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Report to Congressional Committees

December 2015

LITTORAL COMBAT SHIP

Knowledge of Survivability and Lethality Capabilities Needed Prior to Making Major Funding Decisions

This report is an unclassified version of a report prepared in July 2015. All material in this report reflects information as of July 2015.

GAO-16-201

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GAO Highlights

Highlights of GAO-16-201, a report to congressional committees

Why GAO Did This Study

GAO has reported extensively on LCS—an over $34 billion Navy program (in 2010 dollars) consisting of two different ships and interchangeable mission packages. In February 2014, the Secretary of Defense, citing survivability concerns, directed the Navy to assess design alternatives for a possible LCS replacement.

House and Senate reports for the National Defense Authorization Act for Fiscal Year 2014 included a provision for GAO to analyze LCS survivability. Based on congressional interest, GAO also examined lethality. This report examines (1) the extent to which LCS survivability and lethality requirements are aligned with the ship's threat environments and if they have changed, (2 and 3) and if LCS meets its current requirements. GAO also (4) assessed recent decisions pertaining to the Navy's plans to address the Secretary of Defense's concerns. GAO analyzed relevant documents and interviewed Navy officials.

What GAO Recommends

GAO suggests Congress delay funding for fiscal year 2016 LCS until the Navy submits a completed rough water trials report, acquisition strategy, and backfit plan; and consider not fully funding some or all LCS procurement pending analysis of these documents and the final survivability assessments. GAO also recommends several actions for DOD. The department concurred with two recommendations and partially concurred with two others, but did not concur with soliciting an independent technical assessment of the Independence variant. GAO continues to believe that such an independent assessment is warranted.

View GAO-16-201. For more information, contact Michele Mackin at (202) 512-4841 or mackinm@gao.gov.

What GAO Found

The lethality and survivability of the Littoral Combat Ship (LCS) is still largely unproven, 6 years after delivery of the lead ships. LCS was designed with reduced requirements as compared to other surface combatants, and the Navy has since lowered several survivability and lethality requirements and removed several design features—making the ship both less survivable in its expected threat environments and less lethal than initially planned. The Navy is compensating for this by redefining how it plans to operate the ships.

In 2014, the Navy conducted its first operational test of an early increment of the surface warfare mission package on a Freedom variant LCS, demonstrating that LCS could meet an interim lethality requirement. The Navy declared LCS operationally effective. However, the Navy's test report stated that the ship did not meet some key requirements. Further, the Department of Defense's Director of Operational Test and Evaluation has stated that there is insufficient data to provide statistical confidence that LCS can meet its lethality requirements in future testing or operations, and further testing is needed to demonstrate both variants can meet requirements in varied threat environments.

The Navy also has not yet demonstrated that LCS will achieve its survivability requirements, and does not plan to complete survivability assessments until 2018—after more than 24 ships are either in the fleet or under construction. The Navy has identified unknowns related to the use of aluminum and the hull of the Independence variant, and plans to conduct testing in these areas in 2015 and 2016. However, the Navy does not plan to fully determine how the Independence variant will react to an underwater explosion. This variant also sustained some damage in a trial in rough sea conditions, but the Navy is still assessing the cause and severity of the damage and GAO has not been provided with a copy of the test results. Results from air defense and cybersecurity testing also indicate concerns, but specific details are classified.

In February 2014 the former Secretary of Defense directed the Navy to assess options for a small surface combatant with more survivability and combat capability than LCS. The Navy conducted a study and recommended modifying the LCS to add additional survivability and lethality features. After approving the Navy's recommendation, the former Secretary of Defense directed the Navy to submit a new acquisition strategy for a modified LCS for his approval. He also directed the Navy to assess the cost and feasibility of backfitting lethality and survivability enhancements on current LCS. Nevertheless, the Navy has established a new frigate program office to manage this program, and the Navy has requested $1.4 billion for three LCS in the fiscal year 2016 President's budget, even though it is clear that the current ships fall short of identified survivability and lethality needs. GAO has an ongoing review of the Navy's small surface combatant study and future plans for the LCS program.

This report is a public version of a classified report issued in July 2015. Throughout this report, GAO has indicated where information has been omitted or redacted due to security considerations. All information in this report reflects information current as of July 2015 to be consistent with the timeframe of the classified report.

Contents

Abbreviations

ABS	American Bureau of Shipping
ASW	Anti-Submarine Warfare
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
CDD	Capability Development Document
CONOPS	Concept of Operations
FAC	Fast Attack Craft
FIAC	Fast Inshore Attack Craft
IOT&E	Initial Operational Test and Evaluation
LCS	Littoral Combat Ship
MCM	Mine Countermeasures
OPNAV	Office of the Chief of Naval Operations
RAM	Rolling Airframe Missile
SUW	Surface Warfare

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Congressional Committees

In February 2014, citing concerns about the survivability and lethality of the Department of the Navy's Littoral Combat Ship (LCS), the former Secretary of Defense directed the Navy to establish a task force to assess design and concept alternatives for a future LCS replacement. The objective was to identify a ship that was more survivable—that is, able to avoid, withstand, or recover from damage—and more lethal—able to destroy enemy targets. The Navy currently has 24 LCSs (known as seaframes) delivered or under contract with two different shipyards constructing two different ship design variations. The Navy had planned to buy another 28 ships, for a total of 52, as well as 64 mission packages (the reconfigurable combinations of sensors, weapons, and aircraft that provide most of the combat capability that are being procured in three warfare areas).[1] These quantities would make LCS a significant portion of the Navy's surface combatant fleet, at a planned cost of at least $34 billion in 2010 dollars.

The former Secretary directed the Navy to not contract for more than 32 ships, pending decisions about the potential LCS replacement, but did not comment on any changes to mission package quantities. The Navy's task force studied concepts for a modified LCS, new ship designs, and a modified existing ship design. The Navy recommended procuring a modified version of each variant of the LCS seaframe which will have additional weapons and survivability features.[2] The former Secretary of Defense approved the Navy's recommendation in December 2014, and the Navy recently announced that these modified ships will be re-designated as frigates.[3] Procurement of these ships is planned to begin in 2019, and the former Secretary of Defense also directed the Navy to

[1]The Navy is procuring mission packages to conduct surface warfare, anti-submarine warfare, and mine countermeasures.

[2]We have an ongoing review assessing the Small Surface Combatant Task Force Study and the Navy's recommendation to modify LCS.

[3]In the U.S. Navy, a frigate is a surface combatant that is smaller than a destroyer and that provides ship escort and anti-submarine warfare capabilities.

report on the cost and feasibility of back-fitting the existing LCSs with some of the changes planned for the modified LCS.

We have reported extensively on concerns with the combat capabilities of the LCS, including survivability and lethality testing issues that had been demonstrated to date, and identified changes the Navy has made to its descriptions of LCS over time to reflect decreased expectations of LCS combat capability.[4] House and Senate Armed Services committee reports for the National Defense Authorization Act for Fiscal Year 2014 contained a provision that we evaluate the survivability testing of LCS,[5] and based on discussions with Armed Services committee staff we were also asked to include an examination of LCS's combat capability, which includes lethality. This report examines the extent to which LCS: (1) survivability and lethality requirements are aligned with threat environments that the ship is likely to face and to what degree, if any, these requirements have changed over time; (2) meets its current lethality requirements; and (3) meets its current survivability requirements. We also (4) assessed recent decisions pertaining to upcoming changes to the program in light of the former Secretary of Defense's concerns about the lethality and survivability of LCS.

This report is an unclassified version of a classified report that was issued in July 2015.[6] Throughout this report, we indicated where information has been omitted or redacted due to security considerations. The information in this report is current as of July 2015 to be consistent with the timeframe of the classified report.

To identify how LCS survivability and lethality requirements are aligned with the expected threat environment and the extent to which they have changed over time, we analyzed the LCS capability development documents (CDD) which dictate the performance requirements for the

[4]GAO, *Navy Shipbuilding: Significant Investments in the Littoral Combat Ship Continue Amid Substantial Unknowns about Capabilities, Use, and Cost* GAO-13-530 (Washington, D.C.: July 22, 2013); and *Littoral Combat Ship: Additional Testing and Improved Weight Management Needed Prior to Further Investments,* GAO-14-349SU (Washington, D.C.: Apr. 8, 2014); *Littoral Combat Ship: Knowledge of Survivability and Lethality Capabilities Needed Prior to Making Major Funding Decisions*, GAO-15-361C (Washington, D.C.: July 7, 2015) (S//NF).

[5]H.R. Rep. No. 113-102, at 28-29 (2013) and S. Rep. No. 113-44, at 22-23 (2013).

[6]GAO-15-361C.

seaframe and mission packages. LCS has two CDDs—one from 2004 that applies only to the two lead ships (LCS 1 and LCS 2) called the Flight 0 CDD, and one from 2010 that applies to all subsequent ships, called the Flight 0+ CDD. We compared both CDDs to identify areas, if any, where LCS requirements have changed. We also analyzed the two LCS warfighting concepts of operations (dated 2007 and 2011) and spoke with a cognizant Navy official about the pending third revision of this document. In addition, we reviewed relevant Navy policies stipulating general survivability and shock requirements for ships. To assess the extent to which LCS meets its current survivability and lethality requirements, we analyzed Navy and Director, Operational Test and Evaluation (DOT&E) test reports for developmental and operational test events and reviewed the 2013 LCS test and evaluation master plan. We also observed one day of the Total Ship Survivability Trial conducted on LCS 3 in October 2014. For our lethality objective, we assessed only the lethality of the core seaframe and the surface warfare (SUW) mission package. We reviewed the Navy's Required Operational Capabilities and Projected Operating Environment for LCS Class Ships instruction, and also analyzed contractor-developed total ship vulnerability assessment reports and integrated survivability assessment reports, which were developed in the preliminary design phase of the program and were contract-required deliverables for both variants. To assess the recent decisions pertaining to upcoming changes to the LCS program, we analyzed available Navy documentation related to the future acquisition of a modified LCS. For each objective, we also interviewed relevant Navy and DOT&E officials. A more detailed description of our scope and methodology is presented in appendix I.

We conducted this performance audit from June 2014 to July 2015 in accordance with generally accepted government auditing standards.[7] Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[7]Although dated December 2015, the findings in this report are current as of July 2015.

Background

The LCS consists of two distinct parts: (1) a seaframe, which is essentially the ship itself, and (2) a mission package, which is an interchangeable set of sensors, weapons, aircraft, surface craft, and subsurface vehicles carried on and deployed from the seaframe to perform three different primary missions: mine countermeasures (MCM), SUW, and anti-submarine warfare (ASW). LCS was initially developed to provide a lower-cost surface combatant with a smaller crew than other ships and modest combat capabilities in focused areas, compared to higher cost multi-mission surface combatants like destroyers. LCS is envisioned to operate in both littoral waters and the deep ocean in all theaters of operation. Early in the program, the Navy decided to forgo a number of traditional ship requirements in order to help reduce the costs and the weight and size of LCS, which in turn made the ship less robust in terms of weaponry and survivability than other surface combatants. Those decisions were validated by the Department of Defense's (DOD) Joint Requirements Oversight Council.

Both LCS variants initially leveraged commercial ship designs, and were modified in accordance with established sets of technical criteria, called rules, that were developed by the American Bureau of Shipping (ABS).[8] ABS is a not-for-profit ship classification society that provides independent technical assessments to ensure vessels are built in accordance with the applicable rules, and can also conduct periodic surveying of in-service ships.[9] ABS was under contract with the Navy to provide technical expertise on the LCS program and to develop rules used in the design of LCS, but this contract ended in June 2012.

LCS Acquisition

The Navy awarded contracts to two contractor teams that developed designs for the LCS seaframe reflecting different solutions to the same set of requirements. The Navy is procuring two distinct variants: a steel monohull design with an aluminum superstructure called the Freedom variant, and an all-aluminum trimaran design called the Independence variant. The Freedom variant has odd hull numbers and is being built at

[8]LCS was designed to the ABS Guide to Building and Classing Naval Vessels and the ABS Guide to Building and Classing High-Speed Naval Craft rules.

[9]There are 12 ship classification societies in the world that belong to the International Association of Classification Societies LTD.

Marinette Marine in Marinette, Wisconsin. The Independence variant has even hull numbers and is being built at Austal USA in Mobile, Alabama.

The Navy has contracted for 24 seaframes with equal numbers of both variants and has taken delivery of four to date. Twenty seaframes are currently covered under block buy contracts and the Navy anticipates funding construction of seaframes through 2016[10], with deliveries continuing until 2020. The Navy plans to contract for two additional ships in fiscal year 2016 and plans to award further contracts for three LCS seaframes in both 2017 and 2018—though the Navy's acquisition strategy for these years is still in development. Table 1 shows the status of the LCS seaframe procurement.

Table 1: Littoral Combat Ship (LCS) Seaframes Status

Hull number	Status as of June 2015
LCS 1-4	Navy has accepted delivery
LCS 5-14	Under construction at two shipyards
LCS 15-23	Under contract and Congressional funding has been received
LCS 24	Under contract; Congressional funding requested in fiscal year 2016
LCS 25-26	Under contract*; Congressional funding requested in fiscal year 2016
LCS 27-32	Planned for fiscal year 2017 and 2018; acquisition strategy still in development
LCS 33-52	Modified LCS acquisition strategy still in development

Source: GAO analysis of Navy documentation. | GAO-16-201

*LCS 25 and 26 are options under the block buy contracts.

The Navy requested $1.4 billion for three LCS seaframes in its fiscal year 2016 budget request. The Navy's plans to begin development and procurement of the new modified LCS are not yet known, although the Navy has stated that its goal is to begin procurement of the lead ships in 2019.

Each LCS will be capable of carrying an SUW, ASW, or MCM mission package, as required by the circumstances. The mission packages are being developed in increments; the Navy plans to develop four SUW

[10]The Navy requested funding in its fiscal year 2016 budget to procure what would have been the last ship in its 20 ship block buy, but has since added two further ships as options under the same contracts.

increments, four MCM increments, and one ASW increment.[11] The mission packages will provide the bulk of the combat capability or lethality for the ship. The Navy has 10 mission packages in its inventory and currently plans to buy 64 mission packages. According to Navy officials, the recent decision to develop a modified LCS has not changed the current end quantity of mission package purchases.

Survivability

Survivability is the ability of a ship to avoid, withstand, or recover from damage. It consists of three elements: susceptibility, vulnerability, and recoverability.

- **Susceptibility** is the degree to which a ship can be targeted and engaged by threat weapons. Some ways of improving a ship's susceptibility include avoiding or defeating a threat by using a combination of tactics, signature reduction, countermeasures, and self-defense systems. LCS uses speed, maneuverability, modern defensive weapons, organic systems (e.g., 57mm gun), and sensors to counter surface, air, and underwater threats.

- **Vulnerability** is a measure of a ship's ability to withstand initial damage effects from threat weapons and to continue to perform its primary warfare mission areas. LCS design uses three different vulnerability scenarios that, dependent on the severity of the damage, allow it to

  - continue to perform its primary mission;
  - exit the battle area under its own power; and
  - conduct an orderly abandon ship.

- **Recoverability** is a measure of a ship's ability to take emergency action to contain and control damage, prevent loss of a damaged ship, minimize personnel casualties, and restore and sustain primary mission capabilities. The LCS seaframe provides most of the survivability features for the crew, including damage control and

[11]The Increment 1 SUW mission package included a prototype Maritime Security Module including two rigid-hulled inflatable boats for use by the embarked small boat crews and Visit, Board, Search and Seizure gear. The Increment 2 package is the same as Increment 1 except the Maritime Security Module is now production representative.

safety systems. For example, LCS has three redundant firefighting systems.

The Navy specified LCS survivability to be greater than that of auxiliary ships, which have a comparably low survivability level, but less than that of frigates and amphibious assault ships—as shown in table 2. According to Navy officials, the Navy designed LCS to what they refer to as a Level 1+ standard, meaning it had additional features beyond those of other Level 1 ships, including

- tailored survivability requirements for underwater shock and limited fragmentation and bullet armor; and
- improved ability to withstand flooding after a damage event.

Table 2: Comparison of Ship Survivability Levels

Level	Description	Types of ships
Level 1	Low survivability. Represents least severe environment and excludes need for ship to sustain operations in a battle group during a conflict.	Patrol combatant and mine-warfare craft, shuttle ships, naval strategic sealift and material support ships, all other auxiliary ships/craft
Level 2	Moderate survivability. Ability to sustain operations in a battle group during a conflict.	Frigates, amphibious warfare ships, underway replenishment station ships
Level 3	High survivability. The most severe environment. Ability to sustain operations while taking battle damage from anti-ship cruise missiles, mines, and torpedoes.	Battle force surface combatants, aircraft carriers

Source: Navy documentation | GAO-16-201

Note: This instruction, OPNAVINST 9070.1, has since been replaced by OPNAVINST 9070.1A, Survivability Standards for Surface Ships and Craft of the U.S. Navy (Sept. 13, 2012). However, some Navy acquisition documentation still refers to this older instruction.

The requirements for LCS survivability are defined in the 2004 Flight 0 CDD for LCS 1 and LCS 2 and the 2010 Flight 0+ CDD for all subsequent ships. The Flight 0+ CDD is more explicit than the Flight 0 CDD in terms of survivability requirements. An updated Navy instruction replaced the definitions in the table above, and changed how programs were to define the survivability of their ships.[12]

[12]OPNAVINST 9070.1A requires programs to derive a minimum survivability baseline that is based on the program's initial capabilities document and concept of operations, where survivability is considered in terms of capabilities, while the older instruction 9070.1 required consideration of survivability in terms of characteristics. OPNAVINST 9070.1A, Survivability Standards for Surface Ships and Craft of the U.S. Navy (Sept. 13, 2012).

Lethality

Lethality is ability of a weapon system—in this case LCS—to damage or destroy threats, including an enemy ship, aircraft, or missile. Lethality enables survivability because if LCS is able to sink or damage an approaching enemy vessel before it attacks, that enemy vessel may be unable to fire at LCS. The LCS CDD defines requirements related to lethality and identifies specific threats that LCS is expected to be able to destroy and the range at which it should do so. The seaframes provide sensors and communications systems needed for ship operations and self-defense weapons for both the SUW mission and defense against enemy aircraft and missiles, called anti-air warfare. The SUW mission package augments the ship's lethality by adding two 30mm gun mounts and an armed helicopter. Eventually, a surface-to-surface missile is planned to be added to the third increment of this mission package. Table 3 depicts the combat system equipment carried on the seaframes and the weapon systems that are added with the mission packages.

Table 3: Littoral Combat Ship (LCS) Seaframe and Mission Package Weapons Systems

Weapon system	Core seaframe	Surface warfare mission package	Anti-submarine warfare mission package	Mine counter measures mission package
1 x 57mm gun	●	The core seaframe weapon systems accompany all three mission packages.		
4 x .50 caliber crew-served machine guns	●			
1 x RAM/SeaRAM anti-air warfare missile system[a]	●			
Soft-Kill Weapons System (anti-air warfare)[b]	●			
2 x 30mm guns	○	●	○	○
Longbow-Hellfire surface-to-surface missiles[c]	○	●	○	○
MH-60 helicopter armed with Hellfire missiles	○	●	○	○
MH-60 helicopter armed with torpedoes[d]	○	○	●	○

Key: ●= System included. ○= System not included.

Source: GAO analysis of Navy documentation. | GAO-16-201

[a]For anti-air warfare, the Freedom variant carries 21 RIM-116 Rolling Airframe Missiles (RAM) in a Mk 49 launcher; the Independence variant carries 11 RAM in a launcher called SeaRAM that is based on the Navy's widely used Phalanx Close-In Weapons System.

[b]This system launches radio frequency and infrared decoys and other countermeasures to protect the ship from anti-ship missiles.

[c]This system is not yet installed on any LCS. It is planned for installation on the third increment of the SUW mission package, and operational testing is expected in 2019. The Navy plans for LCS to carry 36 Hellfire missiles.

[d]The LCS magazine can carry 9 MK-54 torpedoes.

LCS was designed to be able to address the threat of small boats. Figure 1 depicts examples of two types of small boats.

Figure 1: Examples of Small Boats

Fast attack craft (FAC)

Fast inshore attack craft (FIAC)

Source: Defense Video and Image Distribution Service. | GAO-16-201

Test Events

The Navy uses several types of testing to evaluate the weapon systems it develops, as required by DOD acquisition policy and statute. Developmental testing is typically sponsored by the program office, is often conducted in conjunction with the contractors, and is used to assess whether the system design is satisfactory and meets technical specifications. Developmental test events, such as combat system ship qualification trials, allow the Navy to verify and validate combat and weapon system performance. Technical evaluation is a testing activity used to assess the readiness of the system for operational testing. Operational testing includes live-fire testing, and is used to determine that the system can effectively execute its mission in an operational environment when operated by typical sailors against relevant threats. Operational testing is required by statute.[13]

The Navy has used a combination of developmental and operational testing and modeling and simulation to demonstrate the survivability and

[13]10 U.S.C. § 2399.

lethality of LCS. DOD granted the LCS program a waiver to relieve the Navy of the requirement to do full-scale survivability testing. Such waivers are common in shipbuilding, as it is unrealistic to use a production ship and a live test to assess certain types of damage—for example, how fire spreads throughout the ship. DOT&E—the agency responsible for approving test plans—approved a modified live fire test and evaluation plan that takes advantage of testing on similar components and utilizes historical combat data. In place of live testing, the Navy has used a number of surrogate tests and modeling and simulation to try to retire risk in these areas. Surrogate testing uses decommissioned ships (where available) or representative portions of ship structure, and subjects them to damage similar to what might be caused by threat weapons. These tests help inform and validate the results of computer-based modeling and simulation. The Navy also conducts test events to demonstrate the effectiveness of the ship's weapon systems and sensors, and it has a test plan to demonstrate the effectiveness of each mission package increment on each seaframe variant.

Our Prior Recommendations

We have reported extensively on the risks of proceeding with LCS procurements without the requisite knowledge provided through adequate testing. In 2013 and 2014, we concluded that the Navy continued to make further investment decisions in the seaframes and mission packages with an absence of key information.[14] In these reports, we identified that until the Navy completes operational testing, the Navy could invest approximately $34 billion (in 2010 dollars) for up to 52 seaframes and 64 mission packages that may not provide a militarily useful capability. We also found in 2013 and 2014 that unknowns persist with the Independence variant given that it had not completed the same testing as the Freedom variant. We recommended that the Navy re-evaluate its business case for LCS and conduct a number of operational test events on both variants prior to making a decision to contract for more ships, including the following:

- Deploying to a forward overseas location. The Freedom variant has deployed overseas twice; the Independence variant has not yet deployed.

[14]GAO-13-530 and GAO-14-749.

- Completing rough water, ship shock, and total ship survivability testing. Both variants have now completed rough water trials; the Freedom variant completed total ship survivability testing in 2014, but the Independence variant has not yet conducted this testing. Neither ship will complete full-ship shock trials until 2016.

- Completing initial operational testing and evaluation of the SUW mission package on the Freedom variant and the MCM mission package on the Independence variant. The Navy completed operational testing of the SUW mission package on the Freedom variant, but has not completed operational testing of the MCM mission package on the Independence variant.

DOD largely disagreed with these recommendations, citing the business imperative of not slowing down production of the seaframes. We believe that while the pricing of the seaframes is important, there is greater risk in awarding additional contracts before key knowledge is gained about the capabilities and operational concepts of the LCS.

- We also recommended in 2013 that the Navy report to Congress on the relative advantages and disadvantages of the two seaframe variants. We recommended that the Navy present to Congress a comparison of the capabilities of the two variants in performing each mission because we had found that the officers in the fleets—the end users of the ships—said that they believed there were advantages and disadvantages to the two designs. Congress directed the Navy in the National Defense Authorization Act for Fiscal Year 2014 to provide additional information on some of the risk areas we identified.

The Navy provided Congress with a report in May 2014 assessing the expected survivability attributes and the concept of operations for the ships, but in terms of comparing the two variants the Navy essentially suggested that since the two variants are built to the same requirements they perform the same way. The Navy did not present a more detailed comparison that would address our recommendation. We believe that completing this type of analysis would still be valuable to understanding differences in performance between the seaframes.

Survivability and Lethality Requirements Less Than Other Combatants, and Have Been Reduced over Time

The Navy designed LCS with survivability and lethality capabilities that are not aligned with the projected operational environment in which the ship will operate, and over time it has lessened or removed some survivability and lethality requirements. The Navy's original operational concept envisioned LCS as requiring less survivability and lethality features than other surface combatants, which would in turn make LCS less costly than other surface combatants. Over time the Navy has further reduced some survivability and lethality requirements, making LCS less survivable and lethal than it was initially envisioned. And, in response, the Navy continues to refine its operational concepts for LCS. Specific details about changes to these requirements were redacted from this report because they are classified.

The Flight 0+ CDD defines the survivability capabilities required after the ship takes a hit, rather than stating specific design requirements as is the case in the earlier Flight 0 CDD.[15] There are three specific design features that would enhance LCS's survivability that are identified in the Flight 0 CDD, but not in the Flight 0+ CDD. Officials from Office of the Chief of Naval Operations (OPNAV), who are the resource sponsors for the LCS program, stated that these changes were made early on to save cost, and in one instance weight onboard the ship. Specific differences in survivability requirements between the 2004 Flight 0 and the 2010 Flight 0+ CDDs and details about changes to LCS requirements were redacted from this report because they are classified.

Since 2004, the Navy has also reduced some LCS lethality requirements. Our analysis shows that the poor performance of some systems might have contributed to this decision. Additional details on these changes are classified.

To compensate for any gaps in the ship's survivability and lethality capabilities, the Navy continues to redefine the concept of operations (CONOPS) for LCS.[16] We reported in 2013 that the Navy had made a number of changes to descriptions of how the LCS might be employed

[15]OPNAVINST 9070.1A sets forth a new requirement that programs derive survivability requirements based on capabilities.

[16]The Navy has two CONOPS for LCS; one discusses how the ship will be used operationally, called the Warfighting CONOPS; the other, called the Platform Wholeness CONOPS, discusses how the ship will be maintained and supported.

and the capabilities it would bring to the warfighter.[17] We found that documentation developed early on in the program had very optimistic assumptions of where and how LCS could be used, as compared with more current sources, but these assumptions have been lessened over time. By redefining LCS CONOPS, the Navy can help ensure that LCS will be in harm's way less frequently, which could compensate for the ship's susceptibility and vulnerability without more costly materiel changes to the ship. While pragmatic, this approach can limit the ship's utility in the full scope of potential operations and can require more capable ships to be tasked to defend LCS instead of performing other missions. LCS was originally planned to free up more costly ships to perform more complicated missions; partnering LCS with ships providing defensive protection limits the Navy's ability to achieve these efficiencies.

Additional details on these CONOPS changes are classified.

Recent SUW Testing Inadequate to Determine If LCS Meets Its Requirements

On April 17, 2014, the Navy completed operational testing of the LCS's SUW mission package, employing an Increment 2 mission package onboard USS Fort Worth (LCS 3). During this test, the ship and its embarked helicopter demonstrated that it could meet the interim requirement for this increment. In prior live SUW test events, LCS did not demonstrate that it could kill all the required targets. Specific details about test events and results were redacted from this report because they are classified.

While the April 2014 test proved successful, further testing is needed to demonstrate that both variants of LCS can meet all its SUW requirements—incremental and threshold—and in all the threat environments in which the ships will operate. This is due to the following considerations:

- LCS did not demonstrate it could meet all its requirements in these test events;
- Testing only demonstrated that LCS could meet its requirements in one operational test event and is inadequate to provide statistical confidence in the ship's performance; the test environment was not

[17] GAO-13-530.

operationally stressing and the crew got extensive training and practice;

- Only one of the two variants were tested; and
- Meeting threshold capability will require missile integration.

These issues are discussed below.

LCS Did Not Demonstrate It Could Meet All Interim SUW Requirements

Recent operational testing has revealed that a Freedom variant LCS was not able to meet all its interim lethality requirements. Specific details of these shortcomings were redacted because the information is classified.

SUW Testing Inadequate to Provide Statistical Confidence in Performance

DOT&E officials told us that the amount of live testing done to date on the LCS SUW mission package is insufficient to provide statistical confidence that LCS can consistently demonstrate this level of performance. The DOD acquisition instruction states that scientific test and analysis techniques—which DOT&E states includes statistically based measures—should be employed in a test program and provide required data to characterize system behavior. The amount of testing to date is consistent with the approved test plan, but DOT&E stated that the tests were constrained due to the Navy not providing the funding and resources to allow for further testing. Due to the limited number of live operational test runs, DOT&E believes the existing evidence is not sufficient, nor does it predict LCS's performance in varied environments (e.g., bad weather) or provide sufficient confidence that LCS could repeat this performance in other tests. So, while there is no requirement in the test plan to achieve statistical confidence, as DOT&E states the sparse data available do not allow a strong statement about LCS's ability to meet requirements in other operational scenarios.

As an illustration of this point, the same ship and crew attempted the same operational test event one week prior to the successful run and were unsuccessful before the test event was cancelled due to range restrictions. As such, DOT&E has not yet made its determination that LCS is operationally effective in performing the SUW mission because of a stated lack of available data to support such an assessment. The Navy's operational test organization has made its determination about effectiveness, which is documented in its final report. Further information about their assessment is classified.

Further, while operational testing did demonstrate that LCS could defeat the interim requirement number of Fast Inshore Attack Craft (FIAC), range safety considerations made this testing less operationally stressing than a real-world encounter. Additional information about these issues was redacted because it contained classified information.

Operational Testing Limited to Freedom Variant; None to Date on the Independence Variant

This operational testing of SUW was conducted using only a Freedom variant LCS. While the guns are the same on the two variants and in the mission package, the gunfire control systems, sensors, consoles, and some enabling software are all different, as are the gun placements and ship handling characteristics. As such, testing on a Freedom variant cannot be used to predict performance of the SUW mission package on an Independence variant. The Navy will not operationally test the initial SUW mission package on the Independence variant until September 2015. As shown in table 4, most of the SUW operational testing on this variant is in the future and program officials told us that the Navy is still gaining an understanding of the effectiveness of the 57mm gun weapon system on the Independence variant. For example, DOT&E told us that in a developmental test in January 2015 the LCS 2 had difficulty achieving a hit on a stationary target with the 57mm gun.

Table 4: Independence Variant Littoral Combat Ship Performance in Surface Warfare Live Test Events

Test event	Date completed	Notes
LCS 4 Developmental Test	July and September 2014	SUW mission package testing. Multiple test engagements.
LCS 2 Developmental Test	January 2015	57mm gun only. Core ship self defense test.
LCS 4 Developmental Test	August 2015	Analysis reports pending.
Technical Evaluation	August 2015	Analysis reports pending.
Initial Operational Test and Evaluation phase	September 2015	Analysis reports pending.

Source: GAO analysis of Navy documentation. | GAO-16-201

Additional details about Independence variant testing were redacted because they contained classified information.

LCS Will Not Demonstrate It Can Meet Full Threshold SUW Performance until a Missile Is Integrated

LCS will not demonstrate threshold lethality requirements outlined in the CDD until 2017, at the earliest, after the Navy installs and tests the SUW mission package with the Longbow-Hellfire missiles. Since Longbow-Hellfire has not yet been integrated with LCS, the actual performance of the missile on LCS remains unknown. In November 2013, the missile contractor demonstrated that a Longbow-Hellfire missile could be modified to fire vertically from a ship rather than horizontally from a helicopter, and the Navy continues to conduct testing with DOT&E including 2014 testing examining the lethality of Longbow-Hellfire against small boats, though this testing did not use moving sea-based targets.

A key challenge in integrating the missile with LCS is managing its weight and accompanying equipment on the ship, given the weight and center of gravity challenges on which we have previously reported.[18] Further, software integration with the combat management system will be required. An analysis of the capability of this missile was redacted because it contained classified content.

The Navy Does Not Yet Fully Understand the Extent to Which LCS Will Meet Current Survivability Requirements

While the Navy has conducted a variety of surrogate tests and simulations, it has not yet demonstrated whether LCS meets its survivability requirements. As a result, significant unknowns remain regarding the vulnerability, susceptibility, and recoverability of LCS. According to current plans, the Navy will not have completed its test plan to demonstrate the survivability of LCS until approximately 2018, at which point it plans to have more than 24 ships either in the fleet or under construction.[19] The Navy has not fully demonstrated the vulnerability of the seaframes, the susceptibility of the ship to air threats and computer penetrations, or how the crew will respond to damage. If future survivability concerns are identified, the Navy may have to again revise the LCS warfighting CONOPS to compensate for these issues. This could also have implications on the proposed modified LCS, since they plan to leverage the LCS designs. The main risks pertain to the following issues:

- Vulnerability of the ships due to the use of aluminum and a novel hullform on the Independence variant that has not been fully tested;

[18]GAO 14-749.

[19]The exact acquisition strategy for the next few years is still in development.

- Air warfare capability;
- Cybersecurity; and
- Recoverability of the ships not fully demonstrated.

These issues are discussed below.

Navy Does Not Fully Understand LCS Vulnerability, and Some Knowledge Gaps Will Remain Unresolved on the Independence Variant

The two LCS variants are new ship designs, and the Independence variant uses an aluminum alloy and a trimaran hullform that is unlike other ships in the Navy's inventory. Therefore, the Navy needed to gather information to characterize how these ships would react to various types of damage. The Navy conducted modeling and simulation activities and surrogate testing, including the following:

- Weapons effects tests conducted on two decommissioned Finnish aluminum mono-hulled fast-attack craft;
- Fire tests on representative LCS bulkheads and fire insulation;
- Underwater explosion testing of representative panels of ship structure;
- Testing of stress loading on representative Independence variant aluminum structure;
- Penetration tests of representative Independence variant structures; and
- Furnace testing of Independence class types of aluminum to determine response of aluminum to heat and stress loading.

Further, the Navy is using computer models and simulations to predict how LCS might react to damage. Subject matter experts in weapons effects, damage control, fire dynamics, and other fields will then analyze the model predictions of primary and secondary damage caused by various weapons. These experts will update and expand on the model predictions to determine how cascading damage and crew response to such damage affect mission capability. Their interpretation of the modeling and simulation results, coupled with lessons learned from other testing and real world events, forms the basis of the assessment of whether the LCS meets its survivability requirements.

However, the Navy still lacks robust knowledge in several vulnerability areas, largely related to how fire will affect the aluminum structure of both

variants, and how underwater explosions will affect the aluminum trimaran Independence variant. The Navy does not plan to complete its validation and accreditation of the models used to simulate damage until 2017, and its technical experts will not complete their analysis and issue their final survivability assessment reports until approximately 2018. Navy officials stated that until that time its technical warrant holders cannot certify that the two variants meet their survivability requirements and that no further modifications to the design or operational CONOPS are necessary. Navy officials further stated that these reports are typically not finalized until several years after delivery, and cited examples of recent shipbuilding programs including CVN 78, DDG 1000, LPD 17, and LHA 6. However, the lead LCS seaframes were delivered in 2008 and 2009 respectively, meaning that the Navy does not expect to finalize these reports until approximately a decade after delivery. Additional test activities and simulations still remain to be done before the Navy can better characterize the ships' vulnerability, and the Navy does not plan to fully assess some potential vulnerabilities with the trimaran hull.

Knowledge of the Vulnerability of Aluminum Incomplete

The Navy still lacks knowledge of how aluminum will react to fire and some blast events, which it does not expect to better understand until it completes a live-fire test event in late 2015. The Freedom variant design has an aluminum deckhouse mated to a steel hull, while the Independence variant is entirely made of aluminum with no steel structure. Historically, many Navy ships have been made largely out of steel, though several classes—recent examples include the CG 47 Ticonderoga class cruisers and the FFG 7 Oliver Hazard Perry class frigates—have utilized an aluminum deckhouse. The lower density of aluminum provides advantages in that it is lighter than steel, which helps LCS achieve its high speed requirement. However, aluminum is also known to lose stiffness more quickly than steel at elevated temperatures in a fire, and the Navy has identified that this phenomenon needs further study on LCS. The Independence variant uses an alloy of aluminum that has not been used in prior Navy ship construction, so accumulated Navy knowledge about how the aluminum on older ships reacts to damage cannot be applied wholesale to the Independence variant. In addition, both variants—though more so the Independence variant—use extruded aluminum planks—complex shapes that are formed by pushing heated aluminum through a die using a hydraulic press. While extrusions have industrial advantages, the Navy has no experience with the damage responses from extruded planks. One shipyard identified this as a knowledge gap in a 2004 report to the Navy, stating that the computer models it used to simulate damage did not account for the use of this type of structure. The Navy plans to conduct live-fire testing on a full-scale

mock-up of a section of an Independence variant deckhouse in late 2015 to help provide additional data to mitigate some of these knowledge gaps. This mock-up is called the Multi-Compartment Surrogate, and the Navy plans to test it with internal blasts, fragmentation, and fire.

Vulnerability of the Independence Variant Hull to Underwater Shocks Is Unknown

The Navy has knowledge gaps related to the underwater shock vulnerability of the trimaran shape of the Independence variant, in part because of a lack of experience with the hullform in other Navy ships. Specifically, technical experts from the Naval Sea Systems Command have stated that they do not fully understand how the hull would react to whipping caused by an underwater explosion. Underwater explosions create a shock wave and a highly compressed gas bubble that expands and contracts. This can cause a type of vertical or horizontal flexing of the ship called a whipping force. The severity of this whipping force and the resulting damage is a function of the size of the explosion and the distance from the hull, among other factors, and not all shocks lead to a whipping response. If the whipping is significant enough, this vibration could cause catastrophic damage and may cause a ship to break apart. Naval Sea Systems Command technical experts have identified a lack of experimental data on the whipping response of a trimaran hullform. These technical experts stated that there is currently no algorithm in existence to model how this hull type would perform, and stated that there is no plan to invest in such an algorithm or a physical hull model for testing since the LCS CDD has no explicit requirement for LCS to survive a whipping response, though it does have an underwater shock requirement.[20] DOT&E has stated that a case could be made that there is an inherent whipping requirement because LCS is supposed to be able to support an orderly evacuation after a mine or torpedo encounter, which would not be possible if the ship were to break apart.

The Navy's existing model has successfully been used to predict the whipping response of other conventional Navy hullforms and is thus being used for LCS modeling. While Naval Sea Systems Command technical experts state that this model contains the requisite physics to model the whipping of a trimaran hullform, they also point out that it has not been validated for this type of analysis and that there is no test data to correlate the results, which is why DOT&E believes a whipping surrogate test is

[20]Navy officials stated that many other combatants have shock hardening requirements without a whipping requirement.

needed. Further, the Navy has not yet conducted a Full Ship Shock Trial on both ships. This test—where both variants will be subject to an underwater explosion and assessed for damage—is planned for 2016. This trial should provide some test data on how the Independence variant responds to a shock event. Though this test will not induce severe whipping motions, the Navy plans to use the data to compare the results with its model predictions.

Ship's Performance in Rough Seas Not Fully Understood, with Both Variants Suffering Damage in Trial

The vulnerability of the ship's hulls to various sea conditions also remains unknown. Due to the dynamic nature of waves, the Navy cannot rely on modeling and simulation alone to provide an accurate assessment of a ship's performance in rough seas. The Navy conducts seakeeping and structural loads trials to determine with instrumentation how ships will respond to different sea conditions. Seakeeping trials are used to evaluate the way a ship behaves in various sea conditions, while structural loads trials are used to evaluate the effect of waves on the ship's structure to determine if it is adequate to withstand damage. These tests are planned and executed by the Naval Surface Warfare Center Carderock Division's Ship Systems Engineering Station in Philadelphia.

The Freedom variant has deployed twice and as a result sailed across the Pacific Ocean. In addition, in March 2015 this variant completed a seakeeping and structural load trial in rough water to define its performance characteristics. The Navy started this testing in 2011 on LCS 1, but it was suspended when a hull crack and water leak were found. The Navy has not yet provided an analysis report or details from this event or the subsequent 2015 test, which Navy officials state is still being written.

For the Independence variant, the Navy conducted a seakeeping and structural loads trial event on LCS 2 in January-February 2014. In this trial the ship was subject to rough water conditions up to and including sea state 6, defined as having average waves of 8-11 feet and winds of 22-27 knots. This test event—dubbed Phase 2—was following up on earlier Phase 1 testing in lower sea states that was conducted in March 2011 and May 2012. According to the Navy, neither the final test report for the Phase 1 seakeeping trials, nor the final test report for the Phase 2 seakeeping and structural loads trial for this variant, have been finalized, despite these trials occurring several years ago.

According to LCS program officials, the ship tested in the Phase 2 trials sustained damage during the testing. The Navy has not yet provided us with the analysis reports, stating that the report is still undergoing

revisions. Consequently, we are unable to assess the significance or cause of this damage. DOT&E has reported that this testing resulted in weld cracking to structural stanchions in the mission package bay and has resulted in weight limitations to the launch, handling, and recovery equipment for the mission packages on both LCS 2 and LCS 4—although they have also not seen the test reports. Officials from the LCS program office initially told us that part of the reason for the delay in generating these reports is due to a disagreement between the program office and the technical study team from the Naval Surface Warfare as to the cause of the damage, citing that they do not believe the ship was adequately inspected prior to the trial. The Navy later stated in its technical comments that there was not a disagreement, and that the Navy and the technical team agree that the damage identified after the trial resulted from quality control issues during construction, but cannot confirm that the damage occurred during the trial itself because no pre-trial inspection was conducted. As such, the current value of the data obtained as part of the rough water trial on the Independence variant is in question. The program office has not sought additional assistance from an independent technical authority such as a ship classification society to help analyze the data and determine the vulnerability of the Independence hullform. Classification societies are often used to assess damage to in-service ships; a similar analysis was conducted by ABS after USS Port Royal hit a coral reef in order to provide an independent review of the damage the ship sustained.

Air Defense and Cybersecurity Issues

Our classified report discussed issues with the air defense and cybersecurity of LCS. Additional information about the performance of LCS in air warfare testing and results from cybersecurity testing has been redacted because it contained classified information.

The Navy will not be able to fully demonstrate LCS anti-air warfare capability until it completes two future activities: modeling in a high-fidelity computer simulation called the Probability of Raid Annihilation (PRA) Testbed, and live-fire testing onboard the Self Defense Test Ship. DOT&E also requires “lead ship testing” which was going to occur on LCS 5 and 6 but has now been postponed to LCS 7 and 8. The Navy needs to complete the testbed simulations and live-fire events to characterize LCS’s susceptibility to representative anti-ship cruise missile (ASCM) threats.

- **PRA Testbed:** LCS anti-air warfare performance will be modeled through the PRA Testbed—a rigorous modeling and simulation environment using representative LCS combat system suite and

weapons configurations. The Navy plans to use this PRA Testbed to conduct a full course of ASCM self-defense assessments, including simulations that would be costly or difficult to test with live targets. This testing was planned to occur in fiscal year 2016 for the Independence variant and fiscal year 2018 for the Freedom variant, but according to DOT&E officials it has slipped to 2017-2018 for the Independence variant and 2018-2019 for the Freedom variant.

- **Self Defense Test Ship:** The Navy also plans to conduct live end-to-end testing against both LCS variants and also against the unmanned Self Defense Test Ship. This ship is remote controlled so it can be subjected to live-fire testing, and will be equipped with the same combat system equipment found on the two LCS variants. According to test plans, the Navy envisioned conducting Self-Defense Test Ship tests using Independence class equipment between fiscal year 2015 and 2016 and Freedom class equipment in fiscal year 2016. This testing has slipped to fiscal year 2016 for the Independence variant and 2017 for the Freedom variant.

Recoverability of Ship Partially Demonstrated in Testing to Date

In 2014, the program office completed the Total Ship Survivability Trial onboard LCS 3, a Freedom variant ship. This test is an at-sea event with the ship's crew in which damage from threat weapons is simulated. The test allows the Navy to collect information on how well the crew is able to use the installed fire fighting and damage control systems to control damage and reconstitute the ship. The Navy plans to conduct this same test event on the Independence variant in fiscal year 2015.

Program officials told us they were generally satisfied with the results of the test; we have not yet had the opportunity to review the final report, as it is still being finalized. This test is important as LCS's small crew may limit the crew's damage control efforts following an attack if the damage were severe enough or if it took a long time to combat. According to DOT&E, the test highlighted the existence of significant vulnerabilities in the Freedom class design and that much of the ship's mission capability was lost because of damage caused by the initial weapons effects or from the ensuing fire that happened before the crew could respond. LCS documentation does not identify how many crew members would have to be lost to degrade the crew's response capability. Further discussion on this topic is classified and is not included in this report.

DOT&E also stated that LCS does not have sufficient redundancy to recover the lost capability. For example, LCS has limited redundancy in its power supply systems, and DOT&E officials told us that the ship does

not have the ability to employ auxiliary casualty power systems like the crews can employ on other Navy ships to recover in the event of major damage. According to Naval Sea Systems Command documentation, a casualty power system allows the ship's crew to make temporary power connections to limited equipment if the installed power connections are damaged, allowing this equipment to keep using the installed shipboard power generation systems. Such a system can facilitate keeping the ship afloat, extinguishing shipboard fires, propelling the ship out of a danger area, or in maintaining communications and a limited self-defense capability. LCS relies instead on separated and redundant battery backup power supplies and the ship build specifications indicate no casualty power equipment on board. A battery backup power may not enable the ship to operate as long as harnessing the ship's main power generators would allow. Navy officials stated that modern Navy ship designs including DDG 1000 and LPD 17 do not use a casualty power system.

Compressed Time Frame for Incorporating Major Program Changes

The Navy is currently planning significant changes to the LCS program under a compressed time frame, which provides little opportunity for incorporating knowledge from the results of its survivability and lethality assessments. The Navy completed its Small Surface Combatant Study and just recently provided it to us. The Navy used analysis from this study to decide to modify the two LCS variants to be more survivable and lethal. In December 2014, the former Secretary of Defense announced that he approved the Navy's recommendation. The former Secretary of Defense further directed the Navy to provide his office by May 1, 2015: (1) an acquisition strategy to support the design and procurement of the new small surface combatant no later than fiscal year 2019 and sooner if possible; and (2) an assessment of the cost and feasibility of back-fitting the existing LCS with enhanced survivability and lethality systems. In addition, he also required the Navy to submit to the Office of the Secretary of Defense a service cost position and a plan to control overall program costs. The Secretary of Defense assumed a total quantity of 52 LCS and small surface combatants, but left the decision on the final number and mix of ships to the discretion of the Navy. However, according to Navy documentation, the Navy is notionally planning on 20 modified LCS—the costs of which have not been fully determined.

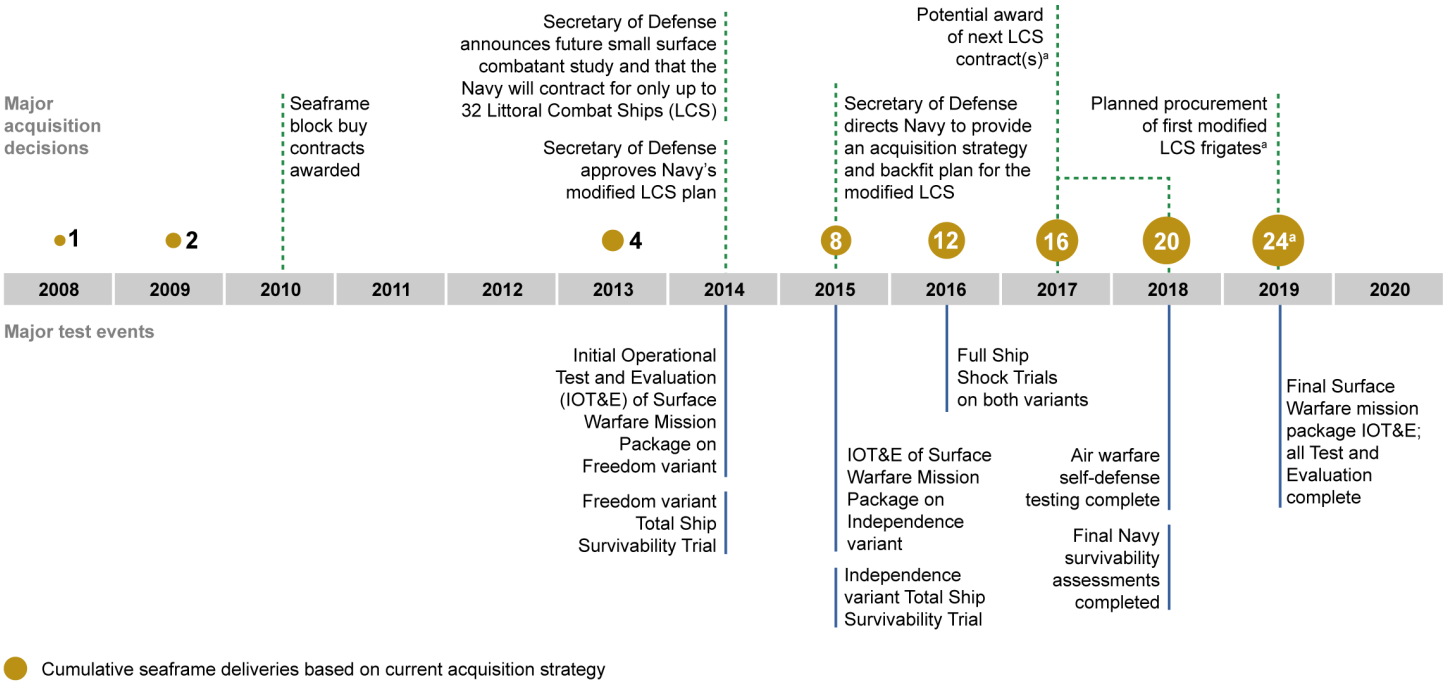
The House report on the National Defense Authorization Act for Fiscal Year 2015 includes a provision that we analyze the Small Surface Combatant Study and the Navy's plans moving forward; we just began this work after receiving the Navy's study, and we plan on issuing a separate report on these issues. As part of this review we will also assess

the acquisition strategy and cost and feasibility assessments recently submitted to the Secretary of Defense. According to statements by senior Navy officials, the modified LCS will be redesignated as a frigate. An initial fact sheet issued by the Navy shows that these ships will still be able to carry either the SUW or ASW mission packages, but the Navy will add additional combat capability by including a towed multifunction sonar array, an over-the-horizon missile, and 25mm guns to the seaframes. The Navy is continuing to refine its plans, but initial information, including a recent DOT&E report, indicates that the improvements will largely focus on improving lethality. However, DOT&E stated that the improvements to the ships would not be sufficient to overcome the vulnerability features of LCS.

According to the Navy, modifying the LCS allows it to support the current industrial base with no break in production schedule. There are 20 seaframes currently under contract with the shipyards—10 at each shipyard—in various stages of construction in addition to any other planned work at the shipyards. According to the current schedule, the shipyards will be building LCSs already under contract until approximately 2019, and the Navy plans to award additional contracts before transitioning to the frigate. Further, Navy documentation identifies multi-month delays to almost all of the seaframes currently under construction at both shipyards. These late deliveries may prolong the time required for the shipyards to complete work under the existing LCS contracts, meaning that any future delays associated with the introduction of the modified LCS may not impact the workload in the shipyards.

As shown in figure 2, the Navy's proposed acquisition schedule will result in the Navy making key program decisions without the benefit of knowledge gained through ongoing survivability and lethality assessments.

Figure 2: Major Littoral Combat Ship (LCS) and New Small Surface Combatant Milestones



Source: GAO analysis of Navy documentation. | GAO-16-201

[a]The Navy has not yet finalized its acquisition strategy for ships beyond 2016.

For example, the Navy plans to determine its acquisition strategy for the new small surface combatant by May 2015, exercise options to begin upgrading current LCS ships in fiscal year 2017, and buy the lead small surface combatant (modified LCS) by 2019. According to this schedule, the Navy will need to begin estimating and planning the 2019 budget in 2017. However, as previously mentioned, at that time, the Navy will not yet have completed plans to fully demonstrate the survivability of both variants or completed testing to demonstrate that both variants meet threshold lethality requirements. Unknowns about the Independence variant are particularly significant, as that ship has conducted less operational testing to date than the Freedom variant and has not yet deployed overseas. Nevertheless, the Navy still plans to proceed with equal numbers of each variant, as reflected in its 2010 block buy decision.

Conclusions

The actual lethality and survivability performance of LCS is still largely unproven through realistic testing, 6 years after delivery of the lead ships, with 2 additional ships delivered and 20 more ships under construction and/or under contract. The LCS program was intended to be lower in cost than more capable multi-mission surface combatants, and the Navy limited requirements for susceptibility and vulnerability to help achieve that end. Since the program was initially authorized and funded, costs have increased and the Navy has further reduced the ship's lethality and survivability requirements. While current plans to protect LCS with more capable ships in higher-threat environments may be a more cost effective solution to addressing capability limitations, these changes also reflect an ever-shrinking set of situations in which LCS can operate without placing added demands on the larger combatants. Further, although the Navy has a significant lack of knowledge of the Independence variant's lethality and survivability capabilities with no plans to seek additional analysis from an independent technical authority to resolve questions on its rough water trial report, it continues with plans to buy equal numbers of both variants.

The Navy is quickly embarking on an effort to redesign the LCS to address lethality and survivability concerns. This effort comprises a major program change. Direction from the former Secretary of Defense to develop an acquisition strategy for the new small surface combatant—and to assess back-fitting some systems on the current LCS—by May 2015 with the first ship procured in 2019 leaves little time to develop important knowledge about current limitations of the ships in these areas. Consequently, the Navy risks leaving some limitations unaddressed, and potentially inefficiently modifying these designs while testing continues. The Secretary of Defense conveyed a sense of urgency by setting this time frame of May 2015, only 5 months after he approved the Navy's recommendation. The Navy has cited maintaining the industrial base and avoiding a production break as an imperative for its decision-making. Yet, current work in the shipyards will continue through at least 2019. Each shipyard currently has 10 LCS in various stages of construction—some having not even started construction—and most are experiencing schedule delays. The expedited time frame puts the Navy at risk for making decisions uninformed by more complete knowledge about not only the current LCS, but also about precisely what systems will be selected for the modified LCS. Importantly, the Navy will not have completed the survivability assessments for the two variants until 2018. Until that time, the Navy cannot be assured that it fully understands the survivability of the two ships or what capabilities might need to be augmented. Making premature decisions may exacerbate the situation

the Navy is in today—with an inventory of ships and systems that do not perform as initially envisioned.

At the same time, Congress is being asked to fund three LCS in fiscal year 2016—ships that DOD has acknowledged do not meet its needs. At this point, Congress must consider this funding request before the Navy has completed its new acquisition strategy or assessed the feasibility of backfitting certain upgrades onto the existing ships.

While we are making recommendations in this report, we also believe that the recommendations we have made in prior reports with regard to the LCS program still stand as reasonable actions that the Navy should take to improve the program.

Matters for Congressional Consideration

To ensure that the Navy has provided a clear direction for the future of the program before committing funding to construct additional ships, Congress should consider the following options:

1. In the near term, restrict funding for construction of the three LCS seaframes requested in fiscal year 2016 until the Navy submits to Congress and GAO:

    a. An acquisition strategy for the modified LCS that has been approved by the Secretary of Defense;

    b. The Navy's plans to backfit the existing LCS and an analysis of the cost and engineering feasibility and risks of doing so; and

    c. A completed rough water trial report for both variants.

Or,

2. Not funding some or all of the Navy's request in fiscal year 2016 for the three LCS seaframes given the Navy's lack of knowledge of the ships' survivability and lethality capability.

3. Further, given the uncertainties over the long term about the ship's survivability and lethality and proposed changes to future ships, consider not fully funding the Navy's request for future LCS ships beyond fiscal year 2016, pending the completion and analysis of the final survivability assessments for both variants due in 2018.

Recommendations for Executive Action

To ensure that the Navy has a sound acquisition approach moving forward, we recommend that the Secretary of Defense:

1. Ensure that the commitment to buy 20 modified LCS remains an affordable priority given other acquisition needs;

2. Ensure that the Navy's acquisition strategy for the modified LCS does not place industrial base concerns ahead of demonstrating the ship's lethality, survivability, and affordability; and

3. Require the Navy to solicit an independent technical assessment from an organization like a ship classification society on the survivability of the Independence variant seaframe and its ability to meet its applicable requirements.

To ensure that the program has requirements that are testable and measurable and to improve realism of LCS operational testing, we recommend that the Secretary of Defense direct the Secretary of the Navy to:

1. Investigate resourcing and conducting more operationally stressing SUW mission package testing onboard LCS, to include testing in a clutter environment and diverse weather and tactical scenarios to help ensure that the ships can operate effectively in their intended environment.

In the classified version of this report,[21] we make a separate recommendation to the Secretary of the Navy related to defining a currently vague SUW requirement that we redacted because it contained classified information.

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for review and comment. In its written comments, which are reprinted in appendix II of this report, DOD concurred with two of our recommendations, partially concurred with two others, and did not concur with one recommendation.

[21] GAO-15-361C

Regarding our first two recommendations, the department agreed that the Secretary of Defense would ensure that the Navy has a sound acquisition strategy moving forward procuring modified LCS and stated that the Secretary will ensure that industrial base concerns are balanced against cost, schedule and fleet requirements. Our draft report initially stated that the Navy was planning to buy 19 modified LCS based on our reading of the documentation available to us at that time. We have since updated our draft to reflect 20 modified LCS as recommended by the Navy. In addition, although DOD's response is consistent with the intent of our recommendations, the department indicates that it will conduct its review of the Navy's approach in advance of preparing the fiscal year 2017 budget. Given that fiscal year 2017 budget will be submitted in only a few months, we are concerned that the Secretary might not have adequate information prior to making funding decisions for the modified LCS. For example, final survivability assessments for both variants will not be issued until 2018—after acquisition decisions for the modified LCS are planned. We will continue to monitor this issue as part of our ongoing work on the Navy's small surface combatant.

DOD did not concur with our recommendation to solicit an independent technical assessment of the survivability of the Independence variant from an organization such as a ship classification society, stating that such an organization could not provide an independent look and would not have the technical competence to perform a threat weapon-based assessment of the survivability of any Navy ship. The intent of our recommendation was for the Navy to solicit an independent assessment of the structural damage sustained by LCS 2 during rough water trials—but not necessarily to assess the ability of the ship to sustain damage from weapons. With that in mind, we suggested a ship classification society as one option, but it is not the only option. The Navy could contract with an independent naval architecture firm or create an internal independent review board to assess the damage and identify a path forward. We believe that ship classification societies would be a viable option because they are not currently involved with the LCS program or other Navy surface combatant acquisition programs. DOD stated that soliciting such an evaluation by the American Bureau of Shipping (ABS)—a ship classification society—would not be an independent look because both LCS seaframe variants were originally designed, built, and classed to ABS standards. However, we note that the relationship between ABS and the Navy ended in 2012. In addition, there are 11 other classification societies that are members of the International Association of Classification Societies. This Association states that classification societies are independent, self-regulating, and externally audited and

have no commercial ownership in ship construction. Classification societies inspect and assess the structure of ships to ensure safety and adherence to standards, including after a ship sustains damage. Since LCS 2 sustained damage and given the disagreements between the LCS program office and its technical authority as to the cause of this damage, we continue to believe that soliciting an independent third party is a reasonable recommendation.

DOD concurred with our classified recommendation related to defining a currently vague requirement and seeking Joint Requirements Oversight Council validation before operational testing of the remaining SUW mission package increments.

DOD partially concurred with our recommendation related to funding more operationally stressing operational tests to include clutter and diverse weather and tactical scenarios. DOD stated that it will provide sufficient test resources, but stated that it does not believe that testing "every aspect" of weather and tactics is necessary. We agree that it is not necessary to test every type of weather and tactical situation, and urge DOD to ensure that testing identified by DOT&E is completed as necessary to fully demonstrate the performance parameters that are included in LCS test plans.

The Navy also separately provided over 80 technical comments on our draft report. We reconciled the Navy's technical comments with evidence we had from discussions with, and documentation from, officials from the Navy, DOT&E, and the Commander, Operational Test and Evaluation Force. We requested additional documentation to support some of the Navy's comments. We incorporated the Navy's comments as appropriate, such as to provide additional context in the report, but in some cases the Navy suggested changes or deletions that were not supported by the preponderance of evidence or that were based on a difference of opinion and not supported by fact. In those instances, we did not make the suggested changes. In all, we incorporated many of the Navy's comments and, in doing so, found that the message of our report remained the same.

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

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

Michele Mackin
Director, Acquisition Sourcing Management

List of Committees

The Honorable John McCain
Chairman
The Honorable Jack Reed
Ranking Member
Committee on Armed Services
United States Senate

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

The Honorable Mac Thornberry
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

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

Appendix I: Scope and Methodology

Although this report is dated December 2015, our findings are current as of July 2015 to be consistent with a classified report issued in July 2015.

To identify the extent to which Littoral Combat Ship (LCS) survivability and lethality requirements have changed over time, if at all, we analyzed the LCS capability development documents (CDD) which dictate the performance requirements for the ship and mission packages. We analyzed both the Flight 0 CDD dated 2004 and the updated Flight 0+ revision dated 2010, and compared both of these CDDs to identify areas, if any, where LCS requirements might have changed. We also reviewed the Navy's Required Operational Capabilities and Projected Operating Environment for LCS Class Ships instruction, which stipulates where LCS was to be employed. We analyzed the LCS build specifications for both variants for Flight 0 and Flight 0+. To determine the extent to which the warfighting concept of operations (CONOPS) continues to evolve, we analyzed the two LCS warfighting concept of operations (2007 and 2011) and spoke with an official from the Navy's Fleet Forces Command responsible for developing the third revision of the LCS warfighting CONOPS. We attended a portion of the LCS wargame conducted in March 2014. We also analyzed the CDDs for other Navy surface ships to make comparisons with LCS requirements. We reviewed relevant Navy policies stipulating general survivability and shock requirements for ships, and interviewed Navy officials including from the Program Executive Office for LCS for both the seaframes and the mission packages, and obtained written responses from the Office of the Chief of Naval Operations LCS branch. We also interviewed relevant DOT&E officials.

To assess the extent to which LCS meets its current survivability requirements, we analyzed Navy and DOT&E test reports for both developmental and operational test events on LCS and reviewed the LCS test and evaluation master plan and the Navy's Capstone Enterprise Air Warfare Ship Self-Defense test and evaluation master plan. We analyzed the LCS build specifications for both variants for Flight 0 and Flight 0+ ships, and reviewed relevant sections of the American Bureau of Shipping's Rules for Building and Classing Naval Vessels, which are the technical rules that were used to guide development of the LCS designs. We also analyzed the USS Independence Capabilities and Limitations document (2010) and the USS Freedom Combat System Employment Guide, as well as contractor-developed Vulnerability Analysis Reports and Detail Design Integrated Survivability Assessment Reports, and Navy instructions stipulating ship survivability requirements, including OPNAVINST 9070.1, 9070.1A, and OPNAVINST 9072.2A. We reviewed the Total Ship Survivability Trial test plan and also observed a portion of

this test conducted on USS Fort Worth. We reviewed various DOT&E documents, including the Early Fielding Report for LCS, and operational test results from anti-air warfare weapons on other ships. We also analyzed the Navy's USS Independence Seakeeping and Structural Loads Trial Phase II report. We interviewed relevant Navy officials, including from the Program Executive Office LCS for both the seaframes and the mission packages; and Navy technical experts from the Naval Surface Warfare Center Carderock Division and the Naval Research Lab including technical warrant holders responsible for ship vulnerability and shock tolerances. We obtained written responses from the Program Executive Office Integrated Warfare Systems. We also discussed survivability and crew training issues with LCS Squadron One, Navy Fleet Forces Command, and Navy Surface Forces Pacific officials.

To assess the extent to which LCS meets its current lethality requirements, we limited our assessment to the lethality of core seaframe and the SUW mission package because the MCM and ASW mission bring no or little offensive capability packages and both rely on the core seaframe systems for self-defense. The ASW mission package will carry a helicopter that can drop torpedoes, but this system is a well characterized capability that is currently used in the fleet, so we did not assess the effectiveness of this system. Further, the Navy has yet to field a production representative ASW mission package to evaluate. To assess LCS's performance, we analyzed Navy Commander, Operational Test and Evaluation Force reports including the SUW initial operational test and evaluation report, and Navy Surface Warfare Center Corona Division test analysis reports from LCS developmental test events and DOT&E reports. We reviewed the LCS Live Fire Test and Evaluation Management Plan, and the Navy's 57mm and 30mm ammunition Live Fire Test and Evaluation Management Plans. We also analyzed the USS Independence Capabilities and Limitations document (2010) and the USS Freedom Combat System Employment Guide. We reviewed the Navy's Damage Control Book for LCS 3 and the LCS 1 Repair Party Manual. We also interviewed relevant Navy officials, including from the Program Executive Offices for LCS for both the seaframes and the mission packages; the Naval Surface Warfare Center Corona Division; and Navy Commander of Operational Test and Evaluation Force. We also interviewed relevant DOT&E officials. We obtained written responses from the Office of the Chief of Naval Operations LCS branch and from the Program Executive Office Integrated Warfare Systems. We also reviewed the LCS 2 Special Trial report.

To assess the recent decisions pertaining to upcoming changes to the program in response to the Secretary of Defense's concerns with LCS lethality and survivability, we analyzed available Navy documentation on the proposed modified LCS. We also met with the small surface combatant study team. We were not provided with a copy of the study team's report in time to include an analysis of that document in this report.

We conducted this performance audit from June 2014 to July 2015 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Comments from the Department of Defense

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THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

ACQUISITION, TECHNOLOGY, AND LOGISTICS

JUN 19 2015

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

Dear Ms. Mackin:

This is the Department of Defense's response to the Government Accountability Office (GAO) Draft Report, GAO-15-316C, "LITTORAL COMBAT SHIP: Knowledge of Survivability and Lethality Capabilities Needed Prior to Making Major Funding Decisions," dated March 13, 2015 (GAO Code 121226).

The Department acknowledges receipt of the draft report. As more fully explained in the enclosure, the Department partially concurs with recommendations 1 and 5, concurs with recommendations 2 and 4, and does not concur with recommendation 3.

The Department appreciates the opportunity to comment on the draft report. For further questions concerning this report, please contact Dr. James Moreland, Deputy Director for Naval Warfare, at james.d.moreland18.civ@mail.mil or 703-614-3170.

Sincerely,

Frank Kendall

Enclosure:
As stated

CLEARED FOR PUBLIC RELEASE
BY USD(AT&L) on 7 December 2015

Regrade UNCLASSIFIED when separated from enclosure

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GAO DRAFT REPORT DATED MARCH 13, 2015
GAO-15-361C (GAO CODE 121226)

(U) "LITTORAL COMBAT SHIP: KNOWLEDGE OF SURVIVABILITY AND LETHALITY CAPABILITIES NEEDED PRIOR TO MAKING MAJOR FUNDING DECISIONS"

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATIONS

(U) RECOMMENDATION 1: To ensure that the Navy has a sound acquisition approach moving forward, we recommend that the Secretary of Defense ensure that the commitment to buy 19 modified LCS remains an affordable priority given other acquisition needs.

(U) DoD RESPONSE: Partially Concur. The Department of Defense will evaluate the Navy's modified Littoral Combat Ship (LCS)/Frigate plan in preparation for the Fiscal Year 2017 President's Budget submission. The Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)) will ensure the modified LCS/Frigate Acquisition Strategy (AS) is in compliance with the Secretary's direction. However, the Department is committed to the procurement of 20 modified LCS/Frigates in the most affordable manner possible, in order to fulfill the Force Structure Assessment requirement for 52 small surface combatants.

(U) RECOMMENDATION 2: To ensure that the Navy has a sound acquisition approach moving forward, we recommend that the Secretary of Defense ensure that the Navy's acquisition strategy for the modified LCS does not place industrial base concerns ahead of demonstrating the ship's lethality, survivability, and affordability.

(U) DoD RESPONSE: Concur. The USD(AT&L) will ensure that the Navy's AS balances industrial base concerns with cost, schedule, and performance risks for the execution of the modified LCS/Frigate program and Fleet requirements.

(U) RECOMMENDATION 3: To ensure that the Navy has a sound acquisition approach moving forward, we recommend that the Secretary of Defense require the Navy to solicit an independent technical assessment from an organization like a ship classification society on the survivability of the Independence variant seaframe and its ability to meet its applicable requirements.

(U) DoD RESPONSE: Do Not Concur. Both LCS seaframe variants were originally designed, built, and classed to the American Bureau of Shipping (ABS) Naval Vessel Rules. Soliciting such an evaluation by ABS would not be an independent look. Other classification societies would not have equivalent rules to meet U.S. Navy survivability standards and any assessment would not offer the validation desired in the GAO recommendation. Additionally, a ship classification society does not have the technical competence to perform a threat weapon-based survivability assessment of any Navy ship; that knowledge resides solely within the Department.

[redacted]

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~~(C)~~ **RECOMMENDATION 4:** To ensure that the program has requirements that are testable and measurable and to improve realism of LCS operational testing, we recommend that the Secretary of Defense direct the Secretary of the Navy to fully define and seek Joint Requirements Oversight Council validation for the CDD requirement for LCS [redacted] engagements to language that can be used to support testing. Complete this action prior to operational testing of remaining SUW mission package increments.

~~(C)~~ **DoD RESPONSE:** Concur. The Department agrees that the Navy should submit for approval a Surface Warfare (SUW) Capability Production Document to the Joint Requirements Oversight Council addressing the Fast Attack Craft (FAC) and Fast Inshore Attack Craft (FIAC) threats and LCS engagement requirements. The current Test and Evaluation Master Plan (TEMP) is approved only for testing Increment 2 of the SUW mission package, as well as the first increment of the Mine Countermeasure mission package. Testing for Increment 3 or Increment 4 of the SUW mission package has not yet been defined or approved by the Director of Operational Test and Evaluation. An update to the current TEMP will be required to document the needed testing and resources for an adequate operational test of the remaining increments, including examining performance [redacted] and long-range engagements with [redacted] future missile capability.

(U) RECOMMENDATION 5: To ensure that the Navy has a sound acquisition approach moving forward, we recommend that the Secretary of Defense investigate resourcing and conducting more operationally stressing SUW mission package testing onboard LCS, to include testing in a clutter environment and diverse weather and tactical scenarios to help ensure that the ships can operate effectively in their intended environment.

~~(C)~~ **DoD RESPONSE:** Partially Concur. The Department will provide sufficient test resources (i.e., targets and white shipping assets) to ensure the adequacy of LCS developmental and operational testing. The TEMP will be updated to adequately address the intended performance for the SUW mission package. Future SUW mission package testing will include testing in a variety of operationally realistic conditions, [redacted] and a variety of stressing threat target scenarios and tactics, to provide a more complete assessment of LCS [redacted] warfighting capability, while ensuring compliance with at sea testing range safety protocols. The Department does not agree that, to have a "sound acquisition approach," it must include a test strategy that tests every aspect of weather and tactics. However, testing will be conducted sufficiently to be able to assess how the systems will perform in their intended operating environments.

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Appendix III: GAO Contact and Staff Acknowledgments

GAO Contacts

Michele Mackin, 202-512-4841 or mackinm@gao.gov

Staff Acknowledgments

In addition to the contact named above, Diana Moldafsky (Assistant Director), Greg Campbell, Laurier Fish, Laura Greifner, Kristine Hassinger, C. James Madar, Kenneth Patton, John Rastler, Amie Steele, Roxanna Sun, and Hai Tran made key contributions to this report.