Congressional Research Service
Informing the legislative debate since 1914

Navy Littoral Combat Ship/Frigate (LCS/FFGX) Program: Background and Issues for Congress

(name redacted)
Specialist in Naval Affairs

August 11, 2017

Congressional Research Service
7-....
www.crs.gov
RL33741

CRS REPORT
Prepared for Members and Committees of Congress

Summary

The Navy's Littoral Combat Ship/Frigate (LCS/FFG(X)) program is a program to procure a total of 40, and possibly as many as 52, small surface combatants (SSCs), meaning LCSs and frigates. A total of 29 LCSs have been procured through FY2017. For FY2018, the Navy is requesting the procurement of two more LCSs, which would be the 30th and 31st.

The Navy's proposed FY2018 budget, which was submitted on May 23, 2017, originally showed a request for one LCS at an estimated cost of $636.1 million. On May 24, 2017, the Navy announced that it was amending its proposed FY2018 budget to request the procurement of two LCSs rather than one. As amended, the Navy's proposed FY2018 budget requests two LCSs at a total cost of $1,136.1 million, or an average of about $568.1 million each.

Two very different LCS designs are currently being built. One was developed by an industry team led by Lockheed; the other was developed by an industry team that was led by General Dynamics. The design developed by the Lockheed-led team is built at the Marinette Marine shipyard at Marinette, WI, with Lockheed as the prime contractor; the design developed by the team that was led by General Dynamics is built at the Austal USA shipyard at Mobile, AL, with Austal USA as the prime contractor.

The LCS/FFG(X) program has been controversial over the years due to past cost growth, design and construction issues with the first LCSs, concerns over the survivability of LCSs (i.e., their ability to withstand battle damage), concerns over whether LCSs are sufficiently armed and would be able to perform their stated missions effectively, and concerns over the development and testing of the modular mission packages for LCSs. The Navy's execution of the program has been a matter of congressional oversight attention for several years.

The LCS/FFG(X) program now appears to be in flux in certain key respects, including the following:

- **Total program quantity.** Although the program was limited by a December 2015 restructuring to a total of 40 ships, the Navy has a requirement for 52 SSCs, raising a possibility that the current reassessment of the program might lead to a decision by the Department of Defense to expand the total size of the program to something more than 40 ships, and possibly to as many as 52. It is also possible that the program might be reduced to something less than 40 ships.
- **Annual procurement rate.** It is possible the program's annual procurement rate could be increased from the one or two ships per year shown in the FY2017 budget submission to a rate of about three ships per year—a rate similar to those in budget submissions for years prior to FY2017—particularly if the program's total procurement quantity is increased to something more than 40.
- **The down select.** If the program's annual procurement rate is increased to something like three ships per year, it might prompt a reconsideration of whether to conduct a currently planned down select to a single LCS design.
- **Design and builder or builders of the FFG(X)s.** The design of the new frigates, and the shipyard or shipyards that will build them, are uncertain. Navy officials have stated that the Navy is reassessing what capabilities its wants to have in the new frigates, and is examining potential frigate designs based on both LCS hull forms and other frigate-seized hull forms.

Contents

Figures

Tables

Appendixes

Contacts

Introduction

This report provides background information and issues for Congress on the Navy's Littoral Combat Ship/Frigate (LCS/FFG(X)) program, a program to procure a total of 40, and possibly as many as 52, small surface combatants (SSCs), meaning LCSs and frigates. A total of 29 LCSs have been procured through FY2017. For FY2018, the Navy is requesting the procurement of two more LCSs, which would be the 30th and 31st.

The program presents several oversight issues for Congress. Congress's decisions on the LCS/FFG(X) program will affect Navy capabilities and funding requirements, and the shipbuilding industrial base.

For an overview of the strategic and budgetary context in which the LCS/FFG(X) program and other Navy shipbuilding programs may be considered, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .

Background

Program Overview

The Navy's Littoral Combat Ship/Frigate (LCS/FFG(X)) program is a program to procure a total of 40, and possibly as many as 52, small surface combatants (SSCs), meaning LCSs and frigates. The Navy's force-level goal for achieving and maintaining a fleet of 355-ships, which the Navy released in December 2016,[1] includes a goal of achieving and maintaining a force of 52 SSCs.

The LCS/FFG(X) program has been controversial over the years due to past cost growth, design and construction issues with the first LCSs, concerns over the survivability of LCSs (i.e., their ability to withstand battle damage), concerns over whether LCSs are sufficiently armed and would be able to perform their stated missions effectively, and concerns over the development and testing of the modular mission packages for LCSs. The Navy's execution of the program has been a matter of congressional oversight attention for several years.

Prior to a program restructuring that was directed in February 2014 by then-Secretary of Defense Chuck Hagel, the LCS/FFG(X) program was called the LCS program, and included a planned procurement of 52 LCSs. The February 2014 restructuring changed the program into one for procuring 32 LCSs and 20 FFs. A second program restructuring that was directed in December 2015 by then-Secretary of Defense Ashton Carter reduced the program's total planned procurement to 40 ships, to consist of either 28 LCSs and 12 FFs, or 30 LCSs and 10 FFs, depending on exactly when production would shift from LCSs to FFs. The December 2015 restructuring also directed the Navy to reduce the planned procurement rate of the program from about three ships per year to one or two ships per year.

Since the start of LCS procurement, the Navy has been procuring two different LCS designs that are produced in two different shipyards. The December 2015 program restructuring directed the Navy to conduct a down select among these two designs by FY2019 (i.e., the Navy was directed to pick one of these two designs by FY2019), and produce all LCSs/FFs procured in FY2019 and subsequent years to a single design.

[1] For more on the Navy's 355-ship force-level goal, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by (name redacted) .

Until recently, the Navy had planned to conduct the down select in FY2018 or FY2019 and build the FFs to a design based on one of the LCS designs. More recently, however, the Navy has indicated that it is reassessing what types of capabilities it wants to have in the FF, that it is examining potential FF designs based on both the LCS hull forms and other frigate-sized hull forms, and that it plans to shift to production of FFs in FY2020 rather than FY2018 or FY2019.

The LCS/FFG(X) program now appears to be in flux in certain key respects, including the following:

- **Total program quantity.** Although the program was limited by the December 2015 restructuring to a total of 40 ships, the Navy has a requirement for 52 SSCs, raising a possibility that the current reassessment of the program might lead to a decision by the Department of Defense (DOD) to expand the total size of the program to something more than 40 ships, and possibly to as many as 52. It is also possible that the program might be reduced to something less than 40 ships.
- **Annual procurement rate.** It is possible the program's annual procurement rate could be increased from the one or two ships per year shown in the FY2017 budget submission to a rate of about three ships per year—a rate similar to those in budget submissions for years prior to FY2017—particularly if the program's total procurement quantity is increased to something more than 40.
- **The down select.** If the program's annual procurement rate is increased to something like three ships per year, it might prompt a reconsideration of whether to conduct a down select to a single LCS design.
- **Design and builder or builders of the FFG(X)s.** The design of the new FFG(X)s, and the shipyard or shipyards that will build them, are uncertain. Navy officials have stated that the Navy is reassessing what capabilities its wants to have in the new FFG(X)s, and is examining potential FFG(X) designs based on both LCS hull forms and other frigate-seized hull forms.

LCS Sea Frames

In General

The LCS is a relatively inexpensive Navy surface combatant that is to be equipped with modular "plug-and-fight" mission packages, including unmanned vehicles (UVs). Rather than being a multimission ship like the Navy's larger surface combatants, the LCS is to be a focused-mission ship, meaning a ship equipped to perform one primary mission at any given time. The ship's mission orientation can be changed by changing out its mission package, although under the Navy's latest plans for operating LCSs, that might not happen very frequently, or at all, for a given LCS. The LCS design, without any mission package, is referred to as the LCS sea frame.

The LCS's primary missions are antisubmarine warfare (ASW), mine countermeasures (MCM), and surface warfare (SUW) against small boats (including so-called "swarm boats"), particularly in littoral (i.e., near-shore) waters. The LCS/FFG(X) program includes the development and procurement of ASW, MCM, and SUW mission packages for use by LCS sea frames. These three primary missions appear oriented toward countering, among other things, some of the littoral anti-access/area-denial (A2/AD) capabilities that have been fielded in recent years by Iran,[2]

[2] For a discussion of Iran's littoral A2/AD capabilities, including submarines, mines, and small boats, see CRS Report R42335, *Iran's Threat to the Strait of Hormuz*, coordinated by (name redacted) .

although they could also be used to counter similar A2/AD capabilities that might be fielded by other countries.

Additional potential missions for LCSs include peacetime engagement and partnership-building operations; intelligence, surveillance, and reconnaissance (ISR) operations; maritime security and intercept operations (including anti-piracy operations); support of Marines or special operations forces; and homeland defense operations. An LCS might perform these missions at any time, regardless of its installed mission package, although an installed mission package might enhance an LCS's ability to perform some of these missions.

The LCS displaces about 3,000 tons, making it about the size of a corvette (i.e., a light frigate) or a Coast Guard cutter. It has a maximum speed of more than 40 knots, compared to something more than 30 knots for the Navy cruisers and destroyers. The LCS has a shallower draft than Navy cruisers and destroyers, permitting it to operate in certain coastal waters and visit certain shallow-draft ports that are not accessible to Navy cruisers and destroyers.

Annual Procurement Quantities

Table 1 shows past (FY2005-FY2017) and projected (FY2018-FY2022) annual procurement quantities for LCSs/FFG(X)s under the Navy's FY2018 budget submission.

Table 1. Past (FY2005-FY2017) and Projected (FY2018-FY2022) Annual LCS Sea Frame Procurement Quantities

FY05	FY06	FY07	FY08	FY09	FY10	FY11	FY12	FY13
1	1	0	0	2	2	2	4	4
FY14	**FY15**	**FY16**	**FY17**	***FY18***	***FY19***	***FY20***	***FY21***	***FY22***
4	3	3	3	*2*	*1*	*1*	*1*	*2*

Source: Prepared by CRS based on FY2018 Navy budget submission.

Notes: (1) The two ships shown in FY2005 and FY2006 were funded through Navy's research and development account rather than the Navy's shipbuilding account. (2) The figures for FY2006-FY2008 do not include five LCSs (two in FY2006, two in FY2007, and one in FY2008) that were funded in those years but later canceled by the Navy.

Two LCS Designs Built by Two LCS Shipyards

On May 27, 2004, the Navy awarded contracts to two industry teams—one led by Lockheed Martin, the other by General Dynamics (GD)—to design two versions of the LCS, with options for each team to build up to two LCSs each. The LCS designs developed by the two teams are quite different—the design developed by the Lockheed-led team is based on a steel semi-planing monohull (with an aluminum superstructure), while the design developed by the team that was led by GD is based on an all-aluminum trimaran hull (see **Figure 1**). The two ships also use different built-in combat systems (i.e., different collections of built-in sensors, computers, software, and tactical displays) that were designed by each industry team. The Navy states that both LCS designs meet the Key Performance Parameters (KPPs) for the LCS part of the LCS/FFG(X) program.

Figure 1. Lockheed LCS Design (Top) and General Dynamics LCS Design (Bottom)

Source: U.S. Navy file photo accessed by CRS at http://www.navy.mil/list_all.asp?id=57917 on January 6, 2010.

The LCS design developed by the Lockheed-led team is built at the Fincantieri/Marinette Marine shipyard at Marinette, WI,[3] with Lockheed as the prime contractor; these ships are designated LCS-1, LCS-3, LCS-5, and so on. The design developed by the team that was led by GD is built at the Austal USA shipyard at Mobile, AL, with Austal USA as the prime contractor;[4] these ships are designated LCS-2, LCS-4, LCS-6, and so on

Two Block Buy Contracts for Procuring Ships 5-26

Ships 1 through 4 in the program were procured with single-ship contracts. The next 22 ships in the program (ships 5 through 26) were procured under two 10-ship block buy contracts that the Navy awarded to the two LCS builders in December 2010, and which were later extended in each case to include an 11th ship. The Navy sought and received legislative authority from Congress in 2010 to award these block buy contracts.[5]

LCSs in Service

As of June 1, 2017, eight LCSs (LCSs 1 through 8) had been commissioned into service, and a ninth LCS (LCS-10) has been delivered to the Navy and was awaiting commissioning. LCS 9 and LCSs 11 through 29 are in various stages of construction.

LCS Mission Packages

Procurement Quantities

Prior to the program's February 2014 restructuring, the Navy had planned to procure 64 LCS mission packages (16 ASW, 24 MCM, and 24 SUW) for 52 LCSs. The Navy has not announced how the program's February 2014 and December 2015 restructurings have changed planned numbers of mission packages.

Deliveries and Initial Operational Capability (IOC) Dates

Initial increments (i.e., versions) of LCS mission packages are undergoing testing. At May 24, 2017, hearing on Navy FY2018 seapower and projection forces programs before the Seapower and Projection Forces subcommittee of the House Armed Services Committee, Department of the Navy officials testified that

> The LCS Mission Modules program continues the development of the Surface Warfare (SUW), Mine Countermeasures (MCM), and Anti-Submarine Warfare (ASW) capabilities and delivering individual mission systems incrementally as they become available. The LCS with an embarked SUW Mission Package (MP) provides a robust and flexible combat capability to rapidly detect, track, and prosecute small-boat swarm threats. The Surface-to-Surface Missile Module with Longbow Hellfire is currently in

[3] In 2009, Fincantieri Marine Group, an Italian shipbuilding firm, purchased Manitowoc Marine Group, the owner of Marinette Marine and two other shipyards. Lockheed is a minority investor in Marinette Marine.

[4] Austal USA was created in 1999 as a joint venture between Austal Limited of Henderson, Western Australia, and Bender Shipbuilding & Repair Company of Mobile, AL, with Austal Limited as the majority owner.

[5] Congress granted the authority for the block buy contracts in Section 150 of H.R. 3082/P.L. 111-322 of December 22, 2010, an act that, among other things, funded federal government operations through March 4, 2011. For more on block buy contracts, see CRS Report R41909, *Multiyear Procurement (MYP) and Block Buy Contracting in Defense Acquisition: Background and Issues for Congress*, by (name redacted) and (name redacted) .

testing with Initial Operational Capability (IOC) planned for FY 2018. Development and integration of the ASW MP Escort Mission Module (EMM) and Torpedo Defense Module are ongoing. The Department recently awarded an option to build the ASW EMM and is on track to fully integrate with LCS to support IOC with the ASW MP in FY 2019.

The MCM MP provides the capability to detect, classify, identify, and neutralize mines throughout the water column, from the beach zone to the sea floor. Several of the MCM MP systems performed well during MCM MP TECHEVAL. IOC for Airborne Laser Mine Detection System and Airborne Mine Neutralization System was achieved in November 2016. These systems are in production and are being delivered to the fleet today. After cancelling the Remote Minehunting System program in FY 2016 due to poor reliability during TECHEVAL and following the conclusion of the Independent Review Team recommendations, the Department designated the MCM Unmanned Surface Vehicle (USV) as the new tow platform for minehunting operations. The MCM USV is based on the USV already used in the Unmanned Influence Sweep System program and development began in March of 2017. IOC is planned for FY 2020.[6]

LCS Manning and Deployment

Reduced-Size Crew

The LCS employs automation to achieve a reduced-sized core crew (i.e., sea frame crew). The original aim was to achieve a core crew of 40 sailors; the Navy subsequently decided to increase that number to about 50. Another 38 or so additional sailors are to operate the ship's embarked aircraft (about 23 sailors) and its embarked mission package (about 15 sailors in the case of the MCM package), which would make for a total crew of about 88 sailors (for an LCS equipped with an MCM mission package), compared to more than 200 for the Navy's frigates and about 300 (or more) for the Navy's current cruisers and destroyers.[7] The crew size for the frigate may differ from that of the LCS design.

Original 3-2-1 Crewing and Operating Plan

The Navy originally planned to maintain three crews for each two LCSs, and to keep one of those two LCSs continuously underway—an approach Navy officials referred to as the 3-2-1 plan. Under this plan, LCSs were to be deployed at forward station (such as Singapore) for 16 months at a time, and crews were to rotate on and off deployed ships at 4-month intervals.[8] The 3-2-1 plan was intended to permit the Navy to maintain 50% of the LCS force in deployed status at any given time—a greater percentage than would be possible under the traditional approach of maintaining one crew for each LCS and deploying LCSs for seven months at a time. The Navy

[6] Statement of Allison F. Stiller, Principal Civilian Deputy Assistant Secretary of the Navy for Research, Development and Acquisition (ASN(RD&A)), performing the duties and functions of ASN(RD&A), and Lieutenant General Robert S. Walsh, Deputy Commandant, Combat Development and Integration & Commanding General, Marine Corps Combat Development Command, and Vice Admiral William K. Lescher, Deputy Chief of Naval Operations for Integration of Capabilities and Resources, before the Subcommittee on Seapower and Projection Forces of the House Armed Services Committee on Department of the Navy Seapower and Projection Forces Capabilities, May 24, 2017, p. 8.

[7] See *Report to Congress, Littoral Combat Ship Manning Concepts*, Prepared by OPNAV—Surface Warfare, July 2013 (with cover letters dated August 1, 2013), posted at USNI News on September 24, 2013, at http://news.usni.org/2013/09/24/document-littoral-combat-ship-manning-concepts.

[8] See, for example, Grace Jean, "Buying Two Littoral Combat Ship Designs Saves the Navy $600 Million, Official Says," *NationalDefenseMagazine.org*, January 12, 2011.

planned to forward-station three LCSs in Singapore and additional LCSs at another Western Pacific location, such as Sasebo, Japan, and at Bahrain. The 3-2-1 plan has now been superseded by a new crewing and operating plan that the Navy announced in September 2016 (see next section).

New Crewing and Operating Plan Announced September 2016

In September 2016, the Navy announced a new plan for crewing and operating the first 28 LCSs. Key elements of the new plan include the following:[9]

- the first four LCSs (LCSs 1 through 4) will each by operated by a single crew and be dedicated to testing and evaluating LCS mission packages (though they could be deployed as fleet assets if needed on a limited basis);
- the other 24 LCSs (LCSs 5 through 28) will be divided into six divisions (i.e., groups) of four ships each;
- three of the divisions (i.e., 12 of the 24 ships), all of them built to the LCS-1 design, will be homeported at Mayport, FL;
- the other three divisions (i.e., the remaining 12 ships), all of them built to the LCS-2 design, will be homeported at San Diego, CA;
- among the three divisions on each coast, one division will focus on MCM, one will focus on ASW, and one will focus on SUW;
- in each of the six divisions, one ship will be operated by a single crew, and will focus on training the crews of the other three ships in the division;
- the other three ships in each division will each be operated by dual crews (i.e., Blue and Gold crews), like the Navy's ballistic missile submarines;
- the crews for the 24 ships in the six divisions will be unified crews—the distinction between core crew and mission package crew will be eliminated;
- the 24 ships in the six divisions will experience changes in their mission packages (and thus in their mission orientations) infrequently, if at all; and
- 13 of the 24 ships in the six divisions (i.e., more than 50%) are to be forward stationed at any given point for periods of 24 months, with 3 at Singapore, 3 at another Western Pacific location, such as Sasebo, Japan, and 7 at Bahrain.

The Navy states that the new crewing and operating plan is intended to

- reduce disruptions to the deployment cycles of the 24 LCSs in the six divisions that under the 3-2-1 plan would have been caused by the need to test and evaluate LCS mission packages;
- improve training and proficiency of LCS crews;

[9] Source: Navy briefing on new LCS crewing and operating plan given to CRS and CBO, September 26, 2016. See also "Navy Adjusts LCS Class Crewing, Readiness and Employment," *Navy News Service*, September 8, 2016; Sam LaGrone, "Results of New LCS Review is Departure from Original Vision," *USNI News*, September 8, 2016; Sydney J. Freedberg Jr., "Navy Sidelines First 4 LCS; Overhauls Deployment, Crewing," *Breaking Defense*, September 8, 2016; Justin Doubleday, "Navy Introduces Major Change to Littoral Combat Ship Operations," *Inside the Navy*, September 9, 2016; David B. Larter, "Rebooting LCS: Hundreds More Sailors Needed in Sweeping Overhaul," *Navy Times*, September 9, 2016; Justin Doubleday, "Navy Begins Implementing Changes to Littoral Combat Ship Program," *Inside the Navy*, October 10, 2016.

- enhance each LCS crew's sense of ownership of (and thus responsibility for taking good care of) the ship on which it operates; and
- achieve a percentage of LCSs in deployed status, and numbers of forward-stationed LCSs, similar to or greater than what the Navy aimed to achieve under the 3-2-1 plan.

The Navy further states that the 12 frigates to be procured after the 28 LCSs will also use this new crewing and operating plan,[10] and that as the fleet continues to accumulate experience in operating and maintaining LCSs, elements of this new plan might be modified.[11]

LCS Procurement Costs

Sea Frames

A March 2017 Government Accountability Office (GAO) report states that the total estimated acquisition cost of the 40 LCS/FFG(X) sea frames is $26,650.5 million (i.e., about $26.7 billion) in constant FY2017 dollars (an average of about $666.3 million per sea frame), including $3,971.6 million (i.e., about $4.0 billion) in research and development costs, including the detailed design and construction costs of the first two sea frames, and $22,429.2 million (i.e., about $22.4 billion) in procurement costs for the remaining 38 sea frames (an average of about $590.2 million each).[12]

The Navy's proposed FY2018 budget, as amended on May 24, 2017, is requesting the procurement of two LCSs at a combined cost of $1,177.1 million, or an average of about $588.6 million each.

Certain LCS sea frames that were procured in prior years were subject to an LCS program unit procurement cost cap.[13]

---

[10] See "Navy Adjusts LCS Class Crewing, Readiness and Employment," *Navy News Service*, September 8, 2016.

[11] See, for example, Sydney J. Freedberg Jr., "Navy Sidelines First 4 LCS; Overhauls Deployment, Crewing," *Breaking Defense*, September 8, 2016.

[12] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-17-333SP, March 2017, p. 105. The $249.7 million in total program cost not accounted for by research and development and procurement cost may be military construction (MilCon) costs.

[13] The legislative history of the cost cap is as follows:

-- The cost cap was originally established by Section 124 of the FY2006 National Defense Authorization act (H.R. 1815/P.L. 109-163 of January 6, 2006). Under this provision, the fifth and sixth ships in the class were to cost no more than $220 million each, plus adjustments for inflation and other factors.

-- The cost cap was amended by Section 125 of the FY2008 National Defense Authorization Act (H.R. 4986/P.L. 110-181 of January 28, 2008). This provision amended the cost cap to $460 million per ship, with no adjustments for inflation, and applied the cap to all LCSs procured in FY2008 and subsequent years.

-- The cost cap was amended again by Section 122 of the FY2009 Duncan Hunter National Defense Authorization Act (S. 3001/P.L. 110-417 of October 14, 2008). This provision deferred the implementation of the cost cap by two years, applying it to all LCSs procured in FY2010 and subsequent years.

-- The cost cap was amended again by Section 121(c) and (d) of the FY2010 National Defense Authorization Act (H.R. 2647/P.L. 111-84 of October 28, 2009). The provision repealed the three previous cost cap provisions and established a new cost cap of $480 million to be applied to up to 10 LCSs to be procured starting in FY2011, excluding certain costs, and with provisions for adjusting the $480 million figure over time to take inflation and other events into account, and permitted the Secretary of the Navy to waive the cost cap under certain conditions. The Navy states that after taking inflation into account, this cost cap, which was to apply to up to 10 LCSs to be procured in FY2011 and subsequent years, was $538 million per ship as of December 2010. In awarding the two LCS block buy contracts in (continued...)

Mission Packages

A March 2017 GAO report states that the total estimated acquisition cost of 64 LCS mission packages is $7,100.7 million (i.e., about $7.1 billion) in constant FY2017 dollars (an average of about $110.9 million per package), including $2,611.6 million (i.e., about $2.6 billion) in research and development costs and $4,456.3 million (i.e., about $4.5 billion) in procurement costs (an average of about $69.6 each in procurement cost).[14]

In August 2013, the Navy had stated that

> The estimated Average Production Unit Cost (APUC) for all 59 OPN-funded mission packages [the other five mission packages were funded through the Navy's research, development, test and evaluation (RDT&E) account] is $69.8M in Constant Year (CY) Fiscal Year 2010 dollars. This is the most accurate answer for "How much does it cost to buy a mission package?" These mission packages are production-representative assets for Operational Test and deployment. The LCS Mission Modules program will use OPN to procure 23 MCM mission packages, 21 SUW mission packages, 15 ASW mission packages, and 59 sets of common mission package equipment.
>
> The APUC can be broken down into the estimated average initial procurement cost of the three types of mission packages and common mission package equipment. None of the figures in this paper represent budget values.
>
> — Mine Countermeasures (MCM) Mission Packages (23): $97.7M
>
> — Surface Warfare (SUW) Mission Packages (21): $32.6M
>
> — Anti-Submarine Warfare (ASW) Mission Packages (15): $20.9M
>
> — Sets of Common Mission Package Equipment (59): $14.8M...
>
> These estimates do not include the RDT&E expenditures that are associated with mission package development, integration, and test. These RDT&E expenditures include the five RDT&E-funded mission packages intended for use as development, training, and testing assets. Those five mission packages are not production-representative items. Including all prior RDT&E expenditures results in an average Program Acquisition Unit Cost of $99.7M for all 64 mission packages. This not an accurate answer for "How much does it cost to buy a mission package?" as past RDT&E expenditures are not relevant to the purchase price of a mission package today.[15]

LCS Potential Foreign Sales

Industry has marketed various versions of the LCS to potential foreign buyers. A June 8, 2017, press report stated:

> The administration's much touted $110 billion arms proposal to Saudi Arabia, previously slim on specifics, includes seven THAAD missile defense batteries, over 100,000 air-to-

(...continued)

December 2010, the Navy stated that LCSs to be acquired under the two contracts were to have an average unit cost of about $440 million, a figure well below this $538 million figure. (Source: Contract-award information provided to CRS by Navy office of Legislative Affairs, December 29, 2010.)

[14] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-17-333SP, March 2017, p. 107. The $32.8 million in total program cost not accounted for by research and development and procurement cost may be military construction (MilCon) costs.

[15] Navy information paper on LCS program dated August 26, 2013, and provided to CRS and CBO on August 29, 2013.

> ground munitions and billions of dollars' worth of new aircraft, according to a White House document obtained by Defense News and authenticated by a second source.
>
> President Donald Trump's visit to Saudi Arabia on May 20 drew headlines for what was billed as a $110 billion arms agreement. However, experts quickly pointed out that much of the deal was speculative, as any arms sale has to go through the process of being cleared by the State Department, then Congress, before going through an often lengthy negotiating period with industry.
>
> The document does, however, reveal the different buckets that make up the $110 billion figure, including "LOAs to be offered at visit," or letters of agreement that the Kingdom has already requested and the Trump administration supports, totaling $12.5 billion as well as the ten-year sustainment estimates on those programs, totaling $1.18 billion.
>
> Of course, these totals are best-guess estimations and likely represent the ceiling for what could be spent. The figures may well come down, and the timeframes listed may well change, based on final negotiations around the equipment.
>
> The largest pot of money involves the "MOIs to be offered at visit" section, totaling $84.8 billion. That section represents potential sales, or memos of intent, that the Trump team offered to the Saudis while in Riyadh.
>
> Among those listed as potential sales are:
>
> ... $6 billion for four Lockheed Martin-built frigates, based on the company's littoral combat ship design. That order falls under the Saudi Naval Expansion Program II (SNEP II) heading, with planned delivery in the 2025-2028 timeframe.[16]

A May 18, 2017, press report stated:

> The U.S. has reached a $6 billion deal for Saudi Arabia to buy four Littoral Combat Ships made by Lockheed Martin Corp. in a package of major arms purchases as President Donald Trump travels to the kingdom, people familiar with the transaction said.
>
> The U.S. and the Saudi Ministry of Defense "designed and negotiated a package totaling approximate $110 billion," Vice Admiral Joe Rixey, head of the Pentagon's Defense Security Cooperation Agency, said Friday on a conference call with analysts from Saudi Arabia, according to a White House transcript. "When completed, it will be the largest single arms deal in American history."
>
> While the package includes deals that were begun under President Barack Obama's administration—and initial steps toward others that may take years to complete—the final letter of agreement on the Littoral Combat Ships is the highest-profile element.
>
> It includes a better-armed version of the ships, support equipment, munitions and electronic-warfare systems, according to the people, who asked not to be identified in advance of an announcement that may come as early as Saturday morning Washington time. That's when Trump is scheduled to arrive in Riyadh on the first leg of an eight-day trip that will take him across the Middle East and to Europe....
>
> The littoral ships, designed for shallow coastal waters, are part of a package of agreements on weapons sales that already had been approved in late 2015 by the U.S. State Department, which oversees the Foreign Military Sales program. Congress also approved the sale, but it wasn't completed under Obama. From 2009 to 2016, the Obama administration approved $115 billion in potential sales to the Saudis.[17]

[16] Aaron Mehta, "Revealed: Trump's $110 Billion Weapons List for the Saudis," *Defense News*, June 8, 2017.

[17] Anthony Capaccio and Margaret Talev, "Saudis to Make $6 Billion Deal for Lockheed's Littoral Ships," *Bloomberg*, May 18, 2017.

LCS FY2018 Funding Request

For FY2018, the Navy is requesting the procurement of two LCSs, which would be the 30th and 31st. The request for two LCSs in FY2018 is one more than the single LCS that was projected for FY2018 under the Obama Administration's FY2017 budget submission.

The Navy's proposed FY2018 budget, which was submitted on May 23, 2017, originally showed a request for one LCS at an estimated cost of $636.1 million. On May 24, 2017, the Navy announced that it was amending its proposed FY2018 budget to request the procurement of two LCSs rather than one.[18] Navy officials originally stated that an additional $541 million would be needed to convert the originally proposed FY2018 LCS procurement from a one-ship buy into a two-ship buy. A June 29, 2017, budget amendment document from the Trump Administration, however, states that the increase is actually $499.925 million. As amended on June 29, the Navy's proposed FY2018 budget requests two LCSs at a total cost of $1,136.1 million, or an average of about $568.1 million each.

The June 29, 2017, budget amendment document proposes offsets for the additional $499.925 million that come from Navy budget accounts other than the Navy's shipbuilding account, including

- $100 million from the Aircraft Procurement, Navy (APN) account, reducing funding for the F/A-18 Infrared Search and Track [IRST]) program due to the cancellation of procurement of an earlier version of the IRST system while continuing with plans for procuring a later and more advanced version;
- $374.9 million from the Other Procurement, Navy (OPN) account, reducing funding by
  - $325 million for the procurement of a Nimitz-class aircraft carrier reactor fuel core whose procurement can now be deferred to FY2019 due to a deferral in the start of the mid-life refueling overhaul of the aircraft carrier in question;
  - $40 million for the modernization of an amphibious ship, reflecting recently identified opportunities to save on contract costs; and
  - $10 million for the SPQ-9B radar program that is available due to program under-execution;[19] and
- $25 million from the Navy's research and development account, reducing funding for Navy energy activities, due to a change in program strategy that maintains energy funding at previous execution levels.

The Navy's proposed FY2018 budget also requests $26.9 million in so-called "cost-to-complete" procurement funding to cover cost growth on LCSs procured in previous fiscal years, and $143.5 million for procurement of LCS mission module equipment.

[18] For additional discussion of the Administration's decision to amend the propsoed FY2018 budget to request two LCSs rather than one, see David B. Larter, "Life Support: The Navy's Struggle to Define an LCS Bare Minimum," *Defense News*, July 9, 2017.

[19] These three figures add to $375 million rather than $374.9 million. The budget amendment document, however, states that the total reduction is precisely $374.925 million.

FFG(X) Requirements and Design Options

May 2017 Navy Testimony

Regarding the Navy's examination of requirements and design options for the FFG(X)s, the Navy testified at a May 3, 2017, hearing on the LCS/FFG(X) program before the Seapower and Projection Forces subcommittee of the House Armed Services Committee that

> As maritime threats have evolved, the Navy is placing greater emphasis on distributed operations, highlighting the need for a full complement of SSCs and increasing the need for a Frigate with improved lethality and survivability. The Navy is defining the requirements for the Frigate to improve its ability to operate in a more contested environment than LCS, enhancing its role in distributed maritime operations. In this role, both LCS and Frigate will free up our large surface combatants to focus on their primary missions including area air defense, land strike, and ballistic missile defense. The Navy is also seeking to leverage Fleet-wide commonality of combat system elements wherever possible to deliver capability and flexibility in the most cost effective manner.
>
> To accomplish this, the Navy has established a Frigate Requirement Evaluation Team to update the previous Frigate analysis performed in 2014 and investigate the feasibility of incorporating additional capabilities and enhanced survivability features into the current Frigate designs, as well as explore other hull forms. The results of this analysis will inform the top level Frigate requirements based on cost and capability trades involved. The Navy's revised acquisition strategy is under development and will ensure designs are mature prior to entering into a detail design and construction (DD&C) contract. The Navy will engage with industry in order to support an aggressive conceptual design effort, leading to a Request for Proposals to award the DD&C contract in FY 2020.
>
> As we work through the requirements and acquisition processes for the Frigate, we will endeavor to transition from LCS to Frigate in a manner that maximizes the competitive field for our shipbuilding industrial base. We understand the potential implications of future acquisition strategies to our shipyards and their workforces, and these are considerations we do not take lightly. We are committed to delivering increased capability to our sailors at the best value for the American taxpayer, and that includes maintaining a competitive and healthy industrial base.[20]

July 2017 Navy Request for Information (RFI) and Industry Day Briefing

On July 10, 2017, the Navy released a Request for Information (RFI) to solicit industry input on the frigate program.[21] On July 25, 2017, the Navy continued that effort by holding an industry day

[20] Statement of RADM Ron Boxall, USN, Deputy Chief of Naval Operations, Director, Surface Warfare Division, and RADM John P. Neagley, USN, Program Executive Officer, Littoral Combat Ships, before the House Committee on Armed Services Subcommittee on Seapower and Projection Forces, on Littoral Combat Ships and the Transition to Frigate Class, May 3, 2017, pp. 2-3. See also Christopher P. Cavas, "US Navy Considers a More Powerful Frigate," *Defense News*, April 10, 2017; Marc Selinger, "Navy Studying Adding Air Defense, Enhanced Survivability To Future Frigate," *Defense Daily*, April 11, 2017: 1; Sam LaGrone, "Navy Considering More Hulls for Frigate Competition, Expanding Anti-Air Capability," *USNI News*, April 12, 2017; Sydney J. Freedberg Jr., "LCS Frigate: Delay A Year To Study Bigger Missiles?" *Breaking Defense*, April 19, 2017; Sydney J. Freedberg Jr., "Beyond LCS: Navy Looks To Foreign Frigates, National Security Cutter," *Breaking Defense*, May 11, 2017; Megan Eckstein, "Stackley: More Capable Frigate Requires Full and Open Competition, But LCS Builders May Have Cost Advantage," *USNI News*, May 12, 2017;

[21] The original notice for the RFI is posted here (accessed August 11, 2017): https://www.fbo.gov/index?s=opportunity&mode=form&id=cdf24447b8015337e910d330a87518c6&tab=core&tabmode=list&=.

event. The slides for the Navy's briefing for the industry day event were posted on July 28, 2017.[22] Below are reproductions of some of the slides from that briefing.[23]

In the slides, the term parent design means an existing ship design that would be modified to create the design for the frigate. A parent design approach is an alternative to developing a completely new design (i.e., a "clean-sheet" design) for the ship. Compared to a clean-sheet design approach, a parent-design approach can reduce both the time needed to develop the design and the technical and cost risk of the design.

[22] RFI: FFG(X) - US Navy Guided Missile Frigate Replacement Program, accessed August 11, 2017, at https://www.fbo.gov/index?s=opportunity&mode=form&tab=core&id=d089cf61f254538605cdec5438955b8e&_cview=0.

[23] For additional discussion of the RFI, the industry day event, and the Navy's preliminary concepts for the frigate, see David B. Larter, "Frigate Competition Wide Open: Navy Specs Reveal Major Design Shift," *Defense News*, July 10, 2017; Sydney J. Freedberg Jr., "Navy Steers Well Away From An LCS Frigate," *Breaking Defense*, July 10, 2017; David B. Larter, "Exclusive Interview: The Navy's Surface Warfare Director Talks Frigate Requirements," *Defense News*, July 11, 2017; Megan Eckstein, "Navy Hosts Guided-Missile Frigate Industry Day; Analysts Worried About Early FFG(X) Requirements," *USNI News*, July 27, 2017; and David B. Larter, "Experts Question the US Navy's Ideas for A New Frigate, *Defense News*, July 28, 2017. For earlier reports, see Christopher P. Cavas, "US Navy Considers A More Powerful Frigate, *Defense News*, April 10, 2017; and Sydney J. Freedberg Jr., "Beyond LCS: Navy Looks To Foreign Frigates, National Security Cutter," *Breaking Defense*, May 11, 2017.

Slides from Navy FFG(X) Industry Day Briefing

Why FFG(X)?

Evolving threats in the global maritime environment drove the Navy to re-evaluate FF requirements and pursue a guided missile Frigate,

FFG(X)

To address these threats, the ship is intended to:

- Fully support Combatant and Fleet Commanders during conflict by
  - Supplementing fleet undersea and surface warfare capabilities
  - Operating independently in contested environments
  - Extending the fleet tactical grid
  - Hosting and controlling unmanned systems
- Relieve large surface combatants from stressing routine duties during operations other than war, providing a high/low mix of fleet capabilities

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.

5

What will FFG(X) be?

FFG(X) is envisioned as a multi-mission Small Surface Combatant intended to be capable of:

- Employing unmanned systems to penetrate and dwell in contested environments
- Establishing a local sensor network using multiple sensor platforms, both on-board and off-board
- Robustly defending itself in contested environments, including against raids by small boats
- Holding adversary warships at risk with over-the-horizon anti-ship missiles
- Performing anti-submarine warfare missions with active and passive undersea sensors
- Serving as a force multiplier to air-defense capable destroyers escorting logistics ships
- Providing electromagnetic sensing and targeting capabilities and contributing to force-level electromagnetic spectrum control
- Providing electromagnetic information exploitation capabilities and intelligence collection
- Conducting common surface combatant missions during operations other than war, such as presence missions, security cooperation activities, and humanitarian assistance/disaster relief support

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.

6

FFG(X) Program Schedule

- **Responses due 24 August 2017 at 1500**
- **Conceptual Design phase to mature parent designs to meet Navy requirement will award next calendar year**
  - Parent Design
  - US Shipyard
- **Government will provide *System Specifications* and *Government Furnished Information (GFI)* as part of the Conceptual Design RFP**
- **Full and Open Competition for Detail Design and Construction contract award in FY2020**
- **Notional procurement profile (for cost estimating purposes), starting in FY2020:**

1/1/2/2/2/2/2/2/2/2

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.

7

Objectives of the RFI

The **Navy** desires to:

- **Understand Industry's parent designs and their ability to integrate both the warfare system elements and the threshold requirements into the new FFG(X) design**
- **Understand the sensitivities to the parent design for integrating either the warfare systems or the threshold requirements**
- **Understand the drivers in non-recurring engineering, recurring engineering, production schedule, and operations and supports costs**

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.

8

Key Program Assumptions

The **Navy**…

- **Envisions a FY2020 competition that will consider existing parent designs for a Small Surface Combatant that can be modified to accommodate FFG(X) requirements**
- **Plans for the FFG(X) program to use the same crewing, training, and maintenance concepts as LCS**
  - Blue/Gold Crewing: 2 crews for 1 ship
  - Training: Train to Certify/Train to Qualify (T2C/T2Q)
  - Maintenance: Crew PMS and some O-Level Maintenance
- **Desires to drive down life cycle costs:**
  - The threshold manning requirement identified is the maximum acceptable manning value
  - Use common Navy systems across the radar, combat system, C4ISR systems, and launcher elements while encouraging hull, mechanical, and electrical system commonality with other US Navy platforms

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.

9

Key FFG(X) Attributes

The **Navy** considers the following tiers and their values to be the **minimum** acceptable level of performance for the corresponding FFG(X) attributes:

TIER	Attributes	Threshold
1	**Material Availability**	**> 0.64** (as defined by number of operational end items / total end items)
	Operational Availability	**> 0.72** (as defined by uptime **/ (uptime + downtime)**)
	Service Life	**25 years**
	Vulnerability (as defined by the capability to withstand initial damage effects and to continue to perform primary missions)	**Grade A Shock Hardening** for Propulsion, Critical Systems, and Combat System Elements to retain full Air Defense and Propulsion capabilities
2	**Manning Accommodations**	**200 personnel crew max** (including all detachments)
	Range (minimum distance the ship can sail without replenishment when using all of its burnable fuel)	**3000 NM @ 16 kts**
	SWaP-C reservation for future Directed Energy and Active EA	**26 MT, 600 kW, 300 GPM**
3	Space, weight, power, and cooling **service life allowance**	**5%**
	Sustained Speed (as defined by the achievable speed at full-load displacement, normal trim, and clean bottom)	**28 kts at 80% MCR**

[RFI Table 1]

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.

10

FFG(X) Notional Warfare Systems

The following is a list of notional warfare systems that the **Navy** plans to provide as **Government Furnished Equipment** for the **FFG(X)**:

TIER	Warfare Systems
1	**C4I suite** (with accompanying HF/UHF/EHF/SATCOM antennas/CANES)
	COMBATSS-21 Mod Combat Management System (CMS) (Aegis derivative leveraging the common source library)
	Enterprise Air Surveillance Radar (EASR) 3 face fixed array (3x3x3 Radar Modular Assembly)
	MH-60R x 1
	Mk53 Decoy Launching System (Nulka)
	OTH Weapon with FCS (2x4) – canister launched
	SeaRAM Mk15 Mod 31
	***Self Defense Launcher Capability**
	SLQ-32(V)6 (SEWIP Blk II) – Note requirement in previous table for SWaP-C reservation for EA
	Tactical Cryptological System (TCS)
	UAV (1 x MQ-8C) or future similarly sized UAS

TIER	Warfare Systems
2	**7m RHIBs x 2**
	AN/SLQ-61 Light Weight Tow (LWT)
	AN/SQS-62 Variable Depth Sonar (VDS)
	AN/SQQ-89F Undersea Warfare / ASW Combat System
	Cooperative Engagement Capability (CEC)
	Integrate 360 degree EO/IR
	Mission Control System (MCS) (MD-4A)
	Mk110 57mm Gun (with ALaMO)
	Mk160 Gun Fire Control System (GFCS)
	Next Generation Surface Search Radar (NGSSR)
	Surface-to-Surface Missile Module (SSMM Longbow Hellfire)
	TB-37 Multi-Function Towed Array (MFTA)
	UPX-29 Identification Friend/Foe (IFF)

*Ability to support Evolved Sea Sparrow Missile Block 2 and/or Standard Missile-2 Active missiles *[RFI Table 2]*

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.

11

Sensitivity and Cost Drivers

The **Navy** requests that interested parties:

- **Identify specific attributes for which the threshold values can be exceeded for minimal cost increases**
- **Identify any specific threshold value or warfare system which drives a significant design change**
  - With a description of the issue and preferred mitigations, including the NRE cost avoidance and the capability achieved through those mitigations
- **Identify any tradeoffs necessary to meet or exceed thresholds**
  - Including production and cost impacts
  - If tradeoffs are required, vendors are encouraged to prioritize higher Tier (Tier 1) attributes/systems as being the most desired by the Navy

The **Navy** is particularly interested in understanding the design and capability trade-space in ***Cost drivers, break-points, trade-offs,*** *and* ***impacts***

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.

12

Source: Slides from briefing posted on July 28, 2017, at RFI: FFG(X) - US Navy Guided Missile Frigate Replacement Program, https://www.fbo.gov/index?s=opportunity&mode=form&tab=core&id=d089cf61f254538605cdec5438955b8e&_cview=0, accessed August 11, 2017.

Issues for Congress for FY2018

FY2018 Funding Request

One issue for Congress for FY2018 is whether to approve, reject, or modify the Navy's FY2018 funding requests for the LCS/FFG(X) program, including the number of LCSs to be procured in FY2018, funding for LCS mission modules, and funding associated with developing the FFG(X) design.

The Program in General After FY2017

More generally, a potential broad oversight issue for Congress for FY2018 concerns the currently unresolved details of the remainder of the LCS/FFG(X) program, including the program's total procurement quantity, its annual procurement rate, whether there should be a down select to a single LCS design, what the design of the FFG(X) will be, and which shipyard or shipyards will build FFG(X)s. Navy announcements on these points could generate various specific oversight issues for Congress relating to ship costs and capabilities, acquisition strategies, and potential impacts on the shipbuilding industrial base.

Regarding the frigate part of the LCS/FFG(X) program, an April 2017 GAO report states:

> The Navy's current acquisition approach for its new frigate—a ship based on a Littoral Combat Ship (LCS) design with minor modifications—requires Congress to make significant program decisions and commitments in 2017 without key cost, design, and capability knowledge. In particular, the Navy plans to request authority from Congress in 2017 to pursue what the Navy calls a block buy of 12 planned frigates and funding for the lead ship, which the Navy intends to award in 2018. Approval of these plans would effectively represent the final decision for the entire planned buy of 40 LCS and frigates. According to the Navy's approved acquisition strategy, the frigates would still require annual appropriations, so Congress would maintain its oversight through its annual appropriation decisions; however, any decision to reduce or delay the program, should that become warranted, could nevertheless be more difficult as the Navy may point to losses in favorable block buy prices, as has been done previously with LCS.
>
> The Navy's impending request presents a key opportunity for Congress to affect the way forward for the frigate program by ensuring the Navy possesses sufficient knowledge on cost, design, and capability before authorizing an investment of a potential $9 billion for a program that
>
> • has no current formal cost estimate—independent or otherwise,
>
> • will not begin key detail design activities until late fiscal year 2018,
>
> • has significant unknowns in regards to operational performance of the ship upon which its design will be based, and
>
> • based on the existing and planned shipyard workloads, has no industrial base imperative to begin construction in the Navy's planned time frame.
>
> The Navy's previous frigate acquisition plans included achieving a higher degree of ship design knowledge before awarding the lead ship in fiscal year 2019, as the plans included significant detail design activities prior to contract award. As GAO has previously found, such an approach—which has been supported by shipbuilders—offers greater confidence in the understanding of design changes and how they will affect ship construction costs. Further, as GAO's work on best practices for program cost estimates suggests, the Navy's prior plans for frigate design efforts and an award in fiscal year 2019 would have

> provided more information on which to base a decision, including a better understanding of risks and costs. The previous plans also better aligned with LCS test plans to improve the department's understanding of the operational capability and limitations for each ship variant. This knowledge could then be used to inform the Navy's decision on which LCS-based design for the frigate it will pursue. In addition to the valuable knowledge to be gained by not pursuing the frigate in the planned 2018 time frame, the existing and planned LCS construction workload for both shipyards is another important factor to consider. Specifically, each shipyard has LCS construction demands that extend into 2021, suggesting no imperative for the Navy to award the frigate in 2018. Delaying the frigate award until at least fiscal year 2019—when more is known about cost, design, and capabilities—would enable better-informed decisions and oversight for this potential $9 billion taxpayer investment.[24]

As mentioned earlier, the Navy now plans to shift to the frigate design in FY2020 rather than FY2018 or FY2019.

Survivability, Lethality, Technical Risk, and Test and Evaluation Issues

A broad oversight area for Congress for the LCS/FFG(X) program for the past several years concerns survivability, lethality, technical risk, and test and evaluation issues relating to LCSs. Detailed information on this broad oversight area is presented in **Appendix A**.

Additional Oversight Issues Raised in GAO Reports

Additional oversight issues raised in GAO reports include LCS operation and support (O&S) costs,[25] weight management on the LCS sea frames—an issue that can affect the ability of LCSs to accept new systems and equipment over their expected life cycles[26]—and construction quality on the lead ships in the LCS program.[27]

Legislative Activity for FY2018

Summary of Congressional Action on FY2018 Funding Request

Table 2 summarizes congressional action on the Navy's FY2018 procurement funding request for the LCS program.

The amount shown in the requested column of the table reflects the June 29, 2017, Administration budget amendment document that increased the number of LCSs requested for procurement from one to two, and the associated funding request for procurement of LCSs by $499.9 million, increasing that figure from $636.1 million to $1.136.1 million.

[24] Government Accountability Office, *Littoral Combat Ship and Frigate[:] Delaying Planned Frigate Acquisition Would Enable Better-Informed Decisions*, GAO-17-323, April 2017, summary page.

[25] Government Accountability Office, *Littoral Combat Ship[:] Deployment of USS Freedom Revealed Risks in Implementing Operational Concepts and Uncertain Costs*, GAO 14-447, July 2014, 57 pp.

[26] Government Accountability Office, *Littoral Combat Ship[:] Additional Testing and Improved Weight Management Needed Prior to Further Investments*, GAO-14-749, July 2014, 54 pp.

[27] Government Accountability Office, *Littoral Combat Ship[:]Navy Complied with Regulations in Accepting Two Lead Ships, but Quality Problems Persisted after Delivery*, GAO-14-827, September 2014, 35 pp.

Table 2. Congressional Action on FY2018 Procurement Funding Request

Figures in millions, rounded to nearest tenth

		Authorization			Appropriation		
	Request	HASC	SASC	Conf.	HAC	SAC	Conf.
Shipbuilding and Conversion, Navy (SCN) appropriation account							
Procurement of LCSs	1,136.1	1,669.1	596.1		1,567.0		
Cost-to-complete funding for prior-year LCSs	26.9	26.9	26.9		26.9		
Other Procurement, Navy (OPN) appropriation account							
Line 36: LCS common mission modules equipment	34.7	68.7	34.7		19.4		
Line 37: LCS MCM mission modules	55.9	55.9	84.8		43.3		
Line 38: LCS ASW mission modules	0	0	0		0		
Line 39: LCS SUW mission modules	53.0	53.0	53.0		47.7		
Line 40: LCS in-service modernization	74.4	158.4	158.4		43.1		

Source: Table prepared by CRS based on FY2018 Navy budget submission, a June 29, 2017, Administration budget amendment document, and committee reports on the FY2018 National Defense Authorization Act and the FY2018 DOD Appropriations Act.

Notes: HASC is House Armed Services Committee; **SASC** is Senate Armed Services Committee; **HAC** is House Appropriations Committee; **SAC** is Senate Appropriations Committee; **Conf.** is conference agreement.

FY2018 National Defense Authorization Act (H.R. 2810/S. 1519)

House

The House Armed Services Committee, in its report (H.Rept. 115-200 of July 6, 2017) on H.R. 2810, recommended the funding levels for the LCS/Frigate program shown in the HASC column of **Table 2**. The recommended increase in funding for procurement of LCSs is for a total FY2018 procurement of three LCSs, or one more than the two LCSs requested for procurement in the Navy's amended FY2018 budget submission. The recommended increase of $34 million in procurement funding for LCS common mission modules equipment (line 36) is for mine countermeasures unmanned surface vehicles (MCM USVs). The recommended increase of $84 million for LCS in-service modernization (line 40) is for LCS modernization. (Page 380)

Section 1051(q) of H.R. 2810 as reported strikes subsection (e) of Section 121 of H.R. 2647/P.L. 111-84, the FY2010 National Defense Authorization Act, a subsection that required an annual report on certain aspects of the LCS program.

H.Rept. 115-200 states:

> *Littoral Combat Ships capability enhancements*
>
> The committee believes that the Littoral Combat Ship and the Frigate will continue to play a critical role in the mix of warships necessary for Distributed Maritime Operations and believe the Navy should begin Frigate construction as soon as possible. To better expand Frigate capabilities, the committee notes that the Chief of Naval Operations initiated an Independent Review Team to assess Frigate requirements. The committee further notes that the Navy intends to leverage the proposed capabilities of the original Frigate program while adding: increased air warfare capability in both self-defense and escort roles; enhanced survivability; and increased electromagnetic maneuver warfare. The committee supports the Navy's intent to increase the lethality and survivability of the Frigate and further supports backfit options that will provide appropriate enhancements to the existing Littoral Combat Ships. In fiscal year 2019, the committee also believes that

> additional forward fit options for the fiscal year 2019 Littoral Combat Ships should be pursued. Therefore, the committee directs the Secretary of the Navy to prepare a report to the congressional defense committees by March 1, 2018 that details a transition plan to include forward fit options for the fiscal year 2019 Littoral Combat Ships and backfit options for the existing fleet. Specifically, this report should include an assessment of the following elements: deploying an over-the-horizon weapons system; expanding electronic warfare capabilities to include SEWIP Block II or SEWIP Lite; enhancing survivability attributes; and expanding use of unmanned aerial vehicles or unmanned underwater vehicles. (Page 23)

H.Rept. 115-200 also states:

> *Littoral Combat Ship immersive virtual ship environment*
>
> The committee notes that the Littoral Combat Ships (LCS) training and certification capability is a key enabler of the reduced crew size. The Navy indicated that the LCS training is based on a virtual ship-centric concept, accomplished through a combination of classroom instruction, vendor training, shore-based trainers, and sophisticated virtual reality training systems. The committee notes that the original LCS training design relied upon using an immersive, virtual ship environment (IVSE) to replicate key training objectives and protocols for both ship variants. The committee continues to support efforts to fully employ such sophisticated training, particularly live-virtual-constructive training, for the LCS fleet with the objective of improving sailor performance through higher-fidelity, effective training solutions.
>
> Despite the broad acknowledgement of the value of this approach to training, positive fleet feedback from the first immersive course, and the existence of a contract vehicle to support courseware development, the committee believes the Navy has been slow to leverage this capability to address readiness. The committee is concerned about the Navy's commitment to addressing the LCS training environment. In light of ongoing LCS operations and maintenance challenges, the committee encourages the Navy to more fully utilize IVSE courseware. (Page 59)

Senate

The Senate Armed Services Committee, in its report (S.Rept. 115-125 of July 10, 2017) on S. 1519, recommended the funding levels for the LCS/Frigate program shown in the SASC column of **Table 2**. The report recommends the procurement of one LCS (the originally requested number, prior to the Administration's budget amendment), and recommends reducing the funding for procuring that one ship by $40 million for "unit price adjustment." (Page 402) The recommended net increase of $28.9 million for LCS mission modules (line 37) includes an increase of $34 million for "UFR: Additional MCM USV" (meaning an unfunded requirement for additional mine countermeasures unmanned surface vehicles) and a reduction of $5.1 million for "procurement ahead of need." (Pages 404-405) The recommended increase of $84 million for LCS in-service modernization (line 40) is for "UFR: LCS modernization for increased lethality." (Page 405)

Section 1017 of S. 1519 as reported states:

> SEC. 1017. Operational readiness of Littoral Combat Ships on extended deployment.
>
> (a) In general.—Subsection (a) of section 7310 of title 10, United States Code, is amended—
>
> (1) by inserting "Under jurisdiction of the Secretary of the Navy" in the subsection heading after "Vessels";

(2) by striking "A naval vessel (or any other vessel under the jurisdiction of the Secretary of the Navy)" and inserting "(1) Except as provided in paragraph (2), a naval vessel"; and

(3) by adding at the end the following new paragraph:

"(2) (A) Subject to subparagraph (B), in the case of a naval vessel classified as a Littoral Combat Ship and operating on deployment, corrective and preventive maintenance or repair (whether intermediate or depot level) and facilities maintenance may be performed on the vessel—

"(i) in a foreign shipyard;

"(ii) at a facility outside of a foreign shipyard; or

"(iii) at any other facility convenient to the vessel.

"(B) (i) Corrective and preventive maintenance or repair may be performed on a vessel as described in subparagraph (A) if the work is performed by United States Government personnel or United States contractor personnel.

"(ii) Facilities maintenance may be performed by a foreign contractor on a vessel as described in subparagraph (A) only as approved by the Secretary of the Navy.".

(b) Definitions.—Such section is further amended by adding at the end the following new subsection:

"(d) Definitions.—In this section:

"(1) The term 'corrective and preventive maintenance or repair' means—

"(A) maintenance or repair actions performed as a result of a failure in order to return or restore equipment to acceptable performance levels; and

"(B) scheduled maintenance or repair actions to prevent or discover functional failures.

"(2) The term 'facilities maintenance' means preservation or corrosion control efforts and cleaning services.".

(c) Clerical amendments.—

(1) SECTION HEADING.—The heading of such section is amended to read as follows:

"§ 7310. Overhaul, repair, and maintenance of vessels in foreign shipyards and facilities: restrictions; exceptions".

(2) TABLE OF SECTIONS.—The table of sections at the beginning of chapter 633 of such title is amended by striking the item relating to section 7310 and inserting the following new item:

"7310. Overhaul, repair, and maintenance of vessels in foreign shipyards and facilities: restrictions; exceptions.".

Regarding Section 1017, S.Rept. 115-125 states:

Operational readiness of Littoral Combat Ships on extended deployment (sec. 1017)

The committee recommends a provision that would amend title 10, United States Code and provide the Secretary of the Navy with additional flexibility to maintain Littoral Combat Ships (LCS) by allowing government or contractor personnel to conduct maintenance on LCS vessels operating on deployment regardless of ship locations.

This provision would codify the authorities successfully employed in a pilot program authorized by section 1025 of the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015 (Public Law 113–291).

The pilot program was conducted to evaluate maintenance options for LCS vessels on extended deployments from December 2014 to September 2016. The Navy's assessment of the pilot program, which was submitted in a March 2017 report to Congress found, "Based on the pilot program results, cost savings are expected to be notable. Even more importantly, the flexibility to provide timely maintenance in support of schedule changes and mission execution is crucial to long-term success of the LCS Fleet . . ."

The committee concurs with the Navy's assessment of the pilot program and recommends codifying the associated authorities in title 10, United States Code. (Page 227)

S.Rept. 115-125 states:

Littoral Combat Ship

The [original, unamended] budget request included $636.1 million in line item 11 of Shipbuilding and Conversion, Navy (SCN), for procurement of one Littoral Combat Ship.

The committee notes unjustified unit cost growth in the other cost ($37.0 million) and other electronics ($3.0 million) categories.

Therefore, the committee recommends a decrease of $40.0 million for this program. (Page 17)

S.Rept. 115-125 states:

LCS support equipment

The budget request included $48.0 million in line item 17 of Other Procurement, Navy (OPN), for Littoral Combat Ship (LCS) support equipment.

The committee notes this request includes procurement of two MT–30 engines, one Freedom variant main propulsion diesel engine (MPDE), and one Independence variant MPDE to serve as battle spares.

The committee further notes the Navy has previously procured three MT–30s, two Freedom variant MPDEs, and two Independence variant MPDEs in this line item. The committee also notes the P-5a and P-21 budget exhibits were omitted, which detail procurement history and production schedules, and requests these exhibits be restored in the fiscal year 2019 budget request.

Therefore, the committee recommends a decrease of $42.6 million for this program due to procurement early to need.

LCS mine countermeasures mission modules

The budget request included $55.9 million in line item 37 of Other Procurement, Navy (OPN), for Littoral Combat Ship (LCS) mine countermeasures (MCM) mission modules.

The committee notes this request included procurement of two Airborne Mine Neutralization Systems (AMNS). The committee further notes that the initial operational capability of the MCM mission module is planned for fiscal year 2021 and believes at least one AMNS is early to need.

Therefore, the committee recommends a decrease of $5.1 million for this program. (Pages 18-19)

S.Rept. 115-125 also states:

Littoral Combat Ship

The budget request contained $41.0 million in PE 63581N [in the Navy's research and development account] for Littoral Combat Ships. [Note: This line item is not shown in **Table 2**.]

> The committee notes the Littoral Combat Ship project (3096) included no product development and a reduced level of test and evaluation activity.
>
> Therefore, the committee recommends a reduction of $7.0 million, for a total of $34.0 million, to align support costs with program activity. (Page 60)

FY2018 DOD Appropriations Act (Division A of H.R. 3219)

House

H.R. 3219 as reported by the House Appropriations Committee (H.Rept. 115-219 of July 13, 2017) was the FY2018 DOD Appropriations Act. H.R. 3219 as passed by the House is called the Make America Secure Appropriations Act, 2018. H.R. 3219 as passed by the House includes the FY2018 DOD Appropriations Act as Division A and four other appropriations acts as Divisions B through E. The discussion below relates to Division A.

The House Appropriations Committee, in its report (H.Rept. 115-219 of July 13, 2017) on H.R. 3219, recommended the funding levels for the LCS/Frigate program shown in the HAC column of **Table 2**. The recommended funding for procurement of LCSs is for a total procurement of three ships (one more than the amended request). The net increase in funding shown reflects additional funding needed for a three-ship procurement, as well as a reduction of $19.2 million for "Plans cost growth." (Page 161) Recommended changes in funding for OPN lines 36-40 are as follows:

- the recommended reduction of $15.3 million for LCS common mission modules equipment (line 36) is for "Mission bay training devices early to need";
- the recommended reduction of $12.546 million for LCS MCM mission modules (line 37) is for "ALMDS [airborne laser mine detection system] unit cost growth" ($4.120 million), "COBRA [Coastal Battlefield Reconnaissance and Analysis] previously funded" ($0.922 million), and "MCM support equipment excess to need" ($7.504 million);
- the recommended reduction of $5.3 million for LCS SUW mission modules (line 39) is for "Insufficient budget justification"; and
- the recommended reduction of $31.304 million for LCS in-service modernization (line 40) is for "Habitability modifications early to need" ($25.504 million) and "Design changes early to need" ($6.8 million).

Appendix A. Survivability, Lethality, Technical Risk, and Test and Evaluation Issues

As mentioned earlier, a broad oversight area for Congress for the LCS/FFG(X) program for the past several years concerns survivability, lethality, technical risk, and test and evaluation issues relating to LCSs. This appendix presents detailed information on this broad oversight area, first with respect to LCS sea frames, and then with respect to LCS mission packages.

Sea Frames

March 2017 GAO Report

Regarding the LCS sea frames, a March 2017 GAO report assessing DOD weapon acquisition programs stated:

> **Technology Maturity**
>
> Sixteen of the 18 critical technologies—the total number of technologies for both designs—are mature. However, efforts continue to further mature two Independence variant technologies—the aluminum hull structure and the launch, handling, and recovery system. The Navy reported that it expects the results of now completed survivability testing of the aluminum structure by early 2017. Regarding the launch, handling, and recovery system, the program demonstrated unmanned operations during LCS 8's acceptance trial, but has yet to receive Navy certification to conduct manned operations as intended.
>
> **Design and Production Maturity**
>
> The LCS 4 survivability trial in January 2016 revealed weaknesses in the Independence variant design, according to the Director, Operational Test and Evaluation (DOT&E). In July 2016, LCS 6 completed shock trials in accordance with the DOT&E approved plan. This trial was conducted at a reduced severity due to serious concerns about the potential for damage to the ship. LCS 5 did not complete the entire shock trial because the Navy stopped testing in September 2016 due to concerns with the shock environment, personnel, and equipment. The Navy and DOT&E disagree on the need to complete this trial. The program now expects results of rough water trials—testing that occurred and resulted in damage on both designs several years ago—by June 2017.
>
> Since December 2015, five of the eight delivered LCS—ships of both variants—have suffered engineering casualties, which the Navy attributes to shortfalls in crew training, seaframe design, and construction quality. According to the Navy, these failures have resulted in substantial downtime and costs for repairs or replacements. We have found the Navy is responsible for paying for the vast majority of these types of damage, deficiencies, and defects on ships already delivered. While addressing deficiencies in the designs of each variant to increase the operational availability of the ships in-service, the Navy is also working to incorporate changes on follow-on ships. The Navy plans to make improvements to LCS either during construction or sometime after delivery, if funding is available. To date, nine LCS have been delivered and 13 are in various phases of construction. In 2015, the Navy provided the LCS shipbuilders schedule relief; however, even with modified ship delivery dates, both shipbuilders continue to deliver LCS seaframes significantly behind the adjusted schedule. Program officials recently reported the shipyards would not deliver four LCS in fiscal year 2016 as planned. In addition to lagging schedule performance, the shipyards continue to deliver seaframes in excess of cost targets.

Other Program Issues

Following a pattern of LCS engineering casualties, in February 2016, the Navy initiated a program review to assess, among other things, LCS crewing, training, and maintenance. Recommended actions included, returning to a "Blue/Gold" crew rotation model; merging the seaframe and mission package crew into a single, approximately 70-person crew focused on a single mission area; and designating LCS 1-4 as test ships to support testing between fiscal years 2017 and 2022. In merging the seaframe and mission package crew, the Navy acknowledged that switching the LCS mission package—once a key building block of the LCS concept—will occur less often than originally conceived.

Program Office Comments

In addition to providing technical comments, the program office noted as of January 2017, there are nine LCS in the Fleet, with another 17 on contract. By 2018, LCS will be the second largest surface ship class in the Navy. Program officials reported the LCS design is stable, meets all validated and approved requirements, and is in full serial production at both shipyards. Program officials also reported the LCS program is on budget and below the congressional cost cap and hull over hull performance continues to improve, stabilizing the production cycle. Program officials stated LCS 5 and 6 successfully met all test objectives of the approved shock trial test plan, demonstrating the ability of both variants to survive the effects of underwater shock associated with the close-proximity detonation of a 10,000 pound charge. The program office stated they have completed required testing and are incorporating lessons learned into future LCS and frigates.[28]

Regarding the frigate variant of the LCS sea frame, the March 2017 GAO report stated:

> The Navy has not yet fully defined the frigate's design and cost. Despite these uncertainties, the Navy's current acquisition strategy—approved in March 2016—indicates it intends to request authorization from Congress in 2017 to use what it calls block buy contracting to buy all of the planned frigates and for funding the lead ship before solidifying realistic cost and design parameters. This acquisition strategy includes the Navy obtaining block buy option pricing in 2017 from both LCS shipyards for 12 LCS. Then, the Navy plans to combine frigate-specific design upgrades with the LCS priced options to inform its decision on a single frigate contractor and design in July 2018. The estimated cost for the program is uncertain—the Navy expects to have a formal estimate in May 2017, and DOD's Office of Cost Assessment and Program Evaluation has indicated an independent cost estimate will be completed in fiscal year 2018.
>
> The Navy is currently reviewing frigate build specifications received from the two LCS shipbuilders in the lead up to soliciting proposals in September 2017 for the frigate design upgrades. The Navy plans to review these proposals and award the frigate to a single shipyard before beginning detail design—a critical phase of design that more fully defines ship construction needs and cost expectations. Although the Navy has stated detail design will be completed before frigate construction begins in fiscal year 2020, awarding the contract for frigate construction before beginning frigate-specific detail design activities reduces the knowledge that will be available to help inform decisions by the shipbuilders and the Navy in the solicitation and contract award process.[29]

[28] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-17-333SP, March 2017, p. 106.

[29] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-17-333SP, March 2017, p. 127.

December 2016 DOT&E Report

Regarding the LCS sea frames, a December 2016 report from DOD's Director, Operational Test and Evaluation (DOT&E)—DOT&E's annual report for FY2016—states:

> • DOT&E has now evaluated both seaframe variants to be not operationally suitable because many of their critical systems are unreliable, and their crews do not have adequate training, tools, and documentation to correct failures when they occur. No matter what mission equipment is loaded on either of the ship variants, the low reliability and availability of seaframe components, coupled with the small crew size, imposed significant constraints on mission capability. During this last year, problems with main engines, waterjets, communications, air defense systems, and cooling for the combat system occurred regularly and required test schedules to be revised or operations to be conducted with reduced capability (e.g., conducting MCM missions without operational air defense systems). These reliability problems are often exacerbated because, by design, the ship's force is not equipped to conduct extensive repairs; problems cannot be corrected quickly due to the need to obtain vendor support, particularly when several vendor home bases are at disparate overseas locations. The inability of the ship to be ready at all times to reach maximum speed, keep its main air defense system in operation, and to cool its computer servers are substantially detrimental to the ships' ability to defend themselves in time of war, much less conduct their assigned missions in a lengthy, sustained manner.
>
> • The Navy has not conducted any of the planned live-fire air defense test events planned as part of the Enterprise Air Warfare Ship Self Defense TEMP or recently updated LCS TEMP. After multiple years of delays, the Navy had planned to conduct the first of those events on the self-defense test ship in FY16, but postponed the test indefinitely because of anticipated poor performance predicted by pre-test modeling and analysis of the planned test event scenario. Without these tests, an adequate assessment of the Independence-class probability of raid annihilation requirement is not possible. DOT&E expects that the Independence variant will have been in service nearly 10 years by the time that air defense testing is complete, which at the time of this report is not anticipated before FY20.
>
> • The Navy has identified it is not satisfied with the Freedom variant's radar and RAM system for defense against ASCMs. The Navy plans to replace the RAM system with SeaRAM, which is the system installed on the Independence variant. The Navy does not plan to test the existing Freedom-variant air defense systems installed on LCS 1 through 15. DOT&E assesses this to present a high risk for deploying crews, given that many Freedom-variant ships will deploy between now and 2020 when backfits of the SeaRAM system on those hulls are scheduled to begin.
>
> • Neither LCS variant has been operationally tested to evaluate its effectiveness against unmanned aerial vehicles and slow-flying aircraft. Although the Navy had planned to test the Independence variant's capability to defeat such threats in FY15, the testing was canceled in part due to range safety requirements that would have precluded operationally realistic testing. DOT&E concurred with this decision because proceeding with an unrealistic test would have been a needless waste of resources.
>
> • In the report to Congress responding to the NDAA for FY16, DOT&E noted that the envisioned missions, use of unmanned vehicles, and operating environments have shifted relative to the original LCS vision. DOT&E concluded that the current plan to employ LCS as a forward-deployed combatant, where it might be involved in intense naval conflict, appears to be inconsistent with its inherently poor survivability in those same environments.
>
> • The ability of LCS to perform the bulk of its intended missions (SUW, MCM, ASW) depends on the effectiveness of the mission packages. To date, the Navy has not yet

demonstrated effective capability for the MCM, SUW, or ASW mission packages. The Increment 2 SUW mission package has demonstrated some modest ability to aid the ship in defending itself against small swarms of fast-inshore attack craft (though not against threat-representative numbers and tactics), and the ability to support maritime security operations.

• The intentionally small crew size has limited the mission capabilities, combat endurance, maintenance capacity, and recoverability of the ships. The core crew of Independence seaframes does not include sufficient watchstanders qualified to operate the seaframe combat system to maintain an alert posture for extended periods of time. During normal peacetime operations, the combat systems can be overseen by a single combat system manager (CSM), but in any elevated threat environment the manning plan calls for two CSMs to stand watch together to reduce overtasking. Since the ship's crew includes only three qualified CSMs, the ship cannot maintain this alert posture for extended periods, such as might be required when transiting through contested areas, or escorting a high-value unit.

- In September 2016, the Navy released new plans to change the crewing structure. The Navy plans to phase out the 3-2-1 crewing construct and transition to a Blue/Gold model similar to the one used in crewing Ballistic Missile submarines. Originally, core crews and mission module crews were intended to move from hull to hull independently of one another; core crews will now merge with mission module crews and focus on a single warfare area – either SUW, MCM, or ASW. DOT&E does not yet have sufficient information to assess whether the new crewing model will solve the problems observed in the testing of both variants and whether ships will continue to be heavily dependent on Navy shore organizations for administrative and maintenance support.

• Freedom Variant Seaframe (LCS 1 and 3):

- DOT&E's FY15 annual report as well as the comprehensive classified report issued in December 2015 described DOT&E's assessment of the Freedom variant. The Navy did not conduct any additional testing or perform any modifications to the seaframe in 2016 that would affect these assessments.

• Independence Variant Seaframe (LCS 2 and 4):

- Although not all aspects of operational effectiveness and suitability could be examined during the 2015/16 operational test, that testing identified shortcomings in cybersecurity, air defense, surface self-defense, reliability, maintainability, and other operations, which are detailed in the DOT&E November 2016 classified report. DOT&E will issue an operational test report following the testing of the final increment of the SUW mission package to support acquisition decision making regarding the Full-Rate Production decision for the SUW mission package and other aspects of the LCS program.

- Air Defense.

▪ In the Navy-conducted non-firing radar tracking events against subsonic ASCM drones, the Sea Giraffe radar provided LCS crews with only limited warning to defend itself against ASCMs in certain situations.

▪ In the Navy-conducted testing of the Independence variant's ES-3601 ESM system, the Navy used Learjet aircraft equipped with ASCM seeker simulators to represent the ASCM threats. The ES-3601 detected the presence of the ASCM seekers in most instances but did not reliably identify certain threats. Classified results are contained in DOT&E's operational test report of November 2016.

▪ In the developmental test events evaluating the ship's capability to detect, track, and engage so-called low slow flyers (LSFs) (unmanned aerial vehicles, slow-flying fixed-wing aircraft, and helicopters), the only sensor used to provide tracking information for engaging LSFs with the 57 mm gun was the SAFIRE electro-optical/infrared system. The

test events demonstrated that SAFIRE was unable to provide reliable tracking information against some targets. Furthermore, the safety standoff requirements on Navy test ranges were so severe that they precluded meaningful live-fire gun engagements against these targets. Because of these problems and constraints, the program decided to cancel all subsequent live-fire events, including those scheduled for operational testing, conceding that the Independence variant is unlikely to be consistently successful when engaging some LSFs until future upgrades of SAFIRE can be implemented. Future testing against LSFs will not be possible until the Navy finds a solution to the severe safety constraints that preclude engaging realistic targets.

▪ Although the Navy has postponed indefinitely its plans to conduct live-fire testing of the LCS air defense systems, the Navy has conducted some initial testing of the SeaRAM system, as it is employed aboard Arleigh Burke destroyers. In the Navy-conducted live-fire event aboard the self-defense test ship, the SeaRAM system was successful at defeating a raid of two GQM-163 supersonic targets. Although a stressing event, these targets were not representative of the threats they were attempting to emulate. The Navy does not currently have an aerial target that is capable of emulating some modern ASCM threats. During this test, SeaRAM employed the RAM Block 2 missile, which is different than the current LCS configuration that employs the RAM Block 1A missile. However, if the Navy decides to deploy LCSs with the Block 2 missile, then this test and others planned are germane to an LCS evaluation, however incomplete. DOT&E and the Navy continue to conduct test planning to optimize the available resources and ensure that LCS's air defense testing reflects the capabilities of deploying LCSs.

- Surface Self-Defense. The Navy conducted seven test events (four integrated test events and three dedicated operational test events), each consisting of a single attacking small boat. LCS was required to defeat the boat before it reached a prescribed keep-out range. LCS failed to defeat the small boats in two of the events.

▪ The 57 mm gun demonstrated inconsistent performance even in benign conditions, which raises doubts about the ship's ability to defend itself without the SUW mission package installed. The inaccuracy of the targeting systems, the difficulty in establishing a track on the target, and the requirement to hit the target directly when using the point-detonation fuze combine to severely impair effective employment of the gun, and limit effective performance to dangerously short ranges. The Navy has not conducted any testing to determine how well the ship will perform when faced with an attack in a realistic cluttered maritime environment including both neutral and hostile craft; the Navy has also not conducted operational testing to determine how well the ship (without the SUW mission package) will perform against multiple attacking boats. Nevertheless, given the performance observed during operational testing, the combination of faster threats, multiple threats, threats with longer-range standoff weapons, cluttered sea traffic, or poor visibility is likely to make it difficult for LCS (without the SUW mission package) to defend itself.

▪ The ship's electro-optical/infrared camera, SAFIRE, is the primary sensor for targeting the 57 mm gun. The system suffers from a number of shortcomings that contribute to inconsistent tracking performance against surface and air targets, including a cumbersome human-systems interface, poor auto-tracker performance, and long intervals between laser range finder returns. These problems likely contributed to the poor accuracy of the 57 mm gun observed during live-fire events, though the root cause(s) of the gun's inaccuracy has not been determined definitively.

▪ Both of the failures of the surface self-defense test events were caused by MK 110 57 mm gun malfunctions. During the first presentation, the Proximity Fuze Programmer failed, causing all rounds to be fired in the default proximity mode, which then exploded in midair. The crew was unable to repair the failure and continued to fire the gun during the event until the target broached the minimum safety range. Technicians subsequently

repaired the gun on July 7, 2015. The second failed event occurred on July 18 when the 57 mm gun jammed during the event. With the assistance of a civilian gun system technician, the crew downloaded the remaining ammunition, cleared the jam, and restored the gun to "single-sided" operation in about 4 hours by consolidating good components. Until repaired on August 7, 2015, the gun was limited to firing 60 rounds, rather than its normal 120, before reloading.

▪ On two occasions, the shock caused by firing the 57 mm gun unseated network cards, disabling the steering controls on the bridge and forcing the crew to steer the ship from an alternate location. On another occasion, gunfire shook network cables loose, disabling the 57 mm gun. Although the ship was able to recover from these failures within a few minutes and continue the engagement, these types of interruptions have the potential to prolong the ship's exposure to an advancing threat, as was observed during testing.

▪ In the most recent of the seven live fire test events the Navy conducted against a single-boat target, the crew employed the 57 mm differently than it had in previous live-fire events, and defeated the attacking boat with less ammunition and at a slightly longer range than in previous events. One event does not provide conclusive evidence that the ship can be effective in these scenarios, and such performance was never observed during the swarm-defense test events. Nevertheless, these results are encouraging and suggest that the Navy should examine tactics and alternative gun employment modes, including different projectile fuze settings, as a means to enhance LCS's currently limited capabilities.

- Missions of State. LCS 4 completed six mock Missions of State during the 2015 test period requiring the launch and recovery of two 11-meter rigid hull inflatable boats (RHIBs). Although the ship demonstrated the capability to meet Navy requirements for the timely launch of two 11-meter RHIBs to support effective Visit, Board, Search, and Seizure operations in Sea State 2 and below, the time needed to recover the boats aboard ship often exceeded the Navy requirement because of problems with the surface tow cradle and the twin-boom extensible crane (TBEC). Testing revealed operational deficiencies and safety concerns. Observers reported that flaws in the design of the surface tow cradle used in conjunction with the watercraft launch, handling, and recovery system and other problems limit safe launch, internal movement, and recovery of boats to Sea State 2 and below. The cumbersome multi-step boat launch/recovery process has several "single points of failure" – including the surface tow cradle, TBEC, the Mobicon straddle carrier, and a forklift – that increase the likelihood of delays and the possibility of mission failure. The failure of any of these components can halt boat operations and could leave a boat stranded at sea, which happened once during operational testing.

- Endurance and Speed. LCS 4 met its transit range requirement, demonstrating a fuel usage rate that enables it to travel more than 4,200 miles at 14 knots if called upon to do so (threshold 3,500 miles). LCS 4 failed its sprint speed requirement of 40 knots, demonstrating a maximum sustained speed of only 37.9 knots in calm waters. It fell just short of its sprint range requirement (1,000 miles at maximum speed), demonstrating fuel burn rates at maximum speed that would enable it to travel 947 miles. LCS 4 has long-standing problems with her ride control system hardware, including interceptors, fins, and T-Max rudders, that affect the ship's maneuverability at high speeds. The ship also had reported recurring problems with frequent clogging of the gas turbine engine fuel oil conditioning module pre‑filters and coalescers, and found it difficult to maintain high speed for prolonged periods. The crew found it necessary to station extra operators in the machinery room (normally an unmanned space) to change fuel filters and manually control the fuel oil heaters to keep the gas turbine engines in operation during these high-speed runs.

- Cybersecurity. In early 2016, the Navy made substantial changes to the LCS 4's networks, calling the effort "information assurance (IA) remediation," to correct many of

the deficiencies in network security on the baseline Independence variant's total ship computing environment. Previous testing on LCS 2 in 2015 revealed several deficiencies in network protection such as the lack of proper settings and access controls, poor network segmentation, and lack of intrusion detection capabilities. The Navy designed and implemented the IA remediation program to mitigate or eliminate such vulnerabilities and was successful in eliminating some of the deficiencies that placed the ship at risk from cyber-attacks conducted by nascent (relatively inexperienced) attackers.

▪ DOT&E found that the Navy's testing, which included a Cooperative Vulnerability and Penetration Assessment (CVPA) and an Adversarial Assessment in 2016 on LCS 4, was inadequate to fully assess the LCS 4's survivability against cyber attacks originating outside of the ship's networks (an outsider threat). The testing was adequate to determine that some deficiencies remain when attacks occur from an insider threat, however, it was not adequate to determine the full extent of the ship's cybersecurity vulnerability or the mission effects of realistic cyber-attacks. Because of the imminent deployment of LCS 4, the Navy did not allow cybersecurity testers to make changes to the configuration of network components, as a cyber aggressor would almost certainly attempt to do to gain a foothold on the system. Testing was also impeded by electrical work, test site disruptions, and frequent network configuration changes because the test was conducted during a maintenance period. Because of these changes and the installation of systems (including the Harpoon missile and MQ-8B Fire Scout and its control system) after the test completed, DOT&E is uncertain whether an operationally representative configuration of the system was tested. Lack of physical access to many systems imposed by test artificialities, restrictions on the test team, and inadequate test preparation also limited the conduct of the test. The duration of Adversarial Assessment was reduced to less than half the original plan because of the delays experienced during the CVPA. Finally, DOT&E found that the Navy Operational Test Agency's threat emulation used for this test was lacking and did not meet the standards necessary for a robust cybersecurity examination. In July 2016, DOT&E issued guidance on cybersecurity test methods to all of the Service operational test agencies, in part due to the inadequacies in threat emulation observed in the LCS cybersecurity testing.

▪ Although the Navy's IA remediation corrected some of the most severe deficiencies known prior to the test period, the testing revealed that several problems still remain which will degrade the operational effectiveness of Independence-variant seaframes until the problems are corrected. The Navy reported that the second phase of IA remediation intended to correct additional network deficiencies has been installed on all follow on ships; however, DOT&E is unaware of the plans to test these changes on future ships, or whether these changes will correct the problems observed during the LCS 4 test.

- Operational Suitability. The Independence variant (with or without a mission package) is not suitable for SUW missions or MCM missions, and will remain that way until the Navy can reduce the failure rates of mission-essential equipment and correct the deficiencies that require workarounds and unsustainable manning. Unless corrected, the critical operational suitability problems highlighted below will continue to prevent the ship and mission packages from being operationally effective.

- LCS 2 Reliability and Availability. Although not tested in 2016, DOT&E's June 2016 early fielding report on the LCS 2 equipped with the MCM mission package delineated the suitability of the Independence variant. The type and severity of the failures observed on LCS 4 were also observed on LCS 2 during the 2015 Technical Evaluation period for the MCM mission package, suggesting that the reliability and availability problems observed are inherent to the Independence-variant seaframe, rather than isolated to one hull. The MCM mission package places different and greater demands on seaframe equipment than does the SUW mission package. The frequency of seaframe failures observed on the LCS 2 seaframe with the MCM mission package was greater than that observed on LCS 4 with the SUW mission package; implying the frequency of

Independence variant seaframe failures and associated availability are likely mission package dependent (i.e., mission dependent). The following are the most significant seaframe equipment problems observed during the 2015 Technical Evaluation period.

▪ Recurring failures of the main propulsion diesel engines and their associated water jet assemblies hindered test operations throughout the test period. LCS 2 was unable to launch and recover RMMVs on 15 days because of four separate propulsion equipment failures involving diesel engines, water jets, and associated hydraulic systems and piping. These failures would also have limited the ship's capability to use speed and maneuver to defend itself against small boat threats.

▪ LCS 2 experienced multiple air conditioning equipment failures and was unable to supply enough cooling to support the ship's electronics on several occasions. One or more of the ship's three chilled water units was either inoperative or operating at reduced capacity for 159 days (90 percent of the period).

▪ LCS 2 experienced failures of critical systems such as the SeaRAM air defense system (four failures and a total downtime of 120 days), the ship's 57 mm gun (inoperative for 114 days), the SAFIRE electro‑optical/infrared system (inoperative for 25 days), and the Sea Giraffe radar (multiple short outages) that were not repaired immediately because they did not preclude continuation of MCM testing in an environment devoid of air and surface threats. These failures would not have been ignored in a contested location; and many of these failures left the ship defenseless against certain threats for days at a time. Had these failures occurred in theater, the repair efforts would have affected MCM operations, likely forcing the ship off-station to effect repairs and/or embark technicians since the crew does not have the requisite training, parts, or documentation to effect repairs themselves.

▪ Similar to LCS 4, LCS 2 experienced several Ship Service Diesel Generator failures during the period, but was never without at least two of four generators operable (sufficient to power all combat loads, but which leaves the ship with no redundancy in the event of another failure).

▪ A Mobicon straddle carrier failure left the ship unable to conduct waterborne MCM operations for a period of 4 days until a technician could travel from Australia to diagnose the problem and make needed adjustments. This episode demonstrated the crew's paucity of documentation, training, and diagnostic equipment.

▪ Failure of a power conversion unit that supplied 400-Hertz power to the mission bay deprived the ship of MCM mission capability for 20 days while the ship was in port undergoing repairs. The ship also lost the capability to supply 400-Hertz power to the aircraft hangar, where it is needed to conduct pre-mission checks on the MH-60S and AMCM systems. The Navy never determined the cause of the near‑simultaneous failures of the two power conversion units, although technicians considered them related.

- LCS 4 Reliability and Availability. The mission‑essential equipment for conducting SUW on LCS 4 had poor reliability, with a failure that caused a partial loss of capability approximately every day and a complete loss of mission capability every 11 days on average. Based on these failure rates, LCS has a near-zero chance of completing a 14-day mission (the length of time LCS can operate before resupply of food is required) or a 30-day mission (the length of time prescribed by Navy requirements documents) without experiencing an operational mission failure. When averaged over time, and accounting for both planned and unplanned maintenance downtimes, the ship was fully mission capable for SUW missions 24 percent of the 2015 test period, and was fully or partially mission capable 66 percent of the time. The following are the most significant seaframe equipment problems observed during the 2015-2016 developmental and operational test periods.

▪ LCS 4 suffered numerous failures of its propulsion systems, including the diesel engines, gas turbines, and steerable waterjets. The most debilitating problems occurred during the first developmental testing period in May and June 2015, when a combination of failures left the ship with only one working engine for 19 days. Following the July 2015 in-port maintenance period, the reliability of the propulsion systems improved, but single engines and waterjets continued to fail, and LCS spent 40 days of the 136-day test period with one or more engines inoperative or degraded. During the 2016 test periods, observers continued to report failures to the diesel engines and gas turbines that limited the ship's speed.

▪ LCS 4 was seldom able to keep all three air conditioning units fully operational. In one case, the systems were unable to supply enough cooling to support the ship's electronics for a 2-week period. The Navy recognized that the commercial off-the-shelf chilled-water air conditioning systems installed in LCS 2 and LCS 4 had serious reliability problems and, working with the shipbuilder, sourced the air conditioning systems on LCS 6 and follow-on Independence seaframes from a different manufacturer. Since the LCS program has not replaced the air conditioning systems on LCS 2 and LCS 4, those systems are still exhibiting severe reliability problems.

▪ LCS 4 experienced several Ship Service Diesel Generator failures during the periods of observation, but was never without at least two of four generators operable (sufficient to power all combat loads, but which leaves the ship with no redundancy in the event of another failure). Problems with electrical switchboards added to the difficulties, as certain combinations of diesel generators would not share load, reducing the redundancy in the system. Observers recorded four load sheds, which automatically severed power to non-essential systems, and in one case, caused key combat systems to shut down.

▪ During the 2015 test events, LCS 4 experienced numerous instances in which the flow of navigation data (heading, pitch, and roll) to the combat system was disrupted for short periods, which disabled the Sea Giraffe radar and the 57 mm gun and degraded SeaRAM's performance. The worst recorded instance occurred during the September 2015 live fire gun event when the flow of navigation data was interrupted 34 times, leading to a loss of all tracking information and the inability to fire the 57 mm gun for nearly 30 minutes. These outages significantly affected the crew's ability to defeat targets and contributed to the ship's failure to defeat all targets before they entered the keep-out zone. The problem defied early troubleshooting efforts and persisted into early 2016; however, observers did not report any navigation data outages after testing resumed in 2016, indicating that the Navy may have corrected the problem during installation of the IA remediation upgrades and other system changes. The Navy reported that the first instances of navigation data outages observed in 2015 were attributable to a cabling failure; and that the root cause of the failure was determined and corrected permanently. The Navy determined that the navigation data outages observed in 2016 were caused by the IA upgrade that had been recently installed in LCS 4 in early 2016; and the outages were remedied by reverting the network core switches back to the pre-IA upgrade routing protocol.

▪ The Independence variant's primary air defense system, SeaRAM, suffered from poor reliability and availability before, during, and after operational testing aboard LCS 4. Failures caused seven long periods of downtime (greater than 48 hours) between May 16, 2015, and June 18, 2016. Each repair required the delivery of replacement components that were not stocked aboard the ship, and most required assistance from shore-based subject matter experts. These failures left the ship defenseless against ASCMs, and would likely have forced it to return to port for repairs if it had been operating in an ASCM threat area. In addition, the SeaRAM aboard LCS 4 had five short (less than 5 minute) outages during live and simulated engagements against aerial targets, each of which might have resulted in an inbound ASCM hitting the ship. The SeaRAM aboard LCS 2 has also suffered from several long-lived failures.

▪ The ship's ride control system, used for high-speed maneuvering, did not appear to be fully functional at any time during developmental or operational testing in FY15 and FY16.[30]

The December 2016 DOT&E report also stated:

LFT&E [Live Fire Test & Evaluation]

• Neither LCS variant is expected to be survivable in high intensity combat because the requirements accept the risk of abandoning the ship under circumstances that would not require such an action on other surface combatants. Although the ships incorporate capabilities to reduce their susceptibility to attack, previous testing of analogous capabilities in other ship classes demonstrates it cannot be assumed LCS will not be hit in high-intensity combat. As designed, the LCS lacks the redundancy and the vertical and longitudinal separation of vital equipment found in other combatants. Such features are required to reduce the likelihood that a single hit will result in loss of propulsion, combat capability, and the ability to control damage and restore system operation.

• LCS does not have the survivability features commensurate with those inherent in the USS Oliver Hazard Perry‐class Guided Missile Frigate (FFG 7) it is intended to replace. The FFG 7 design proved to retain critical mission capability and continue fighting after receiving a significant hit.

• The LCS 4 Total Ship Survivability Trial (TSST) exposed weaknesses in the Independence-variant design.

- While the auxiliary bow thruster provided a limited means to recover propulsion, much of the ship's mission capability would have been lost because of the primary weapon damage or the ensuing fire and flooding.

- Damage to chilled water system piping caused an unrecoverable loss of several vital systems because of equipment overheating. The chilled water system's lack of cut-off valves does not allow for isolation of damaged sections.

- There is a lack of sufficient separation between the two damage control repair stations (DCRS). The Mission Bay Fire scenario resulted in the loss of both DCRS (one from the primary weapon effects and the second due to the spread of smoke as a result of the proximity to the fire boundary). The rescue and assistance locker located in the Helicopter Hangar is not outfitted with DCRS equipment exacerbating the damage control capability shortfalls.

- Installed damage control systems, such as Aqueous Film Forming Foam (AFFF) and Main Drainage, are designed with motor-operated valves co-located in the compartments that the systems are supposed to protect. As a result, the crew could not access these valves to reconfigure the damaged systems when remote operation was compromised by loss of power or data.

• The Navy conducted a reduced severity shock trial on USS Jackson (LCS 6), executing three shots of increasing severity, ending at 50 percent of the maximum design level. The Navy decided not to test up to the standard 2/3 design level due to concerns the ship would suffer a large amount of damage to non-shock hardened mission‐critical equipment.

• In addition to reducing the shot severity, the Navy took several protective measures to reduce the risk of equipment damage and personnel injury to include:

[30] Department of Defense, Director, Operational Test & Evaluation, *FY 2016 Annual Report*, December 2016, pp. 268-273.

- Removed some equipment before the trial or between shots, such as the Tactical Common Data Link antenna and racks, the navigational radar, and the 57 mm gun.

- Replaced some rigid pipes with flexible connections.

- Replaced some existing bolts with higher strength material.

- Added cable slack in some locations.

- Rerouted some ducts and pipes and modified ship structure to increase shock excursion space around equipment.

- Strengthened some bulkheads where heavy equipment was attached.

- Repaired missing and undersized foundation welds.

- Tied life rafts to the ship to make sure they did not self-deploy during the shots.

• A preliminary assessment of the LCS 6 shock trial demonstrated that:

- The Navy assumptions regarding the performance of non-hardened when exposed to underwater shock are overly conservative. The Navy assumed that these components and systems would become inoperable while the shock trial demonstrated most non-hardened components and systems remained operable or were restored to a limited or full capability prior to the ship's return to port on each shot.

- The ship maintained electrical power generation through all three shots, to include the Non-Vital Ship Service Diesel Generators.

- The SeaRAM system remained operable through all three shots.

- The main gun survived shot one, but the Navy removed it for the later shots, conceding that severe damage was likely. The actual gun survivability/firing capability at higher shock severities cannot be assessed.

- The auxiliary propulsion bow thruster remained operable through all three events.

- The trimaran ship design displayed unique structural behaviors not seen in mono-hull ships. The attenuation of the shock loading above the keel invalidated the Navy approach of using a target keel velocity as the metric to determine shot shock severity and confidence in the pertinent M&S tools to capture the shock trial phenomena. Despite achieving a target keel velocity, the majority of the LCS 6 deck mounted equipment did not experience the shock severity intended by the Navy.

• Based on the LCS 6 shock trial lessons learned, the Navy conducted a shock trial aboard USS Milwaukee (LCS 5) from August 29 through September 23, 2016, starting the trial at more traditional severity levels. However, the Navy stopped the LCS 5 trial after the second shot, thereby not executing the planned third shot due to concerns with the shock environment, personnel, and equipment. The Navy did not view the third LCS 5 shock event as worthwhile because of concerns that shocking the ship at the increased level would significantly damage substantial amounts of non-mission critical equipment, as well as significantly damage a limited amount of hardened, mission critical equipment, thereby necessitating costly and lengthy repairs.

- The electrical distribution system remained operable or was restored to a limited or full capability prior to the ship's return to port after each shot.

- Most non-hardened components and systems, including the RAM air defense system, remained operable or were restored to a limited or full capability prior to the ship's return to port after each shot.

- By not executing the 2/3 level shot, the Navy could not validate the overly conservative assumptions made for the underwater threat shot in the LCS 3 TSST.

- DOT&E will release a more comprehensive classified report in 2017 upon complete analysis of the trial data.[31]

The December 2016 DOT&E report also stated:

Recommendations

• Status of Previous FY15 Recommendations....

- The Navy did not accept DOT&E's recommendation to obtain the intellectual property rights needed to develop high-fidelity digital models of the AN/SPS-75 (TRS-3D) and AN/SPS-77 (Sea Giraffe) radars for the Probability of Raid Annihilation Test Bed (a model used to evaluate the effectiveness of the LCS's air defenses). Although the Navy did respond to DOT&E's August 2015 memorandum, it appears that testing of the Freedom-variant's current configuration of air defense systems will be eliminated entirely, as LCS 17 and follow-on Freedom seaframes will be equipped with SeaRAM. This will leave the air defense capabilities of LCS 1 through 15 untested until the Navy backfits SeaRAM, which is not scheduled to begin until 2020.

- The Navy has not yet accepted or addressed DOT&E's recommendation to improve the shock resistance of mission-critical electronics in the Independence-variant LCS. Until this problem is addressed, LCS is likely to experience a disruption in operations during 57 mm gun engagements and other shock-inducing activities/events.

- The Navy has not yet formally addressed DOT&E's recommendation to work with the vendor to develop changes and improvements to SAFIRE, which are needed to improve the human-machine interface, reduce the time required to develop a new track, improve tracking, and correct other performance issues noted in FY15 testing. DOT&E reiterates this recommendation and suggests that the Navy also consider replacing the SAFIRE system with a more capable targeting system – one that is more user friendly and enables more accurate and effective gunfire for both air defense and SUW missions.

- The Navy has begun to correct the causes of Independence-variant seaframe problems that disrupted gunnery engagements and other operations, however, several problems still remain that will preclude effective gun employment. The debilitating problem of the intermittent loss of navigation data appears to have been corrected; however, the Navy has not yet corrected the 30 mm gun azimuth-elevation inhibits, and the 57 mm gun's azimuth-dependent range errors. Azimuth-elevation inhibit errors or gun turret-drive errors occur intermittently and are of short durations, and prevent the gunner from firing during an engagement. During testing these errors frequently interrupted engagements at key moments. The Navy developed tactics, techniques and procedures that are now in use to mitigate the problem. The Navy is investigating the root cause of this disruptive error.

- The Navy has not yet addressed DOT&E's recommendation to devise a safe method to realistically test the ships' ability to counter LSF threats. The Navy should coordinate with test range authorities to examine the feasibility of reducing the safety standoff restrictions; without changes, no meaningful test of LCS's capability against these threats can be conducted.

- The Navy's recent change to the LCS concept of employment, which changes the crewing structure, training, and operational deployment of the class partially addresses DOT&E's recommendation to provide LCS crews with better training, technical documentation, test equipment, and tools, along with additional spares to improve the crews' self-sufficiency. It is not yet clear whether these changes will fully address the

[31] Department of Defense, Director, Operational Test & Evaluation, *FY 2016 Annual Report*, December 2016, pp. 275-276.

recommendation and will eliminate the maintenance problems DOT&E has articulated in multiple test reports.

- The Navy and LCS program are improving their organic expertise with LCS systems; however, the Navy continues to maintain an outsized reliance on equipment vendors and overseas contractors, especially for the maintenance and repair of some critical mission equipment. DOT&E continues to recommend reducing this reliance on outside vendors to ensure crews and the Navy's in-service engineering agent can fully support LCS repair and maintenance activities.

- As DOT&E recommended, the Navy is investigating options for re-engineering the recovery of watercraft; however, no solutions have been found to correct the problems with RMMV recovery nor has the Navy demonstrated the ability to recover other vehicles like the Knifefish UUV.

- The Navy has not made progress on developing tactics to mitigate system vulnerabilities to mines, mine collision, and entanglement hazards, and other surface and underwater hazards.[32]

The December 2016 DOT&E report also stated:

Recommendations...

FY16 Recommendations. Since December 2015, DOT&E issued three operational test reports for the LCS program, each of which contained multiple recommendations for the Navy's consideration that focus on the improvements needed to achieve operational effectiveness, suitability, and survivability, and to improve future testing. A selection of these recommendations is provided below.

Cybersecurity

1. After implementing changes to correct the deficiencies found in the LCS 4 cybersecurity test, conduct a full cybersecurity test, including a Cooperative Vulnerability and Penetration Assessment and Adversarial Assessment. This testing should be conducted on a ship that has received the second phase of IA remediation and should examine the Increment 3 SUW mission package configuration. Future tests should include a range of malicious activities from stealthy to noisy to gain data needed to characterize the ship's detect and react capabilities and should not be conducted during a ship maintenance period (since this contributed to the inadequacy of the LCS 4 test events).

2. Ensure that vulnerabilities identified on one ship are remedied on all ships.

3. Schedule and conduct a comprehensive cybersecurity assessment of the MH-60S helicopter with ALMDS and with AMNS.

4. Expand future cybersecurity testing to include custom malware for system-specific operating systems and an examination of supervisory control and data acquisition systems and programmable logic controllers. Provide a stable ship configuration that accurately reflects the intended deployment configuration and allows for temporary changes to enable testers to examine mission-critical systems and evaluate the mission effects of cyber-attacks.

Seaframes

[32] Department of Defense, Director, Operational Test & Evaluation, *FY 2016 Annual Report*, December 2016, pp. 276-277.

5. Develop a plan for integration of the MCM mission package with the Freedom-variant seaframe, including launch and recovery of MCM watercraft, and schedule early developmental testing to identify implementation challenges.

6. Improve reliability of mission systems and seaframe support systems to reduce logistics support requirements, crew workload, and unplanned downtime during MCM operations.

7. Improve the performance of the 57 mm gun system to increase the effective range and simplify targeting to enable faster and more lethal performance over a broader engagement range.

8. Improve the air-search radar on both seaframes to support earlier detections of ASCMs and tactical aircraft in both clear and jammed environments. Early detection increases the likelihood of survival against attack.

9. Increase the number of qualified Combat Systems Managers (CSMs) on the Independence-variant to provide additional operators for the seaframe sensors and guns.

10. Improve the reliability of the engineering systems, including diesel and gas turbine engines, steerable water jets, ride-control systems, and air conditioning equipment.

11. Determine the root cause of the Independence variant's fuel oil service system problems that occur during high-speed operations that made it necessary to station additional operators in the machinery room to replace Fuel Oil Conditioning Module pre-filters and control the fuel oil heaters manually.

12. Adequately fund the Air Warfare Ship Self-Defense Enterprise so that adequate testing of the LCS air defense systems can occur.

13. Improve the reliability and availability of SeaRAM.

14. Implement the equipment shock hardening measures employed on LCS 5 and 6 during the shock trial on all ships and survivability improvement findings/recommendations developed as a result of the two shock trial series.

15. Implement the survivability improvement recommendations developed by the LCS 4 TSST team. Most importantly, redesign the Independence variant's chilled water system to enable isolation of damaged sections.

16. Reevaluate LCS susceptibility to influence mines by conducting at-sea trials with the Advanced Mine Simulation System.[33]

Mission Packages

March 2017 GAO Report

The March 2017 GAO report assessing DOD weapon acquisition programs stated:

> **Mine Countermeasures (MCM)**
>
> The Navy designed and produced MCM mission package systems prior to maturing critical technologies. The Navy accepted seven MCM packages without demonstrating they meet threshold performance requirements and, is now replacing a key system—the remote multi-mission vehicle (RMMV). There are six MCM systems (Near Surface Detection, Airborne Mine Neutralization, Remote Minehunting, Coastal Mine Reconnaissance, Buried Minehunting, and Unmanned Mine Sweeping) the Navy plans to

[33] Department of Defense, Director, Operational Test & Evaluation, *FY 2016 Annual Report*, December 2016, p. 277.

assemble and fully test in fiscal year 2020. After the Navy suspended developmental testing in October 2015 following the discovery of significant reliability issues, it studied the package and revised its approach. The Navy is now replacing the RMMV, which towed the AQS-20A sonar, with an unmanned boat. The new boat rides on the surface of the water as opposed to the semi-submersible RMMV. Program officials state the boat will be easier to launch and recover but could be susceptible to wave-movement, which may make it more difficult to find mines. The Near Surface Detection Module and Airborne Mine Neutralization Modules achieved initial capability in 2016. The remaining systems are still in development and are planned to be tested over the next several years.

Surface Warfare (SUW)

The Navy designed and produced SUW mission package systems prior to demonstrating the maturity of key systems leading to changes and delays to the SUW package. The Navy has accepted eight SUW packages with no deliveries planned for fiscal year 2017. One package currently consists of two 30 millimeter guns, an armed helicopter, and two rigid hull inflatable boats. In August 2014, the Navy found that the current package met interim performance requirements on the Freedom variant and, in 2015, the Navy tested this part of the package on the Independence variant. To meet threshold requirements a surface-to-surface missile is required. According to program officials, initial missile demonstrations were successful, but operational testing was delayed by about a year to fiscal year 2018 due to ship integration issues.

Antisubmarine Warfare (ASW)

The Navy reconfigured the ASW package after determining planned systems would not provide adequate capability. According to the Navy, the ASW systems are mature as they have been fielded by U.S. Navy and foreign navies. Navy program officials stated that the package's weight issues have been resolved, and the Navy has purchased an initial ASW package to be used for testing. The Navy is now planning to meet the threshold requirement for ASW in fiscal year 2019, a 2-year delay from last year's estimate.

Other Program Issues

The Navy will not achieve the capability to meet threshold requirements for all three of the mission packages until late fiscal year 2020, by which time it plans to have taken delivery of 24 ships. Starting in 2018, the Navy plans to modify LCS as a frigate and permanently install most of the ASW and SUW mission packages. These changes have, to date, not deterred the Navy from its plans to purchase 64 mission packages.

Program Office Comments

In commenting on a draft of this assessment, the Navy reported it is delivering operationally effective mission package capability to the fleet as it mature increments. The Navy stated it is purchasing the quantity of mission systems and packages needed for system integration, crew training, developmental and operational testing, and LCS deployments. The Navy reports it is purchasing the systems in accordance with relevant laws and DOD regulations. The SUW package achieved initial capability in fiscal 2015 and will meet requirements with the surface to surface missile module in fiscal 2018. ASW capability is planned to have an initial capability and meet requirements in fiscal 2019. The MCM package is delivering systems as they mature. Due to reliability of the RMMV, the Navy reports it is restructuring the MCM package to perform the minehunting mission with a different vehicle. The MCM package is planned to achieve an initial capability in fiscal year 2020. The Navy reported it intends to adjust the

program's package quantities in 2017 to support changes to the LCS and frigate programs.[34]

December 2016 DOT&E Report

The December 2016 DOT&E report states:

> SUW Mission Package
>
> • While equipped with the Increment 2 SUW mission package, LCS 4 participated in three engagements with small swarms of fast-inshore attack craft (small boats). LCS 4 failed the Navy's reduced requirement for interim SUW capability, failing to defeat each of the small boats before one penetrated the prescribed keep-out zone in two of the three events. Although LCS eventually destroyed or disabled all of the attacking boats in these events, the operational test results suggest that the Increment 2 SUW mission package provides the crew with a moderately enhanced self-defense capability (relative to the capability of the 57 mm gun alone) but not an effective offensive capability. In all three events, the ship expended an inefficiently large quantity of ammunition from the 57 mm gun and the two mission package 30 mm guns, while contending with azimuth elevation inhibits that disrupted or prevented firing on the targets. In one event, frequent network communication faults disrupted the flow of navigation information to the gun systems further hindering the crew's efforts to defeat the attacking boats. SAFIRE is a likely contributor to the observed 57 mm gun performance and large ammunition expenditure during surface engagements, and its cumbersome user interface contributed to the workload of already-overtasked watchstanders. LCS 4's failure to defeat this relatively modest threat routinely under test conditions raises questions about its ability to deal with more realistic threats certain to be present in theater, and suggests that LCS will be unsuccessful operating as an escort (a traditional frigate role) to other Navy ships. Additional details about the LCS gun performance and the factors and tactics that contribute to the ship's effectiveness are discussed in DOT&E's November 2016 classified report.
>
> • The Navy has begun work on developing and testing the SSMM, the core component of the Increment 3 mission package. Operational testing in 2015 and 2016 revealed that the ship's radar, the only sensor available to provide initial targeting information to the Longbow HELLFIRE missiles employed from the SSMM, demonstrated performance limitations that might hinder its ability to support missile employment against small boat swarms. The Navy intends to conduct additional developmental testing to better understand these limitations; and the results of these tests will be used to inform future decisions by the Navy to modify missile targeting algorithms and tactics, as needed to overcome the limitations. The Navy plans to demonstrate the ability to meet the original LCS requirements for SUW swarm defense during operational testing of the Increment 3 mission package in FY18.
>
> MCM Mission Package
>
> • DOT&E concluded in a June 2016 early fielding report, based exclusively on the testing conducted before 2016, that an LCS employing the current MCM mission package would not be operationally effective or operationally suitable if called upon to conduct MCM missions in combat. The primary reasons for this conclusions are:
>
> - Critical MCM systems are not reliable.
>
> - The ship is not reliable.

[34] Government Accountability Office, *Defense Acquisitions[:] Assessments of Selected Weapon Programs*, GAO-17-333SP, March 2017, p. 108.

- Vulnerabilities of the RMMV to mines and its high rate of failures do not support sustained operations in potentially mined waters.

- RMMV operational communications ranges are limited.

- Minehunting capabilities are limited in other-than-benign environmental conditions.

- The fleet is not equipped to maintain the ship or the MCM systems.

- The AMNS cannot neutralize most of the mines in the Navy's threat scenarios.

• In the same early fielding report, DOT&E concluded that the current versions of the individual systems that comprise the current MCM mission package, specifically the RMS and the MH-60S AMCM helicopter equipped with ALMDS or AMNS, would not be operationally effective or operationally suitable if called upon to conduct MCM missions in combat.

• Although the Navy has implemented some corrective actions to mitigate the problems observed in earlier testing, the substantive unclassified details of DOT&E's assessment are unchanged from the FY15 edition of this

report. DOT&E's classified June 2016 early fielding report provides additional detail.

• Developmental MCM Systems. The Navy is continuing to develop the COBRA Block I, Knifefish, and UISS programs and has not yet conducted operational testing of these systems. However, early developmental testing or contractor testing of COBRA Block I and Knifefish have revealed problems that, if not corrected, could adversely affect the operational effectiveness or suitability of these systems, in operational testing planned in FY17 or FY18, and subsequently the future MCM mission package. In addition to the problems observed in early testing of developmental systems, DOT&E used lessons learned from earlier testing of the RMS to identify problems that are likely to affect the upcoming phases of Knifefish and UISS operational testing.

- During developmental testing of COBRA Block I in early FY16, test data revealed that the system's probability of detection is low against small mines and mines emplaced in some environmental conditions. Thus, without improvements, the capability of the current system will likely be limited in some operationally realistic threat scenarios. Operational testing, planned for 2017, will characterize the COBRA Block I capability against a broader range of operationally realistic conditions.

- For the Knifefish UUV program, the Navy's developmental efforts are currently focused on system design and have not yet tested Knifefish integration with either LCS seaframe variant. The Navy needs to test battery charging, off-board communications, maintainability, launch and handling equipment and procedures, and the ability of the crew to recover the vehicle reliably while employing the proposed grappling hook capture device to support Knifefish operations on both LCS variants. In addition, it is not yet known how Knifefish operations will be affected by concurrent LCS MCM activities, making operationally realistic testing of the Knifefish UUV in the combined MCM mission package essential.

- The Knifefish vehicle's low frequency broadband sonar is designed to detect bottom, moored, and buried mines. After early contractor testing revealed that sonar transmitter elements were failing prematurely, the Naval Research Laboratory recommended operating the elements at a significantly lower voltage to extend their operational life. While this change will likely improve the sonar's reliability, the reduction of the sonar's transmitting power will also likely reduce the range at which the sonar can detect objects. Although the operational implications of these changes are not yet known, the actions taken to mitigate reliability problems could negatively affect the assessment of operational effectiveness in the upcoming operational assessment.

- Knifefish contractor testing in October uncovered a UUV structural failure mode during launch in which the vehicle broke in half during launch from a test ship. The contractor analyzed the failure and suspects it was caused by a combination of factors including the wave height encountered during launch, the vehicle position on the launch ramp, and the launch ramp geometry. The contractor is considering options to address this failure mode such as redesigning the launch ramp and restricting launches to lower sea states.

- The UISS contractor delivered the first engineering development unit only recently and has not yet conducted testing of a production representative system. The Navy will need to consider integration challenges that include off-board communications, maintainability, launch and handling equipment and procedures, and the ability of the crew to recover the system safely and reliably. Although the Navy plans to characterize UISS performance in dedicated minesweeping scenarios during the initial phases of LCS-based testing, operationally realistic testing of the system in the combined MCM mission package is also essential.

- Currently, LCS sailors do not possess an organic, in-situ means to measure environmental characteristics that are important to plan UISS minesweeping missions. Although the Navy is working on a solution that it hopes to make available by 2020, the lack of this capability may affect the LCS crew's ability to employ UISS effectively in upcoming operational testing that will characterize minesweeping performance over the range of conditions expected in potential threat scenarios.

• Current Navy plans for developing, integrating, and testing mine hunting and mine sweeping systems in the LCS MCM mission package are not adequately funded to mature the MCM capabilities to meet mission requirements.

ASW Mission Package

• The current threat torpedo surrogates have significant limitations in their ability to represent threat torpedoes. As such, operational assessment of each LCS variant with ASW mission package using these test articles will not fully characterize the ship's capability to defeat incoming threat torpedoes. The proposed development of a General Threat Torpedo (GTT) addresses many of DOT&E's concerns; however, the GTT's capability to support realistic operational testing depends on future Navy decisions to procure a sufficient quantity of GTTs.[35]

The December 2016 DOT&E report also stated:

Recommendations

• Status of Previous FY15 Recommendations.

- With respect to the MCM mission package and the cancellation of the RMS program, the Navy appears to have accepted the recommendation to shift to a performance-based test schedule rather than continuing a schedule-driven program. The LCS program needs ample time and resources to correct the numerous serious problems with the MCM mission package.[36]

The December 2016 DOT&E report also stated:

Recommendations...

[35] Department of Defense, Director, Operational Test & Evaluation, *FY 2016 Annual Report*, December 2016, pp. 273-274. See also the separate assessment of the Remote Minehunting System (RMS) on p. 310.

[36] Department of Defense, Director, Operational Test & Evaluation, *FY 2016 Annual Report*, December 2016, pp. 276. See also the separate discussion of previous recommendations regarding the Remote Minehunting System (RMS) on pp. 310-311.

FY16 Recommendations. Since December 2015, DOT&E issued three operational test reports for the LCS program, each of which contained multiple recommendations for the Navy's consideration that focus on the improvements needed to achieve operational effectiveness, suitability, and survivability, and to improve future testing. A selection of these recommendations is provided below....

SUW Mission Package

17. Consider developing multi-ship tactics or build additional capability into future mission packages to enable LCSs, operating in surface action groups, to more effectively counter small-boat swarms that are more threat-representative.

18. Improve the 30 mm gun system's accuracy and expand the guns' effective range so that crews are not limited to a narrow region of success. Without improvements, LCS crews are unlikely to be successful against realistically sized small-boat swarms.

MCM Mission Package

19. Limit procurement of ALMDS, AMNS, and AN/AQS-20A systems, which have significant operational performance limitations that negatively affect LCS MCM mission capability until much needed performance improvements are developed, tested, and proven effective in testing representative of realistic LCS mine-clearance operations. Suspend further use of RMMV v6.0 until completing a comprehensive reliability-centered analysis, correcting high impact failure modes, and testing repairs in an operationally realistic environment.

20. Given the cancelation of the RMS program, accelerate the development the most promising minehunting alternatives, including the USV with a towed AN/AQS-20C or AN/AQS-24C sensor and the Knifefish UUV with pre-planned product improvements.

21. Avoid overreliance on shore-based testing of mission package systems, which often results in unwarranted confidence in system performance in a maritime environment.

22. Fully resource the development of improvements to the ALMDS and AMNS (or alternative systems such as Barracuda). For ALMDS, efforts should focus on reducing the incidence of false contacts and eliminating the need for multi-pass search tactics. For mine neutralization systems, efforts should focus on reducing the incidents of fiber-optic communications losses, developing the ability to neutralize near-surface mines, and operating in high-current environments.

23. Demonstrate through end-to-end testing that the systems included in future mission packages can achieve the area search rate and detection/classification performance needed to support LCS effectiveness in timely and sustained minehunting and clearance operations. Testing should avoid segmented evaluations of individual components of the mission package.

24. Demonstrate viability of multi-ship LCS MCM Concept of Operations (CONOPS) that address operational concerns such as data sharing, contact management, asset scheduling, and mutual interference when multiple ships operate together to accelerate mine-clearance timelines and, since no planned version of the LCS MCM mission package is expected to perform all MCM functions, develop and demonstrate CONOPS for combined LCS and legacy MCM operations.

25. Accelerate development and production of the Navy Instrumented Threat Target (NAVITTAR) to ensure that sufficient resources are available to support planned developmental and operational testing of UISS and the MCM mission package. Implement a reliability improvement program to mitigate the high failure rate of NAVITTARs observed in early testing.

26. Characterize the magnetic properties of additional U.S. test ranges to identify a second suitable location to execute UISS operational testing.

27. To mitigate the risk of poor operational performance in the LCS MCM mission package, the Navy should demonstrate UISS integration aboard LCS in developmental testing prior to the initial phases of LCS-based operational testing, planned in FY18.

28. Provide adequate funding for developing, integrating, and testing mine hunting and mine sweeping systems in the LCS MCM mission package to mature the MCM capabilities to meet mission requirements.

ASW Mission Package

29. Acquire a sufficient quantity of GTTs, when developed, to characterize the capability of each LCS variant with ASW mission package to defeat threat torpedoes during operational assessment.

Future Operational Testing

30. Develop an operationally realistic, cost-effective alternative for training and testing of small-boat defense operations such as an accreditable, operator-in-the-loop simulation that incorporates tactical computing hardware and software and realistic threat presentations.

31. Provide adequate resources to conduct the full complement of test scenarios prescribed by the recently updated TEMP

32. Complete an update to the LCS TEMP to ensure that future tests, including integrated testing and plans for testing the over-the-horizon missile, are clear and resourced appropriately.

33. Fund development of test targets and ranges to adequately test LCS MCM systems, and then maintain and employ these assets to facilitate MCM operator training and proficiency after fielding.[37]

[37] Department of Defense, Director, Operational Test & Evaluation, *FY 2016 Annual Report*, December 2016, pp. 277-278. See also the separate discussion of FY2016 recommendations regarding the Remote Minehunting System (RMS) on p. 311.

Appendix B. Defense-Acquisition Policy Lessons of LCS Program

In reviewing the LCS/FF program, one possible question concerns what defense-acquisition policy lessons, if any, the program may offer to policymakers, particularly in terms of the rapid acquisition strategy that the Navy pursued for the LCS program, which aimed at reducing acquisition cycle time (i.e., the amount of time between starting the program and getting the first ship into service).

One possible perspective is that the LCS program demonstrated that reducing acquisition cycle time can be done. Supporters of this perspective might argue that under a traditional Navy ship acquisition approach, the Navy might have spent five or six years developing a design for a new frigate or corvette, and perhaps another five years building the lead ship, for a total acquisition cycle time of perhaps 10 to 11 years. For a program announced in November 2001, this would have resulted in the first ship entering service in between late 2011 and late 2012. In contrast, supporters of this perspective might argue, LCS-1 entered service on November 8, 2008, about seven years after the program was announced, and LCS-2 entered service on January 16, 2010, a little more than eight years after the program announced. Supporters of this perspective might argue that this reduction in acquisition cycle time was accomplished even though the LCS incorporates major innovations compared to previous larger Navy surface combatants in terms of reduced crew size, "plug-and fight" mission package modularity, high-speed propulsion, and (in the case of LCS-2) hull form and hull materials.

Another possible perspective is that the LCS program demonstrated the risks or consequences of attempting to reduce acquisition cycle time. Supporters of this perspective might argue that the program's rapid acquisition strategy resulted in design-construction concurrency (i.e., building the lead ships before their designs were fully developed), a practice long known to increase risks in defense acquisition programs. Supporters of this perspective might argue that the cost growth, design issues, and construction-quality issues experienced by the first LCSs were due in substantial part to design-construction concurrency, and that these problems embarrassed the Navy and reduced the Navy's credibility in defending other acquisition programs. They might argue that the challenges the Navy faces today in terms of developing an LCS concept of operations (CONOPS),[38] LCS manning and training policies, and LCS maintenance and logistics plans were increased by the rapid acquisition strategy, because these matters were partly deferred to later years (i.e., to today) while the Navy moved to put LCSs into production. Supporters of this perspective might argue that the costs of the rapid acquisition strategy are not offset by very much in terms of a true reduction in acquisition cycle time, because the first LCS to be equipped with a mission package that had reached IOC (initial operational capability) did not occur until late FY2014—almost 13 years after the LCS program was announced. Supporters of this perspective could argue that the Navy could have avoided many of the program's early problems and current challenges—and could have had a fully equipped first ship enter service in 2011 or 2012—if it had instead pursued a traditional acquisition approach for a new frigate or corvette. They could argue that the LCS program validated, for defense acquisition, the guideline from the world of business management that if an effort aims at obtaining something fast, cheap, and good,

[38] A CONOPS is a detailed understanding of how to use the ship to accomplish various missions.

it will succeed in getting no more than two of these things,[39] or, more simply, that the LCS program validated the general saying that haste makes waste.

A third possible perspective is that the LCS program offers few if any defense-acquisition policy lessons because the LCS differs so much from other Navy ships and the Navy (and DOD generally) consequently is unlikely to attempt a program like the LCS in the future. Supporters of this perspective might argue that the risks of design-construction concurrency have long been known, and that the experience of the LCS program did not provide a new lesson in this regard so much as a reminder of an old one. They might argue that the cost growth and construction delays experienced by LCS-1 were caused not simply by the program's rapid acquisition strategy, but by a variety of factors, including an incorrectly made reduction gear[40] from a supplier firm that forced the shipbuilder to build the lead ship in a significantly revised and suboptimal construction sequence.

Author Contact Information

(name redacted)
Specialist in Naval Affairs
[redacted]@crs.loc.gov, 7-....

[39] The guideline is sometimes referred to in the business world as "Fast, cheap, good—pick two."

[40] A ship's reduction gear is a large, heavy gear that reduces the high-speed revolutions of the ship's turbine engines to the lower-speed revolutions of its propulsors.

EveryCRSReport.com

The Congressional Research Service (CRS) is a federal legislative branch agency, housed inside the Library of Congress, charged with providing the United States Congress non-partisan advice on issues that may come before Congress.

EveryCRSReport.com republishes CRS reports that are available to all Congressional staff. The reports are not classified, and Members of Congress routinely make individual reports available to the public.

Prior to our republication, we redacted names, phone numbers and email addresses of analysts who produced the reports. We also added this page to the report. We have not intentionally made any other changes to any report published on EveryCRSReport.com.

CRS reports, as a work of the United States government, are not subject to copyright protection in the United States. Any CRS report may be reproduced and distributed in its entirety without permission from CRS. However, as a CRS report may include copyrighted images or material from a third party, you may need to obtain permission of the copyright holder if you wish to copy or otherwise use copyrighted material.

Information in a CRS report should not be relied upon for purposes other than public understanding of information that has been provided by CRS to members of Congress in connection with CRS' institutional role.

EveryCRSReport.com is not a government website and is not affiliated with CRS. We do not claim copyright on any CRS report we have republished.