CBO TESTIMONY

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The Navy's 2008 Shipbuilding Plan and Key Ship Programs

before the
Subcommittee on Seapower and Expeditionary Forces
Committee on Armed Services
U.S. House of Representatives

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Mr. Chairman, Congressman Bartlett, and Members of the Subcommittee, we appreciate the opportunity to appear before you today to discuss the Navy's shipbuilding programs. Our ongoing analysis of those programs, of the Navy's fiscal year 2008 shipbuilding plan, and of available information from the Navy about specific ship programs indicates the following:

- Executing the Navy's most recent 30-year shipbuilding plan will cost an average of about $22.7 billion a year (in 2008 dollars), or about 30 percent more than the Navy has projected.[1]

- Historical experience (including very recent experience) suggests that a number of the Navy's shipbuilding programs—particularly the DDG-1000 guided missile destroyer and the CG(X) future cruiser—continue to face considerable risk of cost growth.

Overview

In response to a Congressional mandate, the Department of the Navy recently began issuing annual reports that describe its 30-year plans for ship construction. In the report released last year, the Navy presented a plan to expand its battle force fleet from 285 ships in 2006 to 313 ships over the long run.[2] That plan, which was consistent with the Navy's proposed budget for fiscal year 2007, reflected the department's view of its future naval requirements and the types of ships needed to meet those requirements. In May 2006, the Congressional Budget Office (CBO) issued a study analyzing that plan and estimating its potential costs.[3]

The Navy has since updated its long-term shipbuilding plan for fiscal year 2008.[4] The current plan resembles the previous one in that it envisions a 313-ship fleet, but the timing and size of purchases have changed for several categories of ships. The most important difference is that the total number of ships that the Navy hopes to buy over 30 years has grown from 280 to 293 (see Table 1). That 13-ship increase mainly reflects two factors:

- An acceleration in the building of certain ships, such as the DDG(X), which is intended to replace today's Arleigh Burke class guided missile destroyers; and

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1. Unless otherwise indicated, the cost figures in this testimony are in billions of 2008 dollars of budget authority.

2. Department of the Navy, *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY2007* (February 2006).

3. Congressional Budget Office, *Options for the Navy's Future Fleet* (May 2006).

4. Department of the Navy, *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY2008* (February 2007).

Table 1.

Comparison of the Navy's 2007 and 2008 Long-Term Shipbuilding Plans

	2007 Plan (2007 to 2036)	2008 Plan (2008 to 2037)
	Number of Ships Purchased Over 30 Years	
Aircraft Carriers	7	7
Large Surface Combatants	53	66
Littoral Combat Ships	78	85 [a]
Attack Submarines	51	51
Ballistic Missile Submarines	14	14
Amphibious Ships	22	20
MPF(F) Ships	11	11
Support Ships	44	39
Total	**280**	**293**
	Total 30-Year Costs for New-Ship Construction (Billions of 2008 dollars)	
Navy's Estimate	462	462
CBO's Estimate	585	618

Source: Congressional Budget Office based on data from the Navy.

Note: MPF(F) = Maritime Prepositioning Force (Future).

a. CBO assumed that the two littoral combat ships canceled in 2007 (as well as the ones that the Navy is now planning to forgo in 2008 and 2009) would be purchased in 2017, at the end of that ship program.

- A shift in the time period under consideration (the Navy intends to buy more ships in 2037 than in 2007, so moving from a 2007–2036 planning window to a 2008–2037 window increases the number of vessels bought over 30 years).

Despite the rise in the number of ships to be purchased, the Navy estimates that the average annual spending needed to carry out its 2008 plan will be the same as for the 2007 plan.

This past March, CBO provided the Subcommittee with its analysis of the Navy's 2008 plan.[5] Unlike the Navy, CBO concluded that the 2008 plan would require greater average annual spending over 30 years for new ships than the 2007 plan would. The increase stems primarily from the growth in ship purchases (because of the acceleration in construction and the shift in the planning period). However,

5. Congressional Budget Office, *Resource Implications of the Navy's Fiscal Year 2008 Shipbuilding Plan* (March 23, 2007). Some of the cost figures in this testimony have been updated since that report to account for recent cost growth in the littoral combat ship program.

higher projected costs for some types of ships, such as the littoral combat ship (LCS), also play a role in raising the costs of the current plan.

The difference between CBO's and the Navy's estimates for the 2008 plan are attributable to two factors. First (as noted in previous CBO reports), CBO generally estimates that new ships will cost more to build than the Navy anticipates. Second, in updating its analysis for the 2008 plan, CBO revisited its cost-per-ship estimates and, in several cases, raised them because of new information. In updating its plan, by contrast, the Navy adopted a largely top-down approach to estimating ship costs—it assumed that average annual spending for ship construction would be the same as in last year's plan. Since the number of ships in the plan has increased, that approach implicitly assumes that future costs per ship will be lower than the Navy has stated previously. As a result, the difference between CBO's and the Navy's estimates of the costs of the 30-year plan has widened since last year.

The Navy's 2008 Shipbuilding Plan

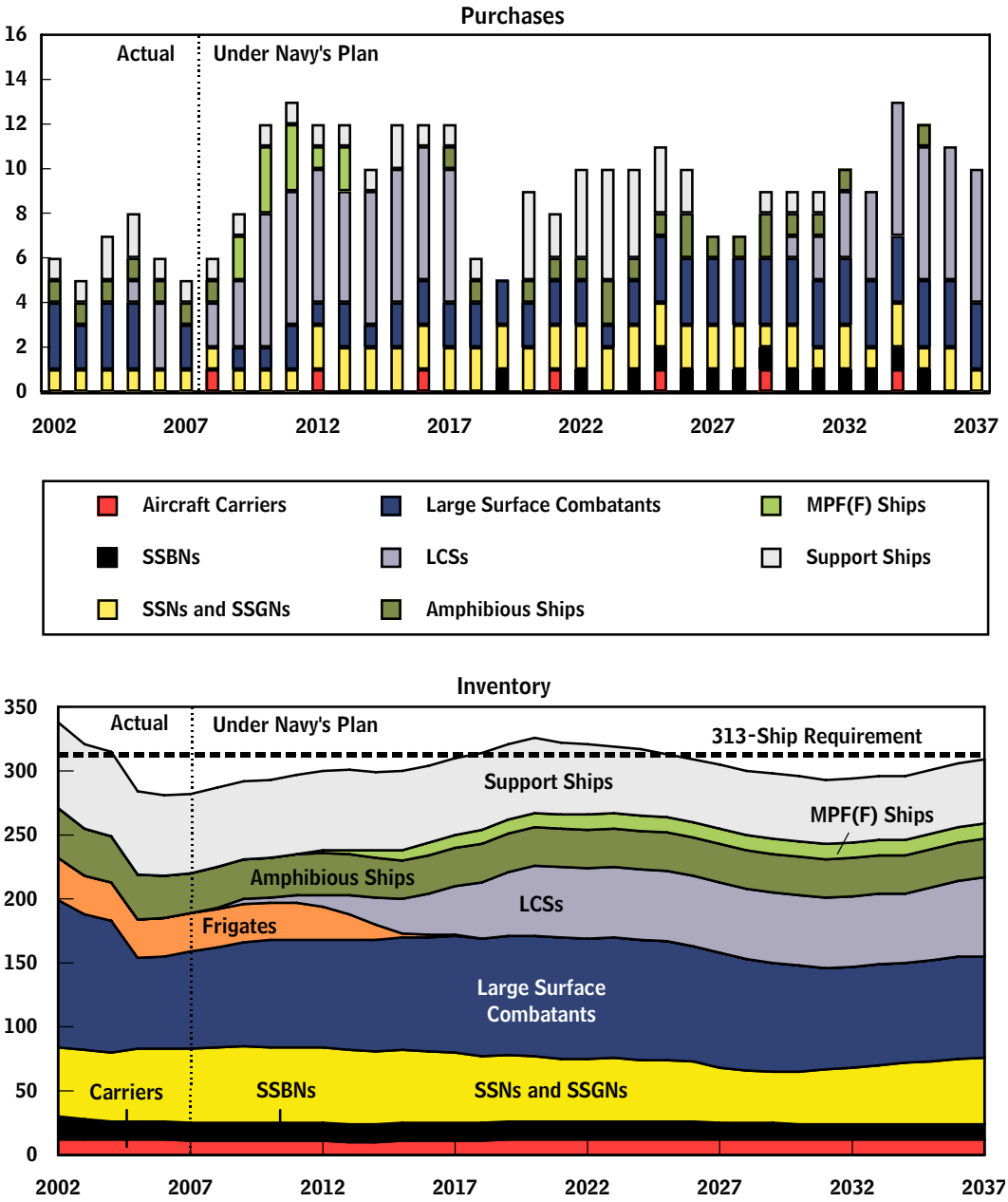
On February 2, 2007, the Secretary of the Navy submitted a report to the Congress on the Navy's fiscal year 2008 goals for ship construction over the next three decades. The report maintains the requirement for a fleet of 313 ships that was first outlined in the Navy's 2007 report. That fleet is intended to comprise the following battle force ships:

- 11 aircraft carriers;
- 69 guided missile destroyers;
- 19 guided missile cruisers;
- 55 littoral combat ships;
- 48 attack submarines;
- 4 guided missile submarines;
- 14 ballistic missile submarines;
- 31 amphibious ships;
- 12 future maritime prepositioning force, or MPF(F), ships, constituting one MPF(F) squadron; and
- 50 logistics and support ships.

Under the current plan, the Navy would purchase 6 ships in 2008 (see Figure 1) and a total of 63 ships between 2008 and 2013 (the period covered by the

Figure 1.

Annual Ship Purchases and Inventory Implied by the Navy's 2008 Shipbuilding Plan



Source: Congressional Budget Office based on data from the Navy.

Notes: SSBNs = ballistic missile submarines; SSNs = attack submarines; SSGNs = guided missile submarines; LCSs = littoral combat ships; MPF(F) = Maritime Prepositioning Force (Future).

CBO adjusted the number of ships purchased under the Navy's plan to reflect the recent decision to forgo buying two LCSs in 2007, to purchase two LCSs in 2008 instead of three, and to buy three LCSs in 2009 rather than six. CBO assumed that the six ships removed from procurement plans for those years would be bought in 2017, at the end of the LCS program.

Department of Defense's 2008 Future Years Defense Program). From 2014 to 2037, the Navy would buy another 230 vessels under its long-term plan—for a total of 293 ships, or an average of 9.8 per year, over 30 years.[6]

CBO adjusted the pattern of ship purchases in the Navy's plan to reflect the service's recent decision to alter the procurement schedule for littoral combat ships. The Navy now intends to forgo buying two LCSs in 2007 (to pay for cost overruns on the first four LCSs), purchase two LCSs in 2008 instead of the planned three, and buy three LCSs in 2009 rather than the six in the current shipbuilding plan. CBO assumed that the six ships removed from the Navy's near-term procurement plans would be bought in 2017, at the end of the LCS program.

If implemented as described, however, the Navy's current plan would not keep the fleet at or above the 313-ship goal over the long term. The number of battle force ships would rise initially, from today's level of about 276 to a peak of 326 in 2020 (see Figure 1). By 2031, however, the fleet would decline to 293 ships, before increasing at the end of the 30-year period to 309 ships.

In particular, relative to the goals for various components of the 313-ship fleet, the Navy would experience shortfalls in attack submarines (40 in 2028 and 2029 versus a stated requirement of 48), guided missile submarines (none after 2028 compared with a stated requirement of 4), and guided missile destroyers (60 in 2037 versus a stated requirement of 69). The shortfalls would result from not buying enough ships at the right times to replace Los Angeles class attack submarines and Arleigh Burke class destroyers as they were retired in the 2020s and 2030s. The Navy's plan is also short one LPD-17 amphibious transport dock.

In addition, the number of ballistic missile submarines (SSBNs) in the Navy's inventory would fall below the stated requirement of 14 beginning in 2027. That shortfall stems from a procurement schedule that would not be fast enough to deliver new submarines to the fleet before the old ones were retired. By 2041, however, the Navy would again have 14 SSBNs in its inventory. Recently, though, the Chief of Naval Operations, Admiral Mike Mullen, stated that because future SSBNs will have nuclear reactors that will last for the life of the ship (rather than having to be refueled midway through their service life), those submarines will spend less time in dry dock and more time at sea. Therefore, the Navy's requirement for SSBNs could drop to 12.

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6. Assuming that the notional service life of the fleet is 35 years, the Navy would need to buy an average of 8.9 ships per year to sustain a 313-ship fleet. During the Clinton and Bush Administrations, however, the Navy has acquired ships at a rate of 6.7 per year. Thus, above-average purchases would be necessary over the next 30 years to meet the Navy's goal for fleet size. By comparison, in the eight years of the Reagan Administration, the Navy bought 147 ships at an average cost of $0.9 billion apiece. In the eight years of the Clinton Administration, the Navy purchased 54 ships at an average cost of $1.2 billion per ship. In the eight years of the Bush Administration, the Navy's purchases will total 53 ships at an average cost of $1.9 billion each.

Finally, the 2008 shipbuilding plan would not replace the Navy's four current guided missile submarines (SSGNs). Those ships—former Ohio class ballistic missile submarines that were converted to a guided missile configuration—are scheduled to be retired in the 2020s. The Navy notes the absence of planned replacements, stating in its report that "plans for the recapitalization of the OHIO Class submarines that have been converted to SSGN have been deferred until the ships are fully operational and their war fighting utility has been tested."[7] That statement leaves open the possibility that either the 30-year plan will need to incorporate replacements for those submarines in the future or the Navy will conclude that the SSGNs are not useful enough to be worth replacing, in which case they would presumably be dropped from the official fleet requirements.

Differences Between the 2008 and 2007 Plans

On the whole, the long-term shipbuilding plan that the Navy submitted this year is similar to the one submitted in February 2006. The procurement schedules and quantities for aircraft carriers, attack submarines, ballistic missile submarines, guided missile cruisers, and future maritime prepositioning ships remain virtually unchanged. For other categories of ships, however, the Navy has made significant changes from the previous plan.

- The procurement quantity for the new guided missile destroyer, the DDG(X), has been increased from two per year to three per year starting in the mid-2020s. That increase reduces the Navy's pending shortfall of guided missile destroyers to 10 ships in 2034 (and to 12 ships in 2042, if the procurement rate of three per year continues beyond 2037).[8]

- Although the total number of amphibious assault ships (LHAs and LHDs) to be purchased over 30 years has not changed, the Navy has made the procurement schedule more regular at one ship every three years (except for a single instance in which the gap between ships would be four years). By comparison, the 2007 plan had an 11-year gap—from 2013 to 2024—when no LHAs or LHDs would have been built. The new plan provides a more stable construction schedule for the private shipyard that builds amphibious assault ships.

- Four large combat logistics ships that would have been purchased in the late 2020s have been eliminated in the 2008 plan. Those ships were intended to replace four AOE-6 class logistics ships that, in the 2007 plan, would have been

7. Department of the Navy, *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY2008*, p. 6.

8. Under the 2007 plan, the Navy would have fallen 15 ships short of its requirement for guided missile destroyers in 2036, and the shortfall would have grown to 27 by 2045 if guided missile destroyers were bought at the then-planned rate of two per year beyond the period of that plan. See Congressional Budget Office, *Options for the Navy's Future Fleet*, pp. 26–28.

retired as their replacements were commissioned. The current plan does not envision retiring the AOE-6 class any time before 2037, meaning that those ships would be more than 40 years old—the notional life span for the class—at the end of the current planning period.

- Overall, the difference of 13 ships between the 2008 and 2007 plans can be accounted for by larger planned ship purchases as well as by the shift in the time period that the two plans cover. For the 29 years that are common to both plans (2008 to 2036), the Navy added 12 destroyers and removed 4 large combat logistics ships. In addition, the 2008 plan dropped the year 2007, when the Navy had planned to buy 7 ships, and added the year 2037, when it intends to purchase 10 ships. Finally, CBO included in the 2008 plan the two LCSs that were canceled in 2007.

The Navy's Planned Spending for Ship Construction

Despite the changes outlined above, the Navy's estimate of the costs of constructing the ships in the 2008 plan is the same as its estimate for the 2007 plan: an average of about $15.4 billion per year in 2008 dollars, or $13.4 billion per year in 2005 dollars (see Table 2).[9] Those costs, known as new-ship construction costs, exclude the expense of refueling reactors on nuclear-powered aircraft carriers and submarines. In addition, the Navy's estimate omits costs for modernizing large surface combatants (cruisers and destroyers) and purchasing mission modules for littoral combat ships, both of which the Navy intends to fund from other procurement accounts. With those related costs included, the Navy's estimate of the average annual funding needed to implement the current plan would rise to $17.3 billion in 2008 dollars—45 percent more than the Navy received for those categories of spending in its 2007 appropriation and about 20 percent more than it requested in its budget for 2008.[10]

In developing its shipbuilding plan, the Navy assumed that its total obligational authority—the budgetary top line—would increase at the same rate of inflation as Department of Defense (DoD) programs overall, about 2 percent a year. In other words, the Navy assumed no real (above-inflation) growth in its budget for the next 30 years.

Since 1990, the Navy has allocated about 8.5 percent of its total budget to ship construction. Under the 2008 plan, it would devote more than 12 percent of its

9. Although most cost figures in this testimony are in 2008 dollars, because the Navy's cost estimates for its original 313-ship plan were presented in 2005 dollars, CBO sometimes also provides 2005 figures for comparison.

10. The Navy intends to fund 40 percent of the construction of its newest aircraft carrier in 2008 and 60 percent in 2009. Historically, funding for ship construction has been much higher than average in years in which carriers have been purchased.

Table 2.

Average Annual Shipbuilding Costs

(Billions of 2008 dollars)

	New-Ship Construction	New-Ship Construction and Nuclear Refuelings	New-Ship Construction, Nuclear Refuelings, LCS Mission Modules, and Surface Combatant Modernization
Navy's Actual Spending, 2002 to 2007	9.6	11.4	11.5
Costs Under the Navy's 2008 Long-Term Shipbuilding Plan			
Navy's estimate	15.4	16.5 [a]	17.3 [a]
CBO's estimate	20.8	21.9	22.7
Costs to Meet the Navy's 313-Ship Requirement over the Long Term (CBO's estimate)	22.0	23.1	23.9
Memorandum:			
Navy's Estimate of Costs Under the 2008 Plan in 2005 Dollars[b]	13.4	14.3 [a]	15.0 [a]

Source: Congressional Budget Office based on data from the Navy.

Note: LCS = littoral combat ship.

a. The Navy's estimate for new-ship construction plus CBO's estimate for the additional costs.

b. The Navy originally presented the costs of its long-term shipbuilding plan in 2005 dollars.

budget to shipbuilding, on average, over the next 30 years. To accommodate the larger budgetary share for ship construction, the Navy made four assumptions:

- That spending on operations and maintenance in the service's accounts would not grow faster than the overall rate of inflation;
- That spending on research and development—which hit a historical high of about $20 billion in 2006—would fall by $4 billion or $5 billion and remain at that annual level through the next 30 years;
- That any increase in pay and benefits for Navy personnel beyond the general rate of inflation would be offset by reductions in the number of personnel (the Navy's end strength); and
- That ship programs would experience no cost growth in the short run and would meet strict cost goals in the long run.

Most of the near-term costs for ship programs shown in the Navy's plan are based on estimates for existing ship designs, but the cost targets for ships to be bought after 2013 generally do not reflect either existing or notional designs.[11] To develop cost targets for future ships, the Navy used a top-down approach. It allocated the total amount of money it plans to devote to new-ship construction over 30 years among different types of ships—surface combatants, amphibious ships, attack submarines, ballistic missile submarines, and aircraft carriers—according to their historical shares of Navy spending. The historical share for a particular category was then divided by the number of ships the Navy wants to buy in that category to calculate the cost goal for each future ship.

In some cases, meeting those goals would require the Navy to reduce the costs of major classes of ships already in production (such as the Virginia class attack submarine and the LHA-6 amphibious assault ship). In other cases, those targets would allow little or no growth in the costs of new classes of ships relative to the costs of the ships they would replace. The Navy realizes that its plan may be inconsistent with its cost goals. The plan report states: "As more accurate cost estimates are determined in future ship development (for ships such as CG(X), SSBN(X), etc.), the Navy may need to adjust the average annual investment objective or revisit warfighting requirements as appropriate."[12]

Inflation in Shipbuilding

An important component of the Navy's and CBO's cost analyses is the role of inflation in the construction of naval vessels. The Navy has examined the inflationary component of past cost increases in shipbuilding programs and concluded that the overall figure ("inflator") that DoD uses to project cost increases for its procurement programs has underestimated the inflation that has actually occurred in the naval shipbuilding industry over the past decade by about 1.8 percentage points per year, on average. The Navy provided CBO with a composite inflator that reflects the growth in labor and materials costs that the industry has experienced in the past and that the Navy expects it to experience through at least 2013. That inflator is an average of about 1.4 percentage points higher per year—from 2008 through at least 2015—than the price increases expected for DoD procurement programs overall: about 3.5 percent for shipbuilding versus 2.1 percent for defense procurement programs as a whole. The Navy incorporated that higher level of inflation into its budget request for 2008 and the associated Future Years Defense Program. In both the Navy's and CBO's analyses, the higher level of

11. Exceptions to that generalization include the CG(X) future cruiser, which would begin to be bought in 2011 but has not yet been designed, and the Virginia class attack submarine and LHA-6 amphibious assault ship, which are under construction now and would be purchased in the long term as well.

12. Department of the Navy, *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY2008*, p. 8.

inflation produces real growth in the future costs of ships. For example, a ship that costs $2.5 billion to build in 2008 will cost $2.9 billion (in 2008 dollars) to build in 2020.

In its analysis of the Navy's previous long-term plan, CBO assumed that cost growth in the shipbuilding industry would continue to be higher than average for many years and then would gradually revert to the level of general inflation for DoD procurement programs by 2025. CBO made the same assumption in analyzing the Navy's current plan.

CBO's Estimate of the Costs of the 2008 Shipbuilding Plan

Buying a total of 293 ships over the 2008–2037 period—or an average of about 9.8 ships per year—would require an average annual shipbuilding budget of $20.8 billion for new construction alone, CBO estimates (see Table 2 on page 8). That amount is about one-third more than the Navy's $15.4 billion target (see Figure 2) and more than double the $9.6 billion per year that the Navy spent on new-ship construction between 2002 and 2007. Including the costs of refueling nuclear-powered aircraft carriers and submarines would raise CBO's estimate to $21.9 billion a year, on average, over the next 30 years.

Those figures exclude costs to modernize existing cruisers and destroyers and to buy the mission modules that are intended to provide much of the combat capability of littoral combat ships. As noted above, the Navy plans to fund those items from accounts other than the ones normally associated with ship construction. However, such modernization programs have been funded from shipbuilding accounts in the past; and in other new-ship programs (such as for the DDG-1000 Zumwalt class destroyer), combat capability is included in a ship's cost and funded as part of the ship's construction. Paying all of the expenses of new-ship construction, nuclear refuelings, modernization of surface combatants, and mission modules for LCSs would require average funding of $22.7 billion annually, CBO estimates.[13]

According to CBO's calculations, the Navy's 2008 shipbuilding plan would cost about $1.3 billion more per year to carry out than the 2007 plan. Of that amount, $0.4 million results from the difference between 2007 dollars and 2008 dollars.[14] The remainder of the increase is attributable to higher ship prices (such as for the LCS) and the overall growth in the number of ships envisioned in the 2008 plan—

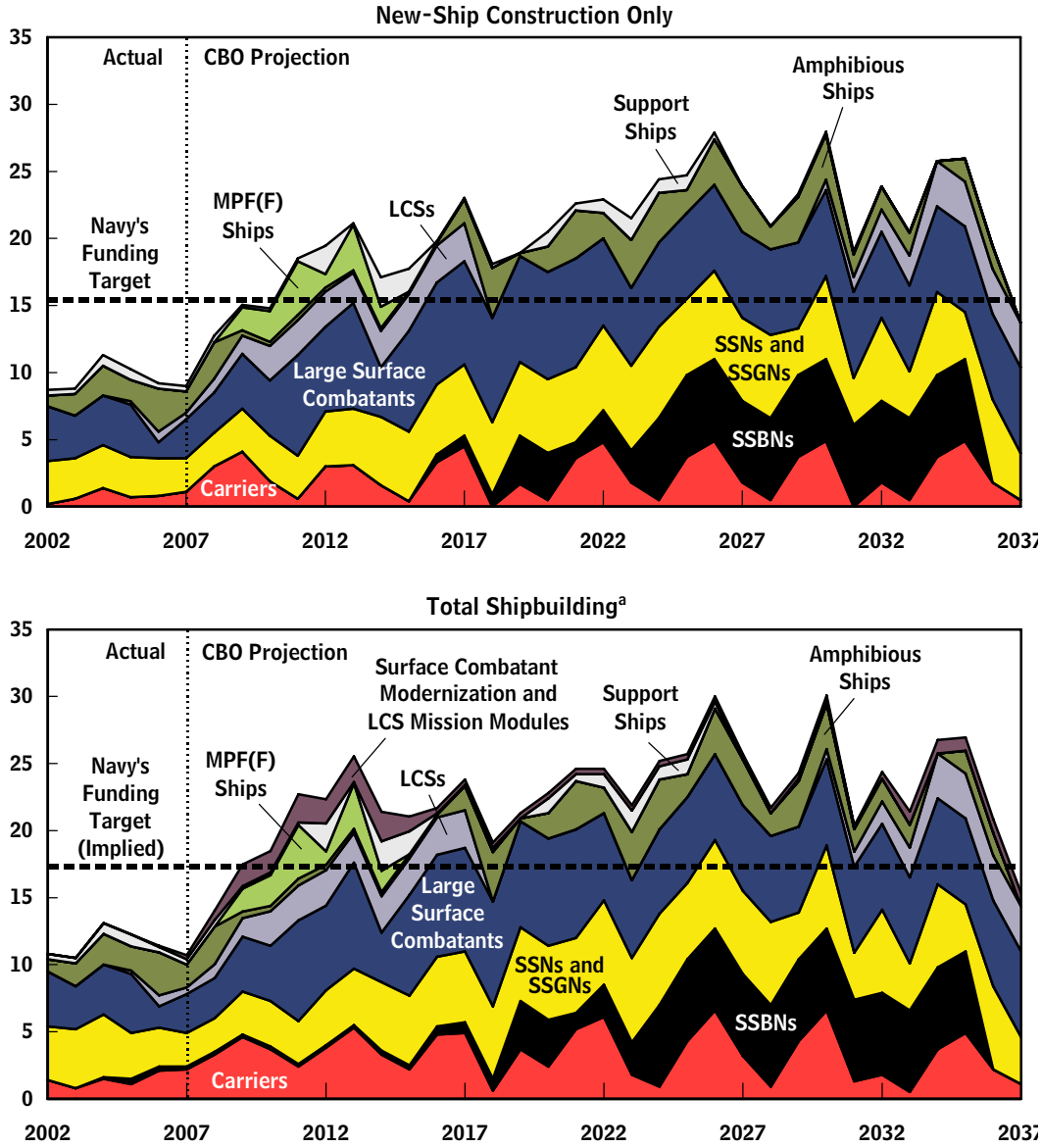
13. The Navy has not stated how many mission modules it plans to buy for each littoral combat ship; CBO assumed that those purchases would average two per ship.

14. CBO estimated that new-ship construction under the 2007 plan would require average annual funding of $19.5 billion in 2007 dollars, which is $19.9 billion in 2008 dollars.

Figure 2.

Annual Costs Implied by the Navy's 2008 Shipbuilding Plan

(Billions of 2008 dollars)



Source: Congressional Budget Office based on data from the Navy.

Notes: SSBNs = ballistic missile submarines; SSNs = attack submarines; SSGNs = guided missile submarines; LCSs = littoral combat ships; MPF(F) = Maritime Prepositioning Force (Future).

Amounts for 2006 exclude supplemental funding related to Hurricane Katrina.

a. Includes costs for new-ship construction, refuelings of nuclear-powered ships, programs to modernize existing large surface combatants, and mission modules for littoral combat ships. The modernization of surface combatants and the mission modules for LCSs are expected to be funded from Navy accounts other than those traditionally associated with shipbuilding.

notably, 12 additional DDG(X) replacements for Arleigh Burke class destroyers over the 2025–2036 period.

Individual Ship Programs

To estimate the costs of the 2008 shipbuilding plan, CBO used Navy data on actual costs for ships now under construction and historical relationships between the cost and weight of ships (as discussed in more detail below). To apply those relationships to ships for which the Navy has yet to develop even a notional design—such as the prospective replacements for the Arleigh Burke class destroyers and the Ohio class ballistic missile submarines—CBO had to make assumptions about the size and capabilities of future ships.

Aircraft Carriers

Under the Navy's plan for a 313-ship fleet, the number of aircraft carriers (CVNs) would decline from 12 to 11. That reduction comes from retiring the *John F. Kennedy* in 2007. To maintain that size force, the Navy's plan would buy seven CVN-78 Gerald R. Ford class aircraft carriers over the 2008–2037 period at a target cost of about $10.1 billion apiece (see Table 3).[15]

To estimate the cost of those new aircraft carriers, CBO relied on the cost of the Navy's most recent carrier, the CVN-77, and adjusted that amount to account for past levels of cost growth and for the higher inflation expected in the shipbuilding industry. The first two ships of the new CVN-78 class would require substantial funding for nonrecurring detail design, but subsequent ships would not need any money for that purpose. CBO estimates that the seven carriers in the Navy's 2008 shipbuilding plan would have an average cost of about $10.1 billion each, the same as the Navy's target.

However, CBO believes that the Navy's cost estimate for the first ship of the class, the *Gerald R. Ford* (CVN-78), is optimistic. In its budget submission to the Congress, the Navy estimates that the CVN-78 will cost about $10 billion in 2008 dollars, including about $2.2 billion for nonrecurring engineering and design.[16] The Navy argues that actual construction time and cost for the CVN-78 will be less than for its predecessor ship, the *George H.W. Bush* (CVN-77). CBO, by contrast, estimates that the CVN-78 will cost about $11 billion, allowing for the cost growth that has affected past shipbuilding programs at the CVN-78's stage of construction. If the CVN-78 experiences cost grow similar to that of other lead ships the

15. The program to build that new class of nuclear-powered aircraft carriers was formerly called the CVN-21 (for 21st century) program.

16. That amount is about $10.5 billion measured in the dollars of the years in which the money has been or will be appropriated.

Table 3.

Comparison of the Navy's Goals and CBO's Estimates of the Costs of Major New Ships

(Billions of 2008 dollars)

	Average per-Ship Cost over the 2008-2037 Period[a]	
	Navy's Cost Target[b]	CBO's Estimate[c]
CVN-78 Gerald R. Ford Class Aircraft Carriers	10.1	10.1
DDG-1000 Zumwalt Class Destroyers	2.3	3.9
CG(X) Cruisers	2.9	4.0
DDG(X) Destroyers (Replacement for Arleigh Burke class)	1.6 [d]	2.2
Virginia Class Attack Submarines	2.3	2.7
SSBN(X) Ballistic Missile Submarines (Replacement for Ohio class)	3.3	6.3
Amphibious Ships	1.5	2.3

Source: Congressional Budget Office.

a. The total amount of money spent on a ship program from 2008 to 2037 divided by the total number of ships bought in that program—except in the case of the DDG-1000 program, for which the average cost per ship reflects the costs of all seven ships in that program.

b. Based on a briefing by the Navy for CBO and the Congressional Research Service, February 10, 2006.

c. CBO's estimates are generally based on historical relationships between cost and weight for individual types of ships; they also incorporate the higher inflation that the naval shipbuilding industry has experienced (compared with that in other defense procurement programs).

d. The Navy's 2008 plan added 12 DDG(X)s and removed 4 large logistics ships compared with the 2007 plan, but it indicated that overall shipbuilding costs would not change. Thus, CBO assumed that the Navy's per-ship cost target for the DDG(X) was lowered to reflect those changes. (CBO also assumed that the funding not allocated to the logistics ships would be spent on the new destroyers.)

Navy has purchased in the past 10 years, costs could be higher still.[17] Moreover, Navy officials have told CBO that the confidence level associated with their estimate is below a 50 percent probability of meeting the cost target, which also suggests that costs could increase. In addition, a number of critical technologies for the CVN-78 are still under development, and difficulties could still arise in integrating the various new technologies associated with that class.

17. For example, the LPD-17, the SSN-774, and the LCS-1 have experienced cost increases of about 70 percent, 11 percent, and 80 percent, respectively.

Surface Combatants

Overall, some of the largest differences between the Navy's and CBO's cost estimates involve the planned family of new surface combatants. Over the next 30 years, those ships include the DDG-1000 guided missile destroyer, the CG(X) future cruiser, the DDG(X) destroyer (a notional replacement for the Arleigh Burke class guided missile destroyer), and the littoral combat ship.

DDG-1000 Guided Missile Destroyer. The Navy's current plan would buy one DDG-1000 Zumwalt class destroyer each year from 2009 to 2013, in addition to the two authorized in 2007. The service's 2008 budget suggests that the Navy expects the first two ships to cost $3.0 billion each and the following five to cost an average of $2.0 billion apiece—meaning that the entire class would have an average cost of $2.3 billion per ship.[18] CBO, by contrast, estimates that the first two DDG-1000s would cost $4.8 billion apiece and the next five would cost an average of $3.5 billion each. The average per-ship cost of the class would be $3.9 billion (see Table 3 on page 13).

The Navy's estimate for the two lead ships of the DDG-1000 class is equivalent to about $230 million (in 2008 dollars) per thousand tons of lightship displacement (the weight of the ship without its fuel, payload, or crew). That figure is smaller than the cost of the lead DDG-51 class destroyer or the lead Ticonderoga class cruiser (see Figure 3). CBO's estimate for the first two DDG-1000s—which equals $380 million per thousand tons—is based on the cost of the lead DDG-51, adjusted for differences in the size of the two types of ships.

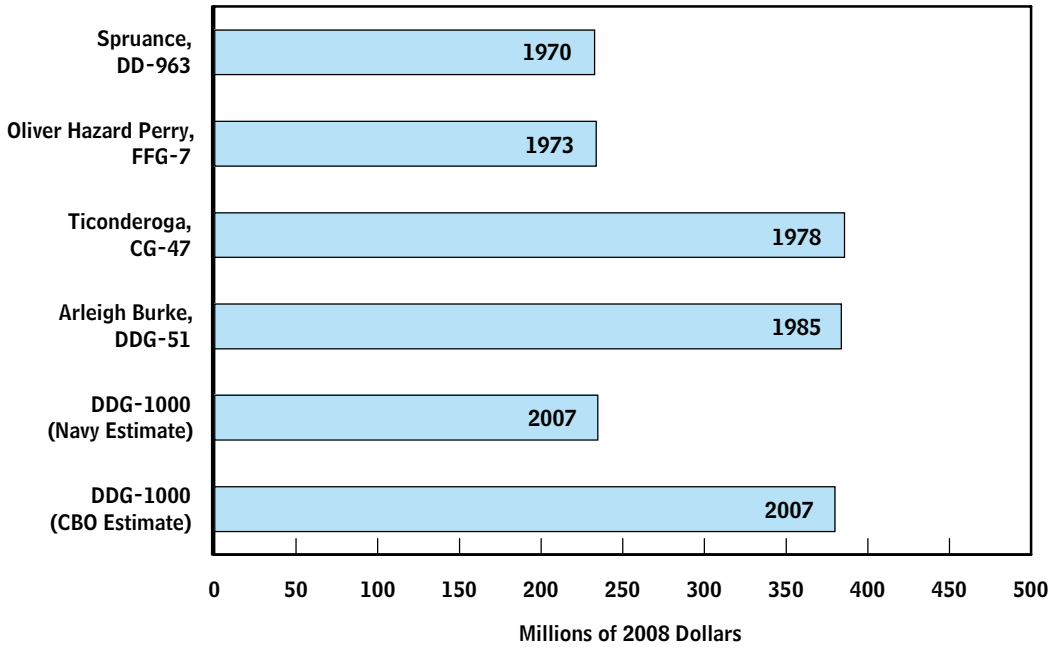
The Navy has argued that comparing the new DDG-1000 with the DDG-51 may not be valid because the older destroyer had various problems in the early stages of construction that increased its cost. In particular, the design of the ship was disrupted and delayed because a new design tool being used at the time was incomplete and not well understood. The design tool had to be abandoned and the design restarted using more-traditional methods. In comparison, the design process for the DDG-1000 is going far more smoothly, and the Navy expects to have the design largely settled when construction begins. In addition, the Navy says, the DDG-51 was a smaller, more densely built ship and thus, on a ton-for-ton basis, was more difficult to construct than the DDG-1000 class will be.

In CBO's view, however, several factors offset those arguments. First, as Navy officials often state, lead ships are generally very difficult to build and typically encounter many problems during construction. The problems with the first few littoral combat ships and with the lead ship of the LPD-17 class of amphibious transport docks—both of which are much less complex technologically than the DDG-1000—illustrate those difficulties. A survey of lead-ship programs shows that although many experience problems in design or construction, those problems

18. The first two DDG-1000s were partially funded in 2007 and earlier years; the rest of the Navy's estimated costs for those two ships (about half) would be funded in 2008.

Figure 3.

Cost per Thousand Tons for the Lead Ship of Various Classes of Surface Combatants



Source: Congressional Budget Office based on data from the Navy.

Notes: The years shown here indicate the year in which each lead ship was authorized.

Costs are per thousand tons of lightship displacement (the weight of the ship itself without its crew, materiel, weapons, or fuel).

vary from program to program. In other words, the lead DDG-1000 may not face the same difficulties as the lead DDG-51, but it will have problems of its own that will increase costs and delay construction.

Second, the DDG-1000 program is incorporating 10 new technologies into the class that are not found on the current generation of destroyers. Those technologies include an electric drive and a distributed-power system, a tumblehome hull (which slopes inward above the waterline to make the ship less visible to radar), the Advanced Gun System, and new radars, as well as composite materials and stealth coatings for the deckhouse. In the past, the Navy has typically introduced just three or four new technologies in a new class of surface combatants.

Finally, a comparison of the Navy's cost estimates for two more DDG-51s and for the seventh DDG-1000 (to be purchased in 2013) illustrates the risk for cost growth in the new destroyer program. The Navy has stated that if the Congress authorized and bought two additional DDG-51s in 2008—which would be the 63rd and 64th ships of their class—those destroyers would cost a total of $3.0 bil-

lion to $3.1 billion, or $1.5 billion to $1.6 billion apiece (in 2008 dollars). At the same time, the Navy's 2008 budget submission to the Congress estimates the cost of building the seventh DDG-1000 in 2013 at about $2.1 billion (in 2013 dollars). Deflated to 2008 dollars (using the inflation index for shipbuilding that the Navy provided to CBO), that estimate equals about $1.6 billion—or the same as for an additional DDG-51, which would have the benefit of substantial efficiencies and lessons learned from the 62 models built previously. The lightship displacement of the DDG-1000 is about 5,000 tons greater than that of the DDG-51s under construction today. In effect, the Navy's estimates imply that those 5,000 extra tons, as well as the 10 new technologies to be incorporated into the DDG-1000 class, will be free.

CG(X) Future Cruiser. The Navy intends to begin buying a new air- and missile-defense surface combatant, the CG(X) cruiser, in 2011, with a second ship to follow in 2013. CBO assumed that a CG(X) would use the same hull, and cost about the same, as a DDG-1000. The Navy's estimates for the 2011 and 2013 cruisers are based on the same assumption; thus, it expects those ships to cost $2.6 billion and $2.4 billion, respectively. However, the Navy is currently conducting an analysis of alternatives to determine what capabilities the CG(X) will have. A version using the DDG-1000's hull and technology is only one option being considered; the Navy says it is also studying versions of the ship that would be larger and more capable, including using nuclear propulsion. (There does not appear to be a design smaller than the DDG-1000 under consideration.) Any design larger than the DDG-1000 is likely to be substantially more expensive than that ship. Using the same method as for its estimate of DDG-1000 costs, CBO estimated that the lead CG(X) would cost $4.9 billion and that the class would average about $4.0 billion per ship (see Table 3 on page 13).

CBO's estimate for the cost of the CG(X) may be optimistic, however. The last time the Navy reused a hull design for a new class of surface combatants was in the 1970s, when it built Spruance class destroyers and Ticonderoga class cruisers, which had the same hull but were designed for different missions. The Spruance class consisted of general-purpose destroyers intended to escort other Navy ships in wartime and designed particularly for antisubmarine warfare. The Ticonderoga class cruisers incorporated the Aegis antiair combat system, the SPY-1 radar, and surface-to-air missiles to counter threats to carrier battle groups from Soviet naval aviation. Reflecting its more complex combat systems, the lead Ticonderoga cost 60 percent more per thousand tons than the lead Spruance, notwithstanding their many common hull and mechanical systems.

DDG(X) Future Guided Missile Destroyer. Besides building the new DDG-1000 Zumwalt class of destroyers, the Navy's 313-ship plan would also maintain a fleet of 62 DDG-51 Arleigh Burke class destroyers. CBO assumed that those ships would be modernized and would serve for about 35 years. That assumption is consistent with the Navy's plan, which would purchase the first replacement for those

ships—a DDG(X)—in 2022.[19] For its analysis of costs and capabilities, CBO assumed that a fully loaded DDG(X) would be somewhat larger and heavier than the DDG-51 (which displaces about 9,200 tons at full load) but smaller than the DDG-1000 (which is intended to displace about 14,500 tons at full load). Specifically, CBO assumed that the new DDG(X) would have a full-load displacement of about 11,000 tons and would not be able to carry both of the Advanced Gun Systems of the DDG-1000. In CBO's projection, those replacement destroyers would have the same cost per thousand tons as today's Arleigh Burke destroyers—or an average cost of about $2.2 billion apiece if bought at a rate of three per year.[20] The Navy's implicit cost target for the DDG(X) is lower: $1.6 billion each (see Table 3 on page 13).[21]

Littoral Combat Ship. The current shipbuilding plan envisions building 55 LCSs between 2005 and 2017. Because those ships are assumed to have a service life of 25 years, the Navy would need to begin procuring their replacements in 2030. The LCS differs from the Navy's usual warships in that the program is divided into two components: the sea frame and mission modules. The sea frame (the ship itself) will be built with the ability to switch mission modules (combat systems) depending on which mission the ship is intended to carry out at a given time. Currently, the Navy expects to use three types of mission modules: for countermine warfare, antisubmarine warfare, and anti-surface-craft warfare. However, it has not yet determined how many mission modules it plans to buy for each sea frame.

The Navy intends for the LCS to be an affordable ship that will be relatively simple to design and build. Originally, the LCS was expected to cost about $250 million per sea frame in 2008 dollars (or $220 million in 2005 dollars). Then, the Navy's 2008 budget envisioned buying 32 LCSs during the 2008–2013 period at an average cost of a little less than $300 million each (excluding mission modules).[22] Shortly after that budget was submitted, however, the Navy stated that the program was suffering from cost growth that was much greater than had already been reported. In early 2007, the Navy testified that the sea frame for the first littoral combat ship (LCS-1) would cost between $350 million and $375 million.

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19. Generally, the Navy retires large surface combatants after no more than 30 years even if their notional service lives are longer. If the DDG-51s lasted only 30 years, replacements would need to start being purchased earlier than 2022.

20. Buying more ships of a given type in the same year reduces their cost because it allows a shipyard's fixed overhead expenses to be spread among more ships.

21. The cost target for DDG(X)s in the Navy's 2007 plan was $2.1 billion. However, the Navy added 12 DDG(X)s to the 2008 plan and removed only 4 logistics ships, while stating that the overall costs of the plan were unchanged. CBO therefore assumed that the cost target for the DDG(X) had declined, reflecting the larger number of ships to be purchased. CBO also assumed that the money saved from removing the logistics ships would be allocated to the DDG(X) program.

22. The Navy says that a mission module will cost about $50 million to $70 million.

Several months ago, press reports indicated that the cost could well exceed $400 million each for the first two LCS sea frames. Recently, the Navy requested that the cost cap for the fifth and sixth sea frames be raised to $460 million, which suggests that the Navy's estimate of the acquisition cost for the first two LCSs would be around $600 million apiece.

Experience had suggested that cost growth was likely to occur in the LCS program. In particular, historical cost-weight relationships—using the lead ship of the Oliver Hazard Perry class of frigates (FFG-7) as an analogy—indicated that the Navy's original cost target for the LCS was optimistic. The first FFG-7, including its combat systems, cost a total of about $650 million (in 2008 dollars) to build, or about $235 million per thousand tons. Applying that per-ton estimate to the LCS program suggests that the lead ships would cost about $575 million apiece, including the cost of one mission module (to make them comparable to the FFG-7). In this case, looking at cost-weight relationships produced an estimate less than the apparent cost of the first two LCSs but substantially greater than the Navy's original estimate.

As of this writing, the Navy has not publicly released an estimate for the LCS program that incorporates the most recent cost growth, other than its request to raise the cost caps for the fifth and sixth ships. CBO estimates that with that growth included, the first two LCSs would cost about $630 million each, excluding mission modules but including outfitting, postdelivery, and various nonrecurring costs associated with the first ships of the class. As the program advances, with a settled design and higher annual rates of production, the average cost per ship is likely to decline. Excluding mission modules, the 55 LCSs in the Navy's plan would cost an average of $450 million each, CBO estimates.

The relatively simple design of the LCS and the large cost increases that have occurred in the program suggest that the Navy may also have trouble meeting its cost targets for the larger, much more complex surface combatants in its shipbuilding plan, such as the DDG-1000 and the CG(X).

Submarines

The attack submarine force continues to be a major source of demand for the Navy's resources. Under the current plan, the Navy would buy two attack submarines a year beginning in 2012 (including Improved Virginia class submarines starting in about 2024). That procurement rate would continue through 2028 and then alternate between one and two submarines a year. The Navy's plan does not envision continuing to use guided missile submarines beyond the 2020s, when the existing Ohio class SSGNs are likely to be retired from service.

Senior Navy leaders have stated—and the 2008 shipbuilding plan assumes—that the cost of Virginia class submarines would have to be reduced by about 15 percent, to less than $2.3 billion each, before the Navy would be able to buy two per

year.[23] However, the Navy's 2008 budget requests an appropriation of about $2.7 billion for the next Virginia class submarine. Approximately 30 percent of that amount (or about $800 million) is for equipment furnished by the government, with the remainder to be spent by the shipyard building the submarine. If the necessary savings are intended to come from the shipyard, its expenses will have to be reduced by more than 20 percent to meet the Navy's cost goal for Virginia class submarines.

CBO estimates that the Virginias built during the 2008–2037 period would have an average cost of $2.7 billion apiece, on the basis of the prices that the Navy is currently paying for Virginia class submarines, the effects of producing two subs per year starting in 2012, and the real cost growth affecting naval shipbuilding. CBO also assumes that the Improved Virginia class would cost about 20 percent more to build than the original Virginia class did, largely because of past cost growth in the shipbuilding industry.

In addition to the attack submarine force, the 2008 plan calls for a force of 14 ballistic missile submarines through 2037. Consequently, the Navy intends to buy its first replacement SSBN in 2019 and purchase one per year starting in 2024 (three years earlier than under the 2007 plan). The design, cost, and capabilities of that replacement submarine are some of the most significant uncertainties in the Navy's and CBO's analyses. The Navy's plan assumes that the first ship of a new class of ballistic missile submarines—an SSBN(X)—would cost $4.1 billion and that subsequent ships would cost about $3.2 billion each. The average cost for 14 SSBN(X)s would be about $3.3 billion (see Table 3 on page 13).

Some senior Navy officials who oversee submarine programs have stated that the most cost-effective strategy for designing a new ballistic missile submarine would be to rely heavily on the Virginia class design. Much of the bow and stern of a Virginia, as well as the nuclear reactor, could be incorporated into the SSBN(X). However, new missile-compartment sections would have to be developed and integrated into the submarine's design. The practicality of using the Virginia class as a model has not yet been explored, and the Navy is only beginning to think about how to design an SSBN(X). No notional design or displacement estimate exists. Most participants in the process and outside observers agree that the new ballistic missile submarine would probably be substantially smaller than existing Ohio class submarines.

Adopting an approach consistent with that thinking, CBO assumed that the Navy would buy 14 SSBN(X)s that would be smaller than Ohio class submarines. CBO assumed that the SSBN(X) would be designed to carry 16 missile tubes (instead of the 24 on existing submarines) and would displace about 15,000 tons submerged—making it roughly twice the size of a Virginia but nearly 4,000 tons

23. The Navy's position is that to purchase two submarines per year in 2012, their cost would have to fall to $2.0 billion each in 2005 dollars, which equals about $2.3 billion in 2008 dollars.

smaller than an Ohio. On the basis of what the Navy is currently paying for a Virginia class submarine, CBO estimated that the average cost of the SSBN(X) would be about $6.3 billion. A smaller design with only 12 or 8 missile tubes could cost $700 million or $1.4 billion less, respectively.

Amphibious Ships

The Navy's 313-ship plan calls for a force of 31 amphibious ships organized around nine expeditionary strike groups. Each group would include one large amphibious assault ship (LHA or LHD class), one amphibious transport dock (LPD), and one dock landing ship (LSD). The 2008 plan would end the LPD-17 class at nine ships—one short of the Navy's stated goal of 10—and would maintain nine LHAs or LHDs by buying replacements for them about every three years.[24]

Specifically, the Navy's plan would purchase an LHA-6 in 2017—in addition to the one being bought in 2007 and the MPF(F) versions of that ship to be purchased in 2010 and 2013—as well as six replacements for the Wasp class LHDs in the 2020s and 2030s. In addition, 12 replacements for today's LSD-41 and LSD-49 class ships, which will start to reach the end of their service lives in about 15 years, would be purchased in the long term.[25] The Navy's cost target for an amphibious ship is $1.5 billion. That target averages the costs of the large LHAs and LHDs (which displace about 40,000 to 45,000 tons) and the smaller LSD replacements (which would probably displace 20,000 to 25,000 tons).

CBO assumed that no future amphibious assault ship would be substantially larger than the lead LHA-6 (a variant of the existing LHD design), which is being bought this year. According to the Navy, the current shipbuilding plan assumes that future large-deck amphibious ships will look much like the first LHA-6. Under that assumption, CBO estimated that the average cost of an amphibious ship—that is, the average for the LHA-6s, LHD replacements, and LSD(X)s—would be $2.3 billion (see Table 3 on page 13).

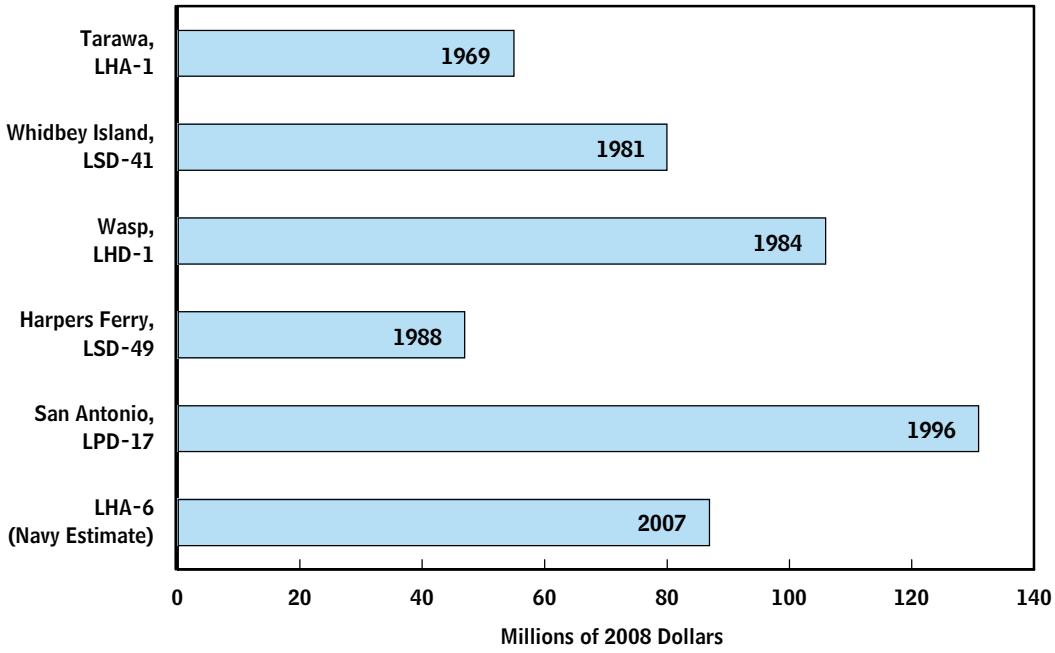
The Navy's experience with the San Antonio (LPD-17) class of amphibious ships serves as a useful illustration of how ship costs rise from one generation to the next on a per-ton basis. It also illustrates the difficulty of reducing those costs to levels that might meet the Navy's targets. On a per-ton basis, the lead LPD-17 was the most expensive amphibious ship ever built, at more than $130 million per thousand tons (see Figure 4). Using the historical cost-weight relationship of either the LSD-41 or LHD-1 amphibious ship as an analogy would have substantially understated the actual costs of the LPD-17. Subsequent ships in the LPD-17 class cost

24. In the Navy's stated requirements, the 10th LPD-17 would be part of the forward-based expeditionary strike group in Japan, which normally is composed of four amphibious ships.

25. According to the Navy, the three LSDs beyond the nine needed for expeditionary strike groups would be used for antiterrorism missions.

Figure 4.

Cost per Thousand Tons for the Lead Ship of Various Classes of Amphibious Ships



Source: Congressional Budget Office based on data from the Navy.

Notes: The years shown here indicate the year in which each lead ship was authorized.

Costs are per thousand tons of lightship displacement (the weight of the ship itself without its crew, materiel, weapons, or fuel).

The LSD-49 is a variant of the LSD-41, and the LHA-6 is a variant of the LHD-8, the last ship of the LHD-1 class. The principal differences between the LHA-6 and the LHD-8 are that the LHA-6 will not have a docking well but will have enhanced aviation capabilities.

between $1.4 billion and a little less than $1.7 billion, or an average of about $90 million per thousand tons. To meet the $1.5 billion cost target in the current shipbuilding plan, the Navy would have to build all future amphibious ships for about $70 million per thousand tons. However, the Navy estimates that the lead LHA-6 will cost about $90 million per thousand tons.

Maritime Prepositioning Ships

In a June 2005 report to the Congress, the Navy outlined the future of the Maritime Prepositioning Force. It described an MPF(F) squadron consisting of 12 ships, most of which would be based on designs of existing amphibious or support ships. The squadron would include two LHA-6s; an LHD; three modified large, medium-speed roll-on/roll-off ships; three modified-design T-AKE support ships; three mobile landing platforms (large flow-on/flow-off ships to carry the squadron's landing craft); and two ships from existing maritime prepositioning squadrons.

However, the Navy's current shipbuilding plan appears to forgo a modified T-AKE design. Instead, the Navy would build the same versions that are now under construction, thus reducing their cost by about $200 million per ship relative to the June 2005 estimates. The Navy also intends to use an existing LHD in the MPF(F) squadron. With those changes, the Navy plans to buy one such squadron at a total estimated cost of about $12 billion. However, CBO estimates that such a squadron would cost about $14 billion, reflecting its higher cost estimates for various ships in the squadron, such as the LHA-6s and current-design T-AKEs.

The Value of Historical Cost-Weight Relationships in Estimating the Prices of Future Ships

As noted above, CBO looks at the relationship between cost and weight (specifically, the cost per thousand tons of lightship displacement) of analogous past or present ships to estimate the prices of future naval vessels. That method assumes, broadly speaking, that what has happened in the past will be repeated in the future. CBO takes into account changes or productivity improvements in shipbuilding practices and procedures; but such changes are frequently offset by, for example, cost increases for labor and materials, unexpected production problems, increased requirements, or new technologies.

In testimony before the Congress, some Navy officials have characterized CBO's methodology as "worst-case analysis" or an "extremely conservative" estimating technique that seeks to include all possible sources of cost risk. Despite its purported conservatism, however, that method would have understated the actual costs of the littoral combat ship, the LPD-17 amphibious warfare ship, and the CVN-76 and CVN-77 aircraft carriers, and it would have closely approximated the cost of the lead Virginia class attack submarine.