



July 2014

# LITTORAL COMBAT SHIP

Additional Testing and  
Improved Weight  
Management Needed  
Prior to Further  
Investments

# GAO Highlights

Highlights of [GAO-14-749](#), a report to congressional committees

## Why GAO Did This Study

LCS represents an innovative approach to Navy acquisitions and operations, consisting of a ship—called a seaframe—and reconfigurable mission packages. These packages provide combat capability to perform three primary missions: surface warfare; mine countermeasures; and anti-submarine warfare. The Navy plans to buy no more than 32 seaframes in two variants from two shipyards, and 64 mission packages, with an estimated acquisition cost of over \$25 billion in 2010 dollars. GAO was mandated to examine elements related to the LCS program. This report examines (1) knowledge that the Navy has gained since GAO issued a report on the LCS program in July 2013 and (2) outstanding acquisition risks with the LCS program. GAO analyzed key documents, including test and weight reports, and interviewed Navy officials responsible for the LCS deployment and program officials. This report is a public version of a sensitive but unclassified report issued in April 2014.

## What GAO Recommends

GAO recommends that the Navy (1) demonstrate certain capabilities for both LCS seaframe variants before the Navy is approved for future contract awards and (2) ensure a timely review of contractor seaframe weight reports and take actions to make contractors more responsive to comments on the reports' content. DOD agreed with the weight report recommendation and partially agreed with the other, noting that it intends to complete as much testing as possible—but not all—before releasing the request for proposals for future contracts.

View [GAO-14-749](#). For more information, contact Michele Mackin at (202) 512-4841 or [mackinm@gao.gov](mailto:mackinm@gao.gov).

July 2014

## LITTORAL COMBAT SHIP

### Additional Testing and Improved Weight Management Needed Prior to Further Investments

## What GAO Found

Since July 2013, the Navy has continued to demonstrate and test various facets of Littoral Combat Ship (LCS) systems and capability, but important questions remain about how LCS will operate and what capabilities it will provide the Navy. The first operational deployment of an LCS to Singapore gave the Navy an opportunity to examine key LCS concepts operationally. The deployment was limited to only one of the two variants carrying one of three mission packages. In addition, mechanical problems prevented the ship from spending as much time operationally as planned. As a result, some key concepts could not be tested. The Navy has completed some additional testing on the seaframes and mission packages, which has enabled the Navy to characterize performance of some systems, but performance has not yet been demonstrated in an operational environment.

Outstanding weight management and concurrency risks related to buying ships while key concepts and performance are still being tested continue to complicate LCS acquisitions. Initial LCS seaframes face capability limitations resulting from weight growth during construction. This weight growth has resulted in the first two ships not meeting performance requirements for sprint speed and/or endurance, as well as potentially complicating existing plans to make additional changes to each seaframe design. Several seaframes now do not have the required amount of service life allowance—margin to accommodate future changes without removing weight over the ship's lifetime—but Navy officials said they have a plan to recover the service life allowance on the *Independence* class variant.

Status of Recent Littoral Combat Ship (LCS) Service Life Allowances		
	Ship	Currently meets service life allowance requirements? <sup>a</sup>
<b>Freedom Variant</b>	<b>LCS 1</b>	No—24 tons less than requirement
	<b>LCS 3</b>	Yes—exceeds requirement by 106 tons
	<b>LCS 5<sup>b</sup></b>	Yes—exceeds requirement by 17 tons
<b>Independence Variant</b>	<b>LCS 2</b>	No—67 tons less than requirement
	<b>LCS 4</b>	No—34 tons less than requirement
	<b>LCS 6<sup>b</sup></b>	No—19 tons less than requirement

Source: GAO analysis of Navy data. | GAO 14-749

<sup>a</sup> LCS has a service life allowance requirement of 50 metric tons. Numbers are rounded.

<sup>b</sup> LCS 1-LCS 4 have been delivered and therefore builder's margin remaining has become part of the service life allowance. LCS 5 and LCS 6 are still in construction and could gain available service life allowances if weight reserved for design and construction variations are not used.

The Navy has not received accurate or complete weight reports from the seaframe prime contractors, and the Navy's lengthy review process has hindered a timely resolution of the Navy's concerns. Additionally, a number of significant test events, including rough water, shock and total ship survivability trials, will not be completed in time to inform upcoming acquisition decisions—including future contract decisions. Finally, the Navy's recent decision to accelerate low rate initial production of mission packages above the quantity necessary for operational testing limits the flexibility that the program will have to adjust to any problems that may arise during operational testing.

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## Abbreviations

ASW	Anti-Submarine Warfare
COTF	Commander, Operational Test and Evaluation Force
DAB	Defense Acquisition Board
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
ESWBS	Expanded Ship Work Breakdown Structure
INSURV	Board of Inspection and Survey
JROC	Joint Requirements Oversight Council
LCS	Littoral Combat Ship
LCSRON	Littoral Combat Ship Squadron 1
MCM	Mine Countermeasures
NAVSEA	Naval Sea Systems Command
NDAA	National Defense Authorization Act
OPNAV	Office of the Chief of Naval Operations
RFP	Request for Proposal
RMMV	Remote Multi-Mission Vehicle
RMS	Remote Minehunting System
SUW	Surface Warfare
TEMP	Test and Evaluation Master Plan

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July 30, 2014

## Congressional Committees

The Department of the Navy's Littoral Combat Ship (LCS) is a program framed by an innovative approach to shipbuilding acquisition and naval operations. Unlike other Navy surface combatants, which generally have fixed mission systems, LCS is intended to be reconfigurable to perform three different primary missions: mine countermeasures, surface warfare, and anti-submarine warfare. The LCS consists of two distinct parts—the ship itself (called a seaframe because of its ability to carry interchangeable payloads similar to an aircraft's airframe) and the interchangeable package of sensors, weapons and aircraft that it carries and deploys, called a mission package. The mission package provides the majority of the ship's combat capability. Two shipyards are currently building an equal number of two different versions of the LCS seaframe. According to current plans, the LCS will represent a large portion of the Navy's future surface combatant fleet, and the Navy plans to spend over \$25 billion in 2010 dollars to acquire up to 32 LCS seaframes and 64 mission packages—a reduction of at least 20 seaframes based on the direction of the Secretary of Defense in February 2014.<sup>1</sup>

In July 2013, we highlighted a number of risks related to the LCS program, including cost growth, schedule delays, and problems related to delivering intended capabilities; and questioned the soundness of the Navy's business case of continuing to buy seaframes and modules given the unknowns related to the program's key warfighting and support concepts.<sup>2</sup> Since that report was issued, the Navy has completed its first operational deployment of an LCS—USS *Freedom*—with a surface warfare mission package, to Singapore. Given the recent deployment and the issues that we and others have raised about the Navy's acquisition of the LCS, the House's and Senate's committee reports for the National

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<sup>1</sup>This estimate does not include \$3.6 billion of procurement money for mission package "replacement, attrition, and technology refresh."

<sup>2</sup>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); and a testimony based on [GAO-13-530](#): *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).

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Defense Authorization Act for Fiscal Year 2014 mandated that we examine a number of elements related to the program.<sup>3</sup> In light of the Navy's current plan to contract for additional ships in 2016 and its ongoing mission package purchases, this report examines: (1) knowledge that the Navy has gained as a result of the initial deployment of USS *Freedom* (LCS 1) to Singapore and ongoing testing of the LCS seaframes and mission packages and (2) outstanding risks with the LCS acquisition program.<sup>4</sup> This report is a public version of a sensitive but unclassified report issued in April 2014. DOD deemed some of the information in the corresponding report as sensitive but unclassified information, which must be protected from public disclosure. Therefore, this report omits certain sensitive information, but the content of both reports is largely the same.

To evaluate the knowledge the Navy has gained since we issued our July 2013 report, we analyzed Navy and Director of Operational Test and Evaluation (DOT&E) reports on recent mission package testing and the approved LCS Test and Evaluation Master Plan, and discussed testing with LCS program office and DOT&E officials. We also analyzed documentation and data pertaining to the deployment of USS *Freedom* to Singapore. We traveled to Singapore to meet with Navy officials responsible for the LCS deployment, toured the ship, and interviewed the commanding officer and crew members. We also traveled to Japan and spoke with officials from the Navy's 7th Fleet who were responsible for operational tasking of USS *Freedom* while it was in the 7th Fleet theater.<sup>5</sup> To assess outstanding risks with the ongoing LCS acquisition program, we examined Navy and shipyard documentation on seaframe and mission package weight management and discussed ongoing design studies that are under way that will likely have an effect on seaframe weight with Navy program office and technical experts. We also assessed the remaining test events identified in Navy documentation against the planned program schedule. We spoke to subject matter experts in naval architecture with backgrounds in designing U.S. Navy ships, and visited

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<sup>3</sup>H.R. Rep. No. 113-102, at 28-29 (2013) and S. Rep. No. 113-44, at 22-23 (2013).

<sup>4</sup>GAO, *Littoral Combat Ship: Deployment of USS Freedom Revealed Risks in Implementing Operational Concepts and Uncertain Costs*, [GAO-14-447](#) (Washington, D.C., July 8, 2014) focuses on LCS operational support and life-cycle sustainment issues.

<sup>5</sup>The 7th Fleet's area of responsibility encompasses more than 48 million square miles of the Indo-Asia-Pacific region.

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both LCS shipyards. 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.

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## Background

The LCS consists of two separate acquisition programs: one for the seaframe and one for the mission packages, which, when integrated with the seaframe and supplemented with aviation support, provide the ship's mission capability. In order to demonstrate LCS mission capability both seaframe variants will be evaluated through developmental and operational testing. Developmental testing is intended to assist in identifying system performance, capabilities, limitations, and safety issues to help reduce design and programmatic risks. Operational testing is intended to assess a weapon system's capability in a realistic environment when maintained and operated by warfighters, subjected to routine wear-and-tear, and employed in combat conditions.

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## Seaframe

The Navy is procuring two different seaframe designs from shipbuilding teams led by Lockheed Martin—which builds its ships at Marinette Marine in Marinette, Wisconsin—and Austal USA in Mobile, Alabama.<sup>6</sup> This report refers to the Lockheed Martin ships as the *Freedom* variant and the Austal USA ships as the *Independence* variant. The two designs reflect different contractor solutions to meet the same set of performance requirements. The most notable difference is that the Lockheed Martin *Freedom* variant (LCS 1 and other odd-numbered seaframes, 3 through 23) is a monohull design with a steel hull and aluminum superstructure, while the Austal USA *Independence* variant (LCS 2 and other even-

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<sup>6</sup>For LCS 2 and LCS 4, General Dynamics/Bath Iron Works was the prime contractor for the Austal USA-built ships. General Dynamics and Austal USA ended their teaming arrangement in 2010. Austal USA is the prime contractor for the 10 other even-numbered seaframes currently under contract.

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numbered seaframes, 4 through 24) is an aluminum trimaran.<sup>7</sup> Figure 1 shows the first two LCS seaframes.

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<sup>7</sup> A trimaran is a ship that has three separate hulls. The Navy is now referring to the *Independence* class variant as a slender stabilized monohull design.

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**Figure 1: Two Variants of Littoral Combat Ships**



Source: Lockheed Martin (image). | GAO-14-749

***Freedom variant***



Source: General Dynamics (image). | GAO-14-749

***Independence variant***

The Navy currently has contracted for 24 seaframes. Twenty seaframes are covered under block buy contracts that anticipate funding construction of seaframes through 2015, with deliveries under those contracts continuing until 2019.<sup>8</sup> The Navy then plans to award additional contracts in 2016 to continue seaframe acquisition beyond the first two block buy contracts. In late February 2014, the Secretary of Defense announced that as part of its fiscal year 2015 budget proposal the Navy would not contract for more than 32 ships, instead of 52 ships as planned.<sup>9</sup> Our analysis is based on the approved acquisition strategy for the program at the time of this report.

See table 1 for the current status of seaframe construction.

**Table 1: Status of Littoral Combat Ship (LCS) Seaframes**

Seaframe number	Status as of February 2014
1-4	Navy has accepted delivery
5-12	Under construction at the two shipyards
13-20	Under contract with the two shipyards; congressional funding has been received
21-24	Under contract but not yet congressionally funded

Source: GAO analysis of Navy documentation. | GAO-14-794

As we previously reported, the Navy is investigating potentially significant design changes to the ships while production is under way.<sup>10</sup> Some of these initiatives include:

- Changes to improve habitability: Part of the LCS concept is to reduce the number of crew on the ship by relying extensively on shore-based support for the ship’s administrative personnel and maintenance

<sup>8</sup>The Navy awarded two block buy contracts for up to 10 ships to both shipyards; the Navy authorized construction of one ship at each shipyard at the time of contract award, and authorized construction of one ship at each shipyard in fiscal year 2011, and two ships at each shipyard per year, from fiscal years 2012-2015. [GAO-13-530](#) contains additional information on the Navy’s contracting strategy.

<sup>9</sup>At this time, the Secretary of Defense also instructed the Navy to submit alternate proposals to procure a capable and lethal small surface combatant generally consistent with the capabilities of a frigate to assist with fiscal year 2016 budget deliberations.

<sup>10</sup> [GAO-13-530](#).

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needs. Prior to the deployment of LCS 1 to Singapore, the Navy added 20 extra beds—called berths—to the ship to accommodate extra people, and has also made a similar change to LCS 2 and subsequent ships. However, the Navy did not add equivalent amounts of crew storage space, additional water and sanitation systems, and food storage, and while the Navy officials stated that the ships still meet requirements, the Navy is investigating changes to better meet Navy standards. The Navy and the shipyards are now evaluating how to make these changes to both variant designs, but the effects have been described by the program office as pervasive throughout much of the ship.

- Changes to increase commonality: many of the systems on the two seaframe variants are not common; commonality can enhance efficient maintenance, training, manning, and logistics. The Navy is investigating making changes to improve commonality between the two variants, including selecting a common combat management system—an architecture that uses computers to integrate sensors (such as a radar) with shipboard weapon systems—for both seaframes.
- Changes to improve safety: the *Independence* variant was designed without bridge wings, which are enclosed areas that extend out to the sides of the ship from the bridge to provide enhanced visibility and safety for the crew for maneuvers like docking the ship. The Navy has added bridge wings to LCS 2, and now plans to add bridge wings to all the ships of this variant.

## Ship Weight

As part of the decision to make any design changes to a ship, the designer needs to consider the effect that the changes might have on ship weight. Weight is a critical aspect of a ship design, and is measured in several ways:

- **Light ship condition:** The ship is complete and ready for service, repair parts are held onboard, and liquids in machinery are at operating levels. Light ship condition does not include items of variable load, such as officers and crew; ammunition; aircraft and vehicles that are fully fueled with repair parts available; full supply of provisions and stores; and full tanks for potable water, lube oil, and fuel. For LCS, the light ship condition does not include installation of a mission package.
- **Full load condition:** Light ship condition plus variable loads. For LCS, full load condition includes an installed mission package and is the condition against which performance requirements are assessed.

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- **Naval architectural limit:** The maximum weight that a ship can displace while still meeting its stability and survivability requirements. For LCS, naval architectural limits are unique to each seaframe variant.

To ensure that ships meet required capabilities, the Navy and its shipbuilders typically engage in intensive estimating, weighing, and reporting processes throughout construction to identify and monitor a ship's weight and stability. As part of these processes, shipbuilders actively estimate and track certain information, including the following:

- **Builder's margin**, which consists of weight and vertical center of gravity allowances included in a weight estimate to cover slight variations of component weight and centers of gravity that take place throughout the design and construction of a ship.<sup>11</sup>
- **Service life allowances**, which refer to weight and vertical center of gravity budgets included in a ship's design to accommodate changes due to ship alterations and unplanned growth during the ship's operational lifetime, which tend to increase displacement and affect stability.

Weights are definitively determined as part of a ship's inclining experiment, which involves moving known weights around the ship and measuring how they change the ship's equilibrium. This allows for the Navy to determine a ship's displacement and the height and longitudinal position of its center of gravity. For most ships, inclining experiments take place immediately prior to delivery and after significant post-delivery maintenance periods, when necessary.

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## Mission Packages

The LCS mission package designs are based on standard shipping containers that are outfitted with a variety of unmanned systems, sensors, and weapons that can be loaded onto and off of the seaframe. Mission packages are also accompanied by an aviation detachment, consisting of an MH-60 helicopter and its flight and support crew, as well as vertical take-off unmanned aerial vehicles. These packages are intended to give the Navy flexibility to change equipment in the field to meet different

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<sup>11</sup>Vertical center of gravity is defined as the vertical distance between the ship's center of gravity and the keel.

mission needs and incorporate new technology to address emerging threats. The Navy plans on fielding one anti-submarine warfare (ASW) increment and four mine countermeasures (MCM) and surface warfare (SUW) increments.<sup>12</sup> The Navy will upgrade all mission packages to the same configuration as additional increments are fielded. The Navy plans to buy a total of 64 mission packages—though this quantity could change if the number of seaframes acquired is reduced. See table 2 for a brief discussion of the mission packages.<sup>13</sup>

**Table 2: Planned Littoral Combat Ship Mission Package Increments**

Mission package	Increment	Key systems
Surface warfare 24 packages planned	1	MK 46 30-milimeter gun system
	2	Maritime security module (2 teams and associated equipment)
	3	Vertical take-off unmanned aerial vehicle
	4	Surface-to-surface missile
Mine countermeasures 24 packages planned	1	Surface-to-surface missile upgrade (if needed)
		Airborne laser mine detection system
		Airborne mine neutralization system
		AN/AQS-20a sonar
	2	Remote multi-mission vehicle
		Vertical take-off unmanned aerial vehicle
		Coastal battlefield reconnaissance and analysis system
		Unmanned surface vehicle with unmanned influence surface sweep system
Anti-submarine warfare 16 packages planned	2 <sup>a</sup>	Surface mine countermeasure unmanned undersea vehicle (Knifefish)
		Multi-function towed array
		Variable depth sonar
		Light weight tow torpedo countermeasure
		Vertical take-off unmanned aerial vehicle

Source: GAO analysis of Navy documentation. | GAO-14-794

Notes: Each mission package is also accompanied by an MH-60 helicopter which carries additional systems and equipment. Mission package increments are cumulative, so an increment 4 mission

<sup>12</sup>The Navy has recently started referring to the mission package increments as “phases,” however, we are retaining the term “increment” because that is the term in Navy acquisition documentation.

<sup>13</sup>GAO-13-530 contains additional details about the planned mission packages and the timeframes for intended operational capability.

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package includes all systems from increment 1-3, with the exception of the SUW package increment 4 surface-to-surface missile, which will replace the increment 3 missile if necessary.

<sup>a</sup>The initial ASW increment was delivered in 2008, but the Navy canceled the increment after analysis showed the module did not contribute significantly to ASW capabilities. The newly configured ASW mission package is currently planned to be the only ASW increment.

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## Initial LCS Deployment

To obtain operational experience with LCS, the Navy last year deployed USS *Freedom* carrying an increment 2 SUW mission package. The ship departed San Diego, California, for operations in the Western Pacific under the command of the Navy's 7th Fleet in early March 2013. The ship was deployed for approximately 10 months, returning to the United States in late December 2013. The 7th Fleet area of responsibility poses unique challenges to the Navy given the vast distances it covers. While on this deployment, USS *Freedom* participated in an international exhibition as well as several multilateral naval exercises with regional navies, including Singapore; Malaysia; Brunei; and Indonesia. The ship also conducted some real-world operations as directed by the 7th Fleet, such as participating in humanitarian assistance disaster relief to the Philippines following a major typhoon. See figure 2 for a map showing the location of the Singapore deployment and the Navy fleet areas of responsibility in the Indo-Pacific region.

**Figure 2: Areas of Responsibility of the Navy's 5th and 7th Fleets and Approximate Location of Singapore Deployment of Littoral Combat Ship *USS Freedom***



Source: GAO analysis of Navy documentation (data); MapResources (map). | GAO-14-749

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## Initial Deployment and Further Testing Yielded Additional Learning about LCS Systems and Capabilities, but Gaps in Knowledge Remain

Since July 2013, the Navy has made progress demonstrating and testing various facets of LCS systems and capability but significant gaps remain in the Navy's knowledge of how the LCS will operate and what capabilities it will provide the Navy. The deployment to Singapore provided the Navy with an opportunity to examine key LCS concepts operationally, including: the ship's smaller manning profile, rotational crewing, and use of off-ship maintenance and support. The deployment was limited because only one of the two variants carrying one mission package was deployed, and mechanical problems prevented USS *Freedom* from spending as much time as planned underway—that is, at sea unanchored and not at port. As a result, some key concepts could not be demonstrated. While the deployment provided useful insight for the Navy, it was never intended to be a substitute for formal testing and evaluation activities. The Navy has also completed additional developmental testing on the seaframes and mission packages, which has enabled the Navy to characterize performance of some systems, but many capabilities have not been demonstrated in an operational environment.

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## Singapore Deployment Provided Useful Knowledge about LCS Operations, but Significant Unknowns Persist Regarding LCS Concepts and Use

Navy officials have stated that they were able to learn some valuable lessons from the deployment of USS *Freedom* to Singapore, and the Navy has taken several steps to analyze post-deployment lessons learned. According to the Navy, the deployment demonstrated the LCS's ability to participate in cooperative exercises and helped carry out the Navy's forward presence mission in Asia, thereby freeing up more costly multi-mission warships to carry out other high-priority Navy duties. Navy officials also said USS *Freedom* demonstrated how a LCS can fill the need for a smaller U.S. ship that can dock in more foreign ports than larger U.S. vessels, which they believe will be a valuable tool for engaging with certain countries that might otherwise be hard to access. Further, USS *Freedom*'s SUW mission package crew was able to conduct some launch and recovery operations with Rigid Hull Inflatable Boats and to participate in boarding exercises, which provided lessons about the operations of these boats as well as the systems on USS *Freedom* needed to launch and recover them. These operations, although undoubtedly useful for the Navy, were never intended as formal testing and evaluation activities—or to replace them. Therefore, key unknowns remain regarding how the Navy will eventually be able to use the LCS and how well the ship meets its performance requirements.

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Initial Deployment Provided  
Insight, but Key Concepts  
Remain Untested or  
Not Validated

USS *Freedom*'s deployment to Singapore represented an opportunity for the Navy to gain insight into the feasibility of the LCS's unique operational concepts. However, some of the fundamental concepts on which the program is premised—such as the maintenance and manning concepts—were demonstrated in a limited manner because the deployment involved only one ship of the *Freedom* variant and this ship is not representative of other ships of that variant. In other cases, certain concepts have not yet been demonstrated. Therefore, some of the lessons learned from the deployment cannot be extrapolated to the entire LCS class or all of the ships planned for the *Freedom* variant.<sup>14</sup> Until additional deployments have been conducted—in conjunction with operational test events—the Navy will have insufficient data to evaluate the feasibility of these concepts on both variants. Table 3 identifies the key concepts that underpin the program and the degree to which the Navy was able to evaluate them on this deployment.<sup>15</sup> Questions remaining regarding LCS's underlying concepts will, in turn, have implications for the practicality of certain requirements and key differences between the two variants—issues that have the potential to affect future acquisition decisions.

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<sup>14</sup>Navy officials told us that LCS 5 and LCS 6 will be the first production representative seaframes that have the majority of various design changes incorporated.

<sup>15</sup> [GAO-14-447](#) focuses on LCS operational support and life-cycle sustainment issues.

**Table 3: Questions about Littoral Combat Ship Operations and Lessons Learned from Initial Deployment of USS *Freedom***

Key concept	Lessons learned from Singapore deployment	Questions remaining
Two distinct seaframe variants operating in the same manner	<p>The Navy was able to obtain some data about performance and strengths and limitations of the USS <i>Freedom</i> seaframe.</p> <p>USS <i>Freedom</i> received a greater than envisioned level of underway refueling: instead of refueling every 13 days as initially estimated, the ship required refueling more frequently, although Navy officials said operations were not altered due to fuel constraints. A senior officer told us that fuel constraints made them less likely to operate the ship at higher speeds which require using the gas turbines in addition to the ship's diesel engines, since use of the turbines limits fuel economy.</p>	<p>Some major equipment has been changed on subsequent <i>Freedom</i> class ships, rendering USS <i>Freedom</i> different in several regards from later ships. Learning about these systems and how they performed on USS <i>Freedom</i> cannot predict how replacement systems might perform on subsequent ships.</p> <p>An <i>Independence</i> class seaframe has not yet deployed, and Navy officials, including those in 7th Fleet and elsewhere, told us that the <i>Independence</i> variant will have different advantages and disadvantages than the <i>Freedom</i> variant that will need to be identified through deployments. The <i>Independence</i> variant has completed test events and operations off the U.S. coast with contractor-based maintenance support, but this is not the same as an overseas deployment in which the ship must be supported remotely in a foreign country.</p> <p>Navy officials told us that they notionally plan for a deployment of an <i>Independence</i> variant before 2017, so this deployment may not occur until after the Navy awards additional seaframe contracts—currently planned for 2016.</p> <p>7th Fleet logistics officials told us that this demand will be more stressing when there are multiple LCS assets operating within the area, although USS <i>Freedom</i> has the smallest fuel capacity of any LCS seaframe. Fuel consumption for an <i>Independence</i> class seaframe is different than for a <i>Freedom</i> class seaframe, so future deployments may show the logistics demand to be different.</p>

Key concept	Lessons learned from Singapore deployment	Questions remaining
Reduced manning	<p>The Navy increased the LCS core crew size from 40 to 50 and included contractor technical experts aboard USS <i>Freedom</i> during the deployment.</p> <p>LCS employs a rotational crewing concept, whereby multiple crews are assigned to one ship and rotate on and off while the ship remains forward deployed. Navy officials told us that rotational crewing is supposed to help ameliorate crew fatigue since the crew is on the ship for less than the full deployment.</p>	<p>Based on our conversations with the crew on the second half of the deployment, they were strained to keep up with some duties even with the additional people. Crew members reported lower than average amounts of sleep than the Navy standard of 8 hours per day, although Navy officials told us operational conditions on all Navy ships may cause a ship's crew to receive less than 8 hours per day. It is unknown what the effect will be if the contractor support is removed.</p> <p>The crew also reported heavy reliance on the mission package crew to conduct seaframe maintenance—which is not their role. The crew reported being more strained when the mission package crew was conducting their own operations. According to Navy officials, focusing the available labor on tasks at hand is consistent with existing fleet practice. However, the three mission packages require different crews and equipment, and can also require different skill sets, e.g., mechanics. It remains to be seen if the manning in each package could alter the extent to which the mission package crew will be able to support the seaframe crew and reduce strain, or how the crew manages if the mission package crew is more heavily tasked with mission package operations.</p>
Novel maintenance approach	<p>USS <i>Freedom</i> also demonstrated a relatively limited range in the theater. This was in part driven by the novel maintenance concept requiring the ship to return to Singapore after 25 days of operations for a 5-day maintenance period that was conducted by contractors flown in from the U.S.</p> <p>The Navy plans to try a revised concept with a longer interval between in-port maintenance for the upcoming 2014 deployment of LCS 3 to Singapore. The Navy also plans to add an additional maintenance location to increase how far LCS can travel.</p>	<p>Future deployments will help determine if revisions to the maintenance concept will improve flexibility. Future deployments will also illustrate whether different maintenance approaches may be needed for the <i>Independence</i> variant.</p>
In-theater mission package swaps	<p>USS <i>Freedom</i> deployed with an increment 2 SUW package, but did not swap out this package in Singapore. The Navy has only executed mission package changes in California.</p>	<p>As identified in Navy wargames, it is unknown how the precise logistics of in-theater mission package swaps will work. There is no mission package change planned for the next deployment.</p>

Source: GAO analysis of Navy analyses and post-deployment data. | GAO-14-794

In addition, mechanical problems hampered the Navy's ability to operate USS *Freedom* as planned during the Singapore deployment. Based on information provided by LCS program officials responsible for LCS fleet introduction, USS *Freedom*'s mechanical failures resulted in 55 days of

mission days lost, which is a significant portion of its 10-month deployment. Navy officials stated many of these days were planned in-port periods.<sup>16</sup> The ship could not fully participate in at least two planned or requested exercises and some operational 7th Fleet presence missions while repairs were conducted. According to the LCS program office, several of the more problematic pieces of equipment that resulted in significant lost underway days are either slated to be replaced on follow-on *Freedom* class ships or have already have been replaced on LCS 3 or LCS 5. Table 4 depicts some of the most significant equipment failures and how the Navy believes they have been corrected on subsequent seaframes.

**Table 4: Problems with USS *Freedom* Equipment That Have Since Been Replaced on Later *Freedom* Class Littoral Combat Ships (LCS)**

System	System description	Mission days lost	Changes on future LCS seaframes
Ship service diesel generators	Generators that provide electrical power to the ship.	11 days	Design changes have been made to these generators on LCS 5 and follow-on ships.
Starboard splitter gear and port combining gear	Gears that allow the ship to run on a combination of diesel engines and gas turbine engines.	20 days	Changes have been or will be made to improve maintainability on LCS 1 and 3. The design will be changed on LCS 5 and follow-on ships to further improve maintainability.
Starboard steerable water jet hydraulic power pack	Hydraulic system for the water jets.	17 days	For LCS 3, the Navy has identified a means of facilitating easier flushing of the system. The Navy has funded efforts to redesign this system on LCS 5 and follow-on ships.
Port steerable water jet	Provides propulsion and steering for LCS.	7 days	The water jet feedback cables have been modified on LCS 5 and follow-on ships.
<b>Total</b>		<b>55 mission days lost</b>	

Source: GAO analysis of Navy documentation. | GAO-14-794

Even with the reduced number of operational mission days, the Singapore deployment raised questions about the practicality of the small crew size. LCS is intended to operate with a crew that is smaller than comparable surface combatants. This reduced manning has long been a

<sup>16</sup> There is disagreement within the Navy as to 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 did not provide documentation for how this number was determined.

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focus of Navy analysis, and the increase to a 50-person crew for the deployment was the maximum size allowed by current program requirements. This number was augmented by civilian contractor technical experts who could assist with troubleshooting and some maintenance. However, as shown in table 3, even with these additional people the deployment provided indications that the crew strained to keep up with duties.<sup>17</sup> Further, the ship is currently at capacity in terms of the number of crew members it can accommodate. Therefore, any increase in crew size would require a significant redesign of the seaframes and would necessitate a revision to the maximum 50-person manning requirement, which has been validated by the Joint Requirements Oversight Council. Officials from the office of the Chief of Naval Operations told us after the deployment that they are not considering any further revision to the manning requirements for the ship, although some manning studies are under way to assess the rank and billet structure for the mission packages and aviation detachment.

Additionally, some of USS *Freedom*'s equipment is unique to that ship, unique to the *Freedom* variant, or unique to LCS class, which we were told made some repair efforts cumbersome and slow. For example, crew members told us that in some cases they had to track down spare parts that were sometimes available only in foreign countries rather than being able to find them in Navy inventories. While some of this may be a first-of-class issue, replacement of some ship systems with more reliable ones or with systems that are more commonly found in the Navy inventory may also reduce these burdens on the crew in the future. According to the LCS program office, replacing these less reliable systems should mean that future deployments of other ships from the *Freedom* class should not incur the same number of failures as USS *Freedom*. However, as DOT&E has observed, no formal operational testing has been conducted to verify and quantify these improvements, although Navy and DOT&E officials said that they were working together on operational test opportunities. Until the Navy completes further underway periods and/or testing it will not be able to determine the significance of improvements on ship availability.

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<sup>17</sup> [GAO-14-447](#) focuses more specifically on the effect of the reduced crew size during the deployment.

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Fleet Observations on  
Deployment Highlight Potential  
Limitations on LCS Usage

This first deployment provided limited insight into how the LCS might be utilized in the different theaters in which the Navy operates. USS *Freedom* was deployed to Singapore and conducted operations for 7th Fleet largely consisting of participation in planned multi-lateral exercises. While 7th Fleet officials noted that a benefit of having LCS in theater was that the ship could participate in international exercises, thereby freeing up other surface combatants for other missions, they were still not certain about the ship's potential capabilities and attributes, or how they would best utilize an LCS in their theater. Until the Navy completes additional testing and deployments, it will not have adequate operational data and operational experience on which to base assumptions regarding LCS utilization. Table 5 discusses some of the observations related to the LCS deployment that we discussed with 7th Fleet officials related to the LCS deployment.

**Table 5: 7th Fleet Observations on Initial Littoral Combat Ship (LCS) Deployment**

Fleet Observation	Significance	Considerations
Fleet users expressed uncertainty about LCS's potential capabilities and attributes, or how they would best utilize an LCS in their theater. Several 7th Fleet officials told us that they thought the LCS in general might be better suited to operations in the 5th Fleet theater (headquartered in Bahrain) than to 7th Fleet due in part to the smaller area of responsibility in 5th Fleet that would make range less of a consideration.	Determining how to best use LCS in different theaters could influence the Navy's decision about the total number of seaframes and mission modules the Navy requires.	The Navy is planning future deployments of LCS to the 7th Fleet.  The Navy held a wargame in March 2014 to try to understand how well LCS supports Navy needs and war plans in various phases of operations in a Pacific theater crisis.
Fleet users expressed interest in several modifications that they would like to see made to the seaframes and/or mission packages to better suit their needs, based on their experience with the deployment. These include <ul style="list-style-type: none"> <li>• A replacement system for an unreliable and poorly performing electronic warfare system called WBR-2000 that is currently installed on the <i>Freedom</i> variant;</li> <li>• An ability to make additional use of the MH-60 helicopter by being able to carry sonar buoys on the ship for helicopter use regardless of whether or not the anti-submarine warfare package is onboard; and</li> <li>• Developing an intelligence, surveillance and reconnaissance-specific mission package to augment existing capabilities.</li> </ul>	According to the 7th Fleet users, these changes would make LCS more reflective of their theater-specific needs.	Officials from the Office of the Chief of Naval Operations stated that there were no such changes currently envisioned, though they are always open to potential improvements.
Fleet users said LCS fuel constraints contributed to a low average transit speed which, coupled with the very long distances ships have to travel within the 7th Fleet theater, make it hard for LCS to easily or efficiently get around the theater.	If limitations of LCS complicate use in operations in the 7th Fleet theater, the Navy may need to consider the impact in terms of the total number of seaframes and mission packages the Navy requires.	Future deployments of LCS to the 7th Fleet theater are planned with different LCS seaframes, which may yield different observations.  Section 124 of the National Defense Authorization Act for Fiscal Year 2014 limits the availability of funds for LCS 25 and 26 until the Navy submits to the congressional defense committees, among other things, a certification that requires in relevant part that the Joint Requirements Oversight Council (JROC)—responsible for validating performance requirements— has assessed the adequacy of the current LCS capabilities development document to meet the requirements of the combatant commands and to address future threats. <sup>a</sup> The JROC could approve increases or reductions or make no changes to requirements, including top speed, range, and endurance.

Source: GAO interviews with 7th Fleet officials and analysis of relevant documentation. | GAO-14-794

Note:

<sup>a</sup>Pub. L. No. 113-66 (2013).

## Navy Has Made Progress with Recent Testing but Additional Testing Needed to Demonstrate LCS Capabilities

Since July 2013, the Navy has completed additional testing on the seaframes and mission modules and is seeing results but has not yet proven performance in an operational environment. Table 6 describes these recently completed events and some important considerations about the testing.

**Table 6: Recently Completed Littoral Combat Ship (LCS) Test Events**

System	Test event	Date	Considerations
Seaframe	Developmental Testing of LCS Launch, Handling, and Recovery Systems on LCS 2 seaframe	August 2013	<ul style="list-style-type: none"> <li>Testing of the Launch, Handling, and Recovery Systems used to lower the mine countermeasures package's minehunting Remote Multi-mission Vehicle (RMMV) and other systems out of the back of the ship.</li> <li>The Navy's Commander of Operational Test and Evaluation Force and the office of the Director, Operational Test and Evaluation (DOT&amp;E) observed this testing and stated that systems showed improved functioning over prior tests.</li> <li>This testing also further demonstrated—although with some reliability problems—the use of multi-vehicle communication systems, a new system that allows the seaframe to control multiple RMMVs simultaneously. This testing showed only use of this system communicating in single-vehicle mode.</li> </ul>
	Combat System Ship Qualification Testing on USS Fort Worth (LCS 3)	Late 2012	<ul style="list-style-type: none"> <li>The Navy obtained initial test results and analysis from this testing in April 2013 and is still evaluating the results.</li> <li>LCS 3 was the first LCS to complete this testing, which represents an opportunity to verify and validate combat and weapon systems performance for new ships. LCS 1 and LCS 2 have not yet formally completed this testing.<sup>a</sup> USS Coronado (LCS 4) is expected to conduct this testing in 2014.</li> </ul>
	LCS 2 rough water trials	January-February 2014	<ul style="list-style-type: none"> <li>These trials allow the Navy to capture data with instrumentation on how the seaframes react to heavy sea conditions, which can be used to verify and validate computer model predictions that help inform expectations about service life and how stress can result in fatigue areas of the ship's structure. Results are not yet available.</li> <li>The Navy has not yet conducted rough water trials for the <i>Freedom</i> variant; testing was initiated in 2011 for LCS 1 but was suspended when a hull crack was identified. Rough water trials for the <i>Freedom</i> variant are now planned to occur with LCS 1 in 2015.</li> </ul>

System	Test event	Date	Considerations
Mission packages	Developmental testing of the mine countermeasures package RMMV and the Remote Minehunting System (RMS) <sup>b</sup>	February-June 2013	<ul style="list-style-type: none"> <li>Testing demonstrated marked improvements in the reliability of the RMMV and RMS which has been a problem for several years, measured by the extent to which the system could perform its mission without failures that prevent the successful completion of a mission.</li> <li>We reported in July 2013 that the contractor had improved reliability from 7.9 hours between operational failures to 45 hours, as compared with the Navy's 75-hour requirement. According to a recent test report, RMS demonstrated operating with hours between such failures exceeding both the Navy's requirement and the contractor's goal of 129 hours.</li> <li>Several factors limit the significance of the testing: <ul style="list-style-type: none"> <li>Testing was conducted using an older configuration of the RMMV than will be used for operational testing which is, according to DOT&amp;E, incompatible with the LCS and will never be used operationally. DOT&amp;E stated that using a non-representative RMMV in developmental testing limits the utility of the data obtained.</li> <li>DOT&amp;E found that the definition of mean time between operational mission failures erroneously added the time that the crew would be spending conducting post-mission analysis of data obtained from RMS operations to the time that the vehicle was actually operating. DOT&amp;E stated this artificially inflates the reliability rate by a factor of at least two. Officials from the Office of the Chief of Naval Operations stated that there are two definitions of this parameter, one definition intended for the purpose of system's engineering and reliability growth and the other intended for the purpose of operational test and evaluation.</li> <li>We noted that while Navy sailors were used to support testing, it did not involve an RMMV integrated with the LCS, but instead the RMMV was operated from a pier. Further testing will be required to replicate these results in a more operationally relevant environment.</li> </ul> </li> </ul>

Source: GAO analysis of Navy test reports. | GAO-14-794

<sup>a</sup>Navy program officials told us they have conducted testing that is at least as rigorous as Combat System Ship Qualification Trials during the developmental testing phase. DOT&E officials disagree, emphasizing that operational effectiveness and suitability can be assessed only through operational testing.

<sup>b</sup>The RMS consists of an RMMV, which operates as a semi-submersible to tow an AN/AQS-20A sonar that is used to detect, classify, locate, and identify minelike objects.

## Outstanding Weight Management and Concurrency Risks Continue to Complicate LCS Acquisition

Although the Navy has gained knowledge related to LCS capabilities and concepts since our July 2013 report, there continue to be significant acquisition risks to the program. Key among these is managing the weight of the ships. Initial LCS seaframes face limitations resulting from weight growth during construction of the first several ships. This weight growth has required the Navy to make compromises on performance of LCS 1 and LCS 2 and may complicate existing plans to make additional changes to each seaframe design. While weight growth is not uncommon over the life of a ship and the Navy builds a weight allowance into ships to account for this growth, LCS has significantly lower available margin compared to

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other ship classes. Compounding these issues, the Navy has not received complete or accurate weight reports from the LCS seaframe prime contractors—and the Navy’s lengthy review process has hindered a timely resolution. Additionally, as we have previously reported, the Navy has considerable testing to complete before the program demonstrates operational capability. Further, the Navy has continued with the acquisition without the knowledge that would be gained from additional testing. For example, since our last report, the Navy has granted the mission modules program approval to accelerate the mission package production rate before completing key test activities to demonstrate their performance.

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**Seaframe Weight Growth Affects Performance and Design Changes, with Navy Oversight Challenged by Inadequate Contractor Weight Reports**

Weight growth occurred on the first four LCS seaframes, which affected the capabilities of both *Freedom* and *Independence* variant seaframes. This situation has led the Navy to accept lower than minimum requirements on two delivered seaframes (LCS 1 and 2) in endurance and sprint speeds, respectively. Further, weight growth has caused three delivered LCS seaframes (LCS 1, 2, and 4) to not achieve the required service life allowance for weight. Weight management in shipbuilding programs, including the LCS, is critical to ensuring that performance requirements associated with survivability, sea keeping (meaning the ability to withstand rough sea conditions), and the ability to accommodate upgrades during ship service lives, are met. For LCS seaframes, specific performance requirements that are sensitive to weight include the following:

- 3,500-nautical-mile range (endurance) when operated at a speed of 14 knots,<sup>18</sup>
- 40-knot sprint speed,
- 20-foot navigational draft (the greatest depth, in feet, of the keel),
- 50-metric-ton service life allowance for weight, and
- 0.15-meter service life allowance for stability.<sup>19</sup>

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<sup>18</sup>In 2009, the Navy received authorization from the Joint Requirements Oversight Council to reduce LCS’s original endurance requirement, which was a 4,300-nautical-mile range when operated at a speed of 16 knots, to the current endurance requirement. This reduction followed a Navy assessment of the two seaframe designs.

<sup>19</sup>The stability service life allowance is associated with a seaframe’s vertical center of gravity as measured from its keel.

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In the LCS program, weight management and reporting processes also rely on accurate mission package weight data. The Navy provides mission package weight estimates to the shipbuilders to include in their full load condition estimates.

Table 7 identifies the Navy's current weight estimates for each of the first six LCS seaframes under full load conditions, along with current service life allowance projections for each ship as compared to the required 50 metric tons. As is depicted, there are several seaframes that do not have the required amount of service life remaining due to weight growth.

**Table 7: Weight Analysis of Littoral Combat Ship Seaframes, January 2014**

Estimates in metric tons

Ship	Naval architectural limit	Full load condition	Required service life allowance (weight)	Available service life allowance (weight)	Builder's margin	GAO observations
<b><i>Freedom variant</i></b>						
LCS 1	3,400.0	3,374.2	50.0	25.8	N/A	Ship does not meet service life allowance requirements.
LCS 3	3,550.0	3,394.3	50.0	155.7	N/A	Ship meets service life allowance requirements.
LCS 5	3,550.0	3,482.7	50.0	67.3	30.4	Ship meets service life allowance requirements and has builder's margin available.
<b><i>Independence variant</i></b>						
LCS 2	3,188.0	3,204.5	50.0	-16.5	N/A	Ship exceeds its naval architectural limit and does not meet service life allowance requirements, but according to Navy officials, margin in fuel weight could compensate.
LCS 4	3,188.0	3,171.5	50.0	16.5	N/A	Ship does not meet service life allowance requirements, but according to Navy officials, margin in fuel weight could compensate.
LCS 6	3,188.0	3,156.7	50.0	31.3	29.2	Ship does not meet service life allowance requirements, but according to Navy officials, available builder's margin could provide an offset and margin in fuel weight could compensate.

Source: GAO analysis of Navy documentation. | GAO-14-794

**Notes:**

LCS 1-LCS 4 have been delivered and therefore builder's margin remaining has become part of the service life allowance. LCS 5 and 6 are under construction.

Contractor officials responsible for construction of the LCS seaframes told us that weight growth on at least some of the seaframes was due in part to design changes made by the Navy during construction.

LCS 2 faces the most significant weight challenges of any of the first six seaframes, but Navy officials stated they have a strategy to mitigate the issue while still meeting requirements. According to Navy estimates, LCS 2 is so heavy in the full load condition that it exceeds its naval architectural limit—an outcome that provides no service life allowance for

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weight and restricts the ship's ability to execute its required missions. Subject matter experts in naval architecture who we interviewed stated that operating a ship in excess of its naval architectural limit can make it prone to failure in certain weather or damage conditions, and the ship can also see a decreased service life due to structural fatigue. Navy officials stated that they will limit fuel loads on LCS 2, as necessary, to ensure the naval architectural limit is not exceeded. In addition, the Navy is developing design modifications for *Independence* variant seaframes to reduce fuel capacity—estimated to total over 100 metric tons—in order to restore service life allowances. Although this reduction will reduce the endurance of these ships, the Navy reports that this variant has excess fuel capacity—as demonstrated during LCS 2 calm water trials in June 2013—and will still meet LCS range at transit speed requirements after the fuel reduction.

Further, as table 7 shows, three of the other LCS seaframes—LCS 1, LCS 4, and LCS 6—also do not currently meet their service life allowance requirements for weight when configured in normal, full load conditions. For example, LCS 1 and LCS 4 have near or less than 50 percent of the required 50 metric ton service life allowances for weight (25.8 and 16.5 tons, respectively), and the Navy projects LCS 6 will enter service with less than 63 percent (31.3 metric tons) of its required 50 metric ton service life allowance for weight. At present, LCS 6 has over 29 metric tons of builder's margin available, which if still available at delivery could offset that particular ship's estimated service life allowance deficit for weight.

Weight growth contributed to LCS 1 and LCS 2 not achieving some requirements related to endurance and sprint speed respectively, when operated in normal, full load conditions. For instance, although LCS 1 meets its sprint speed requirement of 40 knots, excess weight growth to date in part prevents that ship from achieving the 3,500 nautical miles at 14 knots endurance requirement. Alternatively, LCS 2 can only sprint at 39.5 knots under full loads, but is predicted to exceed the endurance requirement by over 800 nautical miles, albeit at potential risk to its naval architectural limit, as discussed above.<sup>20</sup>

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<sup>20</sup> LCS 2 contractor officials told us that the calculated speed in the full load condition LCS 2 is 36.5 knots.

## LCS Has Low Weight Growth Margins Compared to Other Ship Classes

Complicating the weight growth on early LCS seaframes is the fact that LCS requirements for service life allowances already fall short of the growth margins called for under Navy and industry recommended practice.<sup>21</sup> Table 8 outlines recommended service life allowances for different ship types as compared to LCS requirements.

**Table 8: Navy Recommended Service Life Allowances by Ship Type as Compared to Littoral Combat Ship Requirements**

Ship types	Weight (percentage)	Vertical center of gravity (meters) <sup>a</sup>
Surface combatants	10.0	0.30
Aircraft carriers	7.5	0.76
Amphibious warfare ships (large decks)	7.5	0.76
Amphibious warfare ships (other)	5.0	0.30
Auxiliary ships	5.0	0.15
Special ships and craft	5.0	0.15
LCS requirements	1.4 to 1.6 <sup>b</sup>	0.15

Source: GAO analysis of Navy and industry documentation. | GAO-14-749

Notes: Service life allowances are measured against the full load condition at the time of ship delivery.

<sup>a</sup>Vertical center of gravity is the height of the ship's vertical center of gravity measured from the bottom of the keel.

<sup>b</sup>We calculated the percentage range by dividing the LCS service life allowance requirement for weight (50 metric tons) by the estimated full load condition displacements for LCS 5 and LCS 6 (3,482.7 and 3,156.7 metric tons, respectively). We used LCS 5 and LCS 6 because the Navy views these as the first production representative ships.

Because of the LCS's comparatively low service life allowance requirements, the Navy's ability to accommodate alterations and growth on these ships over their expected 20-year minimum service lives will be significantly more constrained than is typical for other surface ships. In 2012, the Office of the Chief of Naval Operations highlighted the importance of this issue across ship classes, noting in an instruction that inadequate service life allowances for weight and vertical center of gravity have resulted in expensive corrective ship changes or in the inability to modernize ships through installation of new weapons systems.

<sup>21</sup>Society of Allied Weight Engineers, *Recommended Practice Number 14: Weight Estimating and Margin Manual for Marine Vehicles* (Los Angeles, Calif.: May 22, 2001).

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## Low Growth Margins May Complicate Future Changes

Navy program officials told us they expect that most future weight—and capability—growth on LCS would occur within mission packages, not seaframes. However, as we previously reported, the Navy is considering changes to the seaframe designs that could further increase weight estimates.<sup>22</sup> As mentioned above, these changes could include increases in: (1) habitability to support larger crews than initially anticipated; (2) commonality between the seaframe variants and with other Navy ships; and (3) changes to improve safety. We reported in July 2013 that the Navy had undertaken several technical studies on these initiatives. These studies have not yet been completed. Navy officials stated that the possible changes are low risk and would not affect LCS performance requirements. However, some changes, including those related to habitability, are likely to add weight. According to the program office, weight considerations occur for every change and corresponding trades are required to be made in order to approve the change. For example:

- Early estimates indicate that roughly 10 to 20 metric tons could be added due to accommodations for a larger crew, and would require pervasive modifications to each seaframe design. If so, these changes would heighten weight challenges and resulting service life allowance shortfalls.
- A change was made to LCS 2 in a recent maintenance period to increase the size of the rescue boat from 5 meters to 7 meters, which will make the boat more stable in heavier seas. This change resulted in an approximately 15 metric ton weight increase to LCS 2; it is planned for all *Independence* variant seaframes. According to the contractor, by removing weight from other areas of LCS 6 and follow-on ships designs, the larger rescue boat will add 1.3 metric tons.
- Another proposed change would increase commonality and combat capability by replacing the *Freedom* variant's rolling airframe missile system with the heavier missile system found on the *Independence* variant. While the specifics of this potential change have not yet been determined or approved, Navy technical experts told us that such a modification would

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<sup>22</sup>[GAO-13-530](#).

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subsequently increase the *Freedom* variant's weight and could also result in center of gravity changes.

Weight constraints could make future modifications more costly than anticipated. For instance, subject matter experts in naval architecture told us that the Navy may find it has to seek lighter alternatives to the systems or equipment it wants, which could complicate the redesign and construction modification efforts or make them more costly—or both. Because the Navy has not yet completed technical studies evaluating its possible changes, the weight effects remain unknown. According to Navy officials, preliminary studies on the habitability changes should be completed this year, and more detailed design work will not occur until fiscal year 2015. The Navy has established a weight working group with Navy and shipyard representatives that program officials said is intended to try and identify ways to offset weight growth from some of these design changes.

Additionally, once a ship is delivered and handed over to the fleet, fleet operators and maintainers assume responsibility for these weight management processes, which continue throughout the ship's service life. For ships that are weight constrained—meaning, at or nearing their naval architectural limits for displacement—these weight management processes are typically more robust and costly. For instance, a Navy instruction states that weight must be kept within naval architectural limits and provides that for ships that are weight constrained, any additional weight must be compensated for by removing weight from the ship.<sup>23</sup> Inclining experiments must usually be completed following maintenance periods to ensure the ship's naval architectural limits remain unbreached. As operational assets, LCS 1 and LCS 2 are—according to Navy reporting—both in a weight constrained status.<sup>24</sup>

#### Mission Package Weights Continue to Evolve, but Growth Margin Is Constrained

According to Navy officials, the seaframes have low growth margins because the mission packages are supposed to be flexible enough to accommodate any future upgrades and growth. However, weight challenges exist on the mission packages as well, and weight and space

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<sup>23</sup>Naval Sea Systems Command Instruction 9096.3E, *Weight and Moment Compensation and Limiting Drafts for Naval Surface Ships* (Feb. 14, 2005).

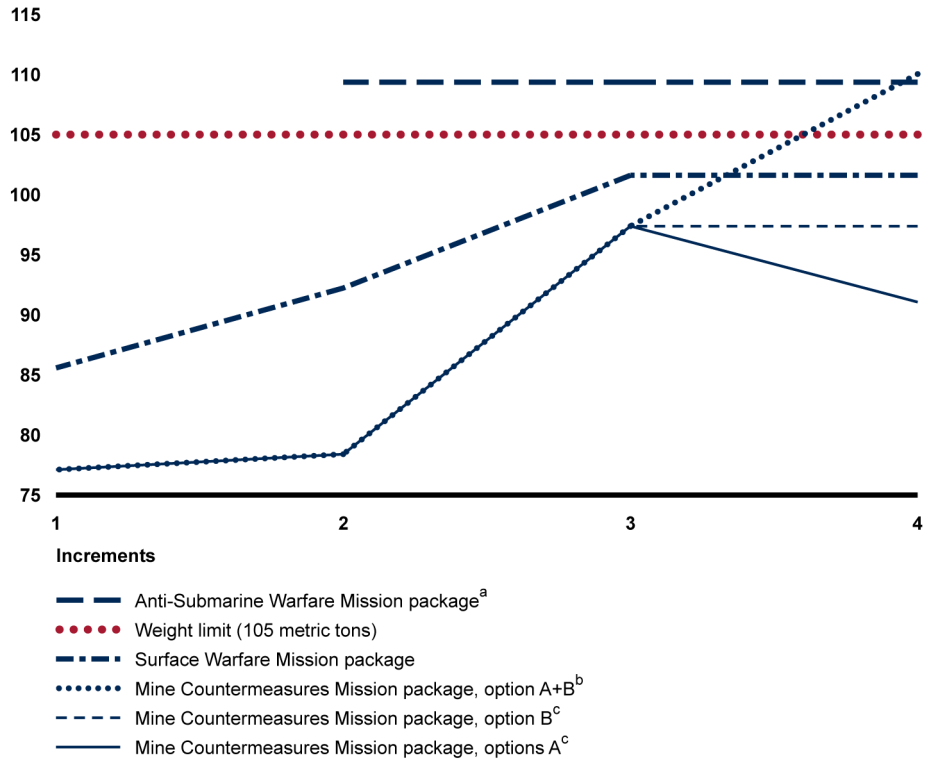
<sup>24</sup>LCS 3 exceeds the required service life allowance for weight and LCS 4 has not yet delivered and is not yet an operational asset, so it is not yet included in this reporting.

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constraints are limiting the extent to which the Navy can accommodate new mission package systems. Similar to the seaframes, the Navy also tracks and manages mission package weights. Mission packages (regardless of which type) are required to consume no more than 180 metric tons when installed aboard a seaframe. Of this 180-metric-ton allocation, 105 metric tons are allotted to the actual mission package equipment, whereas 75 metric tons are reserved for fuel to power that equipment. However, LCS requirements documents do not include a service life allowance requirement for mission packages, and based on current weight estimates, room for future growth on the final increments ranges from approximately 14 metric tons for some configurations of the MCM mission package to none for the ASW mission package. According to Navy officials, future additions to mission packages—beyond the systems currently planned for increment 4 configurations—will be offset by removing existing systems, described below, to the extent required to meet the 105 metric ton weight limitation. For MCM, Navy officials stated that they cannot include all the current increment 4 systems that they are buying in a package at one time, so they have recently developed two options with different system configurations. Figure 3 highlights current mission package weights that are estimated for each increment of mission package capability, including the two MCM options but excluding potential weight reduction efforts.

**Figure 3: Current Littoral Combat Ship Mission Package Weight Estimates, by Increment**

Projected weight (in metric tons)



Source: GAO analysis of Navy documentation. | GAO-14-749

<sup>a</sup>The Navy currently plans for only one increment of anti-submarine warfare capability, introduced in increment 2.

<sup>b</sup>The projected weight of the mine countermeasures mission package at increment 4 will differ depending on the systems included. Mine countermeasures mission package increment 4 Option A+B reflects a configuration with the weight for the Surface Mine Countermeasures Unmanned Undersea Vehicle (Knifefish), the Unmanned Influence Sweep System, and the weight of the other increment 4 systems. This option with both systems onboard is not feasible as the two systems cannot be included in one mission package together due to space constraints. They are depicted to highlight weight challenges.

<sup>c</sup>The mine countermeasures mission package increment 4 Option A reflects the weight for the Surface Mine Countermeasures Unmanned Undersea Vehicle (Knifefish) in addition to the other increment 4 systems, but without the Unmanned Influence Sweep System. The mine countermeasures mission package increment 4 Option B reflects the weight for the Unmanned Influence Sweep System in addition to the other increment 4 systems, but without Knifefish.

At present, the Navy anticipates that the equipment associated with an increment 4 SUW package will require slightly less than the 105-metric-ton allotment. This estimate is contingent on surface-to-surface missile systems not yet selected delivering within the assigned weight margins.

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The Navy has identified a weight reduction plan to provide an additional 5 metric tons.

Navy weight estimates for increment 4 of the MCM mission package, however, do not reflect all the systems being acquired for that package. Space and weight constraints have required the Navy to modify how it intends to outfit increment 4 of the MCM mission package. Although the Navy plans to acquire all the systems planned for that increment, space and weight limitations will not allow LCS seaframes to carry all of these systems at one time. According to LCS program officials, MCM mission commanders will have either (1) the Unmanned Influence Sweep System and the unmanned surface vehicle that tows it, or (2) the minehunting Surface Mine Countermeasures Unmanned Undersea Vehicle—called Knifefish—available—but not both systems. As a result, LCS seaframes outfitted with the increment 4 MCM package may have decreased minesweeping or mine detection capability.<sup>25</sup> These scenarios would preclude LCS from meeting its MCM minesweeping performance requirements; Knifefish is a new capability that was recently added to the program, and officials from the mission module program office stated that it is not a capability currently defined in LCS requirements documentation. The Navy has identified some options for weight reduction for this package that could bring the combined weight with these two systems included together to just under 105 metric tons, but physical space constraints would still prohibit both being carried together.

Further, ASW mission package equipment is also estimated to exceed its 105-metric-ton allotment by approximately 4 metric tons. In response, the Navy has identified weight reduction options within that package that it estimates will shed a combined 10 metric tons of weight. Several of these options require redesign of existing systems, which could introduce risk.

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<sup>25</sup>Minehunting is the process of using sensors to localize and identify individual mines for avoidance or later neutralization. Minesweeping uses either acoustic and magnetic emissions to detonate mines designed to target a ship's acoustic or magnetic signature (called influence mine sweeping) or a physical device to cut the tether of moored mines so that they float to the surface, where they can be detonated or recovered for intelligence purposes (called mechanical minesweeping). While Navy mine warfare officials stated that minehunting is the preferred mode of clearing mines since it is more precise, minesweeping is sometimes the only option due to time or environmental constraints.

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## Deficiencies in Contractor Reports Have Hindered Navy Oversight of LCS Weight Challenges

The Navy has faced challenges obtaining accurate and complete weight estimates from the contractors. The Navy's primary mechanism for tracking seaframe weights are quarterly weight reports, which are produced and delivered by each of the LCS prime contractors per contract requirements. These reports provide data on the physical characteristics of seaframes under construction, including the magnitude, location, and distribution of weight within each ship. These data are based on estimated and calculated weights derived from design drawings, historical data, and vendor-furnished information, and are updated with actual component weight information during construction by the shipbuilder. Under the terms of their contracts, LCS prime contractors are required to prepare and report data within weight reports in accordance with Navy and industry recommended practices, which include using the Navy's Expanded Ship Work Breakdown Structure (ESWBS) classification system to structure and summarize data.<sup>26</sup> ESWBS facilitates the grouping of materials, equipment, and ship components in a consistent reporting format, which in turn positions Navy reviewers to audit the contractors' work. At their highest level, ESWBS groupings are organized around major systems of the ship, such as the hull structure and propulsion plant, but ESWBS groupings are broken down to include individual components of these respective systems, such as diesel engines.

An inclining experiment is important as it represents the point where weight data transitions from estimated or calculated data into actual data. According to Navy officials, when the weight of a ship is determined at an inclining experiment, the weight totals should be very close to those identified in the preceding weight reports. Acceptable deviation is considered to be only 0.5 percent or less, according to Navy technical experts. In the LCS program, however, inclining experiments for the first two seaframes revealed weight growth that the prime contractors had not fully accounted for within their weight reports. For example, the LCS 1 inclining experiment that followed that ship's initial post-delivery work periods revealed that the ship weighed approximately 90 metric tons more than expected. However, it was unclear to the prime contractor where this excess weight was located or how it was distributed within the ship, though Navy program officials told us that they now believe it was

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<sup>26</sup>Society of Allied Weight Engineers, *Recommended Practice Number 12: Weight Control Technical Requirements for Surface Ships*, Revision Issue No. C (Los Angeles, Calif.: May 22, 2002).

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due largely to additional insulation and paint. In response, Lockheed Martin increased its weight estimates for LCS 3 and worked with the Navy to evaluate and resolve the 90 metric ton discrepancy. As part of these analyses, Lockheed Martin was able to assign much of the weight growth to individual ESWBS accounts, and subsequently inclined LCS 3 to within 1 percent of that ship's revised weight estimate. However, full resolution of the 90 metric tons weight discrepancy remains incomplete. Weight reports for LCS 5 and follow-on ships identified over 23 metric tons of weight that Lockheed Martin and the Navy have not yet identified as belonging within specific ESWBS accounts. Similar to LCS 1, LCS 2's inclining revealed an approximately 5 percent deviation from expected weight, and General Dynamics' Bath Iron Works and Austal USA have over 13 metric tons of weight, outside of the ESWBS accounts, on later *Independence* variant seaframes. Carrying forward excess weight can have impacts on the ships over the course of their service lives, and may have impacts on construction of follow-on seaframes. In order to remedy persisting deficiencies in the weight reports, Navy officials stated that the administrative contracting officer—responsible for ensuring that the contractor is fulfilling the contract under the specified terms, including price, schedule, and quality—could withhold a percentage of progress payments. To date, however, Navy officials report that they have not pursued such withholds in the LCS program.

As part of the terms of the block buy contracts for LCS seaframes, the Navy is required to review and comment on weight reports within 60 days after they are submitted by a prime contractor.<sup>27</sup> During the past 2 years, the Navy has, in several cases, provided detailed comments back to the contractors on weight reports that it identified as deficient. Comments back to the prime contractors identified fundamental classification and estimating errors and the use of outdated weight information, among other reporting deficiencies, which the Navy judged as time sensitive and critically important to address (see appendix II, which contains excerpts from Navy comments on contractor weight reports). The Navy often requested LCS prime contractors to modify and resubmit the report within 30 days—consistent with the terms of the contracts.

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<sup>27</sup>According to Navy program officials, contracts for the first four seaframes included a requirement that the Navy complete its review and comment on weight reports within 45 days.

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However, the prime contractors have not addressed the Navy's comments and resubmitted weight reports, largely because the Navy's review is typically taking longer than 60 days. One contractor stated that the Navy's review took 6 to 12 months. According to Navy officials, reviews of weight reports now take less than 6 months. Nevertheless, by the time that the Navy's comments for one particular report are submitted to the contractor, the contractor has often already submitted the next quarter's weight report. As a result, LCS contractors stated to us that they generally do not make revisions to the previously submitted reports. Thus, issues raised in the Navy's comments are not immediately addressed by the contractors. These revisions can affect weight estimates, but cannot be identified until a corrected weight report has been submitted. As a result, serious issues within weight reports persist that could obscure timely identification of negative weight trends within one or both seaframe variants.

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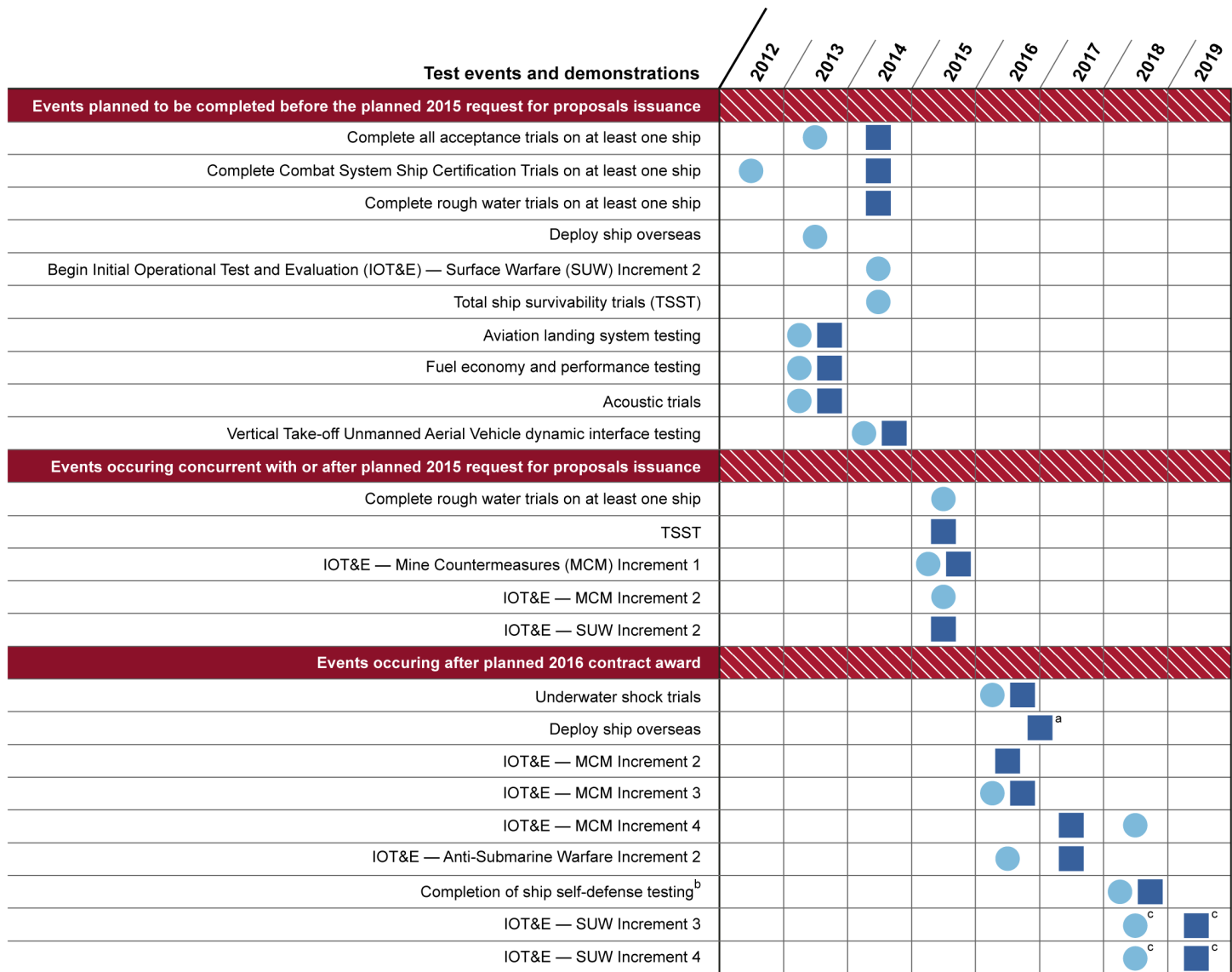
### Risk of LCS Concurrency Remains—with Mission Package Procurement Exceeding Levels Needed for Operational Testing

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. Since we issued our report in July 2013, the Navy received approval from DOT&E for the LCS test and evaluation master plan (TEMP), which sets forth the testing that must be completed to ensure that the program meets requirements. In order to determine the degree to which the information from test events would be available to inform the Navy's decision to purchase additional seaframes, we compared the Navy's current acquisition strategy—which calls for releasing a request for proposals in 2015 in support of a planned 2016 award of future seaframe contracts—with the program's test schedule as outlined in the most recent TEMP. Figure 4 illustrates the test events that will be completed before and after these acquisition events.<sup>28</sup>

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<sup>28</sup>If the Department of Defense and/or the Navy opt to make a change to the program's future acquisition strategy, these dates may change. As noted above, in February 2014, the Secretary of Defense announced that as part of its fiscal year 2015 budget proposal the Navy would not contract for more than 32 ships, instead of the 52 as planned.

**Figure 4: Timing of Key Littoral Combat Ship Test Events and Demonstrations Versus Planned Issuance of Request for Proposals and Seaframe Contract Awards**



● Freedom Variant  
 ■ Independence Variant

Source: LCS Test and Evaluation and Master Plan and Navy documentation. | GAO-14-749

<sup>a</sup>According to the Navy, the exact deployment date of the *Independence* variant is classified, but it is notionally planned to deploy before 2017.

<sup>b</sup>This testing includes completion of air warfare testing.

<sup>c</sup>Schedule depends on availability of replacement missile solution, if necessary.

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As shown in figure 4, we found that a number of significant test events as outlined in the TEMP will not be completed in time to inform the development or release of a request for proposals or the award of follow-on contract(s), or they will be completed on one variant but not both. Many of these test events are part of operational testing. Operational testing includes live-fire testing, which provides timely assessment of the survivability and lethality of a weapon system. The significance of conducting operational testing is reflected by the fact that statute requires a program to complete realistic survivability tests and initial operational testing before starting full rate production.<sup>29</sup> The Navy plans to continue buying seaframes before completing operational test events that demonstrate the capability of the seaframes, that is, equipped with mission packages that can meet initial requirements.<sup>30</sup> Other tests highlighted in the figure include shock and survivability tests, which demonstrate that the ship designs can safely absorb and control damage. Realistic survivability tests are required by statute before a program proceeds beyond low-rate initial production.<sup>31</sup>

Moreover, based on current test plans, DOT&E has concerns about the adequacy and nature of some tests, which led to lengthy revisions of earlier versions of the TEMP. Due to these concerns, DOT&E issued a conditional approval letter stating that the test plan was not adequate to support later phases of operational testing, and that the out-years of the program are still not well defined. Final performance requirements are defined in the program's capabilities development document, and last year the Navy developed requirements for increment 2 SUW and increment 1 MCM to support testing. However, no requirements currently exist for the other increments. DOT&E granted the Navy approval to move to the operational testing of increment 2 SUW and increment 1 MCM as described in the TEMP, which the Navy plans to begin in 2014 and 2015, respectively, but DOT&E required the Navy to update and resubmit the TEMP to support testing for later increments. As such, the above schedule may change with subsequent TEMP submissions.

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<sup>29</sup>10 U.S.C. §§ 2399, 2366.

<sup>30</sup>[GAO-13-530](#) contains additional information about mission package capabilities.

<sup>31</sup>10 U.S.C. § 2366.

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Pace of Mission Package  
Procurement Outpacing  
Levels Needed for  
Operational Testing

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To help mitigate the concurrency in the LCS program—in particular to better align planned contractual actions with obtaining knowledge through some of these test events—we recommended in July 2013 that the Navy reassess its acquisition strategy. Specifically, we recommended that the Department of Defense (DOD) limit future seaframe acquisitions until it completed a full-rate production review. We also recommended that DOD report to Congress on the relative advantages of each seaframe variant for each key LCS mission prior to awarding any additional seaframe contracts. In its written response, DOD did not agree with our recommendations aimed at slowing the pace of seaframe procurements. DOD cited the need to buy ships at the planned pace to keep pricing low and saw no value in reducing production pending the full-rate production decision. DOD agreed that the Navy could, if requested by Congress, report on the performance of each seaframe variant against current LCS requirements, but did not address the need to provide an assessment of the relative costs and advantages and disadvantages of the variants against operational and mission needs. Such steps remain important to help ensure that the level of capability provided by LCS is militarily useful given the warfighter’s current capability needs and that continued investment in the program is warranted.

The Navy continues to move forward with a strategy that buys mission packages before their performance is demonstrated. The Navy held a Milestone B review for the mission packages in January 7, 2014, which would typically authorize a program to begin system design and demonstration efforts and determine the low-rate production quantity, which is necessary to—among other things—provide production configured or representative articles for operational tests.<sup>32</sup> Based on this review, the Assistant Secretary of the Navy for Research, Development, and Acquisitions authorized the program to effectively accelerate mission package production, granting the program approval to procure 5 test units and up to 27 production mission packages.<sup>33</sup> According to DOD guidance, low-rate production usually begins at Milestone C, when programs are

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<sup>32</sup>Low-Rate Initial Production quantities are generally 10 percent of the total production quantity.

<sup>33</sup>In October 2012, the Office of the Secretary of Defense, Acquisition, Logistics, and Technology changed the status of the LCS mission module program from an Acquisition Category (ACAT) ID to an ACAT IC, thereby giving the Assistant Secretary of the Navy for Research, Development, and Acquisitions decision making authority for mission module acquisitions, including approval of the Milestone B decision.

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authorized to begin initial production. As we highlighted in our last report, continuing into what is essentially full-rate production—as this 32 mission packages is half of the total planned quantity of mission packages for the program—increases the risk that the Navy will be purchasing systems that have not been validated to meet requirements through testing.<sup>34</sup> We also recommended in July 2013 that the Navy only buy the minimum quantities of mission module systems required to support operational testing. DOD did not agree with this recommendation, stating that mission package procurements were at a rate necessary to: support (1) developmental and operational testing of the two seaframe variants with each mission module increment; (2) fleet training needs; and (3) operational LCS ships. In its memorandum on the Navy's Remote Minehunting System (RMS) operational assessment and Milestone C decision, DOT&E raised similar concerns, stating for example that the Navy should strictly limit any production of RMS, including the Remote Multi-mission Vehicle (RMMV), until greater system maturity and reliability are demonstrated on the version of RMS that will be initially fielded.

We also recommended in July 2013 that the Navy ensure that the program baseline submitted for the mission modules' Milestone B establish program goals for cost, schedule, and performance for each mission module increment. DOD partially concurred with this recommendation, but our review of the program baseline found that it does not define the thresholds and objectives for performance for each increment of the mission modules. Officials from the office of the Chief of Naval Operations stated that there is no plan to update the baseline to include this performance information since they believe that the LCS mission package increments actually represent only one increment of capability. Without defined performance thresholds and objectives for each mission package increment, decision makers will continue to lack information needed to effectively monitor the development of the increments, and a baseline against which to measure performance.

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<sup>34</sup>If the Navy curtails LCS production at 32 seaframes, the end number of mission package quantities could change.

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## Additional Reporting Should Provide Congress with Key Information to Support Decision Making

We raised two matters for Congressional consideration in our July 2013 report. First, to ensure that continued LCS investments are informed by adequate knowledge, we suggested that Congress consider restricting funding for additional seaframes until the Navy completes ongoing technical and design studies related to potential changes in LCS requirements, capabilities, and the commonality of systems on the two seaframe variants. Second, to ensure timely and complete information on the capabilities of each seaframe variant prior to making decisions about future LCS procurements, we suggested that Congress consider requiring DOD to report on the relative advantages of each variant in carrying out the three primary LCS missions.

In the National Defense Authorization Act (NDAA) for Fiscal Year 2014, Congress directed the Navy to complete a number of studies that are in line with our recommendations to provide additional information on some of the risk areas that we identified.<sup>35</sup> The legislation restricts the obligation or expenditure of fiscal year 2014 funding for construction or advanced procurement for LCS seaframes 25 and 26 until the Navy submits the required reports and certifications. However, as LCS 25 and LCS 26 are not yet under contract, the Navy cannot use fiscal year 2014 money to fund these seaframes. As of the end of January 2014, Navy officials told us that they had just begun coordinating efforts and collecting data to write reports as required in the NDAA for Fiscal Year 2014. A copy of this NDAA requirement can be found in appendix III.

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## Conclusions

The Navy has made progress since our last report in demonstrating LCS capabilities. In particular, completing the initial deployment of an LCS with a mission package to an overseas location provided the Navy with important real-world lessons learned that are being used to refine plans for subsequent deployments. However, these deployments are not a substitute for operational testing. Completing further developmental and operational test events will continue to provide the Navy will valuable data with which it can evaluate the performance of systems and make adjustments, as needed. The Navy still has a great deal of learning to do about the ships, the integrated capability that they are intended to provide when equipped with the mission packages, and how the overall LCS concept will be implemented. Not having adequate knowledge—such as

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<sup>35</sup> Pub L. No. 113-66, § 124 (2013).

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the results of additional deployments and key operational test events—may result in the Navy buying ships that are more costly or burdensome to manage over the course of their service lives. Events such as rough water trials, shock and total ship survivability trials are intended to provide confidence that the ships will last their intended lifespan and are survivable, while deployments and operational testing of initial mission packages help provide confidence that the LCS will meet its performance requirements. Moving forward without this information complicates potential design changes to seaframes or mission packages.

As we have concluded in past work, the Navy's continued approach of procuring the ships before proving their capabilities through testing increases the risks of costly retrofits or reduced performance. In addition, the Navy's recent decision to accelerate the acquisition of mission packages further limits the flexibility that the program will have to adjust to any problems that may arise during operational testing. With the Navy's planned fiscal year 2016 contract awards for seaframes fast approaching, we believe the recommendations that we made in July 2013 are still important steps that the Navy can take to reduce risks to the program, but additional steps are also warranted.

Further, the Navy's ability to manage the ships' weight has been constrained, as the contractors' reporting has not been accurate or in a format that would be most useful to naval engineers. The Navy could improve the expediency with which it reviews and comments on contractor weight reports. Tools are available to improve the contractor's weight reporting, such as pursuing financial withholds, and modifying the LCS contracts to include additional mechanisms to ensure better reporting. More accurate and timely reporting will help the Navy target the drivers of weight growth and assess the feasibility of the additional design changes being considered for both seaframe variants.

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## Recommendations for Executive Action

1. We recommend that the Under Secretary of Defense for Acquisition, Technology, and Logistics require—before approving the release of the request for proposals for future contracts for either seaframe variant—that both variants:
  - a. Have deployed to a forward overseas location;
  - b. Have completed rough water, ship shock, and total ship survivability testing; and

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- c. Have completed initial operational test and evaluation of the SUW mission package on the *Freedom* variant and the MCM mission package on the *Independence* variant.
2. To improve the Navy's ability to effectively oversee weight management of the LCS seaframes, we recommend the Secretary of the Navy direct the LCS Seaframe Program Manager to
- a. Take steps to ensure that the Navy completes its reviews and submits comments, if any, on the weight reports to the contractors within the timeframes dictated by the contract; and
  - b. Consider actions to make the contractor more responsive to the Navy's identified accuracy and content problems in the weight reports, including pursuing financial withholds or modifying the contract language.

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## Agency Comments and Our Evaluation

We provided a draft of this report to DOD for review and comment. In its written comments, which are included in appendix IV, DOD partially agreed with our recommendations to complete certain testing and deployment activities before approving the release of the request for proposals for future seaframes. DOD agreed with our recommendations related to seaframe weight management.

DOD officials stated that they have every intention of completing as many as possible of the test and demonstration items that we identified in our recommendation before releasing the request for proposals (RFP) for future seaframe contracts, but disagreed that the release of the RFP should hinge on completion of these events. DOD officials stated that creating a break in the production of the seaframes would increase program costs and have significant industrial base considerations. We are not advocating a production break, but we do believe it is conceivable that subsequent seaframe unit cost increases could be lower than the potential increases in overall program costs if testing uncovered the need for costly retrofits, redesign, and/or requirements changes that would then have to be made to ships in production. We chose to use the release of the RFP as a decision point because we believe that drafting an RFP that is based on key knowledge of LCS performance serves as an important risk mitigation tool for the government. Specifically, if the government goes forward with an RFP that is not fully informed by the results of the important test activities we identified in our recommendation, any changes that might be later identified as necessary would have to be reflected in an amended RFP, which could delay the award of contracts and potentially cause a production break. The department noted that a

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Defense Acquisition Board (DAB) review is planned in the fiscal year 2016 time frame and that the Board will approve the Navy's acquisition strategy for LCS before additional seaframe contracts are awarded. DOD stated that this review will take into account the progress of testing for both seaframes, and that every item we identified in our recommendation will be completed prior to the DAB except for the completion of the full-scale ship shock trials. We believe it will be important that the department makes certain that the DAB review occurs at a point when the Navy can be directed to pause and revise its acquisition strategy and the RFP for LCS if necessary to ensure it reflects the most current knowledge gained from testing and deployments. It is possible that continued testing could inform changes to the numbers of each variant procured, changes that would need to be incorporated into the acquisition strategy before the DAB authorizes the Navy to continue to buy more seaframes.

Further, we continue to believe that the Navy needs to identify a means to conduct a full-scale ship shock trial before committing to contracts for further seaframes. Because the LCS seaframes are based on commercial designs—though heavily modified—we believe these trials are important to ensure that the Navy is buying ships that will meet its survivability needs. This is especially true with the Independence class variant, which is based on a novel hullform for the Navy and represents the Navy's first-time use of aluminum for a ship of this size. The Navy has itself identified that it lacks sufficient data on which to confidently base assumptions of this variant's performance in an underwater shock environment, which makes completing this test event before DAB review and award of contracts important.

DOD agreed to take steps as we recommended to improve the weight management of the LCS seaframes, and plans to review within 180 days the process by which it reviews the contractor weight submissions and the methods by which it can ensure that the contractors are responsive to Navy accuracy and content concerns.

We also provided relevant portions of the draft report (in particular, the sections on weight management) to the contractors and incorporated their technical comments as appropriate.

We are sending copies of this report to the appropriate congressional committees and the Secretaries of Defense and the Navy. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

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If you or your staff have any questions about this report, please contact me at 202-512-4841 or [mackinm@gao.gov](mailto:mackinm@gao.gov). Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix V.

A handwritten signature in black ink that reads "Michele Mackin". The script is fluid and cursive, with the first name "Michele" and last name "Mackin" clearly distinguishable.

Michele Mackin  
Director, Acquisition and Sourcing Management

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*List of Committees*

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

The Honorable Richard J. Durbin  
Chairman  
The Honorable Thad Cochran  
Ranking Member  
Committee on Appropriations  
Subcommittee on Defense  
United States Senate

The Honorable Howard P. "Buck" McKeon  
Chairman  
The Honorable Adam Smith  
Ranking Member  
Committee on Armed Services  
House of Representatives

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

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# Appendix I: Objectives, Scope, and Methodology

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To assess the Navy's lessons learned from the deployment of the first Littoral Combat Ship (LCS) to Singapore, we analyzed reports from various LCS stakeholders, including Navy 7th Fleet Destroyer Squadron 7 (responsible for LCS during the deployment), and the Office of the Chief of Naval Operations (OPNAV). We also traveled to the forward-deployed location in Singapore, and interviewed USS *Freedom*'s commanding officer and some of the crew; as well as officials from the LCS fleet introduction program office (PMS 505); Destroyer Squadron 7; and Commander, Logistics Force Western Pacific. We also traveled to Japan to interview 7th Fleet officials involved with LCS logistics; policy and planning; warfare requirements; strategy; and operations. Furthermore, we conducted interviews with relevant Navy officials, such as the OPNAV office that is the resource sponsor for the LCS program (N96); LCS seaframe program office (PMS 501); and the LCS and Joint High Speed Vessel Council. To assess what knowledge the Navy has obtained about LCS since our previous report, we analyzed DOD, Navy and contractor documents, including test and evaluation letters of observation from the Commander, Operational Testing and Evaluation Force (COTF); testing reports from the Director, Operational Testing and Evaluation (DOT&E); as well as the Board of Inspection and Survey (INSURV) reports. We analyzed documentation from the LCS mission module program office (PMS 420), including an LCS contractor test report. Furthermore, we interviewed officials from OPNAV; the LCS and Joint High Speed Vessel Council; Naval Sea Systems Command (NAVSEA); DOT&E; COTF; INSURV; the Naval Surface Warfare Center; the LCS seaframe program office; the LCS mission module program office; and the Navy Modeling and Simulation Office. Finally, we leveraged previous GAO reports on the LCS dating back to 2005.

To assess additional risks for the LCS program related to weight management, we analyzed Navy and contractor documentation including weight reports; inclining experiment reports; LCS seaframe contracts; the LCS Capabilities Development Document; and seaframe building specifications. To understand weight management and reporting practices, we analyzed the Society of Allied Weight Engineers Recommended Practices and NAVSEA policies on weight management. Furthermore, we conducted interviews with Lockheed Martin; Bath Iron Works; Marinette Marine; Austal USA; the American Bureau of Shipping; and the Navy's Supervisor of Shipbuilding. To evaluate the naval architecture limits of the LCS seaframes, we interviewed retired naval architects with significant Navy ship design experience, as well as American Bureau of Shipping representatives. We also met with technical experts from the Naval Systems Engineering Directorate (SEA05). We

analyzed Navy and contractor documents, including the LCS test and evaluation master plan; DOT&E test and evaluation master plan approval memo; the LCS mission modules Milestone B documentation; and the Navy's acquisition decision memorandum. Furthermore, we conducted interviews with officials from DOT&E; COTF; and INSURV.

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: Selected Navy Comments on Recent LCS Weight Reports

	Navy comment	Comment date	Associated prime contractor	Ships affected
Classification errors	"Main structural elements such as shell, framing and decks are calculated by frame... This results in nearly impossible review and audit capability. This method does not adhere to Extended Ship's Work Breakdown Structure (ESWBS)..."	May 2012	Austal USA	LCS 6
	"Weight report structure and format are problematic. The subject quarterly weight report consisted of various disjointed, mislabeled, and conflicting files which are difficult to assemble and correlate for reporting purposes."	April 2013	Austal USA	LCS 6 and follow-on Independence variant seaframes
	"It appears the computer aided design effort to incorporate detail data for Group 1 weights is fraught with ESWBS classification errors...It appears Group 1 has been arbitrarily classified to the point of a loss of control of the details."	November 2013	Austal USA	LCS 6 and LCS 8
Estimating errors	"The LCS 3 quarterly weight reports overestimated the ship by approximately 90 tons. The details of that same database have essentially been carried over to the LCS 5 accepted weight estimate and subsequent quarterly weight reports...The last two quarterly weight reports have not shown any progress toward improving the details (via recalculations) and reducing risk..."	April 2013	Lockheed Martin	LCS 5 and follow-on <i>Freedom</i> variant seaframes
	"The LCS 6 and LCS 8 calculated light ship condition with remaining margin is projected to be 56 tons lighter than LCS 4 inclined light ship condition. When the...correction is incorporated into the projection, the full load condition for weight exceeds the (naval architectural limit) for displacement by...30 tons. Specifically, the service life allowance for weight is deficient by 30 tons. This is a serious and unprecedented situation that has to be addressed quickly."	November 2013	Austal USA	LCS 6 and LCS 8
Non-submission	"Submittal did not include an updated quarterly weight report...a no-submittal indicates the projected full load of the ship at delivery is currently unknown."	December 2012	Austal USA	LCS 6 and follow-on Independence variant seaframes
Use of outdated information	"Mission package descriptions, weights and centers have not been updated in years. The Contractor must update the mine countermeasures and surface warfare mission packages with the latest values."	June 2013	Lockheed Martin	LCS 5 and follow-on <i>Freedom</i> variant seaframes

Source: GAO analysis of Navy documentation. | GAO-14-794

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# Appendix III: 2014 National Defense Authorization Act Navy Reporting Requirements

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Section 124 of the National Defense Authorization Act for Fiscal Year 2014 restricts the obligation or expenditure of fiscal year 2014 funding for construction or advanced procurement for LCS seaframes 25 and 26 until the Navy submits the required reports and certifications. This section reads:

**SEC. 124. LIMITATION ON AVAILABILITY OF FUNDS FOR LITTORAL COMBAT SHIP**

(a) LIMITATION—None of the funds authorized to be appropriated by this Act or otherwise made available for fiscal year 2014 for construction or advanced procurement of materials for the Littoral Combat Ships designated as LCS 25 or LCS 26 may be obligated or expended until the Secretary of the Navy submits to the congressional defense committees each of the following:

- 1) The report required by subsection (b)(1).
- 2) A coordinated determination by the Director of Operational Test and Evaluation and the Under Secretary of Defense for Acquisition, Technology, and Logistics that successful completion of the test evaluation master plan for both seaframes and each mission module will demonstrate operational effectiveness and operational suitability.
- 3) A certification that the Joint Requirements Oversight Council—
  - a) has reviewed the capabilities of the legacy systems that the Littoral Combat Ship is planned to replace and has compared such capabilities to the capabilities to be provided by the Littoral Combat Ship;
  - b) has assessed the adequacy of the current capabilities development document for the Littoral Combat Ship to meet the requirements of the combatant commands and to address future threats as reflected in the latest assessment by the defense intelligence community; and
  - c) has either validated the current capabilities development document or directed the Secretary to update the current capabilities development document based on the performance of the Littoral Combat Ship and mission modules to date.
- 4) A report on the expected performance of each seaframe variant and mission module against the current or updated capabilities development document.

- 5) Certification that a capability production document will be completed for each mission module before operational testing.

(b) REPORT—

(1) IN GENERAL—Not later than 60 days after the date of the enactment of this Act, the Chief of Naval Operations, in coordination with the Director of Operational Test and Evaluation, shall submit to the congressional defense committees a report on the current concept of operations and expected survivability attributes of each of the Littoral Combat Ship seaframes.

(2) ELEMENTS—The report required by paragraph (1) shall set forth the following,

- a) A review of the current concept of operations of the Littoral Combat Ship and a comparison of such concept of operations with the original concept of operations of the Littoral Combat Ship.
- b) An assessment of the ability of the Littoral Combat Ship to carry out the core missions of the Cooperative Strategy for 21st Century Seapower of the Navy.
- c) A comparison of the combat capabilities for the three missions assigned to the Littoral Combat Ship seaframes (anti-surface warfare, mine countermeasures, and anti-submarine warfare) with the combat capabilities for each of such missions of the systems the Littoral Combat Ship is replacing.
- d) An assessment of expected survivability of the Littoral Combat Ship seaframes in the context of the planned employment of the Littoral Combat Ship as described in the concept of operations.
- e) The current status of operational testing for the seaframes and the mission modules of the Littoral Combat Ship.
- f) An updated test and evaluation master plan for the Littoral Combat Ship.
- g) A review of survivability testing, modeling, and simulation conducted to date on the two seaframes of the Littoral Combat Ship.
- h) An updated assessment of the endurance of the Littoral Combat Ship at sea with respect to maintenance, fuel use, and sustainment of crew and mission modules.
- i) An assessment of the adequacy of current ship manning plans for the Littoral Combat Ship and an assessment of the impact that increased manning has on design changes and the endurance of the Littoral Combat Ship.
- j) A list of the casualty reports to date on each Littoral Combat Ship, including a description of the impact of such casualties on the

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design or ability of that Littoral Combat Ship to perform assigned missions.

(3) FORM—The report required by paragraph (1) shall be submitted in classified form and unclassified form.

# Appendix IV: Comments from the Department of Defense



ACQUISITION

## ASSISTANT SECRETARY OF DEFENSE

3015 DEFENSE PENTAGON  
WASHINGTON, DC 20301-3015

MAR 25 2014

Ms. Michele Mackin  
Director  
Acquisition and Sourcing Management  
U.S. Government Accountability Office  
441 G Street, N.W.  
Washington, DC 20548

Dear Ms. Mackin:

This is the Department of Defense response to the GAO Draft Report, [REDACTED] 'LITTORAL COMBAT SHIP: Additional Testing and Improved Weight Management Needed Prior to Further Investments,' dated March 4, 2014 (GAO Code 121166).

The Department acknowledges receipt of the draft report. As more fully explained in the enclosure, the Department partially concurs with recommendation 1 and concurs with recommendation 2.

The Department appreciates the opportunity to comment on the draft report. For further questions concerning this report, please contact Mr. Jack Evans, Deputy Director for Naval Warfare, at [john.j.evans.civ@mail.mil](mailto:john.j.evans.civ@mail.mil) or 703-614-3170.

Sincerely,

  
Katrina McFarland

Enclosure:  
As stated

GAO DRAFT REPORT DATED MARCH 4, 2014

**“LITTORAL COMBAT SHIP: ADDITIONAL TESTING AND  
IMPROVED WEIGHT MANAGEMENT NEEDED PRIOR TO  
FURTHER INVESTMENTS”**

**DEPARTMENT OF DEFENSE COMMENTS  
TO THE GAO RECOMMENDATIONS**

**RECOMMENDATION 1:** We recommend that the Under Secretary of Defense for Acquisition, Technology, and Logistics require—before approving the release of the request for proposals for future contracts for either seaframe variant—that both variants:

- a. Have deployed to a forward overseas location;
- b. Have completed rough water, ship shock and total ship survivability testing, and
- c. Have completed initial operational test and evaluation of the SUW mission package on the Freedom variant and the MCM mission package on the Independence variant.

**DoD RESPONSE:** Partially Concur. The Department has every intention to complete as many as possible of the items identified in sub-parts (a), (b), and (c) of the GAO recommendation prior to release for the Request for Proposals (RFP) for future seaframe contracts, however, the Department disagrees that the RFP release should hinge on the completion of certain testing and operational deployments suggested in the GAO report.

A Defense Acquisition Board (DAB) review is planned in the FY 2016 timeframe to review the program prior to award of the FY 2016 seaframes contract. The DAB will evaluate all program information, including available test data, and inform the Undersecretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) on the program’s readiness to proceed with further construction of seaframes. USD(AT&L) will need to approve the Acquisition Strategy (AS) for the next procurement of seaframes in Fiscal Year (FY) 2016 prior to release of the RFP. Approval of the AS will be informed by the status of the progress of testing for both seaframes, including the items identified by the GAO. Current plans indicate that the first INDEPENDENCE variant ship deployment to a forward overseas location prior to award of future contracts for seaframe variants, however, operational considerations could change this planned deployment date beyond the control of the acquisition community. The FREEDOM variant completed an overseas deployment to a forward location in December 2013. The Littoral Combat Ship (LCS) seaframe program test plan includes rough water testing, ship shock testing, and total ship survivability testing. Total ship survivability testing of the INDEPENDENCE variant and full scale shock trials of both variants will not complete prior to RFP release. Likewise, initial operational testing of the Mine Countermeasures (MCM) mission package on the INDEPENDENCE variant will not be completed prior to the release of the RFP. Initial operational testing of the Surface Warfare mission package on the FREEDOM variant is currently planned to be completed

prior to release of the RFP. Rough water testing of both variants will be completed as ocean conditions allow.

LCS serial production is now optimized at both shipyards to deliver seaframes at very favorable prices to the Government. If the completion of all testing recommended by the GAO were to create a break in serial production, the increased cost and impact to the industrial base associated with the production break would be an important factor in the decision to proceed. Placing the construction program on hold would cause increased program cost even on the last ships of the block buy due to increased shipbuilder overhead cost, vendor based pricing, and negative impact on shipyard manpower, and will have significant industrial base implications as well as cross program impacts at shipyards. Additionally, a construction hold would create a multi-year gap between the first 24 ships and completion of the class which would negatively impact the fleet laydown requirements, and impact the cost and schedule of the Mission Module procurements and the sustainability and maintainability of the ships. By the time of the DAB review, the first INDEPENDENCE variant ship should have deployed to a forward overseas location, total ship survivability testing of both variants should have completed, and initial operational testing of the MCM mission package on the INDEPENDENCE variant should have completed. The only GAO-identified testing remaining to complete would be the full scale shock trials of both variants. The Department will review the test schedule and make any adjustments that can reasonably be made to complete as much testing as possible suggested by GAO prior to release of the RFP and the DAB review for the next procurement of seaframes. In any case, considerable developmental testing of the seaframes and the mission packages will also be completed prior to RFP release and the DAB review and will inform both decisions. For reference purposes this recommendation will be identified as item [REDACTED]-01.

**RECOMMENDATION 2:** To improve the Navy's ability to effectively oversee weight management of the LCS seaframes, we recommend the Secretary of the Navy to direct the LCS Seaframe Program Manager to:

- a. Take steps to ensure that the Navy completes its reviews and commenting, if necessary, on the weight reports within the timeframes dictated by the contract;
- b. Consider actions to make the contractor more responsive to the Navy's accuracy and content problems in the weight reports, including pursuing financial withholds or modifying the contract language.

**DoD RESPONSE:** Concur. The Navy agrees to review within 180 days the internal processes for reviewing weight reports for the LCS program and to take steps that will ensure the weight report reviews are conducted within the contractual timelines. The Navy also agrees to review within 180 days the methods available to ensure the contractors are more responsive to accuracy and content issues identified by the Navy and to implement those methods when deemed necessary. For reference purposes this recommendation will be identified as item [REDACTED]-02.

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# Appendix V: GAO Contact and Staff Acknowledgments

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## GAO Contact

Michele Mackin, 202-512-4841 or [mackinm@gao.gov](mailto:mackinm@gao.gov)

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## Staff Acknowledgments

In addition to the contact named above, the following staff members made key contributions to this report: Diana Moldafsky (Assistant Director); Greg Campbell; Jenny Chow; Christopher R. Durbin; G. Oliver Elliott; Laura Greifner; Kristine Hassinger; Kenneth Patton; C. James Madar; Sabrina Streagle; Roxanna Sun; and Hai Tran.

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