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LITTORAL COMBAT SHIP

Deployment of USS *Freedom* Revealed Risks in Implementing Operational Concepts and Uncertain Costs

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Highlights

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July 2014

LITTORAL COMBAT SHIP

Deployment of USS *Freedom* Revealed Risks in Implementing Operational Concepts and Uncertain Costs

Why GAO Did This Study

The LCS was intended to be a low-cost surface combatant that uses innovative operational concepts, such as minimal crew size, to lower operations and support costs. In 2013, the Navy deployed USS *Freedom*, one of two LCS variants, to Singapore to “prove its concept,” demonstrate operational capabilities, and collect data on the ship’s manning, training, maintenance, and logistics needs.

The House report accompanying the National Defense Authorization Act for Fiscal Year 2014 mandated that GAO analyze the Navy’s sustainment plans for its LCS program—including lessons from the USS *Freedom* deployment. This report addressed (1) the benefits and limitations of the operational data that have been collected on LCS ships; (2) the extent to which the Navy has evaluated risk in its operational support and sustainment concepts for LCS; and (3) how LCS life-cycle cost estimates compare with those for other surface-ship classes. GAO analyzed documents from the 2013 deployment, and LCS and surface-ship life-cycle costs, and interviewed program officials and USS *Freedom* crews.

What GAO Recommends

GAO is emphasizing its prior recommendations that, before buying more LCS ships, the Navy (1) conduct and consider the results of a risk assessment and (2) collect additional data and update cost estimates. The Department of Defense expressed concerns that its life-cycle cost data are not comparable across ship types. GAO believes the analysis provides a reasonable comparison using the best available data from the Navy, as discussed in the report.

View GAO-14-447. For more information, contact John Pendleton at (202) 512-3489 or pendletonj@gao.gov.

What GAO Found

The USS *Freedom* deployment provided beneficial data on operational support and sustainment concepts for the Littoral Combat Ship (LCS), but these data have limitations, and the Navy still lacks key data on LCS ships and concepts. The USS *Freedom* deployed for 10 months with a surface-warfare mission package, and the Navy collected data on items such as systems reliability and crew sleep hours. However, several factors limited the operational lessons learned. For example, mechanical problems prevented the ship from spending as much time at sea as planned. Further, the Navy continues to lack operational data for key operational and warfighting concepts, such as deployment with the other mission packages—mine countermeasures and antisubmarine warfare—and data on the other LCS variant which, under current plans, will comprise half the ship class.

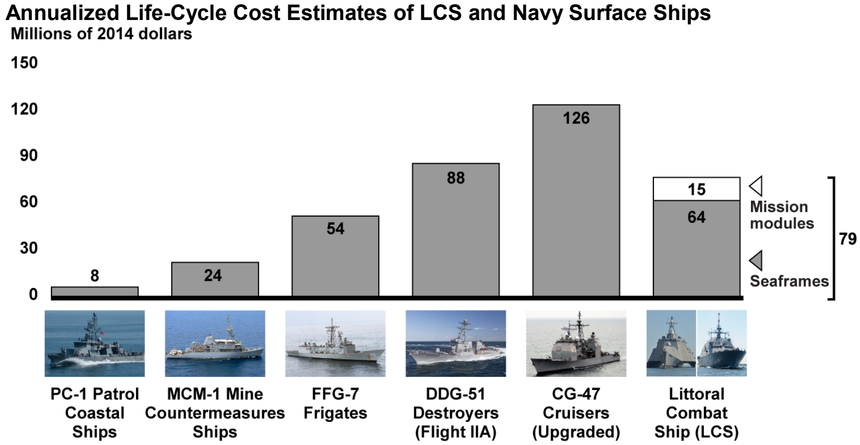
Although the Navy is adjusting some operational support and sustainment concepts, it has not yet addressed risks that remain in executing key concepts.

- *Manning:* The crew experienced high workload and fell short of the Navy’s sleep standards despite adding personnel for the deployment.
- *Training:* Gaps remain in fully training LCS sailors prior to deployment.
- *Maintenance:* The Navy is adjusting maintenance requirements and has not yet determined the optimal mix of contractor and crew workload to perform preventative maintenance.
- *Logistics:* The Navy is reallocating duties among crew and shore support, but the infrastructure needed to support both variants is incomplete.

Without fully analyzing risks in key concepts, the LCS may have operational limitations, deficits in personnel and materiel readiness, and higher costs.

The Navy has produced life-cycle cost estimates for the LCS seaframes and mission modules. Although those estimates contain uncertainty and there are inherent difficulties in comparing the life-cycle costs of ships with differing capabilities and missions, the best available Navy data indicate that the annual per ship costs for LCS are nearing or may exceed those of other surface ships, including those with greater size and larger crews, such as frigates.

Annualized Life-Cycle Cost Estimates of LCS and Navy Surface Ships



Source: GAO analysis of Navy information (data); Department of Defense (DOD) (photos). | GAO-14-447

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Abbreviations

DOD	Department of Defense
LCS	Littoral Combat Ship
LCS Squadron	LCS Class Squadron
NAVMAC	Navy Manpower Analysis Center

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Congressional Committees

For over 10 years, the Navy has been refining the concept of operations for its newest class of surface warship—the Littoral Combat Ship (LCS). The LCS was intended to be a comparatively low-cost surface-combatant ship that could operate in the shallow waters close to shore, known as the littorals. Its design concept consists of two distinct parts—the ship itself (seaframe) and the interchangeable mission modules it is expected to carry and deploy (i.e., surface warfare, mine countermeasures, and antisubmarine warfare). In early 2013, the Navy deployed its first LCS—USS *Freedom*—to Singapore to "prove its concept," demonstrate operational capabilities, and collect cost and other data on the ship's manning, training, maintenance, and logistics needs in the actual overseas environment in which it is expected to operate. The Navy recognizes that the LCS program faces distinct challenges as it continues to assess a number of operational support and sustainment concepts—such as reliance on shore support and the use of flyaway maintenance teams (i.e., contractors flown to the ship to conduct maintenance)—to determine whether they can be used together to minimize crew size and lower operations and support costs over the long term. As we previously reported, the Navy's acquisition approach to the LCS program involves a significant degree of concurrency; that is, the Navy is buying the ships while key concepts and performance are still being tested.[1] The Navy is procuring two seaframe variants of different hull types from two different contractors.[2] To date, the Navy has committed to procuring 24 seaframes, 12 of each variant, and plans to contract for up to 8 additional

[1]GAO, *Navy Shipbuilding: Significant Investments in the Littoral Combat Ship Continue Amid Substantial Unknowns about Capabilities, Use, and Cost*, GAO-13-530 (Washington, D.C.: July 22, 2013).

[2]This report refers to LCS 1 and the other odd-numbered seaframes as the *Freedom* variant, and LCS 2 and the other even-numbered seaframes as the *Independence* variant.

seaframes—while still testing the operational concepts it will use to employ the vessels.[3]

In prior reports, we identified numerous challenges related to the acquisition of LCS seaframes and mission modules and the implementation of their unique operational concepts. In February 2010, we reported several potential risks in implementing the new operational concepts for the LCS.[4] In September 2013, we issued a For Official Use Only report and found deficiencies in the Navy's LCS life-cycle cost estimates, noting that uncertainty exists in these estimates because they were developed without actual operational and cost data. We recommended that the Navy conduct and consider the results of a risk assessment to identify operational limitations if the Navy's approach to personnel, training, and maintenance cannot be implemented as envisioned and that the Navy collect additional operational data and update its cost estimates before contracting for additional ships. The Navy partially concurred with the risk recommendation and concurred with the operational data and updated cost estimates recommendation, but has not yet completed implementation of these recommendations.

In its report accompanying HR 1960, a bill for the National Defense Authorization Act for Fiscal Year 2014, the House Armed Services Committee mandated that GAO review and analyze the Navy's operational support and sustainment[5] plans for its LCS program.[6] For this report, we addressed (1) the benefits and limitations of the operational data that have been collected on LCS ships; (2) the extent to which the Navy has evaluated risk in its operational support and sustainment

[3]The Navy had planned to contract for up to 28 additional seaframes, but on February 24, 2014, the Secretary of Defense announced that as part of its fiscal year 2015 budget proposal the Navy would contract for no more than 32 LCS—instead of the 52 ships previously planned—until the Navy evaluates potential courses of action, including the current LCS program and provides a report to the Secretary of Defense, which is due by July 31, 2014. The Navy has not specified which variants it will procure in the future.

[4]See GAO, *Littoral Combat Ship: Actions Needed to Improve Operating Cost Estimates and Mitigate Risks in Implementing New Concepts*, GAO-10-257 (Washington, D.C.: Feb. 2, 2010).

[5]For the purposes of this review, operational support and sustainment for LCS includes manning, training, maintenance, and logistics—both onboard and shore-based support.

[6]H.R. Rep. No. 113-102, at 115-116 (2013). We provided a preliminary briefing on February 26, 2014.

concepts for the LCS in the areas of manning, training, maintenance, and logistics; and (3) how LCS life-cycle cost estimates compare with those for other surface-ship classes.

To address the benefits and limitations of the operational data that have been collected on LCS ships, we analyzed and compared USS *Freedom*'s planned deployment schedule with its actual executed schedule. We reviewed documentation related to USS *Freedom*'s operational activities while it was deployed, including execution orders, concepts of operations, and exercise briefings. We also interviewed forward-deployed crew members in Singapore and Navy officials responsible for the ship's operational employment at 7th Fleet in Japan to discuss the successes and challenges of the deployment, including any limitations. Further, we analyzed the operational activities of USS *Independence* and interviewed Navy officials to determine what operational data have been collected on the *Independence* variant. Finally, we reviewed and analyzed the LCS wholeness and warfighting concepts of operations to identify any additional LCS operational and warfighting concepts that still need to be demonstrated in an operational environment.

To assess the extent to which the Navy has evaluated risk in its operational support and sustainment concepts for the LCS in the areas of manning, training, maintenance, and logistics, we reviewed relevant data-collection and analysis plans and mid-point and final reports on the *Freedom* 2013 deployment to Singapore from the Commander Naval Surface Forces Pacific, 7th Fleet, and the Center for Naval Analyses. We also interviewed officials from organizations responsible for collecting and analyzing data from this deployment. We reviewed the LCS wholeness concept of operations, the life-cycle sustainment plans for the LCS, and various other Navy documents associated with LCS manning, training, maintenance, and logistics, and interviewed USS *Freedom* crews who participated in the 2013 deployment to obtain their perspectives on the implementation of these concepts.

To assess how LCS life-cycle cost estimates compare with those for other surface-ship classes, we modified a framework used in a similar comparison published by the Congressional Budget Office in 2010.[7] To do this, we reviewed cost estimates in the current LCS Seaframe Program Life Cycle Cost Estimate (2011) and the LCS Mission Module Program Life Cycle Cost Estimate (2013). Although the Navy to date has not updated these life-cycle cost estimates to reflect changes in the program, the Navy adjusted the estimates for inflation to fiscal year 2014 dollars. Using these data, we calculated an annual per ship life-cycle cost estimate for the combined LCS seaframes and mission modules to account for differences in the number of ships and mission modules and their respective expected service lives. We also obtained life-cycle cost data in fiscal year 2014 dollars from the Navy for five surface ships, patrol coastal ships, mine countermeasures ships, frigates, destroyers, and cruisers, and used these data to calculate an annual per ship life-cycle cost estimate for each of these five surface ships. We then compared these data with the data we calculated for the LCS seaframes and mission modules. We analyzed and assessed these data and found them to be sufficiently reliable for the purposes of reporting the estimated life-cycle costs of these surface ships. We selected the non-LCS surface ships used for our comparison because cost data were readily available and they all conduct at least one mission that the LCS is also expected to perform. A more detailed-description of our scope and methodology is presented in appendix I.

We conducted this performance audit from September 2013 to July 2014 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[7]In 2010, the Congressional Budget Office completed a preliminary study of LCS life-cycle costs and compared them to the costs of other ship classes in the surface fleet. This analysis included Navy data on operations and support costs for mine countermeasures ships, frigates, destroyers, and cruisers and other life-cycle costs components, and compared those costs to projections for each LCS seaframe variant—excluding mission modules. We modified the Congressional Budget Office’s analytic framework to conduct further analysis using additional and updated data for the LCS, its mission modules, and other surface-ship classes. See Congressional Budget Office, *Life-Cycle Costs of Selected Navy Ships* (Apr. 28, 2010).

Background

The LCS was intended to be a comparatively low-cost surface combatant that could address the challenges of operating U.S. military forces in the shallow waters close to shore, known as the littorals. The ship is designed for three principal missions: surface warfare, mine countermeasures, and antisubmarine warfare—to address threats posed by small surface boats, mines, and submarines, respectively. Its design concept consists of two distinct parts—the ship itself (seaframe) and the interchangeable mission modules it is expected to carry and deploy. These mission modules consist of containers carrying various unmanned systems, sensors, and weapons that provide different combat capabilities for the ship's three principal missions. These mission modules are intended to give the Navy the flexibility to change equipment to meet different mission needs while forward deployed. The mission modules, when combined with the mission-module crew and an aviation detachment—consisting of an MH-60 helicopter and its flight and support crew, as well as vertical takeoff unmanned aerial vehicles—make up a mission package. The LCS is designed to embark with only one mission package at a time.

The Navy envisioned the LCS as a ship that could operate with a much smaller crew size than other surface combatants, with preventative maintenance duties performed primarily by contractors. This concept would in turn lead to lower operations and support costs, which traditionally account for about 70 percent of the total cost over a ship's lifetime. The Navy planned the LCS to have a core crew of 40 sailors and mission-module crews of 15 to 20 sailors—far fewer than the crew of approximately 170 sailors for a frigate and approximately 250 sailors for a destroyer. To meet its operational, maintenance, support, and administrative needs with these reduced manning levels, the Navy is developing a new maintenance and support concept.[8] Unlike other ships, the LCS would have no onboard administrative personnel and a limited ability to conduct maintenance at sea; instead, it would rely heavily on shore-based support, including flyaway maintenance teams made up of contractors flown in to conduct scheduled maintenance. The Navy also opted to use a rotational crewing concept, whereby three crews rotate between two ships, one of which is forward deployed. The Navy has used

[8]Details related to unique LCS operational support and sustainment concepts are found in the U.S. Fleet Forces Command, *LCS Platform Wholeness Concept of Operations Revision D* (Jan. 9, 2013), the Navy's high-level document summarizing manning, training, equipping, and sustaining concepts for LCS seaframes and mission packages.

a different form of rotational crewing on ballistic missile submarines for years but has not used it widely on surface combatants.[9]

As of July 2014, the Navy has accepted delivery of four LCS seaframes—two of each variant—and has already contracted for 20 more seaframes (10 of each variant). The Navy plans to award contracts for up to eight additional seaframes.[10] Twelve seaframes are currently in production, and at the same time the Navy is in the process of incrementally developing and procuring the three mission packages.

Several Navy organizations and commands have responsibilities for managing the LCS program, overseeing training, and maintaining readiness of LCS ships:

- *The Program Executive Office Littoral Combat Ship* provides a single program executive who is responsible for acquiring and maintaining the littoral mission capabilities of the LCS class—from procurement to fleet employment and sustainment.
- *The LCS Class Squadron* (LCS Squadron) oversees LCS seaframes, mission modules, and their crews for numerous functional area requirements including, among others, administrative, personnel, operational, maintenance, logistics, training, and facilities.
- *The LCS Council*—established by the Chief of Naval Operations in August 2012 to ensure the successful introduction of the LCS into the fleet—created an LCS Plan of Action and Milestones to address program challenges and continues to use this tool to monitor progress

[9]GAO, *Force Structure: Ship Rotational Crewing Initiatives Would Benefit from Top-Level Leadership, Navy-wide Guidance, Comprehensive Analysis, and Improved Lessons-Learned Sharing*, GAO-08-418 (Washington: D.C.: May 29, 2008). The Navy uses rotational crewing on mine countermeasures ships and patrol coastal ships.

[10]The Navy had planned to contract for up to 28 additional seaframes, but on February 24, 2014, the Secretary of Defense announced that as part of its fiscal year 2015 budget proposal the Navy would contract for no more than 32 LCS—instead of the 52 ships previously planned—(a further reduction from the original 55-ship plan), until the Navy evaluates potential courses of action, including the current LCS program and provides a report to the Secretary of Defense, which is due by July 31, 2014.

across the program.[11] Our September 2013 report contains a description of how the council tracks progress through the LCS Plan of Action and Milestones, and a status update on the LCS Plan of Action and Milestones can be found in appendix II.

USS *Freedom* Deployment Provided Some Data on LCS Operations, but the Navy Still Lacks Key Operational Data on LCS Ships and Concepts

The USS *Freedom*'s deployment to Singapore was an opportunity for the Navy to learn lessons about the feasibility and sustainability of unique LCS operational support and sustainment concepts in an operational environment. The Navy was able to collect data during the deployment on items such as systems usage and reliability and crew sleep hours. However, several factors, such as mechanical failures during the deployment, limited the operational lessons learned and the extent to which they are projectable across the LCS class. Additionally, the Navy continues to lack overseas deployment data for the *Independence* variant ships and for additional operational and warfighting concepts—such as overseas mission-package swaps and deployment with the mine countermeasures and antisubmarine-warfare mission packages.

Deployment to Singapore Intended to Examine Operational Concepts

In March 2013, the Navy deployed its first LCS—USS *Freedom*—to Singapore with an increment 2 surface-warfare mission package for the first-ever overseas-based operational deployment of an LCS.[12] Navy officials saw the deployment as an opportunity to examine the feasibility of LCS manning, training, maintenance, and logistics concepts in an operational environment including, among other things, using a minimally sized crew, swapping out one crew with another while forward deployed, and maintaining the ship primarily with private contractors. Although the Navy concept of operations envisioned 40 sailors in the LCS core crew, the core crew was increased to 50 for the Singapore deployment as a pilot program to address crew fatigue and workload concerns that the

[11] In March 2013, the Chief of Naval Operations expanded the duties of the council to include responsibilities for the Joint High Speed Vessel and added a Rear Admiral, Commander of the Military Sealift Command, to the renamed Littoral Combat Ship and Joint High Speed Vessel Council. See U.S. Navy, *Littoral Combat Ship and Joint High Speed Vessel Council Charter* (March 2013).

[12] There are three mission packages (surface warfare, mine countermeasures, antisubmarine warfare), and nine different capability increments within these three packages. All carry different crews and equipment and operate differently from one another. Increment 2 of the surface-warfare mission package does not include the surface-to-surface missile that is planned for increments 3 and 4.

Navy was already aware of before the deployment. USS *Freedom* deployed for 10 months and conducted one crew swap midway through the deployment, operating in 7th Fleet's area of responsibility and using Singapore as a logistics and maintenance hub (see fig. 1).[13]

Figure 1: USS *Freedom* in Singapore

USS *Freedom* departs Changi Naval Base, Singapore.

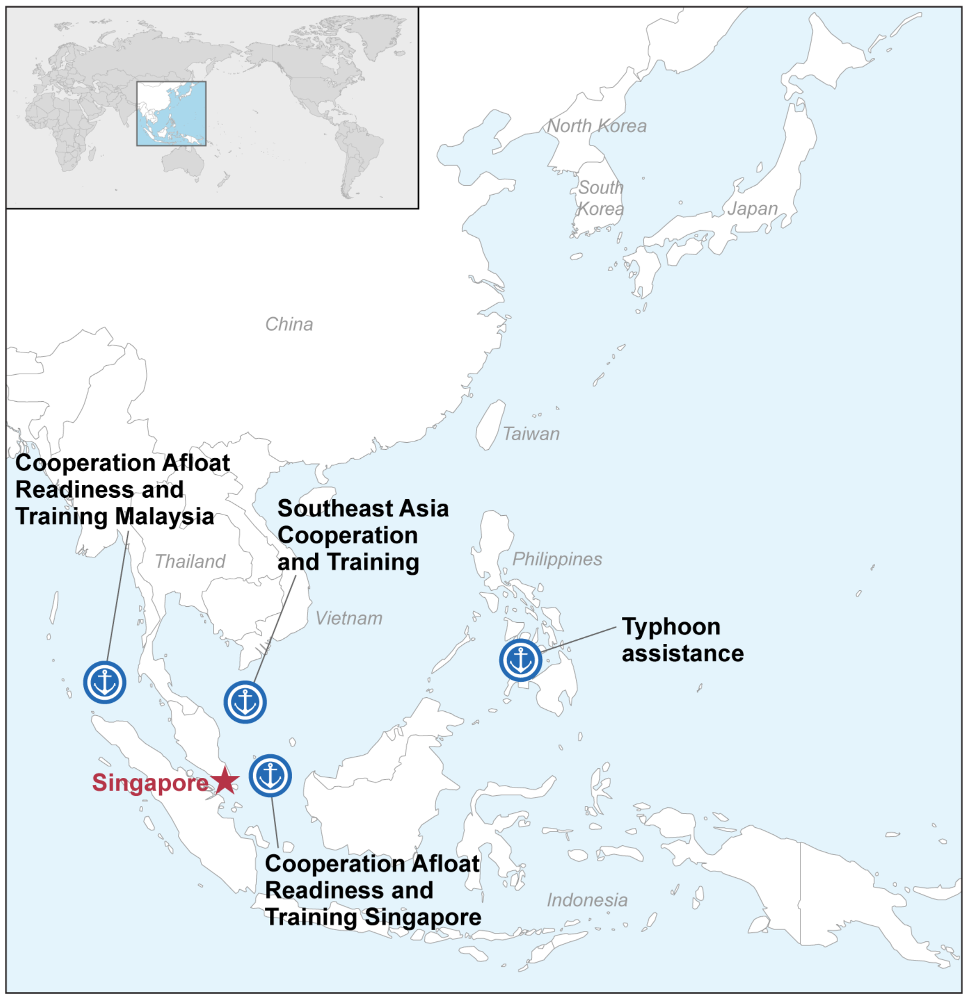
Source: Department of Defense (DOD). | GAO-14-447

[13]U.S. Navy 7th Fleet, a Navy component command, had operational control of USS *Freedom* across the 7th Fleet area of responsibility which covers more than 48 million square miles and spans from west of Hawaii to the western coast of India.

USS *Freedom* Deployment Provided Some Useful Data on Operational Support and Sustainment Concepts, but Several Factors Limited the Lessons Learned

During its 10-month deployment to the 7th Fleet area of responsibility, USS *Freedom* participated in joint exercises with regional partners, maritime security operations, and disaster-relief efforts in the Philippines following Typhoon Haiyan. Figure 2 provides an overview of the operational area for the USS *Freedom* deployment and shows the sites of selected events.

Figure 2: USS *Freedom* Deployment Operational Area and Selected Events



Source: GAO analysis of Navy information (data); Map Resources (map). | GAO-14-447

The ship and crew implemented some of the LCS-specific operational support and sustainment concepts, including a crew swap that took place in August 2013 as well as the use of contractor teams for scheduled maintenance periods in Singapore.[14] Additionally, several commands and organizations responsible for analyzing lessons learned from the deployment—including the Commander Naval Surface Forces Pacific, the Naval Warfare Development Command, and the Center for Naval Analyses—collected data during the USS *Freedom* deployment on equipment reliability rates and crew-reported sleep statistics, among other things. For example, the *Freedom* crew provided daily reports on the amount of time they spent sleeping, training, and completing preventative and corrective maintenance. After USS *Freedom* returned to San Diego, nearly every LCS stakeholder—including the operational commander of the ship in Singapore (Commander, Destroyer Squadron Seven) and each of the USS *Freedom* crews—produced lessons-learned summaries. According to Navy officials, they were able to learn some operational lessons from the 10-month deployment. For example:

- The *Freedom* deployment demonstrated the LCS's ability to participate in theater security-cooperation activities, such as joint exercises with regional navies, and helped carry out the Navy's forward-presence mission in Southeast Asia—thereby freeing larger multimission warships to carry out other high-priority Navy duties.
- Navy officials are implementing a condition-based maintenance system on the LCS, whereby sensors provided some useful data on system usage and reliability.[15] For example, medium-pressure air compressors had seen high casualty rates on USS *Freedom* prior to the deployment. However, Navy officials reported that USS *Freedom* did not experience significant failures of these compressors during the Singapore deployment because they were constantly monitored by sensors and were replaced before they could fail.

Navy officials reported that data and lessons learned collected during the USS *Freedom* deployment will be used to develop and refine the concept of operations for the USS *Fort Worth* (*Freedom* variant) deployment and the LCS wholeness concept of operations. USS *Fort Worth* (LCS 3) is

[14]The USS *Freedom* blue and gold crews executed a crew turnover in August 2013 in the port of Sembawang in Singapore.

[15]Condition-based maintenance is the process of scheduling maintenance based on actual need through analysis of data from the seaframe's equipment. The data is obtained in real time or near-real time from sensors embedded in seaframe components or systems, and then monitored and analyzed ashore.

scheduled to deploy to Singapore in late 2014, and the next revision of the wholeness concept of operations is scheduled for completion in November 2014.

Although the Navy collected some useful data from the deployment, mechanical issues reduced time at sea with 55 total mission days lost, limiting the operational lessons learned. The operational effect of these lost mission days was that the ship had to cut short its participation in two joint exercises and did not complete at least two of its planned presence operations.[16] Our analysis of USS *Freedom*'s actual executed schedule showed that these mechanical failures contributed to limiting the ship's underway time to 35 percent of its deployment in the 7th Fleet area of responsibility (see table 1). Underway time includes all time the ship operated outside of port in the 7th Fleet area of responsibility including time spent transiting to and from Singapore.

Table 1: USS *Freedom* Underway Time in 7th Fleet Area of Responsibility

Activity	Number of days	Percentage of time
Underway	53	
In transit under way to/from Singapore	40	
Total underway days	**93**	**35%**
In port in Singapore	155	
Other port time	17	
Total time in port	**172**	**65%**
Total days in 7th Fleet, including transit	**265**	**100%**

Source: GAO analysis of Navy data. | GAO-14-447

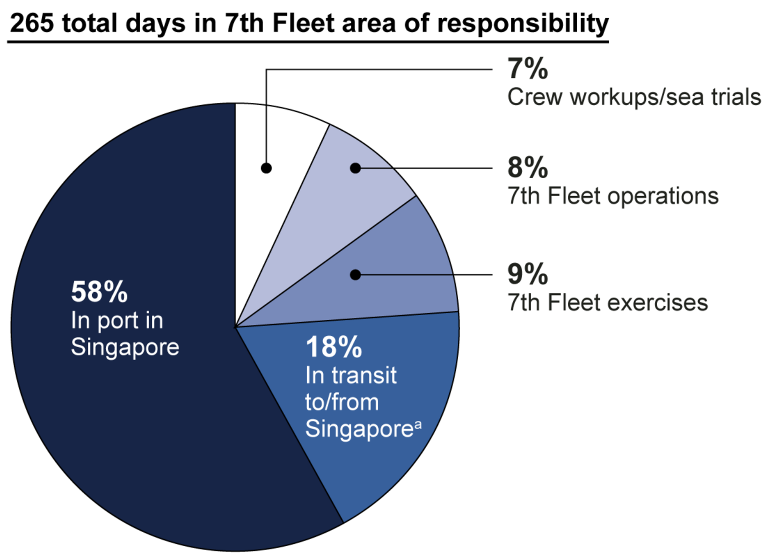
Note: Underway percentage is calculated using USS *Freedom* executed schedule and includes all time the ship operated outside of port in the 7th Fleet area of responsibility (i.e., under way), including transit to and from Singapore.

The 7th Fleet concept of operations for the USS *Freedom* deployment stated that the ship should spend more time outside of Singapore (i.e., greater than 50 percent) than in port in Singapore. However, during its

[16]Specific equipment failures resulting in lost mission days are sensitive information. There is disagreement within the Navy on how many mission days were lost due to mechanical failures. The LCS fleet introduction program office provided us with documentation showing that 55 days were lost; other Navy offices stated that 28 days were lost, but they did not provide documentation for how this number was determined.

10-month deployment, USS *Freedom* spent 58 percent of its time in port in Singapore (see fig. 3). According to 7th Fleet officials, other ships deployed to the 7th Fleet area of responsibility typically spend about 20 percent of their time in port. LCS program officials explained that the unique LCS maintenance concept—USS *Freedom* returned to port every 25 days to undergo a 5-day preventative maintenance availability and every 120 days for more-intensive 2-week intermediate maintenance—resulted in a rigid deployment schedule with more port time than other deployed Navy ships. However, Navy officials acknowledged that the mechanical issues on this deployment extended the ship's time in port. LCS program officials told us that while equipment problems limited operational lessons learned, the Navy gained experience conducting emergent repairs overseas and putting stress on the LCS maintenance concept.

Figure 3: USS *Freedom* Operational Activities in 7th Fleet Area of Responsibility



Source: GAO analysis of Navy data. | GAO-14-447

[a]In-transit time includes stops in Guam, Philippines, Brunei, and some taskings from 7th Fleet (e.g., tracking vessels of interest).

Additionally, some *Freedom* systems, such as several water-jet components and the satellite communication system, are unique to that hull, and their performance data cannot be generalized even to other *Freedom* variant ships. USS *Freedom* is different in several respects from later (follow-on) ships of its own variant, since some major equipment has been changed. As a result, learning about these systems' performance during deployment cannot be directly applied to predict how the replacement systems might perform on other ships of the *Freedom* variant. According to the Navy, improving these systems should mean that future deployments of other ships from the *Freedom* variant will not incur the same number of equipment problems as USS *Freedom* did. However, as the Department of Defense's Director of Operational Test and Evaluation noted, no formal operational testing has been conducted to verify and quantify the effect of these changes, so further deployments or additional underway time, or both, will be necessary before the effects of these improvements on ship availability can be determined.[17]

The Navy Continues to Lack Operational Data on the Other LCS Variant

The Navy continues to lack operational data, specifically overseas deployment data, on the other LCS variant—the *Independence* variant—which, under current plans, is expected to comprise half of the LCS ship class (see fig. 4).

[17]Director, Operational Test and Evaluation, *Fiscal Year 2013 Annual Report* (January 2014).

Figure 4: *Independence* Variant Littoral Combat Ship (LCS)

USS *Independence* (LCS 2)

Source: Department of Defense (DOD). | GAO-14-447

In September 2013, we reported that the Navy had not scheduled an overseas operational deployment for an *Independence* variant LCS and therefore would not have comparable actual data and lessons learned for this variant. We recommended that the Navy collect actual operational data on this variant and the Navy concurred, stating that it would identify the actions and milestones needed to collect additional actual operational data on the *Independence* variant. However, the Department of Defense's Director of Operational Test and Evaluation noted in January 2014 that the core combat capabilities of the *Independence* variant seaframe remain largely untested and that equipment reliability problems have degraded the operational availability of USS *Independence* (LCS 2).[18]

While the Navy deployed a *Freedom* variant LCS to Singapore for nearly all of 2013, our analysis found that, over the same period, USS *Independence* spent about 8 months, or 65 percent, of 2013 in port or dry

[18]Director, Operational Test and Evaluation, *Fiscal Year 2013 Annual Report*.

dock maintenance periods, limiting any operational data that the Navy could obtain when operating the ship out of its homeport in California. In addition, according to Navy officials, from October 2012 to December 2013, USS *Independence* spent only 44 days under way.[19] Navy officials told us that an *Independence* variant LCS needs to deploy to Singapore to determine whether the LCS operational support and sustainment concepts will be feasible and effective in supporting this variant, since not only does it have different systems than the *Freedom* variant that require different logistical support, but Singapore presents unique environmental conditions such as high humidity and warm ocean temperatures. At the time of our review, the Navy stated that it has notional plans to deploy an *Independence* variant LCS sometime before 2017. Navy officials also noted that an extended test period is planned in 2014 for the mine countermeasures mission package for USS *Independence*. This testing will take place in the Gulf of Mexico near Florida, and the ship will use Pensacola to exercise the maintenance concept outside of homeport.

Additional LCS Concepts Need Operational Demonstration

LCS operational and warfighting concepts that require demonstration in an operational environment include overseas mission-package swaps, deployments of the mine countermeasures and antisubmarine warfare mission packages, and tests of warfighting concepts in exercises related to operational plans, among others.[20] According to the 7th Fleet USS *Freedom* deployment concept of operations, the *Freedom* deployment was intended to support validation of warfighting and wholeness concepts. However, the deployment largely focused on sustainment concepts, and key warfighting concepts were not demonstrated. Table 2 shows the key LCS systems and concepts demonstrated during the USS *Freedom* deployment to Singapore and those that require future deployments to demonstrate their feasibility.

[19]During this period, USS *Independence* underwent major safety-related modifications that required lengthy time either in port or in dry dock. LCS program officials said that in 2011, the USS *Independence* spent 5 months under way completing mine countermeasures mission package testing, but they acknowledged that recent operational data are limited. They added that since the ships have been delivered, USS *Freedom* has spent 29 percent of its time under way, while USS *Independence* has spent 26 percent of its time under way.

[20]Operational plans refer to any plan for the conduct of military operations prepared in response to actual and potential contingencies.

Table 2: Key Littoral Combat Ship (LCS) Systems and Concepts Demonstrated during USS *Freedom* Deployment to Singapore and Those That Require Future Overseas Deployments for Demonstration

	System/concept	Planned for and demonstrated during deployment	Not yet demonstrated during a deployment
Mission package	Surface warfare[c]	✓	
	Mine countermeasures		✓
	Antisubmarine warfare		✓
Wholeness concepts[a]	Shore-based maintenance concept in Singapore	✓	
	Overseas crew swap	✓	
	Core crew size of 50	✓	
	LCS rotational crewing strategy[d]		✓
	16-month deployment		✓
	Shore-based maintenance concept outside of Singapore		✓
Warfighting concepts[b]	Theater security cooperation	✓	
	Exercise related to operational plans		✓
	Overseas mission-package swap		✓

Source: GAO analysis of Department of Defense (DOD) data. | GAO-14-447

[a]Concepts found in U.S. Fleet Forces Command, *LCS Platform Wholeness Concept of Operations Revision D* (Jan. 9, 2013).

[b]Concepts found in classified warfighting concept of operations.

[c]USS *Freedom* deployed with an increment 2 surface-warfare mission package. Four total increments are planned for this mission package.

[d]The LCS rotational crewing strategy consists of three crews rotating between two ships, one of which is forward deployed.

To date, none of the mission packages have been completely developed, tested, and deployed.[21] There are nine different capability increments within the three mission packages. USS *Freedom* deployed with an increment 2 surface-warfare mission package. There are two other mission packages for the LCS—mine countermeasures and antisubmarine warfare—neither of which has yet deployed. The three mission packages each require different crews and equipment and

[21]The Navy is pursuing an evolutionary acquisition strategy for the mission packages. This means that it plans to deliver improving levels of capability over multiple increments (four for surface warfare, four for mine countermeasures, and one for antisubmarine warfare). The Navy's threshold performance requirements as currently defined in LCS requirements documentation will be met only when the final increment of each package is completed, and not by each individual increment. See GAO-13-530.

operate differently from one another, and the manning for each package differs in skill sets. This can alter the extent to which the mission package crew will be able to support the seaframe crew; to determine this, each mission package will need to be deployed. Navy officials said that the USS *Fort Worth* deployment beginning in late 2014 will address some, but not all, of these gaps. For example, *Fort Worth* will utilize the rotational crewing strategy, deploy for 16 months, and implement the shore-based maintenance concept outside of Singapore. However, *Fort Worth* will not swap mission packages while deployed. Navy officials also noted that additional war gaming is required to refine the operational use of the LCS seaframe and mission packages. The Navy held an operational war game in March 2014 to try to understand how well the LCS would support the Navy's needs and operational plans in various phases of operations in a Pacific theater crisis, but it has not yet released any formal reporting on the results of this effort.

In September 2013, we recommended that the Navy collect actual operational data on the *Independence* variant prior to contracting for additional LCS ships in 2016. Our work shows that the Navy still lacks key operational data needed to refine its concepts and develop more-reliable cost estimates. We believe our 2013 recommendation is still valid.

The Navy Has Not Yet Fully Addressed Risks to Its Operational Support and Sustainment Concepts That Were Identified by the USS *Freedom* Deployment

Although the Navy is adjusting some operational support and sustainment concepts based on data collected and lessons learned during the USS *Freedom* deployment, it has not yet addressed some risks that remain in executing and sustaining key manning, training, maintenance, and logistics concepts. Federal standards for internal controls state that decision makers should comprehensively identify risks associated with achieving program objectives, analyze them to determine their potential effect, and decide how to manage the risk and identify what actions should be taken.[22] This is an ongoing process, since operating conditions continually change. In 2010, we reported that the Navy faced several risks in implementing new LCS concepts for manning, training, and maintenance necessitated by the small crew size, and recommended that the Navy conduct and consider the results of a risk assessment to identify operational limitations if the Navy's approach to manning, training, and

[22] GAO, *Standards for Internal Control in the Federal Government*, GAO/AIMD-00-21.3.1 (Washington, D.C.: November 1999).

maintenance cannot be implemented as envisioned; develop possible alternatives to these concepts; and make policy and process changes to reduce risks to the LCS program.[23] At the time of this review, the Navy had not fully addressed our prior recommendation, although Navy officials told us that they have undertaken a number of activities to manage risks in the LCS program. For example, the LCS program office convenes a risk-management board on a regular basis to identify potential program risks. As the program attempts to manage and mitigate these risks, the maiden deployment of USS *Freedom* identified additional issues with the manning, training, maintenance, and logistics concepts that have not been fully addressed by the Navy. Key observations from the deployment, the actions the Navy has taken to address them, and the outstanding risks that still remain in further implementing LCS operational support and sustainment concepts are summarized below in table 3.

Table 3: Summary of Risks to Littoral Combat Ship (LCS) Operational Support and Sustainment Concepts and Navy Actions to Address Observations from USS *Freedom* Deployment

Concept area	Observations from *Freedom* deployment	Navy actions to address these observations	Remaining risks
Manning	*Freedom* crews averaged about 6 hours of sleep per day compared to the Navy standard of 8 hours Core crews augmented by mission-module crew and contractor ship riders, which is not part of the manning concept	Navy is conducting a manpower study to validate the size and composition of *Freedom* core crew and surface-warfare mission-module crew; expected completion in 2015	Navy has not yet conducted further manpower studies to validate *Independence* variant core crew and other two mission-module crews Manpower studies do not account for the issue of core crews relying on mission-module crew and contractor ship riders to assist with their core crew functions
Training	Not all core crew members were fully trained prior to deployment Sailors were training while deployed, which is not part of the LCS concept of operations Sailors widely reported the inadequacy of the training they received	Navy is training late-addition ensigns and "plus-up" personnel to minimize training while deployed Navy is developing simulator-based training to replace current vendor training Navy is making some improvements to existing training based on crew feedback	Training time during deployment not accounted for in LCS work day While new training is being developed, sailors will still require training while under way Gaps in training may exist until 2019, when the LCS training curriculum is expected to be fully implemented

[23]GAO-10-257.

Concept area	Observations from *Freedom* deployment	Navy actions to address these observations	Remaining risks
Maintenance	*Freedom* had a limited range due to its rigid maintenance schedule Lack of continuity in contractor personnel conducting maintenance was an issue Crew said that some maintenance would be performed more efficiently by contractors while some should be executed by crew	Future deployments will have a longer, more-flexible interval for scheduling maintenance Navy is continuously reviewing maintenance requirements and the mix of contractor- and sailor-executed workload Navy is implementing a pilot condition-based maintenance program to increase maintenance efficiency	Navy is still working to manage the scope of who is executing the work and establishing baseline tools to ensure accountability Navy may utilize its maintenance contractors and LCS crews inefficiently until it determines the most-appropriate timing and number of planned LCS maintenance checks and the optimal mix of contractor- and crew-performed maintenance
Logistics	Distance support reporting process not followed, resulting in duplication of effort among the crew and shore support personnel Several limitations of LCS support infrastructure such as poor pier-side Internet connectivity	Navy is revising instructions for the LCS Squadron's Forward Liaison Element Some reporting that was originally to be completed by shore support will be conducted by the crew Navy is exploring options with the host-nation government to improve pier-side support	The logistics infrastructure needed to support four LCSs in Singapore and at other planned forward operating stations has not been completed LCS crews may be burdened with additional reporting requirements not factored into their workday Additional lessons may be learned on supporting *Independence* variant ships when deployed

Source: GAO analysis of Navy and Center for Naval Analyses data. | GAO-14-447

Our work shows that the Navy has not fully identified, analyzed, and mitigated the risks associated with LCS concepts. Having such a risk assessment would enable decision makers to identify and assess the operational effects if these concepts cannot be implemented as envisioned; alternatives to mitigate these risks; and information to link the effectiveness of these new operational concepts with decisions on program investment. If the operational concepts for manning, training, maintenance, and logistics cannot be implemented as desired, the Navy may face operational limitations, may have to reengineer its operational concept, or may have to make significant design changes to the ship after committing to building most of the class. The 2013 deployment of USS *Freedom* to Singapore highlighted that these risks remain. Therefore, we continue to believe that our 2010 recommendation is valid.

For additional details and information on our observations from the deployment, actions the Navy has taken to address them, and the outstanding risks that still remain in further implementing LCS concepts in the areas of manning, training, maintenance, and logistics, see appendix III.

Available LCS Cost Data Are Limited, but Annual Per-Ship Costs May Be Approaching Those of Other Multimission Surface Ships with Larger Crews

Although the Navy's life-cycle cost estimates for the LCS seaframe and mission modules contain uncertainty, they indicate that the annualized per ship costs for the LCS may be approaching those of other multimission surface ships with larger crews. The Navy planned to use data collected during USS *Freedom*'s deployment, particularly data on maintenance costs, to update and improve the life-cycle cost estimates for the LCS seaframe. The Navy collected cost data during USS *Freedom*'s deployment to Singapore; however, Navy officials explained that much of the data may be of limited usefulness for projection across the LCS ship class. We reported in September 2013 that a lack of operational data had prevented the Navy from developing life-cycle cost estimates for the LCS seaframe above a relatively low confidence level. Although the Navy's LCS cost estimates contain uncertainty, especially in regard to operations and support costs, and there are inherent difficulties associated with comparing the life-cycle costs of various surface ships with differing capabilities and mission sets, we found that the per ship per year cost estimates for the LCS program are nearing or may exceed the costs of other surface ships, including multimission ships with greater size and more crew members, such as guided-missile frigates and destroyers.

Usefulness of USS *Freedom* Deployment for Updating LCS Cost Estimates May Be Limited

During the course of our prior review, Navy officials explained that they planned to update and improve life-cycle cost estimates for the LCS seaframe, in part by using data collected during USS *Freedom*'s deployment to Singapore. The deployment provided additional data associated with actual operations and support costs specific to USS *Freedom*, including maintenance and emergent repair costs. However, according to Navy officials, much of these data may be of limited usefulness for projection across the LCS ship class. In early 2014, Navy officials said that they were evaluating the deployment data but that first-time deployments on any ship class include costs related to issues that are not representative of the entire ship class and will therefore limit their ability to update the LCS life-cycle cost estimate for the seaframes. Two such factors are described below:

- Certain problematic engineering systems that required emergent repairs and increased the overall deployment cost figures have been or will be replaced on future LCSs.
- The fuel capacity and efficiency of USS *Freedom* will differ from other *Freedom* and *Independence* variant ships.

In September 2013, we recommended that the Navy identify actions and milestones to collect additional actual operational data on the

Independence variant and to update operations and support cost estimates for both variants.[24] Navy officials said that an updated life-cycle cost estimate for the LCS seaframe would likely be available in the fall of 2014. However, based on the Navy's LCS deployment schedule, this update will likely not include additional overseas deployment-related cost data for either LCS variant; USS *Fort Worth* will not deploy until late 2014, and the Navy has only notional plans to deploy an *Independence* variant LCS sometime before 2017.[25] Navy officials explained that the Navy will not have a life-cycle cost based on actual deployment data for the LCS until it is operating multiple LCSs from a forward location such as Singapore in accordance with employment and operational concepts.

LCS Life-Cycle Cost Estimates Contain Uncertainty

The Navy estimated in 2011 that operations and support costs for the LCS seaframes would be about $50 billion over the life of the ship class. In 2013, it estimated that operations and support costs for the mission modules would be about $18 billion. Both of these estimates were calculated in fiscal year 2010 dollars.[26] However, as we reported in September 2013, the seaframe estimate is at the 10 percent confidence level, meaning that there is 90 percent chance that costs will be higher than this estimate.[27] We reported that those estimates were at a low level

[24]We recently reported that more-comprehensive and more-complete cost data can help the Department of Defense improve the cost-effectiveness of sustaining weapons systems. GAO, *2014 Annual Report: Additional Opportunities to Reduce Fragmentation, Overlap, and Duplication and Achieve Other Financial Benefits*, GAO-14-343SP (Washington, D.C.: Apr. 8, 2014).

[25]According to the Navy, the exact deployment date of the Independence variant is classified, but it is notionally planned to deploy before 2017. Navy officials said that an extended mine countermeasures mission-package test period is planned for the USS *Independence* in 2014 in the Gulf of Mexico near Florida, which will likely allow the Navy to update some cost data associated with that variant.

[26]See LCS Seaframe Program Life Cycle Cost Estimate (2011) and the LCS Mission Module Program Life Cycle Cost Estimate (2013). A Program Life Cycle Cost Estimate document provides a detailed explanation of the program's cost components including research, development, test, and evaluation cost, along with operations and support costs, such as maintenance and system improvement, among others. Aircraft accompany LCS and commonly accompany other Navy surface vessels, but their operations and sustainment are funded through the Naval Air Systems Command rather than being included in the ships' operations and support costs.

[27]The confidence level is an output of the statistical risk analysis of the parameters and assumptions used to build the point estimate. Cost-estimating experts agree that a confidence level of between 55 percent and 65 percent is desired to set a program's budget, recognizing that the tendency is for costs to overrun in a program's early phases.

of confidence due to overall lack of operational data on both LCS seaframes and operating concepts that are unique among the surface fleet. In lieu of actual LCS data, the Navy used operations and support data from other surface ships, such as frigates, and modified them to approximate LCS characteristics (referred to by the Navy as modified analogous data) to build the LCS cost estimate. For example, maintenance cost estimates were calculated by modifying analogous data from frigates and destroyers, among other ships, even though the maintenance concepts for these ships differ from those for the LCS.[28] Moreover, since the time when the Navy developed the seaframe estimate in 2011, it has made several programmatic changes to LCS concepts that will increase the overall cost to operate and sustain the ship class.[29] For example:

- The number of shore personnel to support the ship has more than tripled—from 271 to 862—since the estimate was developed in 2011, as support requirements have become better understood.
- The Navy has increased the total number of core crew members onboard each ship from 40 to 50 in order to better address workload and watch-standing requirements.[30]

As the Navy continues to better understand the work requirements associated with the ship class, the required numbers of shore support and ship crew have risen. Navy officials explained that such changes are necessary for the success of the program and acknowledged that those changes would increase the overall costs of the LCS and should be included in future LCS life-cycle cost estimates.

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[28]The LCS Seaframe Program Life Cycle Cost Estimate (2011) provided estimates for all levels of maintenance—organizational, intermediate, and depot—for both variants.

[29]Operations and support costs traditionally account for about 70 percent of the total cost over a system's lifetime.

[30]The Navy increased the core crew size from 40 to 50 for USS *Freedom*'s deployment to Singapore, and this number is now the class standard across both variants. Additionally, *Freedom* deployed with three ensigns as part of a pilot program seeking to increase the junior officer ranks within the LCS community, and officials said the Navy intends on continuing and expanding this program to attach four ensigns to each LCS crew.

LCS Costs May Be Approaching Those of Other Surface Ships with Larger Crews

From the outset of the program, the Navy has described the LCS as a low-cost alternative to other ships in the surface fleet, yet the available data indicate that the per year, per ship life-cycle costs are nearing or may exceed those of other surface ships, including multimission ships with greater size and larger crews. The LCS consists of two distinct parts—the ship itself (seaframe) and the interchangeable mission modules it is expected to carry and deploy. These mission modules consist of various unmanned systems, sensors, and weapons that provide different combat capabilities for the ship's three principal missions. Many LCS cost estimates only refer to the acquisition cost of individual seaframes rather than the total life-cycle cost of the seaframe and mission modules. The operations and support costs for the LCS seaframe that are included in the life-cycle cost estimates are significant—due in part to unique LCS operational concepts—while the LCS mission modules that provide each ship with operational capability account for a significant component of the costs for the ship class. As we noted above, the cost estimates for both the seaframe and the mission modules contain uncertainty; however, we believe that when combined they provide the best available estimate to date of the overall life-cycle costs for the LCS program. Moreover, because the Navy has acknowledged it has made several programmatic changes to LCS concepts that will increase the overall costs to operate and sustain the ship class, it is likely that the per ship, per year life-cycle costs for the program will be higher than this current estimate.[31]

We analyzed the Navy's life-cycle cost estimates for LCS seaframes (2011) and mission modules (2013), which the Navy adjusted for inflation to fiscal year 2014 dollars, and used updated Navy life-cycle cost estimates provided in April 2014 by Naval Sea Systems Command for patrol coastal ships, mine countermeasures ships, frigates, destroyers, and cruisers.[32] These ships were selected for comparison because they

[31]While the Navy told us that material selection changes may increase the reliability of select systems and therefore decrease short-term emergent repair costs, the effects of these changes on long-term operations and support costs is unknown.

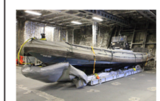
[32]In 2010, the Congressional Budget Office completed a similar and preliminary study of LCS life-cycle costs and compared them to the costs of other ship classes in the surface fleet. This analysis provided us with a framework by which to conduct further analysis using additional and updated data for the LCS, its mission modules, and other surface ship classes. For additional information see Congressional Budget Office, *Life-Cycle Costs of Selected Navy Ships*.

have been in the surface fleet for decades and historical cost data are readily available, and they all conduct at least one mission that the LCS is also expected to perform. We calculated the life-cycle costs on a per ship annualized basis to account for differences in the number of ships and expected service life of each class. As shown in figure 5, we found that per ship life-cycle costs per year for the LCS program are nearing or may exceed those for other surface ships, including guided-missile frigates and multimission destroyers.

We are providing a descriptive comparison of annual life-cycle costs per ship using available data and are not assessing the relative benefits and capabilities of these various ship classes. Navy officials point out that the below estimates may not include the full costs of developing, modernizing, and sustaining software and combat systems installed on the surface ships we use for comparative purposes (e.g., Aegis ballistic missile defense system used on cruisers and destroyers). Additionally, officials stated that the acquisition costs presented are not to be interpreted as replacement costs since a replacement value for the specific ship would have to take into account changes in productivity, design specifications, and legislative and contracting environments. Despite the inherent difficulties associated with comparing the life-cycle costs of various surface ships with differing capabilities and mission sets, and at different points in their respective service lives, we believe this analysis is useful because it provides a framework for comparing the life-cycle cost estimates of various surface ships on a per ship, per year basis, thereby accounting for variations in expected service life and the number of ships. For an overview of the surface ships used in figure 5, including their missions and crew sizes, see appendix IV. We used the Navy's expected ship service lives of record, although the Navy has made decisions to retire vessels before they've reached their expected service lives in some instances and has extended the service lives of other vessels, such as destroyers.[33] For LCS seaframes, the Navy used a 25-year expected service life to calculate life-cycle costs, which is an average of the 20-year service-life threshold and 30-year service-life objective outlined in key performance parameters.

[33] See GAO, *Military Capabilities: Navy Should Reevaluate Its Plan to Decommission the USS Port Royal*, GAO-14-336 (Washington, D.C.: Apr. 8, 2014).

Figure 5: Life-Cycle Cost Estimates of Littoral Combat Ship (LCS) and Various Navy Surface Ships in Constant Fiscal Year 2014 Dollars

	Navy surface ships estimates *(based on actual data)*					Littoral Combat Ship (LCS) estimates	
	 **PC-1 Patrol Coastal Ships**	 **MCM-1 Mine Countermeasures Ships**	 **FFG-7 Frigates**	 **DDG-51 Destroyers (Flight IIA)**	 **CG-47 Cruisers (Upgraded)**	 **LCS seaframes[a]**	 **LCS mission modules[b]**
Number of ships/modules	13 ships	14 ships	51 ships	34 ships	22 ships	55 ships	64 modules
Life-cycle costs per ship/ module	$243 million	$717 million	$1,607 million	$3,508 million	$4,410 million	$1,592 million	$449 million
• Research and development	0 million[c]	3 million	2 million	91 million	9 million	66 million	37 million
• Procurement	33 million	282 million	579 million	1,501 million	1,964 million	506 million	61 million
• Operations and support	210 million	432 million	1,026 million	1,916 million	2,436 million	1,013 million	292 million
• Other[d]	0 million	0 million	0 million	0 million	0 million	7 million	59 million
Expected service life	30 years	30 years	30 years	40 years	35 years	25 years	30 years
Average life-cycle cost per year[e]	$8 million	$24 million	$54 million	$88 million	$126 million	$64 million $79 million	$15 million

Source: GAO analysis of Navy information (data); Department of Defense (DOD) (photos). | GAO-14-447

Notes: Numbers may not add due to rounding. Life-cycle cost estimates for patrol coastal ships, mine countermeasures ships, frigates, destroyers, and cruisers were calculated by Naval Sea Systems Command in April 2014 in fiscal year 2014 constant dollars. For these ship classes, research and development costs are derived from class Selected Acquisition Reports. Procurement costs are derived from the Naval Sea Systems Command Historical Cost of Ships database. Multiyear historical averages for operations and support costs are derived from the Navy Visibility and Management of Operating and Support Costs database. As of April 2014, the Navy reduced its planned number of LCSs to 32 from an original requirement of 55 ships. The Navy created its Program Life Cycle Cost Estimate in 2011 based on the original requirement of 55 ships and has not updated this document to reflect the Navy's plan for 32 LCSs. We did not independently validate the underlying data for the Navy's estimates.

[a]LCS seaframe life-cycle cost estimates are based on the purchase of 55 seaframes. The seaframe cost estimates are calculated in fiscal year 2010 constant dollars, and Naval Sea Systems Command adjusted them for inflation to fiscal year 2014 constant dollars using the appropriate Navy inflation factors in April 2014 for the purposes of this table. The seaframe estimate is at the 10 percent confidence level meaning there is a 90 percent chance that the costs will be higher than this estimate.

[b]LCS mission-module life-cycle cost estimates are based on the purchase of 64 mission modules. The mission-module cost estimates are calculated in fiscal year 2010 constant dollars, and Naval Sea Systems Command adjusted them for inflation to fiscal year 2014 constant dollars using the appropriate Navy inflation factors in April 2014 for the purposes of this table. The mission-module estimate is at the 50 percent confidence level.

[c]The patrol costal class acquisition strategy was a nondevelopmental item. The United States bought the design specification from Vosper-Thornycraft, with Bollinger Shipyards (Lockport, Louisiana) designated as the U.S. Licensee. Therefore, there is no research and development cost for the patrol coastal class.

[d]Other includes costs of disposal and, for LCS mission modules, the costs of technology replacement and upgrades. Naval Sea Systems Command noted that end-of-service-life disposition is variable; ships in some classes are sold to other countries; current market conditions support disposal on a

"sales basis," yielding revenue for the United States. Therefore, no disposal costs are shown for the other surface ship classes.

[e]We calculated the life-cycle costs on a per ship annualized basis to account for different ship numbers and expected ship service lives.

Although the LCS has been identified by the Navy as a low-cost alternative to other surface ship classes, the available data indicate that the costs of the LCS may exceed or closely align with the costs of other multimission surface ships with larger crews. Without comprehensive life-cycle cost estimates, the Navy may be hindered in its ability to evaluate the merits of investing in LCS ships compared with other alternatives, conduct long-term budgetary planning, or determine the level of resources required to implement the program in accordance with the LCS concept of operations.

In 2013, we recommended that the Navy collect actual operational data on the *Independence* variant and update operations and support cost estimates for both variants prior to contracting for additional LCS ships in 2016. Our work shows that the Navy still lacks operational data and that life-cycle cost estimates are still not comprehensive. We continue to believe that the Navy should have greater clarity on the performance of its operational concepts and greater confidence in its cost estimates before it enters into contracts for additional LCS ships.

Agency Comments and Our Evaluation

In written comments on a draft of this report, the Department of Defense (DOD) noted it is concerned with the conclusions drawn from the analysis of life-cycle cost data across ship classes. DOD added that due to known gaps in existing ship class cost data, the available data do not allow for an accurate comparison of the life cycle costs among LCS and other existing surface ship classes. DOD's comments are summarized below and reprinted in their entirety in appendix V. DOD also provided technical comments, which we have incorporated as appropriate.

In its comments, DOD noted differences in the scope of cost data across the ship classes and differences in life-cycle phases among the ship classes included in our life-cycle cost analysis. For example, DOD commented that there are gaps in the Navy's record keeping for operations and support costs, so that some potential costs may not be captured in the estimates the Navy provided us, such as system modernization, software maintenance, and program startup, which could understate the costs of the other surface ships. However, these data are the most comprehensive operations and support cost data that the Navy could provide us. As we noted in the report, the Navy also has used these data from other surface ship classes to build its LCS life-cycle cost estimates. Moreover, we discussed in the report the known limitations to comparing the life-cycle costs of these ship classes, including that the estimates may not include the full costs of developing, modernizing, and sustaining software and combat systems installed on the ships, as well as past acquisition costs not aligning with what current production costs would be, and the ships being at different points in their service lives. Despite the known limitations, we believe our analysis uses the best available data to provide a reasonable comparison of the life-cycle costs across the ship classes. Consequently, we have made no revisions to the report, as suggested by DOD.

Finally, DOD provided us with additional information to clarify that the Navy's mission-module program life-cycle cost estimate is at the 50 percent confidence level. We verified this information and updated the report to include this confidence level.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, and the Secretary of the Navy. In addition, the report is available at no charge on the GAO website at http://www.gao.gov. If you or your staff have any questions about this report, please contact me at (202) 512-3489 or at pendletonj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report are listed in appendix VI.

John H. Pendleton
Director
Defense Capabilities and Management

List of Committees

The Honorable Carl Levin
Chairman
The Honorable James Inhofe
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Richard Durbin
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The Honorable Thad Cochran
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Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Howard P. "Buck" McKeon
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Committee on Armed Services
House of Representatives

The Honorable Rodney Frelinghuysen
Chairman
The Honorable Pete Visclosky
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Scope and Methodology

To address the benefits and limitations of the operational data that have been collected on Littoral Combat Ships (LCS), we analyzed and compared the planned USS *Freedom* deployment schedule with the actual executed schedule. We reviewed documentation related to operational activities while deployed including execution orders, concepts of operations such as the 7th Fleet USS *Freedom* deployment concept of operations, and exercise briefings. We also analyzed operational data from the deployment, including readiness data and equipment casualty reports. We interviewed forward-deployed crew members in Singapore as well as Navy officials responsible for the ship's operational employment at 7th Fleet in Japan to discuss the successes and challenges of the deployment, including any limitations. Further, we analyzed the operational activities of USS *Independence* and interviewed Navy officials to determine what operational data has been collected on *Independence* variant ships. Finally, we reviewed and analyzed the LCS wholeness and warfighting concepts of operations to determine any additional LCS operational and warfighting concepts that still require demonstration.[1]

To assess the extent to which the Navy has evaluated risk in its operational support and sustainment concepts for the LCS in the areas of manning, training, maintenance, and logistics, we reviewed relevant data-collection and analysis plans and mid-point and final reports on the *Freedom* deployment to Singapore in 2013 from Commander Naval Surface Forces Pacific, 7th Fleet, and the Center for Naval Analyses, and we interviewed officials from organizations responsible for collecting and analyzing data from this deployment. We reviewed the LCS wholeness concept of operations, the life-cycle sustainment plans for the LCS, LCS manpower estimate report, LCS training plans, and various other Navy documents associated with LCS manning, training, maintenance, and logistics, and interviewed USS *Freedom* crews who participated in the 2013 deployment, to obtain their perspectives on the implementation of these concepts. We also reviewed the extent to which the Navy has analyzed the costs and benefits associated with the use of contractor flyaway maintenance teams. Finally, we discussed with LCS program office officials and other LCS stakeholders any actions that were being taken to analyze potential risks or mitigate them for future LCS deployments.

[1] U.S. Fleet Forces Command, *LCS Platform Wholeness Concept of Operations Revision D* (Jan. 9, 2013) and classified warfighting concept of operations.

To assess how LCS life-cycle cost estimates compare with those for other surface-ship classes, we modified a framework used in an earlier and similar comparison conducted by the Congressional Budget Office.[2] To do this, we reviewed cost estimates in the current LCS Seaframe Program Life Cycle Cost Estimate (2011) and the LCS Mission Module Program Life Cycle Cost Estimate (2013), both prepared by the cost-estimating division of the Naval Sea Systems Command, and determined that these are the latest estimates available from the Navy. Although the Navy to date has not updated these life-cycle cost estimates (which were estimated using fiscal year 2010 dollars) to reflect changes in the program or the number of ships to be purchased, the Navy adjusted the estimates for inflation to fiscal year 2014 dollars. Using these data, we calculated an annual per ship life-cycle cost estimate for the combined LCS seaframes and mission modules to account for differences in the number of ships and mission modules and their respective expected service lives. We also obtained life-cycle cost data in fiscal year 2014 dollars from the Navy for five surface ships (patrol coastal ships, mine countermeasures ships, frigates, destroyers, and cruisers) and used these data to calculate an annual per-ship life-cycle cost estimate for each of these five surface ships so as to account for differences in the number of ships and their expected service lives. We then compared these data with the annual per ship life-cycle cost data we calculated for the LCS seaframes and mission modules. We analyzed and assessed these data and found them to be sufficiently reliable for the purposes of reporting the estimated life-cycle costs of these surface ships. The five non-LCS surface ships we used for our comparison were selected because historical cost data were readily available and they all conduct at least one mission that the LCS is also expected to perform. Further, we interviewed Navy LCS program officials and cost estimating officials to determine the extent to which data from the USS *Freedom* deployment in 2013 may be used to refine future life-cycle cost estimates.

[2] In 2010, the Congressional Budget Office completed a preliminary study of LCS life-cycle costs and compared them to the costs of other ship classes in the surface fleet. This analysis included Navy data on operations and support costs for mine countermeasures ships, frigates, destroyers, and cruisers and other life-cycle costs components, and compared those costs to projections for each LCS seaframe variant—excluding mission modules. The analysis provided an early glimpse into the seaframe costs of the LCS program and provides a useful framework by which to conduct further analysis using additional and updated data for the LCS, its mission modules, and other surface-ship classes. See Congressional Budget Office, *Life-Cycle Costs of Selected Navy Ships* (Apr. 28, 2010).

We interviewed officials, and where appropriate obtained documentation, at the following locations:

Department of the Navy

- Office of the Chief of Naval Operations
- Naval Sea Systems Command
  - Program Executive Office Littoral Combat Ship, Fleet Introduction Office
  - Cost-Estimating Division
  - Program Executive Office, Ships
- U.S. Fleet Forces Command
- Naval Warfare Development Command
- Navy Manpower Analysis Center
- Southwest Regional Maintenance Center
- LCS Class Squadron
  - Operations
  - Training
- Commander, Naval Surface Force, U.S. Pacific Fleet
- Commander, Naval Air Force, U.S. Pacific Fleet
- Naval Supply Systems Command
- U.S. 7th Fleet
  - Operations
  - Logistics
  - Warfare requirements
  - Training and exercises
- U.S. Pacific Fleet
- Commander, Logistics Force Western Pacific
  - Maintenance
  - Logistics
- Commander, Destroyer Squadron Seven
- Navy Region Center, Singapore

- LCS Class Squadron Forward Liaison Element

Other Organizations

- Congressional Budget Office
- Center for Naval Analyses

We conducted group discussions with USS *Freedom* blue and gold crew officer and enlisted personnel who participated in the 2013 Singapore deployment. The discussions involved small-group meetings designed to gain more in-depth information about specific issues that cannot easily be obtained from single or serial interviews. Our design included multiple groups with varying characteristics but some homogeneity—such as rank and responsibility—within groups. For example, with few exceptions we met with officers separately from enlisted personnel and we met separately with personnel from each major ship department such as engineering, combat systems, and operations. Most groups involved three to five participants. Participants were selected based on their availability by USS *Freedom* commanding and executive officers in Singapore and the LCS Class Squadron in San Diego to ensure we had at least three members from each major ship function. Discussions were held in a semistructured manner using a broad list of discussion topics to encourage participants to share their thoughts and experiences related to the crew-swap experience, crew integration, maintenance, systems reliability, training, logistics support, quality of life, and overall satisfaction with the LCS experience. We assured participants that we would not link their names to their responses.

To gain a broad perspective of crew experience during the USS *Freedom* deployment, we conducted 17 small-group sessions with USS *Freedom* officers and enlisted personnel across all ship departments. Table 4 provides a summary of the composition of the group discussions held by GAO analysts in Singapore (during deployment) and in San Diego (postdeployment). All discussions were held aboard USS *Freedom*.

Table 4: Summary of USS *Freedom* Crew Discussion Groups

USS *Freedom* department	Blue crew	Gold crew
Operations	● ○	○
Engineering	● ○	○
Combat systems	● ○	○
Supply	○	○
Surface-warfare mission module	● ○	○
Department heads	○	
Junior officers	○	
Commanding officer and executive officer	● ○	○

Legend:

● During deployment

○ Postdeployment

Source: GAO. | GAO-14-447

Note: For two discussion groups, we combined *Freedom* blue and gold crew supply department and mission-module personnel, respectively, for logistical purposes.

Our group discussions were not designed to (1) demonstrate the extent of a problem or to generalize results to the entire USS *Freedom* crew population or to other LCS variants, (2) develop a consensus to arrive at an agreed-upon plan or make decisions about what actions to take, or (3) provide statistically representative samples or reliable quantitative estimates. Instead, they were intended to generate in-depth information about the discussion group participants' attitudes and reasons for their attitudes toward specific topics and to offer insights into the range of concerns and support for an issue. The generalizability of the information produced by our discussion groups is limited for several reasons. First, the information represents the responses of USS *Freedom* officers and enlisted personnel from the 17 groups described above. Second, while the composition of the groups was designed to assure a distribution of Navy officers, enlisted personnel, seniority, and ship departments, the group participants were not probabilistically sampled. Third, participants were asked questions about their specific experiences on the Singapore deployment. The experiences of other USS *Freedom* personnel who did not participate in our group discussions may have varied. Because of these limitations, we did not rely entirely on group discussions, but rather used several different methodologies to corroborate and support our conclusions.

We conducted this performance audit from September 2013 to July 2014 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Littoral Combat Ship Plan of Action and Milestones, as of March 2014

In 2012, the Chief of Naval Operations received the results of four internal studies he requested to assess, among other things, the Littoral Combat Ship (LCS) across aspects of manning, training, and maintenance to assist in preparing the USS *Freedom* for deployment in March 2013. Two of the four studies were independent Navy studies—one conducted by the Board of Inspection and Survey (the Navy's ship-inspection entity) and one conducted by the office of the Chief of Naval Operations. These two studies identified concerns with, among other things, LCS manning, training, and maintenance, and recommended steps to improve aspects of the program. The other two studies were two war game reports, which identified findings and made recommendations on LCS operations and sustainment. All four of these reports identified numerous operational support and sustainment issues, such as insufficient manning of ships leading to crew fatigue, inadequate training of crews, incomplete maintenance plans, and insufficient shore support, and culminated in about 170 recommendations for improvement.

The LCS Council developed a Plan of Action and Milestones document as directed by the Chief of Naval Operations to address the findings and recommendations from the four internal Navy reports. The Plan of Action and Milestones is organized around lines of operation (e.g., fleet introduction and sustainability, platform and capabilities evolution, and developing and aligning concept of operations and other documentation) and has over 1,000 action items and milestones—many directly addressing operational support and sustainment issues. Each of the lines of operation has subordinate action items, with a stakeholder assigned responsibility for each action item, and both a start date and expected finish date for the tasking. Table 5 below provides an update on the number of discrete (nonrecurring) subtasks that the Navy has completed as of March 2014.

Table 5: Status of Littoral Combat Ship (LCS) Plan of Action and Milestones Action Items as of March 2014

Line of operation	Fleet introduction and sustainment	Platform and capabilities evolution	Concept of operations, doctrine, and policy
Lead stakeholder	Commander, Naval Surface Force, U.S. Pacific Fleet	Office of the Chief of Naval Operations, Surface Warfare Directorate	U.S. Fleet Forces Command
Number of nonrecurring action items	261	168	70
Scheduled completion dates for all action items	9/2018	9/2018	11/2017
Nonrecurring action items completed by March 25, 2014	171	91	34
Percentage of nonrecurring action items completed as of March 25, 2014	66%	54%	49%
Number of nonrecurring action items overdue	9	5	0

Source: GAO analysis of Department of Defense (DOD) data. | GAO-14-447

Appendix III: Remaining Risks in Implementing Littoral Combat Ship Operational Support and Sustainment Concepts

The Navy is adjusting some operational support and sustainment concepts based on data collected and lessons learned during the USS *Freedom* deployment, but it has not yet addressed some risks that remain in executing and sustaining key manning, training, maintenance, and logistics concepts.

Manning Risks and Navy Actions to Address Them

The Littoral Combat Ship (LCS) manning concept calls for a relatively small crew to operate the ship. The minimal crew size drives many of the other LCS concepts, since LCS sailors are expected to spend most of their time operating the ship rather than performing training, maintenance, or administrative functions. The last revision of the LCS wholeness concept of operations, approved in January 2013, called for a core crew size of 40 and mission-module crews of 15 to 19 sailors.[1] The maximum number of core crew members allowed by LCS key performance parameters is 50.[2] To add berthing spaces for additional crew members beyond 50, the ships would require significant design changes. A number of internal Navy reports issued in 2012 raised concerns about the adequacy of a 40-member core crew size, with crew fatigue and overwork

[1]The core crew operates the LCS seaframe, with sailors organized into four departments: combat systems, engineering, operations, and supply, overseen by the ship's commanding and executive officers. A separate crew operates the mission module deployed with the seaframe, in addition to the aviation detachment crew responsible for the MH-60 helicopter and vertical takeoff unmanned aerial vehicles that are part of each LCS mission package.

[2]Key performance parameters are system characteristics that are considered critical or essential to the development of an effective military capability. Failure of a system to meet a validated key performance parameter threshold brings the military utility of the associated systems into question, and may result in a reevaluation of the program or modification to production increments. The Navy established these LCS manning parameters in 2003.

as potential negative effects of this manning concept.[3] In response to these concerns, the Navy added 10 sailors to the USS *Freedom* core crew deploying to Singapore as part of a pilot program. Navy leadership determined early in the deployment that these additional crew members were helpful in performing maintenance and watch-standing duties, and decided to permanently increase LCS core crews to 50 sailors. The Navy also added three ensigns to the *Freedom* crews prior to deployment, and intends on continuing and expanding this program to attach four ensigns to each LCS crew.[4] In addition to the core and mission-module crews, contractors were also onboard during the course of the deployment to assist with equipment troubleshooting and repair.

Despite the addition of 10 sailors to the core crew and contractor support, data collected from the *Freedom*'s deployment show that sailors' sleep hours did not increase compared to the sleep hours reported in studies that examined LCS with 40-member crews; this suggests that the Navy has not fully addressed crew fatigue issues by increasing crew size.[5] Specifically, the Center for Naval Analyses found that *Freedom* crews averaged about 6 hours of sleep per day compared to the Navy standard of 8 hours; some key departments, such as engineering and operations, averaged even fewer. While Navy officials told us that sailors do not realistically expect 8 hours of sleep while they are under way and may choose to have more down time rather than sleep, the LCS must adhere to Navy manpower standards, including those for crewmember fatigue

[3]Two of the studies were independent Navy studies—one conducted by the Board of Inspection and Survey (the Navy's ship-inspection entity) and one conducted by the office of the Chief of Naval Operations. These two studies identified concerns with, among other things, LCS manning, training, and maintenance, and recommended steps to improve aspects of the program. Two other studies were war game reports, which identified findings and made recommendations on LCS operations and sustainment. All four of these reports identified numerous operational support and sustainment issues, such as insufficient manning of ships leading to crew fatigue, inadequate training of crews, incomplete maintenance plans, and insufficient shore support, and culminated in about 170 recommendations for improvement. In September 2013, we issued a For Official Use Only report that assessed the extent to which the Navy addressed these recommendations.

[4]Ensign is the junior commissioned officer rank in the United States Navy. Navy officials explained that the ensign program will be helpful in building an officer corps for this relatively new ship class.

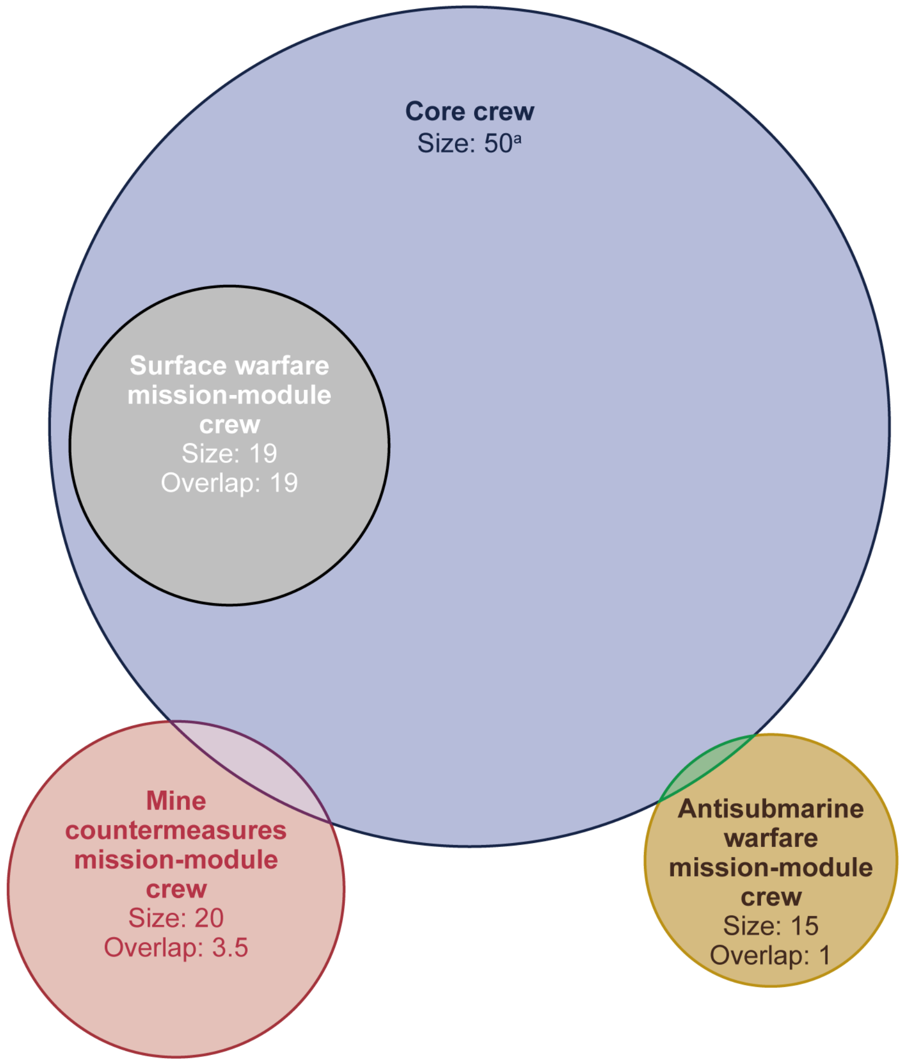
[5]The Center for Naval Analyses compared both crews' sleep hours during the deployment against those collected during a 2010 sleep study and Rough Water Trials conducted in 2011.

levels and workload hours found in Navy standard workweeks. These standards are set to minimize potential adverse effects on morale, retention, and safety.[6] Crew members told us that their sleep hours decreased significantly during major equipment casualties, particularly those affecting the ship's diesel generators and other engineering systems. Navy officials said that follow-on ships have been outfitted with different systems that are supposed to be more reliable than those on *Freedom*, which should decrease the amount of corrective maintenance required, and thereby decrease crew fatigue on future deployments. However, as previously discussed, these systems have not been fully tested or operated on the LCS, and their reliability has yet to be proven by actual experience.

Additionally, we found that core crews depended heavily on sailors from the surface warfare mission-module crew to perform watch standing, training drills, and engineering maintenance over the course of the deployment. This is a departure from what was envisioned in the concept of operations, and creates a situation that may not be sustainable under a different pace of operations or with a different mission module deployed. Officers and enlisted sailors from both core and mission-module crews told us that mission-module sailors were heavily leveraged to help complete core crew functions and that the crews were fully integrated. The crews added that the surface warfare mission module is uniquely qualified to help with core crew functions, since these sailors' billet structure—their mix of skills and expertise—completely aligns with that of the core crew. For example, there are engineers in the surface-warfare mission-module crew to operate and maintain the motors on the module's rigid-hull inflatable boats. Since these boats are not part of the antisubmarine warfare mission modules, there are no engineers in those crews. Sailors from the core crews' engineering department told us they depended on the qualified mission-module engineers to assist them and were at a loss as to how the engineering department would function effectively if deployed with the other mission modules. Figure 6 shows the extent of overlap between the core crew billets and the three mission-module crew billets.

[6] Office of the Chief of Naval Operations Instruction 1000.16K Change Transmittal 1, *Navy Total Force Manpower Policies Procedures*, Encl. 1, App. C., paras. 1.b. and 4.a. (Oct. 4, 2011).

Figure 6: Extent of Overlap in Billets between Littoral Combat Ship (LCS) Core Crew and Mission-Module Crews



Source: GAO analysis of Navy data. | GAO-14-447

[a]The Navy has increased the core crew from 40 to 50, but it is still determining the billet structure for the 10 additional sailors.

Core crews also relied heavily on support from the maintenance contractors embarked during the course of the deployment.[7] Program officials and crew members cited these contractors' expertise with engineering systems and said they were of great assistance, essentially becoming additional highly experienced engineers always on watch in the engineering space. Engineering department crew members told us that the ship would not have gotten under way if not for these contractors. Program officials do not yet know whether contractors will always be embarked during future LCS deployments, but they said that the Navy utilizes contractors on other surface combatants when they are deployed and underway. Navy officials noted that USS *Fort Worth*, deploying in late 2014, will have two contractor personnel onboard.

The Navy Manpower Analysis Center (NAVMAC) is in the ongoing process of analyzing the workload of USS *Freedom'*s core and surface-warfare mission-module crews.[8] The Navy expects the analysis to be complete by February 2015, and it will establish the manning requirement for *Freedom* variant core crews and surface-warfare mission-module crews. NAVMAC's analysis produces a Ship Manpower Document, which establishes the required number and composition of personnel on the ship. The ship manpower document is developed by analyzing the ship's required operational capabilities, projected operational environment, and concept of operations as a starting point and building an independent assessment of the required number and composition of the crews, based on Navy standards and observations of operations. However, the NAVMAC analysis uses as its baseline LCS program concepts that delineate work between independent and separately operating core and mission-module crews, so it does not account for the significant leveraging of mission-module crew or for embarked contractors to perform core crew functions. Additionally, the analysis may not fully account for some additional work that crews are performing that is not included in the concept of operations, like training while under way. NAVMAC officials said that they collaborate with program offices and type commanders early in a ship's acquisition phases so that initial crew projections and manning concepts are feasible and realistic, but they said

[7]As many as six contractors were aboard USS *Freedom* during its transit from San Diego to Singapore with a minimum of two contractors onboard at any given time.

[8]NAVMAC leads the manpower requirements-determination process, which identifies multiyear manpower requirements to support the budgeting process.

that they expect some changes to the LCS manning structure based on their initial observations.

Manpower requirements for the other variant and mission modules have not yet been validated. A similar study to determine the requirements for *Independence* variant crews is scheduled to begin in 2016. Since the mine countermeasures and antisubmarine warfare mission modules are still being developed, validation of their crews has not been scheduled. Without validating the optimal crew size and billet structure for all LCS crews and without accounting for the full scope and distribution of work performed by sailors across all ship departments, the Navy risks that crew fatigue will exceed Navy standards and could negatively affect crew members’ performance as well as morale, retention, safety, and ultimately the operational readiness of the ship class.

Training Risks and Navy Actions to Address Them

The LCS training concept calls for sailors to report to a core or mission-module crew qualified to stand watch and carry out their other duties. Most LCS training is conducted off the ship in a classroom or simulator setting as operational demands do not allow sufficient time for training during operational periods. Crews are expected to be fully trained (qualified and certified) prior to deployment, and there is no training department embedded within the crew and no training required while under way.[9]

During discussions with *Freedom* crews, we found that not all sailors had completed training prior to deploying to Singapore. The 10 sailors added to the crew as part of the “plus-up” pilot program were identified in the months leading up to the March 2013 deployment date and did not undergo LCS-specific training or complete their qualifications prior to deploying. Some of these 10 additional crew members were junior sailors and told us they had limited sailing experience but were ultimately able to earn their qualifications over the course of the deployment. More-experienced core crew members who completed LCS training were in

[9]Train-to-qualify is the process of training an individual in an off-ship environment in the knowledge, skills, and abilities required to competently perform tasks associated with a designated ship-board watch station or position. Train-to-certify is the advanced training for a team once qualification has been achieved by individuals. It is achieved through demonstrated proficiency in operating equipment and completing scenarios as a team, and also relies heavily on shore-based training.

part responsible for instructing and training these additional 10 sailors, a collateral duty not accounted for within the standard LCS workday or envisioned in the LCS concept of operations. The Navy is in the process of reviewing and defining training needed for the 10 additional sailors, but since the training pipeline for LCS service can take about 2 years to complete, the Navy risks repeating this situation on upcoming deployments.[10]

While the Navy is reviewing training for the late-addition ensigns and the 10 “plus-up” sailors, it considers the training process to have been validated by the *Freedom* deployment, since no major training omissions or deficiencies were identified. However, we found that in addition to the 10 “plus-up” sailors not receiving all training prior to deployment, sailors from the original 40-person crews were training over the course of the deployment as well. The Center for Naval Analyses found that more than half of the qualification and instructed training that occurred during the deployment was for the original core crews, not the crew plus-ups. The Center for Naval Analyses added that sailors will train no matter what—at times out of necessity but also to maintain proficiency and in support of career development and well-being—and that time must be made available for training during deployments. The Center for Naval Analyses calculated the average amount of training conducted by all crew members over the course of the deployment to be about an hour a day. However, this hour is unaccounted for in the Navy’s expected LCS workday and detracts from the time a sailor could otherwise be resting or performing other collateral duties. The most common reasons for performing training, drills, and underway instruction while deployed were to cover training that was not provided prior to the deployment or to maintain proficiency. LCS program officials explained that much of this training was planned to be conducted during the deployment, and that underway training will likely continue until the new curriculum is fully implemented over the next several years. However, requiring LCS sailors to train while deployed was not envisioned in the LCS wholeness concept of operations, and it can exacerbate crew fatigue levels and negatively affect performance, morale, retention, safety, and the operational readiness of the ship.

[10]In February 2010, we reported that the Navy faced risks in its ability to identify and assign LCS personnel given the time needed to achieve the extensive training required. See GAO, *Littoral Combat Ship: Actions Needed to Improve Operating Cost Estimates and Mitigate Risks in Implementing New Concepts*, GAO-10-257 (Washington, D.C.: Feb. 2, 2010).

In addition to sailors not being fully trained prior to deployment, we heard concerns about the quality of the training the sailors received. The Navy is aware of this and is investing heavily in virtual reality–based training simulations and a curriculum to prepare sailors for LCS service as envisioned in the concept of operations. Specifically, the Navy has budgeted for construction of another LCS training facility in Mayport, Florida, and awarded several contracts valued up to $300 million to develop training simulations. While the final LCS training infrastructure is being developed, the program is training sailors through a combination of classroom instruction, vendor training (whereby contractors or original-equipment manufacturers train sailors on how to operate certain equipment), shore-based trainers, and very limited on-hull "school ship periods" to complete the qualification and certification process. Enlisted sailors from both core crews across ship departments expressed general dissatisfaction with the LCS training they received prior to the deployment. Some cited the obsolescence of vendor training and the limited utility of the 3-week LCS Academy in preparing them to serve on the LCS, and others stated that insufficient training left them ill-prepared to deal with contingencies on the deployment. *Freedom* officers said that it will take time for training to adapt to the needs of LCS sailors, but that it would make sense to cut the training that is not proving useful to LCS sailors in the short term until a more-tailored curriculum is developed. Navy training officials told us that they are aware of some of the quality issues with the current training and are attempting to make reasonable improvements that are cost-effective, but they pointed out that this interim training will be phased out over the next several years. While the program seeks to have useful and applicable training available for sailors progressing through the training pipeline now, the officials added that it would not be prudent to make major investments to overhaul temporary training.

Navy officials told us that they are in the process of reviewing a revised LCS training plan that should be released in 2014. The training plan will lay out the schedule and process for replacing current training with the new simulations being developed. While this plan was not released early enough for inclusion in our review, earlier versions of LCS training plans did not include measures of effectiveness or training effectiveness-evaluation plans. In light of crew feedback on the inadequacy of current training, and unless the Navy acts on this feedback and builds effectiveness measures into its new training plan, it risks making significant investments to develop training that will not meet LCS sailors' training needs. Additionally, the Navy risks deploying LCS crews that are not properly qualified and certified, which in turn could negatively affect the crews' ability to operate and maintain the ship and perform warfighting duties as expected.

Maintenance Risks and Navy Actions to Address Them

Because of the relatively small size of LCS crews, the maintenance concept calls for contractors to perform most preventative maintenance during regularly scheduled in-port periods. During the Singapore deployment, USS *Freedom* executed this concept, returning to port every 25 days to undergo a 5-day preventative maintenance availability and every 120 days for a more-intensive 2-week intermediate maintenance availability. Flyaway maintenance teams of about 30 contractors were flown to Singapore for the 5-day maintenance periods, and about 60-70 contractors for the 2-week periods. Because of the regular returns to Singapore for maintenance availabilities, the USS *Freedom* had a somewhat limited range in theater, and Navy officials noted that this rigid maintenance periodicity limited operational flexibility. Navy officials explained that this was a deliberate decision and that future deployments will have a longer, more-flexible interval for scheduling in-port maintenance. During the maintenance availabilities, there were some maintenance checks that could not be completed because the needed parts, tools, or equipment were not prepositioned by the contractor in time. The Navy attributes some of these issues to changing the maintenance schedule without enough lead time for the contractor to adequately respond. The Navy notes that contractor execution rates improved over the course of the deployment, and the Navy has established an improved maintenance scheduling process that should help prevent this problem on future deployments.

Although contractors reportedly improved their positioning of materiel in time for the scheduled maintenance periods, Navy officials and *Freedom* crews said that lack of continuity in contractor personnel is an issue. They said that it is not unusual to see different contractors sent every month to perform scheduled maintenance. This presents a problem, since there is a learning curve associated with new maintainers coming onboard to execute their assigned maintenance checks. *Freedom* sailors told us that the burden of teaching new contractors how to complete their checks often falls on them, as does the task of repairing any equipment broken in the course of an inexperienced or unqualified contractor trying to maintain it. While Navy officials said that quality-assurance provisions will be included in the maintenance contracts expected to be awarded later in 2014, officials acknowledged that these provisions may not address this problem.

Although contractors perform much of the preventative maintenance on LCS, the crews are still responsible for performing limited checks between scheduled maintenance periods. Sailors are largely responsible for performing more-frequent daily or weekly maintenance checks, and contractors for those that are required monthly or quarterly. During the deployment, the Center for Naval Analyses reported that *Freedom* sailors performed both scheduled and corrective maintenance actions each day (see fig. 7).

Figure 7: USS *Freedom* Sailor Conducting Engine Maintenance during Singapore Deployment

USS *Freedom* crewmember performs maintenance on diesel engine.

Source: Department of Defense (DOD). | GAO-14-447

However, crew members told us that unexpected levels of maintenance activities impacted crew fatigue levels. Navy officials stated this maintenance effort reflects the materiel reliability issues that they say have been remedied for follow-on LCS ships. Yet crew members told us of several instances where some of their preventative maintenance responsibilities would be better suited to contractors and other examples of how some routine maintenance activities could be shifted from contractors to crew. For example, members of the combat systems department crew reported that approximately 90 percent of combat systems spaces are sensitive and therefore require the presence of LCS crew members in the workspace while contractors complete maintenance on department systems. Crew members must essentially “shadow” contractors as they perform such basic tasks as changing batteries and cleaning filters. Each maintenance activity has a tag that specifies the amount of time it should take to perform the check, and crew members voiced frustration over having to watch contractors take the full amount of time to perform the check even if they could have performed it in a fraction of the time specified on the tag.

A major action item in the LCS Plan of Action and Milestones calls for developing an integrated and coordinated plan for the planning, executing, tracking, reporting, and quality assurance of planned maintenance between the ship’s force, shore sailors, the LCS Squadron, and contractors on both variants. However, this broad action item, as well as another action item calling for the continuous review of maintenance requirements, extends out to December 2015 for completion. Program officials said that the current process for refining maintenance requirements—where changes in the frequency or responsibility for maintenance actions is reviewed and approved by the Navy’s in-service engineering agents or through maintenance effectiveness reviews—is adequate, but added that the program is still working to develop a tool that would allow better management and coordination of maintenance activities.[11] For example, greater visibility into the full scope of planned maintenance work performed by both crew and contractor personnel would allow program managers greater foresight into how and when certain parts should be repaired or replaced.

[11]Maintenance requirements are established and managed by the Navy’s in-service engineering agents who must approve shifts in the responsibility of a maintenance check from a contractor to a crew member or vice versa. Maintenance checks are permitted to be conducted more frequently than what the requirement calls for, but in-service engineering agent approval is needed to extend the periodicity of a check (e.g., changing a required check from being performed monthly to quarterly).

The Navy is implementing a pilot condition-based maintenance program, whereby sensors installed on ship systems collect usage and reliability data, with the intention of conducting maintenance based on the condition of the equipment rather than according to a predetermined schedule. As more data are collected on equipment failure rates by condition-based maintenance sensors and as knowledge of LCS systems grows, the Navy intends for some maintenance requirements to be eventually phased out without increasing the risk of failure or sacrificing reliability. For example, there are a number of shut-off valves on the *Freedom* variant with a scheduled maintenance requirement to check them every month. These could be continuously monitored by sensors rather than being checked by a contractor or crew member on a monthly basis. The LCS program office has plans to expand the condition-based maintenance program on other LCS ships; for example, USS *Fort Worth* is being fitted with additional sensors in preparation for its late 2014 deployment.

The maintenance concept for LCS may be changed in the future. The LCS program office requested that a business-case analysis be conducted to develop a sustainment strategy that will provide the most cost-effective solution for providing LCS maintenance outside the continental United States. The analysis, completed in April 2013, compared five alternatives to the current contractor-based maintenance approach and recommended shifting responsibility from contractors to shore-based Navy personnel to achieve cost savings and other improvements. The Navy is exploring options to enact this recommendation under different scenarios and plans to do so as more LCSs are deployed to more forward operating stations. For example, the Navy plans to use reservists to conduct some LCS maintenance in lieu of contractors and intends to shift more maintenance responsibility to shore-based Navy personnel. However, program officials said that they may be somewhat limited in carrying out the recommendation by statutory maintenance requirements that govern how maintenance is performed abroad for ships, such as the LCS, that are homeported in the United States.[12] The Navy is planning to award 5-year maintenance contracts later this year, and officials said there will be enough flexibility built into the contracts to allow experimentation with different maintenance alternatives.

[12]Section 7310 of title 10 U.S.C. states that a naval vessel homeported in the United States or Guam may not be overhauled, repaired, or maintained in a shipyard outside the United States or Guam, other than in the case of voyage repairs.

Logistics Risks and Navy Actions to Address Them

Shore-based support networks perform LCS logistics functions such as administrative tasks, emergent repairs, and management of ship support needs. Primary support is provided by the LCS Squadron in San Diego. For the USS *Freedom* deployment, several entities based in Singapore provided additional support, including the LCS Squadron Forward Liaison Element—12 LCS Squadron personnel sent to Singapore for the course of the deployment to provide local support and coordination on maintenance activities and ship reporting—and the Commander, Logistics Group, Western Pacific—7th Fleet's principal logistics group stationed in Singapore, which was responsible for emergent maintenance on USS *Freedom*.[13] Navy officials noted several command and control–related challenges associated with this distance support concept during the *Freedom* deployment. For example, the ship's crew did not follow established distance support processes to address emergent maintenance needs, resulting in significant opportunity costs and duplication of effort. The LCS Squadron is revising its written instructions to resolve this issue for future deployments. However, some of the reporting duties that were supposed to be performed by shore support teams under original distance support concepts—such as reporting of equipment casualties—have now become crew responsibilities. Officials said the time difference between San Diego and Singapore was creating a lag in reporting and response times and cited this as a reason for shifting some reporting duties back to the crew. As mentioned earlier, adding additional responsibilities to an LCS sailor's already-full workday may exacerbate crew fatigue and may require reallocation of workloads or other revisions to the LCS concept of operations.

We found several additional limitations of the LCS support infrastructure over the course of the deployment. For example, the Navy noted that existing Internet resources ashore were insufficient for managing maintenance, and the Navy continues to explore options with the host nation for improving connectivity. Another issue still being resolved is finding adequate providers for facilities maintenance and ship cleaning, as the services contracted for *Freedom*'s deployment were not up to

[13]Commander, Logistics Group Western Pacific, principal logistics agent for the 7th Fleet, located in Singapore, is responsible for emergent maintenance and replenishments for ships throughout 7th Fleet including USS *Freedom* during its deployment. Emergent maintenance is unplanned need-based maintenance, for example, repairs required by an equipment casualty or malfunction. Emergent maintenance is defined in Office of the Chief of Naval Operations Inst. 4700.7L, Encl. 8, para. 9 (May 25, 2010).

sailors' expectations. The Navy would also prefer to have LCS hulls cleaned while deployed and is in the process of determining a cost-effective way to execute this task in compliance with statutory maintenance requirements.[14] Finally, USS *Freedom* required nearly three times as many underway refuelings as were scheduled.[15] Navy logisticians in Singapore scheduled seven at-sea refuelings for the deployment but 18 were eventually required. LCS program officials say that this was a scheduling error rather than an indication of higher-than-expected fuel burn rates. As the Navy gains more operational experience in an overseas environment, it expects to learn additional lessons about more-accurately scheduling LCS refuelings.

Additionally, Navy officials acknowledged that the logistics footprint needed to support four LCSs in Singapore by 2017 must be defined and expanded over the next several years. The Navy is in the process of determining the final logistics requirements to support additional ships at Singapore and other forward operating stations; these efforts are scheduled to be completed by April 2014.[16] Currently, there is only a temporary tension-fabric structure in Singapore to house spare parts, tools, and working space for maintenance contractors, but this temporary structure does not have adequate space to house support elements for four LCS of both variants, according to Navy officials. Permanent support facilities have not been built in Singapore or other potential forward operating stations, and the lack of operational data on the *Independence* variant limits the Navy's ability to accurately plan for logistics support when both variants deploy. Without a clear understanding of the logistics needs of both variants, the Navy risks being underprepared to support both while forward deployed.

[14]Section 7310 of title 10 U.S.C. states that a naval vessel homeported in the United States or Guam may not be overhauled, repaired, or maintained in a shipyard outside the United States or Guam, other than in the case of voyage repairs.

[15]USS *Freedom* has the least fuel capacity of existing LCS ships. Navy officials noted that *Independence* variant ships have at least 50 percent more fuel capacity and additional fuel capacity has been added to follow-on *Freedom* variant ships.

[16]See LCS Plan of Action and Milestones.

Appendix IV: Overview of Navy Surface Ships Used in Life-Cycle Cost Comparison

Cruisers (CG)

Large guided-missile combat vessel with multiple target response capability.

Length: 567 feet

Displacement: 9,754 metric tons

Speed: 30 plus knots

Armament: Mark 41 vertical launching system Standard Missile; Vertical Launch Anti-Submarine Rocket Missile; Tomahawk Cruise Missile; six Mark-46 torpedoes (from two triple mounts); two Mark 45 5-inch/54 caliber lightweight guns; two Phalanx close-in-weapons systems; two helicopters

Crew: 29 officers, 297 enlisted

Destroyers (DDG)

Large guided-missile combat vessel with multiple mission offensive and defensive capabilities.

Length: Flight IIA: 509 feet

Displacement: 9,648 metric tons

Speed: 30 plus knots

Armament: Standard Missile; Vertical Launch Anti-Submarine Rocket missiles; Tomahawk Cruise Missile; six Mark-46 torpedoes (from two triple mounts); Close In Weapon System, 5" Mark 45 Gun, Evolved Sea Sparrow Missile; two helicopters

Crew: 24 officers, 279 enlisted

Frigates (FFG)

Fulfill a protection of shipping mission as anti-submarine warfare combatants for amphibious expeditionary forces, underway replenishment groups, and merchant convoys.

Length: 445 feet

Displacement: 4,165-4,369 metric tons

Speed: 29 plus knots

Armament: Six Mark-46 torpedoes (from two triple mounts); one 76 mm (3-inch)/62 caliber Mark 75 rapid fire gun; one Phalanx close-in-weapons system; one or two helicopters

Crew: 17 officers, 198 enlisted

See next page.

Mine Countermeasures Ships (MCM)

Mine sweepers/hunter-killers capable of finding, classifying and destroying moored and bottom mines.

Length: 224 feet

Displacement: 1,333 metric tons

Speed: 14 knots

Armament: Mine neutralization system; four .50 caliber machine guns

Crew: 9 officers, 83 enlisted

Patrol Coastal Ships (PC)

Perform coastal patrol and interdiction surveillance, including maritime homeland security.

Length: 179 feet

Displacement: 387 metric tons

Speed: 35 knots

Armament: Two Mark 38 25mm machine guns; four .50 caliber machine guns; two Mark 19 40mm automatic grenade launchers; two M-60 machine guns

Crew: 4 officers, 25 enlisted

Littoral Combat Ship (*Freedom* Variant)

Designed to defeat asymmetric antiaccess threats such as mines, quiet diesel submarines, and fast surface craft.

Length: 387 feet

Displacement: 3,400 metric tons

Speed: 40 plus knots

Armament: See Littoral Combat Ship mission modules

Crew: 50 plus mission package crew

See next page.

Littoral Combat Ship (*Independence* Variant)

Designed to defeat asymmetric anti-access threats such as mines, quiet diesel submarines and fast surface craft.

Length: 418 feet

Displacement: 3,100 metric tons

Speed: 40 plus knots

Armament: See Littoral Combat Ship mission modules

Crew: 50 plus mission package crew

Littoral Combat Ship Mission Modules

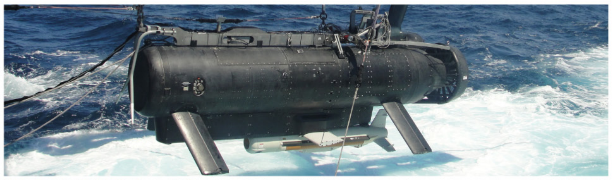
Each mission module, when combined with the mission-module crew and an aviation detachment, provides warfighting capabilities for one of the three focused mission areas.

Surface warfare: Maritime security and destruction of small-boat threats

Mine countermeasures: Detection and neutralization of mine threats

Antisubmarine warfare: Detect, classify, localize, and destroy enemy submarines

Crew: 15-20



Source: Department of Defense (DOD). | GAO-14-447

Appendix V: Comments from the Department of Defense

Note: The Department of Defense provided comments and a security review on a draft of this report. DOD deemed certain technical information to be sensitive but unclassified, which GAO omitted from the report to allow for public release.

THE ASSISTANT SECRETARY OF DEFENSE
3015 DEFENSE PENTAGON
WASHINGTON, DC 20301-3015

ACQUISITION

JUN 5 2014

Mr. John Pendleton
Director
Defense Capabilities and Management
U.S. Government Accountability Office
441 G Street NW
Washington, DC 20548

Dear Mr. Pendleton:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-14-447SU, "LITTORAL COMBAT SHIP: Deployment of USS Freedom Revealed Risks in Implementing Operational Concepts and Uncertain Costs," dated April 17, 2014 (GAO Code 351865). The Department acknowledges receipt of the draft report.

The Department is concerned with the conclusions drawn from the analysis of life cycle cost data across ship classes contained in the draft report in statements such as the following on page 23 of the draft report:

> "…we found that the per-ship life-cycle cost per-year for the LCS program are nearing or may exceed those for other surface ships, including guided missile frigates and multi-mission destroyers."

The Department recommends that you modify your conclusions by saying that the available data does not allow for an accurate comparison of the life cycle costs among LCS and other existing surface ship classes due to known gaps in existing ship class cost data. The data gaps detailed below should also be identified clearly in the final report and associated with Figure 5 at page 25 and on the Highlights page at the beginning of the draft report.

Differences in the scope of cost data across the ship classes The cost of combat system development, software maintenance, and ship modernization is not fully included in the legacy platform (i.e., non-LCS) historical costs. For example, Aegis combat system development, procurement, modernization, baseline upgrade, sustainment, and training costs should be applied to the DDG 51 and CG 47 costs. The Navy funds DDG 51 and CG 47 ship and combat system midlife modernization efforts separately from the ongoing operation and sustainment of those ship classes. These efforts are not fully captured in the Visibility and Management of Operating and Support Cost (VAMOSC) database so gaps exist in reported costs for areas such as system modernization and software maintenance. Further, Navy systems that are purchased through Participating Acquisition Resource Managers would not necessarily be included in a legacy ship's historical costs, whereas the LCS data includes all of those costs.

Differences in life cycle phases among the ship classes The costs from FFG 7 and CG 47 Classes only include the later stages in their service lives. This reflects the savings achieved through system maturity and experience in sustainment, procurement, and operations that have not yet been experienced by the LCS program. Likewise, many of the first of class costs for the DDG 51 program would have been captured in Flight I actuals and thus are not included in the Flight IIA costs, as they are in LCS. Additionally, many of the costs associated with DDG 51 program startup to establish land-based development, integration, and test sites; shore support; training simulators; indirect support; and military construction are not captured by Flight IIA costs, but program startup is included as part of the LCS costs. Disposal costs are not captured consistently across the platforms (seaframe and mission modules includes disposal; other surface ships do not) causing LCS costs to be skewed higher.

Confidence Level of the Cost Estimate of the LCS Mission Modules The draft report states that the Navy did not have a confidence level for its formal Program Life Cycle Cost Estimate although the Navy's submission indicated it used a 50% confidence level.

The Department appreciates the opportunity to comment on the draft report. For further questions concerning this report, please contact Mr. James MacStravic, Deputy Assistant Secretary of Defense, Tactical Warfare Systems, 703-697-9387.

Sincerely,

Katrina McFarland

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Appendix VI: GAO Contact and Staff Acknowledgments

GAO Contact

John H. Pendleton, (202) 512-3489 or pendletonj@gao.gov

Staff Acknowledgments

In addition to the contact named above, Suzanne Wren, Assistant Director; Steven Banovac; Kristine Hassinger; Joanne Landesman; Carol Petersen; Michael Silver; Amie Steele; Sabrina Streagle; Grant Sutton; and Chris Watson made key contributions to this report.

Related GAO Products

Navy Shipbuilding: Significant Investments in the Littoral Combat Ship Continue Amid Substantial Unknowns about Capabilities, Use, and Cost. GAO-13-738T. Washington, D.C.: July 25, 2013.

Navy Shipbuilding: Significant Investments in the Littoral Combat Ship Continue Amid Substantial Unknowns about Capabilities, Use, and Cost. GAO-13-530. Washington, D.C.: July 22, 2013.

Defense Acquisitions: Realizing Savings under Different Littoral Combat Ship Acquisition Strategies Depends on Successful Management of Risks. GAO-11-277T. Washington, D.C.: December 14, 2010.

Navy's Proposed Dual Award Acquisition Strategy for the Littoral Combat Ship Program. GAO-11-249R. Washington, D.C.: December 8, 2010.

Defense Acquisitions: Navy's Ability to Overcome Challenges Facing the Littoral Combat Ship Will Determine Eventual Capabilities. GAO-10-523. Washington, D.C.: August 31, 2010.

Littoral Combat Ship: Actions Needed to Improve Operating Cost Estimates and Mitigate Risks in Implementing New Concepts. GAO-10-257. Washington, D.C.: February 2, 2010.

Defense Acquisitions: Realistic Business Cases Needed to Execute Navy Shipbuilding Programs. GAO-07-943T. Washington, D.C.: July 24, 2007.

Defense Acquisitions: Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships. GAO-05-255. Washington, D.C.: March 1, 2005.

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