightship displacement.[5] The Navy has not estimated the cost of the second 10 ships of the frigate program; CBO estimates those ships would cost an average of $1.1 billion per ship, or another $10.9 billion, assuming the Navy uses the same design and the ships are built by Marinette Marine.

Operation and Support Cost

The Navy has not yet reported how much it estimates the FFG(X) will cost to operate and maintain throughout its expected 25-year service life. Operation and support costs, which would include modernizing combat systems later in the ship's service, typically represent most of the total lifecycle cost of a weapon program. CBO estimates that if the FFG(X) were in service today, its direct costs for operation and support would be $63 million per ship annually.[6] If the indirect and overhead costs associated with operation and support of the FFG(X) were included, then the estimated amount would be $130 million per ship annually.

Total Operation and Support Costs From 2026 to 2060. The total direct cost of operating and supporting a force of 20 FFG(X)s over their service life (2026 to 2060) would be almost $40 billion. If indirect and overhead costs were included as well, then the total cost would be about $90 billion over that period. (Operation and support costs have historically risen at a rate higher than the rate of general inflation in the economy as a whole. The difference between those rates is included as real growth in CBO's estimates, as calculated in 2020 dollars.)

Accounting for Dual Crews. CBO derived its cost estimate for the FFG(X)'s crews by adjusting the operating costs of an Arleigh Burke Flight IIA to account for the FFG(X)'s different full-load displacement and crew size. The FFG(X) requires 200 personnel, compared with 314 for the destroyer; however, because the frigate will eventually use a dual-crew system to achieve greater operational availability, CBO accounts for two crews in its estimate. (Dual crews—one operating the ship, one training ashore—increase the amount of time ships spend on deployment.)

The dual-crew system would be similar to that used by the Navy's LCSs. The advantage of using two crews to operate one ship is that the ship is more often available for naval operations.[7] Under the Navy's current operating cycles for surface combatants, single-crewed ships spend about 20 percent of their service life on deployment and dual-crewed ships spend more than twice that. Thus, operation and support costs are higher for dual-crewed ships but their utility as warships is also greater. Those higher costs include the pay and benefits of the second crew, higher maintenance costs because the ship spends more time conducting operations, and a larger shore-based infrastructure to aid in the ship's maintenance and to house and train the crews.

The Navy's Cost Estimate to Procure the FFG(X)

In the Navy's 2021 budget, which was submitted to the Congress before the winner of the FFG(X) competition was announced, the service estimated that the first FFG(X) would cost $1.2 billion in 2020 dollars (or $1.3 billion in nominal, or current, dollars). The average cost of the second through tenth ships, the Navy estimated, would be $835 million per ship. The total cost for the first 10 ships would be $8.7 billion (or $9.8 billion in nominal dollars). After the award, the Navy told CBO that its decision to award the program to Fincantieri to build a ship based on the Italian FREMM would not substantially change its cost estimate.

5. Lightship displacement is the weight of the water displaced by the ship when it is mostly empty or without its crew, stores, ammunition, or fuel or other liquids. Full-load displacement is the weight of the ship with all of those items included. CBO uses the lightship displacement of ships (expressed in long tons) in its estimate of procurement costs and full-load displacement to estimate operation and support costs. For a discussion of the relationship between cost and weight in ships, see Congressional Budget Office, *How CBO Estimates the Cost of New Ships* (April 2018), www.cbo.gov/publication/53785.

6. CBO estimated operation and support costs in three categories: direct costs, indirect costs, and overhead costs. Direct costs include the crew's salaries as well as fuel, supplies, and repairs and maintenance. Indirect costs include spending for support units and organizations that enable combat units to fight effectively. Overhead costs refer to other spending that supports combat units, such as recruiting, training, acquisition offices, major maintenance, and medical care. For more detailed information on CBO's approach to modeling operation and support costs, see Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2020 Shipbuilding Plan* (October 2019), pp. 15-16, www.cbo.gov/publication/55685; and *The U.S. Military's Force Structure: A Primer* (July 2016), www.cbo.gov/publication/51535.

7. For a more detailed discussion of the advantages and disadvantages of ships with more than one crew, see Congressional Budget Office, *Preserving the Navy's Forward Presence With a Smaller Fleet* (May 2015), www.cbo.gov/publication/49989; and *Crew Rotation in the Navy: The Long-Term Effect on Forward Presence* (October 2007), www.cbo.gov/publication/19283.

As one of the parameters for the competition, the Navy set generic unit-procurement goals for the 2nd through 10th ships. Specifically, it wanted the FFG(X) to cost an average of $800 million to $950 million per ship in 2018 dollars (including government-furnished equipment such as combat and weapon systems). In 2020 dollars, that target cost range is $836 million to $1 billion. Thus, the cost estimates in the Navy's 2021 budget for the additional FFG(X)s are at the very low end of the range the Navy established at the outset of the competition. In information provided to CBO, the Navy stated that there was a 50 percent chance the cost of the first two ships would exceed its estimates and a 60 percent chance that the cost of the third through tenth ships would be higher than its estimates.

CBO compared the estimated costs of the FFG(X) with those of similar ships and examined factors that support the Navy's estimate and factors that do not.

The Navy's Estimate Compared With the Costs of Other Surface Combatants

Between 1970 and 2019, the Navy purchased seven classes of surface combatant.[8] Those included one cruiser class, the CG-47 Ticonderoga; three destroyer classes, the DD-963 Spruance, the Arleigh Burke, and the DDG-1000 Zumwalt; one frigate class, the Perry; and two variants of littoral combat ships, the LCS-1 Freedom and the LCS-2 Independence. The capabilities of those ships and their cost by weight vary widely. Generally, larger ships are more capable than smaller ones because the larger ships are equipped with more capable combat systems and more weapons, have more installed power, and are built to higher standards of survivability, among other differences.

The lightship displacement of the FFG(X) is expected to be about 6,000 tons. Therefore, according to the Navy's estimates for the program, the lead ship would cost $202 million per thousand tons and the average cost of the first 10 ships of the class would be $145 million per thousand tons.

If the Navy's procurement cost estimates for the FFG(X) prove accurate, the ship would be, by far, the least expensive surface combatant that the Navy has bought since 1970 (measured in cost per thousand tons of lightship displacement). That would apply to both the lead ship and the average cost of the first 10 ships. In addition, the Navy's low estimate compared with the cost of similar past ship programs suggests that the growth in actual costs relative to estimated costs could be large.

Costs for Lead Ships

When CBO used the same metric to calculate the cost to build the lead ships of other classes of surface combatants, it found that every other lead ship built since 1970 cost more to produce, (see Figure 1, top panel). For example, the Perry and Spruance class lead ships cost about 35 to 40 percent more per thousand tons than the Navy expects the FFG(X) to cost. To be sure, today's shipyards, which use modern tools such as computer-aided design and modular building practices, are more efficient than the yards that built the Perry and Spruance in the 1970s. However, those classes were arguably easier to build than the FFG(X) because U.S. warships have generally become more complex in recent decades.[9] In fact, the Spruance, as originally built, was lightly armed for its size, which led to some criticism at the time. The Perry and Spruance, moreover, were built in greater annual quantities than the Navy plans for the FFG(X), which generally reduces per-ship costs. If the Perry and Spruance ships had been built at the FFG(X) program's planned rate of about two per year, their costs might have been even higher, and the difference between their cost per weight and the Navy's anticipated cost per weight for the FFG(X) might have been even greater.

The lead ship of the Flight III variant of the Arleigh Burke, the Navy's most recently upgraded Aegis-capable destroyer, is under construction.[10] The Navy estimates that the ship will cost about 30 percent more per thousand tons than the FFG(X). Although the Flight III is more capable in some respects than the FFG(X), that greater capability is largely a function of the ship's larger size rather than a difference in the complexity and capability by weight of its weapons and sensors. The FFG(X)

8. For the purposes of this report, CBO treats the two variants of the LCS as separate classes.

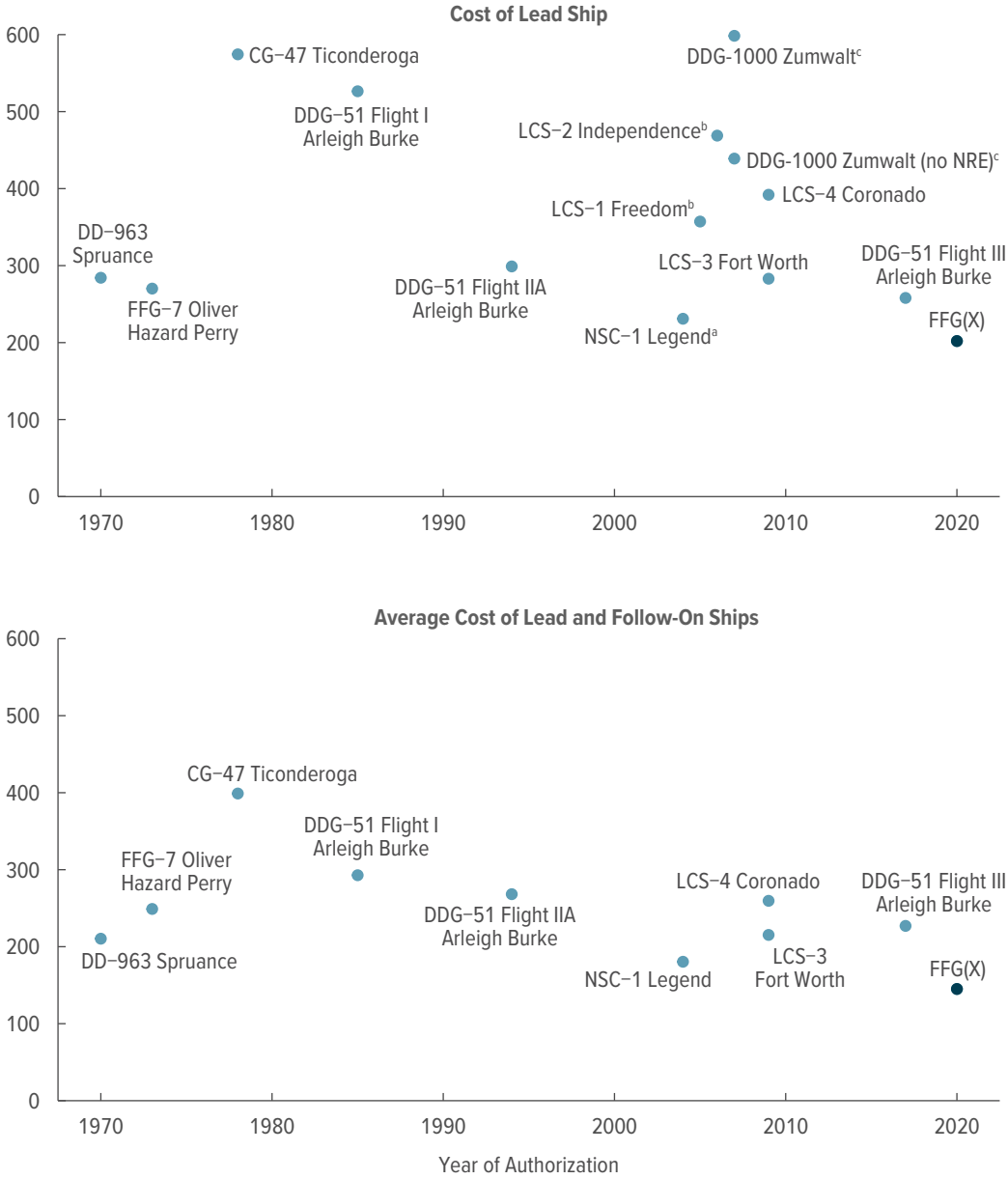
9. See Mark V. Arena and others, *Why Has the Cost of Navy Ships Risen? A Macroscopic Examination of the Trends in U.S. Naval Ship Costs Over the Past Several Decades*, MG-484-NAVY (RAND Corporation, 2006), www.rand.org/pubs/monographs/MG484.html.

10. Aegis is a highly sophisticated, centralized, and automated command-and-control and weapons control system that enables ships to conduct wide-area air surveillance and automatically detect, target, and engage numerous targets. The system includes many components, the most important of which is a powerful multifunction phased-array radar. All of the Navy's existing Aegis-capable ships—its cruisers and destroyers—also carry 90 to 122 vertical launch system (VLS) cells for their weapons.

Figure 1.

Cost of the Navy's Surface Combatants per Thousand Tons of Lightship Displacement

Millions of 2020 Dollars



Every surface combatant built since 1970 cost more by weight to produce than the Navy expects its new FFG(X) frigate to cost.

Source: Congressional Budget Office.

Lightship displacement (expressed in long tons) is the weight of the water displaced by the ship when it is mostly empty, without its crew, stores, ammunition, fuel, or other liquids. The lead ship is the first ship of a new class. Follow-on ships represent the first group of ships built after the lead ship. Among the ships shown, the number of follow-on ships built ranged from 7 to 12 depending on the program.

CG = guided missile cruiser; DD = destroyer; DDG = guided missile destroyer; FFG = guided missile frigate; LCS = littoral combat ship; NSC = national security cutter.

a. The NSC-1 is a Coast Guard cutter that is similar to a frigate in size.

b. LCS-1 and LCS-2 were prototypes purchased with research and development funds; both experienced unusual construction problems. The first LCSs built with shipbuilding funds were the LCS-3 (Freedom class) and LCS-4 (Independence class).

c. The DDG-1000 Zumwalt had unusually extensive nonrecurring engineering (NRE), onetime costs associated with developing the specific design of the ship or specific components. The figure therefore shows the Zumwalt's cost with NRE and without it in relation to the cost of other surface combatants. The class was excluded from the bottom panel because only three ships were built.

and the Flight III both have multimission capability, and most of the combat-system equipment on the FFG(X) will be similar to but smaller or less powerful than the equipment on the Flight III, including the radar and missile systems.

The LCS-3 was built in the same shipyard that is to build the FFG(X). Even though the second ship of a class (the LCS-3 is the second ship in the Freedom class) is generally much less expensive to build than a lead ship, the LCS-3 cost 40 percent more per thousand tons than the Navy's cost estimate for the FFG(X)'s lead ship. The cost of the LCS-3, moreover, excludes the cost of the mission package—the weapons and sensors that equip an LCS to perform its primary mission. (Mission packages for LCSs are procured separately from the ships.) The fact that a mission package was not part of the LCS-3's cost might have been expected to make it cheaper by weight than a frigate such as the FFG(X), not more expensive. Had the cost of a mission package been included in LCS-3's procurement cost, the difference in cost per weight would have been greater than 40 percent.

Costs for 10 Ships

The difference in cost per weight between the FFG(X) and other Navy surface combatants persists when CBO extends its analysis to also include follow-on ships. (Follow-on ships are the group of ships purchased after the lead ship.) As in the case of lead ships, the average cost per thousand tons of the first 10 FFG(X)s is substantially less than the cost of any comparable group of surface combatants the Navy has built since 1970 (see Figure 1, bottom panel).

The Navy's estimate for the FFG(X) of $145 million per thousand tons is not only less than the cost of other surface combatants, it is also less than the cost of a ship that is not a Navy warship. The Coast Guard's national security cutter (NSC) program, the only non-Navy ship that CBO examined, cost $180 million per thousand tons—24 percent higher than the FFG(X)—despite the fact that the NSC, as a Coast Guard ship, has a more limited collection of expensive combat-system equipment and is built to a lower survivability standard (that is, less rugged and with less system redundancy) than the FFG(X).

The Navy's estimate is also less than the cost of Freedom variant LCSs that are being produced today—about $190 million per thousand tons. Yet the LCSs benefit from the production efficiencies gained in building 12 previous Freedom variant ships, as well as the gains in efficiency that accrued as shipyard workers gained familiarity with that ship model. Furthermore, the Freedom class is much less capable than the FFG(X).

The early ships of the Navy's Aegis-capable classes—the Arleigh Burke destroyers and the Ticonderoga cruisers—cost 57 percent to 175 percent more per thousand tons than the Navy projects for the FFG(X). Navy ships less capable than the FFG(X)—the Spruances, the Perrys, the national security cutters, and the LCSs, which either have fewer weapons or lack the ability to defend other ships from air attack—cost 45 percent to 79 percent more, by weight, to build than the Navy's estimate for the FFG(X) (see Table 2).

Cost Growth of Similar Ships

CBO has also found that the less the Navy estimated a ship would cost per thousand tons, the greater its percentage growth actually was. For example, the Navy estimated that the first Arleigh Burke would cost 16 percent less per thousand tons than the first Ticonderoga: The Arleigh Burke's actual cost grew by a little more than 10 percent over the Navy's initial estimates. The Navy estimated that the Zumwalt would cost 32 percent less per thousand tons than the Arleigh Burke, and the Zumwalt's actual cost was 44 percent higher than the original estimate. Finally, the Navy estimated the LCS-1 would cost 47 percent less per thousand tons than the first Oliver Hazard Perry frigate: The LCS-1's actual cost grew by nearly 150 percent over that estimate.

Factors That Support the Navy's Estimate

Several factors favor the Navy's estimates for the FFG(X). First, the Italian FREMM, the model for the FFG(X), is a stable design that has been in production for many years. Although the FFG(X) will carry U.S.-made weapon systems (unlike the Italian version), the FFG(X)'s design is otherwise similar to the FREMM's design. According to Fincantieri, approximately 85 percent of the FFG(X)'s design is the same as the FREMM's design.

Second, little if any new technology is being developed for the FFG(X). The sensors, weapons, propulsion equipment, and power and cooling systems of the FFG(X) are already used on other warships in the U.S. Navy or in European navies, so firm data on their procurement costs are available. The ship's main radar is a smaller version of the new SPY-6 radar being installed on the

Table 2.

Cost of the Navy's FFG(X) If Its Cost by Weight Matched That of Other Surface Combatants

Class of Surface Combatant	Decade of Production	Cost for 10 Ships (Billions of 2020 Dollars)	Average Unit Cost (Billions of 2020 Dollars)	Percentage Above Navy's FFG(X) Estimate
DD-963 Spruance	1970s	12.7	1.27	45
FFG-7 Oliver Hazard Perry	1970s	15.0	1.50	72
CG-7 Ticonderoga	1980s	24.0	2.40	175
DDG-51 Flight I Arleigh Burke	1980s	17.6	1.76	102
DDG-51 Flight IIA Arleigh Burke	1990s	16.1	1.61	85
NSC-1 Legend	2000s	10.9	1.09	24
LCS-3 Fort Worth	2010s	13.0	1.30	48
LCS-4 Coronado[a]	2010s	15.6	1.56	79
DDG-51 Flight III Arleigh Burke[b]	2010s	13.7	1.37	57
Memorandum:				
Navy's Estimate	2020s	8.7	0.87	n.a.
CBO's Estimate	2020s	12.3	1.23	40

Source: Congressional Budget Office.

DD = destroyer; DDG = guided missile destroyer; FFG = guided missile frigate; LCS = littoral combat ship; NSC = national security cutter; n.a. = not applicable.

a. The Coronado's all-aluminum hull design is substantially different from the hull design of the FFG(X).

b. Based on the Navy's budget estimate for the DDG-51 Flight III program.

Arleigh Burke Flight III destroyers. Development of the SPY-6 radar is nearly complete, and cost estimates for that radar have actually declined since the start of the Flight III program.

"We've tried a different approach in the frigate to taking more proven technology, both on the combat systems and with a parent [ship] design," Assistant Secretary of the Navy for Acquisition James F. Geurts stated in June. "And in doing that, you know, trying to bend the normal cost curve as compared to previous programs. . . I'm comfortable that we've got that program positioned well."[11] The FFG(X)'s use of proven technology is a sharp contrast with, for example, the Zumwalt-class destroyer, which was built with a number of new technologies that needed to be integrated into the lead ship. Those challenges contributed to the Zumwalt's 44 percent cost growth.

Third, Fincantieri is an experienced builder of small surface combatants. Although its Marinette Marine shipyard has not built frigates before, the yard has built LCSs. In addition, Fincantieri informed CBO that about half of Marinette Marine's cost to build the FFG(X) (excluding the cost of government-furnished equipment) reflects the yard's contracts with vendors and suppliers, and that about three-quarters of those vendors are on fixed-price contracts.

Fourth, according to press reports, an independent estimate of the FFG(X) program by DoD's office of Cost Assessment and Program Evaluation (CAPE) was a little less than the Navy's estimate.[12] CAPE is generally regarded as an independent assessor of DoD's military programs.

Factors That Do Not Support the Navy's Estimate

There are several reasons that the Navy's cost estimates may be low—some that are unrelated to the FFG(X)'s fixed-price contract and some that are related.

11. See Jon Harper, "Cost Estimates Questioned for New Navy Frigate," *National Defense Magazine* (June 18, 2020), https://tinyurl.com/y22y6vdh.

12. See David B. Larter, "5 Things You Should Know About the Navy's New Frigate," *Defense News* (May 5, 2020), https://tinyurl.com/y2mqxeog.

Factors Unrelated to the FFG(X)'s Fixed-Price Contract
CBO identified four factors unrelated to the FFG(X)'s fixed-price contract that do not support the Navy's estimate. First, the Navy's estimate is at odds with the historical costs of earlier surface combatants, as discussed earlier.

Second, in the past the Navy has almost always underestimated the cost of the lead ship, and a more expensive lead ship generally results in higher costs for the follow-on ships. In its annual analysis of the Navy's shipbuilding plan, CBO found that over the past 30 years, lead ships cost 26 percent more than the Navy's original estimate, using a weighted average.[13] Nearly all of those lead ships cost at least 10 percent more than the original estimate (see Figure 2).[14]

Third, experience with the Arleigh Burke destroyer suggests cost growth is likely. Although the Navy has argued that major parts of the FFG(X)'s estimated cost are known quantities because it is familiar with so much of the ship's combat systems, weapons, and power systems, reducing the risk of cost growth, the same was also true for the Arleigh Burke when it was designed and built. The destroyer's major combat and weapons systems—Aegis and vertical launch system (VLS) cells, as well as elements of the ship's propulsion equipment—had been used in the Ticonderoga-class cruisers.[15] Nevertheless, the lead Arleigh Burke cost a little over 10 percent more than the Navy's original estimate.

Fourth, the FFG(X) will be more densely built than its FREMM counterpart—that is, the FFG(X) will have more steel reinforcement and have more compartmentalization.[16] In the past, the Navy has argued that denser ships are more expensive to build, by weight, than their less dense counterparts.[17] The FFG(X) will be built to about the same survivability standards as the Arleigh Burke and have similar combat and weapon systems. That suggests that the Arleigh Burke's cost per thousand tons may be the most appropriate analogy for the FFG(X) in terms of cost.[18]

Factors Related to the FFG(X)'s Fixed-Price Contract
If some costs are higher than expected, the fixed-price terms of the contract potentially limit the extent to which the Navy may experience increased costs, absent any contract changes. Under the specific terms of the contract, the Navy and Fincantieri agreed on a target cost for the lead ship and the nine optional ships, with a ceiling price above the target price. If costs rise above the target price but are below the ceiling price, the Navy and Fincantieri will share the additional costs under a contractually agreed formula called a share line. (Similarly, if costs underrun the target price, the savings are also shared.) If costs go above the ceiling price, they will be borne entirely by the shipbuilder: The government's liability stops at the ceiling price.[19] The target price, ceiling price, and the government's portion of the share line for the FFG(X) are considered sensitive and are not publicly available. Under the FFG(X)'s contract, the government is not obligated to buy all 10 ships: It is only obligated to buy the lead ship and is free to stop the contract at any point after that.

13. CBO calculated the weighted average by adding the initial costs for all ships in the data set and comparing that sum with the sum of all final costs for the ships in the data set. Unweighted average cost growth is 46 percent.

14. See Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2020 Shipbuilding Plan* (October 2019), p. 23, www.cbo.gov/publication/55685.

15. The VLS is a standardized missile launcher that can hold and fire many different Navy munitions.

16. Fincantieri has indicated, however, that the more easily producible design of the FREMM-based FFG(X) will compensate for the tougher construction standards.

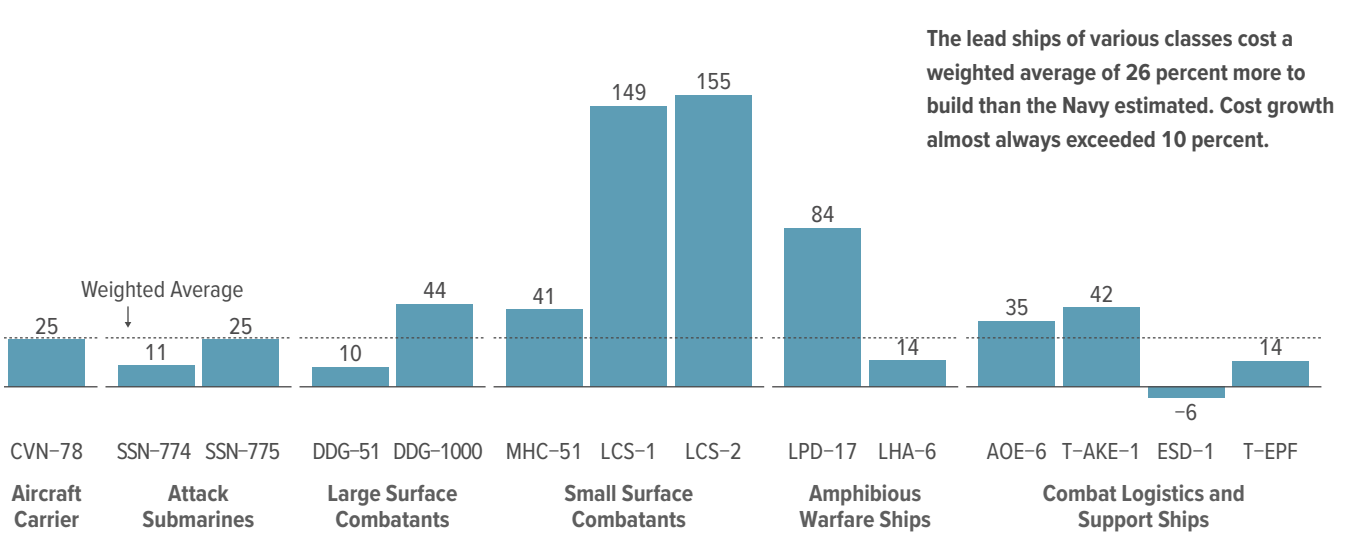
17. See Congressional Budget Office, *An Analysis of the Navy's Fiscal Year 2020 Shipbuilding Plan* (October 2019), p. 10, www.cbo.gov/publication/55685; Testimony of Eric J. Labs, senior analyst, Congressional Budget Office, on the Navy's Surface Combatant Programs before the Subcommittee on Seapower and Expeditionary Forces of the House Committee on Armed Services, *The Navy's Surface Combatant Programs* (July 31, 2008), www.cbo.gov/publication/20065; John Young, Under Secretary of Defense for Acquisition, Technology, and Logistics, letter dated July 2, 2008, to the Honorable Gene Taylor, Chairman, Seapower and Expeditionary Forces Subcommittee of the House Committee on Armed Services in *InsideDefense.com* (July 11, 2008); and Testimony of Allison Stiller, Deputy Assistant Secretary of the Navy, Ship Programs, Subcommittee on Seapower and Expeditionary Forces of the House Committee on Armed Services (March 14, 2008).

18. See David B. Larter, "Fincantieri's FREMM Frigate Design Bulks Up for the US FFG(X) Competition," *Defense News* (July 5, 2019), https://tinyurl.com/yxzn4qwy.

19. For an overview, see Kate Manuel, *Contract Types: Legal Overview,* Report for Congress R41168 (Congressional Research Service, December 29, 2014).

Figure 2.

Cost Growth in the Navy's Lead Ship Programs, 1985 to 2015



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

The lead ship is the first ship of a class.

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

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, 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.

AOE = fast combat support ship; CVN = nuclear-powered aircraft carrier; DDG = guided missile destroyer; LCS = littoral combat ship; LPD = amphibious transport dock; MHC = coastal mine hunter; SSN = attack submarine; T-AKE = ammunition cargo ship; T-EPF = expeditionary fast transport; T-ESD = expeditionary transfer dock.

That said, a fixed-price contract may not succeed in limiting costs to the government for three main reasons. First, fixed prices might not remain unchanged if the contract permits them to be increased to take into account changes in circumstances that are judged to be beyond the contractor's control.

Second, costs may rise on a fixed-price contract when the government makes major changes to the specifications of a shipbuilding program. The Lewis and Clarke T-AKE logistics-ship program in the 2000s provides an example. In that program, the Navy signed a fixed-price contract (similar to the FFG[X] contract) with the National Steel and Shipbuilding Company of San Diego (NASSCO) for 12 ships. After buying several ships, the Navy reduced the number of ships it would buy to 11. That broke the contract, leading to a renegotiation with NASSCO. NASSCO stated that it earned little or no profit and might even have lost money on the first few ships because higher-than-expected commodity prices affected what it paid for materials and its schedule was disrupted by delays in receiving components from suppliers who were damaged by Hurricane Katrina. In renegotiating the contract for the remaining ships, the Navy and NASSCO agreed to higher prices for the early ships and lower prices for later ships. The net result was that NASSCO likely received more money for 11 ships under the renegotiated contract than it would have received for 12 ships under the original contract. The Navy later added three more ships to the program and NASSCO continued to build ships for the Navy.

By the same token, if the Navy wanted to make significant changes to the FFG(X) that were beyond the scope of the change orders allowed by the contract, it would negotiate the price of the revisions with Fincantieri. If,

for example, the Navy decided it wanted the FFG(X) to carry 48 VLS cells rather than 32, Fincantieri and the Navy would have to negotiate the terms of such a change.

Third, the government might revise a contract at the ship builder's request. In a recent precedent, the federal government provided extraordinary contractual relief to Eastern Shipbuilding Group, based in Florida, for its fixed-price, incentive-fee contract to build the Coast Guard's Offshore Patrol Cutter (OPC). In 2016, the Coast Guard had awarded Eastern a contract to build the first nine OPCs that was structured similarly to Fincantieri's FFG(X) contract. But after the contractor encountered unusual construction problems, the shipyard was damaged by Hurricane Michael in October 2018. Eastern requested relief on both the OPC's cost and its schedule, which the Coast Guard granted in June 2019. However, the Coast Guard limited that relief to the first four OPCs and announced that the remaining ships of the contract would be subject to a new competition for their construction.[20]

20. See Ronald O'Rourke, *Coast Guard Cutter Procurement: Background and Issues for Congress*, Report for Congress R25467, version 121 (Congressional Research Service, October 2, 2020), pp. 7–9, https://go.usa.gov/xGsFv; and Eastern Shipbuilding Group, "Eastern Shipbuilding Group Announces the U.S. Coast Guard's Exercise of the Options for Construction of the Lead Offshore Patrol Cutter (OPC) and for the Long Lead Time Material for the Second OPC" (news release, September 28, 2018), https://tinyurl.com/y47kkd62.

This Congressional Budget Office report was prepared in accordance with Report 116-236 from the Senate Armed Services Committee on the 2021 National Defense Authorization Act. In accordance with CBO's mandate to provide objective, impartial analysis, the report makes no recommendations.

Eric J. Labs prepared the report with guidance from David Mosher and Edward G. Keating. David Arthur and Lilia Ledezma provided useful comments. Adebayo Adedeji fact-checked the report. Ronald O'Rourke of the Congressional Research Service and John F. Schank of the RAND Corporation provided helpful comments. (The assistance of external reviewers implies no responsibility for the final product, which rests solely with CBO.) Officials from the Navy and Fincantieri Marinette Marine provided information for the analysis. Mark Doms and Jeffrey Kling reviewed the report. The editor was Elizabeth Schwinn, and the graphics editor was Casey Labrack. An electronic version of the report is available on CBO's website (www.cbo.gov/publication/56669).

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

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