CONGRESSIONAL BUDGET OFFICE
U.S. Congress
Washington, DC 20515

Douglas W. Elmendorf, Director

April 28, 2010

Honorable Jeff Sessions
United States Senate
Washington, DC 20510

Dear Senator:

In response to your recent request, the Congressional Budget Office (CBO) has analyzed the impact of operation and support (O&S) and other types of costs on the total life-cycle costs of four classes of Navy ships. The analysis—which aims to provide context for assessing the costs of the new littoral combat ship (LCS)—focuses on the following ship programs:

- MCM-1 Avenger class mine countermeasures ships,
- FFG-7 Oliver Hazard Perry class guided missile frigates,
- DDG-51 Flight IIA Arleigh Burke class guided missile destroyers, and
- CG-47 Ticonderoga class guided missile cruisers.

CBO chose those four classes because they have been in the fleet for decades, data for them are readily available, and they all conduct at least one mission that the LCS is also expected to perform. Using the Department of Defense's (DoD's) definitions of cost categories, CBO calculated costs over the life of each type of ship in the following six categories:

- Research and development,
- Procurement,
- Personnel,
- Fuel,

- Other operations and support, and
- Disposal.

The resulting total life-cycle cost is smaller than the total ownership cost of a ship, which would also include indirect personnel costs (such as for recruiting, training, and medical support) and long-term infrastructure costs (for changes in bases, housing, and other infrastructure associated with a large-scale change in the size of the Navy). CBO does not have a reliable method to estimate those additional costs, however, so it limited its analysis to a ship's life-cycle cost.

Life-Cycle Costs of Four Types of Ships

CBO's analysis indicates that O&S costs—for personnel, fuel, and other items—make up 49 percent to 56 percent of the life-cycle costs of the four types of ships listed above (see Table 1). Personnel is the largest single element of O&S costs. For a small vessel with a relatively large crew, such as the MCM-1 class mine countermeasures ship, personnel costs represent 38 percent of the ship's life-cycle cost, compared with 29 percent for a CG-47 class cruiser, which is seven times bigger but has only four times as large a crew. Fuel costs account for a much smaller share of the life-cycle cost: 8 percent to 11 percent in the case of the frigate, destroyer, and cruiser. For the mine countermeasures ship, fuel costs make up only 1 percent of the life-cycle cost, largely because that ship travels at very slow speeds during mine-clearing operations.

Procurement costs account for most of the rest of those four ships' life-cycle costs, ranging from 43 percent to 50 percent. Disposal costs for destroyers and cruisers have averaged a little less than $1 million per ship. In the case of FFG-7 frigates, the Navy has often sold retired ships or given them away to other countries. The Navy has not disposed of MCM-1 ships yet. But when it removed 12 MHC-51 coastal mine hunters, which are similar to the MCM-1s, from the fleet several years ago, it sold one and gave three to other nations. (The remaining eight are awaiting disposal.)

Basis for CBO's Analysis

CBO used the individual ship as the unit of this analysis. It allocated each program's research and development costs among ships by dividing the total amount spent in that category by the number of ships purchased in the program. Procurement costs were estimated as the historical average cost per ship in each class. Personnel costs were computed as all of the current and future pay and benefits (referred to as fully burdened costs) of an average officer and average enlisted crew member, multiplied by the average number of officers and enlisted personnel in a ship's crew. Fully burdened fuel costs represent the price of fuel delivered to the fleet by the Navy's supply system, including the expenses involved in purchasing oil, refining it into fuel, and transporting it to where it is needed. Other O&S costs mostly pertain to maintenance on a

ship. Disposal costs reflect the expense of removing a ship from active service in the fleet. For each ship, CBO estimated those various costs for every year of the ship's notional service life (assuming that all of the ships entered into service today). The costs were then discounted to their present value in 2010 dollars using a real discount rate of 3 percent, which was based on the long-term average yield of 30-year Treasury bonds adjusted for inflation.

Data on acquisition costs—research and development plus procurement—came from DoD's Selected Acquisition Reports for each ship program. CBO estimated the number of personnel and the amount of fuel used per ship as five-year averages from the Navy's Visibility and Management of Operating and Support Costs (VAMOSC) system. The full price of military pay and benefits and the fully burdened price of fuel were calculated using data from DoD and drawing on prior CBO analyses.[1] CBO obtained data on other O&S costs directly from VAMOSC. Disposal costs were modeled using Navy data on the disposal of other ships.

Life-Cycle Costs of the Littoral Combat Ship

CBO included in its analysis equivalent estimates for the LCS-1, *U.S.S. Freedom*. The VAMOSC database currently contains one year's worth of data for that ship. (CBO did not include the LCS-2 in its cost analysis because no data based on normal operations were available for that newly commissioned ship.) CBO projected the life-cycle cost of the LCS-1 under three different assumptions about the average annual amount of fuel the ship will use over its 25-year life: low, moderate, and high. In all three scenarios, procurement costs dominate the life-cycle cost of the LCS-1, ranging from 58 percent to 66 percent of the total. Those procurement percentages are higher than for the other ships that CBO analyzed. However, the LCS-1 is the first ship of a new class, and as happened with the lead ships in most of the Navy's other programs over the past 20 years, it experienced a number of difficulties—and consequent cost growth—during its construction.[2] Personnel costs make up 14 percent to 16 percent of the LCS-1's total life-cycle cost in the various scenarios, and fuel costs account for 8 percent to 18 percent.

1. The price of oil was based on CBO's long-term forecast for oil prices. For the fully burdened price of fuel, CBO relied on data in an information paper from the Naval Sea Systems Command dated October 2, 2007. Since then, the Office of the Secretary of Defense has issued additional guidance on calculating the fully burdened cost of fuel, but the services have not yet implemented that guidance; see "Fully Burdened Cost of Delivered Energy—Methodological Guidance for Analyses of Alternatives and Acquisition Tradespace Analysis," in Defense Acquisition University, *Defense Acquisition Guidebook* (May 22, 2009), available at https://acc.dau.mil/fbcfmethod.

2. The Navy plans to buy a total of 55 littoral combat ships through 2031. CBO estimates the average procurement cost for the LCS-3 through LCS-55 at $550 million per ship (in 2010 dollars), plus $44 million per ship for outfitting and postdelivery costs.

The low-fuel case assumes that the LCS-1 generally operates at relatively low speeds—10 knots or less 90 percent of the time it is under way and 30 knots or more only about 3 percent of the time. That speed profile is based in part on how the Navy operated the LCS-1 between March 2009 and March 2010. In that scenario, operation and support costs total 33 percent of the ship's life-cycle cost: 16 percent for personnel costs, 8 percent for fuel costs (assuming that the ship consumes 25,000 barrels of fuel per year), and 9 percent for other O&S costs. The share attributable to personnel costs is lower than for the other ships that CBO analyzed, reflecting the Navy's goal to reduce crew size on the LCS substantially compared with that on other Navy ships. For example, the LCS-1 is about three-quarters the size of its predecessor, the FFG-7 guided missile frigate, but its crew is less than one-third the size of the frigate's.

The moderate-fuel case—which CBO considers the most likely of the three scenarios—assumes that the LCS-1 operates at 30 or more knots for about 5 percent of the time, at 14 knots to 16 knots 42 percent of the time (a range that might be typical when the ship was traveling from its home port to a deployment location), and at less than 12 knots for the rest of its time under way. In that scenario, O&S costs total 34 percent of the ship's life-cycle cost: 15 percent for personnel, 11 percent for fuel, and 8 percent for other O&S costs.[3] The moderate speed profile would result in fuel usage of about 35,000 barrels per year, slightly less than the 37,600 barrels that the Navy assumed in formulating its 2011 budget request.[4] By comparison, the FFG-7 class frigates consumed about 31,000 barrels of fuel per ship in 2009.

The high-fuel case assumes that the LCS-1 operates at 30 or more knots for about 20 percent of its time under way, an assumption based partly on a speed profile developed by the Naval Sea Systems Command for the LCS program.[5] In that scenario, O&S costs represent about 40 percent of the ship's life-cycle cost—more than in the other scenarios for the LCS-1 but less than for any of the other types of ships considered in this analysis. Personnel costs make up 14 percent of the life-cycle total; fuel costs, 18 percent; and other O&S costs, 8 percent. Projected fuel usage in this scenario is about 67,000 barrels per year. That estimate is unlikely to be exceeded in actual practice: It is twice the historical average for frigates and about 80 percent of the amount used by the Navy's destroyers (which do not have the capability to speed

3. Doubling the assumed price of oil in the moderate-fuel case (from an average of about $85 per barrel to $170 per barrel) results in a distribution of life-cycle costs very similar to that in the high-fuel case.

4. Data about past and projected fuel usage for the LCS-1 were provided to CBO in an information paper from the Navy dated April 6, 2010.

5. Naval Sea Systems Command, *Littoral Combat Ship: Design Reference Mission Profile* (September 30, 2005). The Navy plans to revise its mission scenarios for LCSs in the near future to better reflect how the ships will be used.

at 40 knots, as the littoral combat ship does, but are three times larger than the LCS-1).

I hope that you find this information helpful. If you have any further questions, please contact me or CBO staff. The primary staff contacts for this analysis are Eric J. Labs and Derek Trunkey, who can be reached at (202) 226-2900.

Sincerely,

Douglas W. Elmendorf
Director

Attachment: Table 1

cc: Honorable Ike Skelton
Chairman
House Committee on Armed Services

Honorable Howard P. "Buck" McKeon
Ranking Member

Honorable Gene Taylor
Chairman
Subcommittee on Seapower and Expeditionary Forces
House Committee on Armed Services

Honorable W. Todd Akin
Ranking Member

Honorable David Obey
Chairman
House Committee on Appropriations

Honorable Jerry Lewis
Ranking Member

Honorable Norman D. Dicks
Chair
Subcommittee on Defense
House Committee on Appropriations

Honorable C.W. Bill Young
Ranking Member

Honorable Carl Levin
Chairman
Senate Committee on Armed Services

Honorable John McCain
Ranking Member

Honorable Jack Reed
Chairman
Subcommittee on Seapower
Senate Committee on Armed Services

Honorable Roger Wicker
Ranking Member

Honorable Daniel K. Inouye
Chairman
Senate Committee on Appropriations

Honorable Thad Cochran
Vice Chairman

Identical letter sent to the Honorable Richard Shelby and the Honorable Jo Bonner.

Table 1.

Life-Cycle Costs of Various Navy Ships, Incorporating Current Fully Burdened Costs for Personnel and Fuel

	MCM-1 Class	FFG-7 Class (LAMPS III variant)	DDG-51 Class (Flight IIA)	CG-47 Class (Upgraded)	LCS-1 Low Speed Profile[a]	LCS-1 Moderate Speed Profile[a]	LCS-1 High Speed Profile[a]	LCS-2
Ship Characteristics								
Weight (Full-load displacement in tons)	1,400	4,100	9,500	10,000	3,100	3,100	3,100	2,800
Crew Size[b]								
Officers	8	11	24	24	11	11	11	11
Enlisted personnel	76	170	254	340	43	43	43	43
Total	**84**	**181**	**278**	**364**	**53**	**53**	**53**	**53**
Number of Ships	14	30	34	22	1	1	1	1
Expected Service Life (Years)	30	30	35 [c]	35	25	25	25	25
Ship Costs								
Life-Cycle Cost per Ship (Outlays in millions of 2010 dollars)[d]								
R&D[e]	3	2	72	8	20	20	20	20
Procurement[f]	274	662	1,484	2,014	680	680	680	721
Personnel	243	510	897	1,156	161	161	161	161
Fuel	8	125	331	364	79	112	215	n.a.
Other O&S[g]	103	201	258	489	89	89	89	n.a.
Disposal[h]	0	0	*	*	0	0	0	0
Total	**631**	**1,500**	**3,042**	**4,032**	**1,029**	**1,063**	**1,165**	**n.a.**
Average Life-Cycle Cost per Year (Outlays in millions of 2010 dollars)[d]	21	50	87	115	41	43	47	n.a.

Continued

Table 1. **Continued**

Life-Cycle Costs of Various Navy Ships, Incorporating Current Fully Burdened Costs for Personnel and Fuel

	MCM-1 Class	FFG-7 Class (LAMPS III variant)	DDG-51 Class (Flight IIA)	CG-47 Class (Upgraded)	LCS-1 Low Speed Profile[a]	LCS-1 Moderate Speed Profile[a]	LCS-1 High Speed Profile[a]	LCS-2
				Ship Costs (Continued)				
Breakdown of Life-Cycle Cost per Ship (Percent)[d]								
R&D[e]	*	*	2	*	2	2	2	n.a.
Procurement[f]	43	44	49	50	66	64	58	n.a.
Personnel	38	34	29	29	16	15	14	n.a.
Fuel	1	8	11	9	8	11	18	n.a.
Other O&S[g]	16	13	8	12	9	8	8	n.a.
Disposal[h]	0	0	*	*	0	0	0	n.a.
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**n.a.**

Source: Congressional Budget Office.

Notes: Fully burdened personnel costs include pay, withholding taxes paid by the government, housing benefits, tax advantages, and veterans' benefits. The fully burdened cost of refined fuel includes overhead costs of the Navy and the Department of Defense (DoD); it is about 2.2 times the published price of crude oil, according to data provided by the Navy in 2007. The Navy is revising its method for calculating the fully burdened cost of fuel. One unofficial source calculated that cost for the DDG-51 at 2.26 times the DoD standard fuel price, which would imply that the fully burdened cost of Navy fuel is about 3.2 times the price of crude oil. Using that higher rate would increase the fully burdened cost of fuel by about 45 percent. See Robert Corley, "Evaluating the Impact of the Fully Burdened Cost of Fuel" (thesis, Naval Postgraduate School, Monterey, Calif., September 2009).

Numbers may not add up to totals because of rounding.

LAMPS = Light Airborne Multi-Purpose System (helicopter); R&D = research and development; O&S = operation and support; n.a. = not available; * = between zero and $500,000 or between zero and 0.5 percent.

a. The LCS-1 is assumed to consume 25,000 barrels of fuel per year in CBO's low speed profile, 35,000 barrels in the moderate speed profile, and 67,000 barrels in the high speed profile. By comparison, the ship's actual fuel use in 2009 was about 27,000 barrels, and the Navy has budgeted for the use of 37,600 barrels in 2011.

b. CBO assumes that there will be 4 crews of 8 officers and 32 enlisted personnel for every 3 LCSs. Air detachments and mission packages will involve additional personnel.

c. The service life of the DDG-51 Flight IIA destroyers may be extended to 40 years, but original costs and planning reflect a 35-year service life.

d. These figures represent the projected cost for each type of ship if it began its service life now. Costs were discounted to their present value using a 3 percent real (inflation-adjusted) discount rate.

e. Some R&D costs for an entire class were spread over other variants of a ship than the ones shown here. R&D costs for the LCS program as a whole total about $1 billion, excluding costs associated with ship construction.

f. Procurement costs for the LCS-1 and LCS-2 are estimated, not final. They include outfitting and postdelivery costs but exclude costs for mission packages.

g. Other O&S costs are mostly for maintenance. The figures for the LCS are based on 2009 data, which may not match future maintenance costs. In addition, maintenance costs have not been adjusted to reflect ships' operational tempos.

h. In the past, some of the ships in the classes showing zero disposal costs were sold to other countries, and on average, their disposal produced revenue for the United States. CBO assumed that the same thing would occur with the LCS class; therefore, although a zero disposal cost is shown here, disposal of those ships could actually yield revenue for the government.