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STATEMENT
BY

J. MICHAEL GILMORE
DIRECTOR, OPERATIONAL TEST AND EVALUATION
OFFICE OF THE SECRETARY OF DEFENSE

BEFORE THE
SENATE ARMED SERVICES COMMITTEE

ON

THE NAVY’S LITTORAL COMBAT SHIP PROGRAM

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J. Michael Gilmore
Director, Operational Test and Evaluation (DOT&E)
Office of the Secretary of Defense

Chairman McCain, Ranking Member Reed, and distinguished members of the Committee, thank you for the opportunity to discuss my assessment of the Littoral Combat Ship (LCS) program. The first LCS was commissioned in 2008, and the Navy now has in commission a total of eight ships, with two more anticipated in the coming months. The Navy has also deployed three LCSs in the past three years, with each of the three ships conducting freedom of navigation and forward presence missions in the western Pacific. Despite the success of delivering ships to the Navy, and recent peacetime operations during deployments, the LCS program has not yet demonstrated effective warfighting capability in any of its originally-envisioned missions: surface warfare (SUW), mine countermeasures (MCM), and anti-submarine warfare (ASW). The effectiveness of the ship is closely tied to the capabilities of the installed mission packages; yet, the Navy has not yet delivered effective mission packages that meet the Navy's own requirements for any of these missions. Furthermore, all of the ships have suffered from significant and repeated reliability problems with both seaframe and mission package equipment. 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. Unless corrected, the critical problems that I have highlighted in multiple DOT&E reports and multiple formal memoranda over the last seven years will continue to prevent the ship and mission packages from being operationally effective or operationally suitable in war.

With respect to survivability, neither LCS variant is expected to be survivable in high-intensity combat because the Navy's requirements accept the risk of abandoning the ship under circumstances that would not require such an action on other surface combatants. As designed, the LCS lacks the shock hardening, redundancy, and the vertical and longitudinal separation of 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. Thus far, the results of the LCS Live Fire Test and Evaluation (LFT&E) program confirm this assessment. While there is still much work to be done, the LFT&E program has already identified over 100 technical improvements that could be applied to improve LCS's performance against threat weapons, although, given the ships' fundamental limitations, none of these improvements will make the ships' survivability comparable to that of the Navy's other surface combatants. Once I have all the shock trial data in hand and have analyzed it in conjunction with the data from the Total Ship Survivability Trials (TSST) and the Navy's Survivability Assessment Reports, I will issue a more comprehensive assessment of both seaframes' survivability.

Understandably, the Navy's concept of employment and concept of operations (CONOPS) for these ships has changed over time. The original vision for the class was to rely heavily on off-board and largely unmanned systems, which would allow engagement of the threats well away from the seaframe, thus enabling the ship to remain out of harm's way and survivable. Second, the Navy championed the idea of interchangeable mission packages through modularity in order to add to LCS's flexibility and contribution to a dynamic war effort. As the Navy stated several years ago, "By having the flexibility to swap out mission packages, Navy has a ship that can adapt to meet the ever-changing spectrum of mission requirements."[1] Notably, both of these cornerstones of the program have been either abandoned or not yet realized, as the limitations of the mission packages and seaframes have become clear through testing and experimentation.

The Navy has most recently decided, following a program review, to employ a "semi-permanent" installation of specific mission packages, making any given ship dedicated to a single mission, a sharp and limiting contrast from the Navy's original concept, as well as from the traditional multi-mission frigates that LCS is now envisioned to replace. Moreover, the off-board, unmanned systems that would have enabled the seaframes to stay far from danger have not yet been developed: neither the SUW or ASW mission packages plan to use unmanned undersea or unmanned surface vehicles to accomplish those missions, and the MCM mission package's off-board vehicles have encountered significant developmental delays or cancelation, the primary MCM system, the Remote Minehunting System (RMS), being recently canceled after more than 15 years of development. Although all the mission packages will employ a helicopter or an unmanned aerial vehicle, those assets will not obviate the need for the ship itself

1 Statement of the Honorable Sean J. Stackley, Assistant Secretary of the Navy (Research, Development, and Acquisition) and Vice Admiral Richard Hunt, Director, Navy Staff before the Subcommittee on Seapower and Projection Forces of the House Armed Services Committee, July 25, 2013.

to be engaged in high-intensity battle where the crews will face threats like small boats, submarines, naval combatants, and shore defenses that are likely to employ weapons like anti-ship cruise missiles (ASCMs), torpedoes, and mines. Therefore, the use of LCS as a forward-deployed combatant, where it will be involved in intense naval conflict, is inconsistent with the ships' inherent survivability in those same environments.

One of the primary design features and selling points of the LCS seaframe was its speed. With the ability to sprint at 40 knots, the ship enjoys some enhanced ability to defeat fast small boats (albeit not the ever growing numbers that are faster) and some lightweight torpedoes, thereby protecting itself in some scenarios. However, such speed capabilities provide no benefit in conducting ASW or MCM; furthermore, the Navy's CONOPS require LCS, in some scenarios, to remain stationed near much slower units who are providing the LCS with dedicated air defense support to have any reasonable chance of surviving attacks using ASCMs launched in the littorals also obviates the need for the high speed. Moreover, this CONOPS implies that destroyers and cruisers will be required to provide this protection to LCSs, which is contrary to the concept that independently operated LCSs will free up the Navy's destroyers and cruiser and "allow [them] to focus on the high-end missions," which is what the Navy has touted in the past. The realities of intense Naval conflict and the multitude of threats in the littoral environment paired with the evolved CONOPS has therefore also called into question the need for high speed as one of the primary design considerations for this class of ship. Indeed the Navy plans to modify future LCSs (the so-called frigate design) by eliminating the high top speed requirement.

I want to correct one misconception about LCS and my assessments. LCS was bought to "punch below its weight class," to specifically counter asymmetric threats in the littorals. LCS was not designed to be a destroyer, which has survivability and lethality capabilities to counter peer threats. No evaluation should hold LCS to that standard with respect to survivability or mission capabilities. Nevertheless, I have found no evidence to date that LCS will be effective or survivable even in the scenarios and missions in which it was designed to be successful. Those capabilities may yet appear as the Navy progresses in the development of the Increment 3 SUW mission package, the incorporation of an over-the-horizon missile onto the seaframes, a restructuring of the MCM mission package, and the long-awaited ASW mission package, which showed some promise in early developmental testing. To date, however, LCS does not provide a lethal capability in the primary missions it was built for, and given the change in CONOPS, its design is not survivable in those missions either.

Seaframe Suitability

After operational testing of the *Freedom* variant equipped with the Increment 2 SUW mission package in 2014, and recent operational testing in 2015 – 2016 of the *Independence* variant equipped with the same mission package, DOT&E has sufficient data to conclude that both seaframe variants are 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. As an example, when averaged over time, and accounting for both planned and unplanned maintenance downtimes, LCS 4 was fully mission capable for SUW missions just 24 percent of the 2015 test period. Failures of the propulsion and maneuvering subsystems and the ship's computing network, which are fundamental to ship operations, caused LCS 3 to return to port for repairs or reduced readiness while at sea for weeks at a time during its 2014 operational test period. Both variants fall severely short of the Navy's reliability requirements, and have a near-zero chance of completing a 30-day mission (the Navy's requirement) without a critical failure of one or more seaframe subsystems essential for wartime operations. The trend of poor reliability of critical seaframe systems has also affected the deployments of LCS 1 and 3, and most recently LCS 4, and these deployments did not exercise the ships in stressing wartime operational tempo. The poor suitability demonstrated during the operational test periods are therefore, not anomalous, but in fact, a clear indication that these ships will not be operationally available nor fully mission capable more than a fraction of the time in wartime conditions. The recent problems observed during peacetime are likely only the tip of the iceberg for the problems crews might deal with when in more severe combat. Such results also have grave implications for operations and sustainment costs, which will plague the Navy for years to come if these inherent engineering problems are not corrected.

The intentionally small crew size has limited the mission capabilities, combat endurance, maintenance capacity, and recoverability of the ships. For example, the small crew size has limited the *Independence* variant from operating with sufficient watchstanders to maintain an alert posture for extended periods of time. By design, the ship's small crew does not have the capacity to effect major repairs. Instead, the Navy's support concept depends on the use of remote assistance in troubleshooting problems and the use of Navy repair organizations and contractors for repair assistance. However, the Navy's limited stock of repair parts for LCS systems, many of which were sourced from offshore vendors, can result in long logistics delays and occasionally forces the Navy to resort to cannibalization of another ship in order to expedite repairs. Because of the planned reliance on shore-based contractor support, in many cases the LCS crew lacks the documentation, training, test equipment, and tools required to troubleshoot and repair serious problems as they emerge. An example of this limitation occurred during LCS 4's operational testing during 2015 and 2016, where the ship's primary air defense system, SeaRAM, suffered from seven long periods of downtime (greater than 48 hours). 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. During the LCS 3 operational test period, the crew was unable to repair multiple critical systems, such as the ship's navigation data distribution system, the air search radar, and Link 16 tactical link, each of which resulted in multiple days of downtime while awaiting assistance from contractors to troubleshoot and repair the systems. The limited ability of the crew to effect repairs became particularly acute during the 2015 MCM technical evaluation period; the LCS 2 crew relied on shore-based maintenance personnel to complete repairs of the ship's twin boom extensible crane, main propulsion diesel engines, electrical systems, boat davit, straddle lift carrier, and air conditioning units and the mission package's Remote Multi-Mission Vehicles (RMMV) and Airborne Mine Neutralization System (AMNS) Launch and Handling Systems. In the preceding six month work-up period, the ship also called on contractor personnel to troubleshoot, diagnose, and correct problems. It remains to be seen whether the Navy can provide the same level of support in theater for wide-area, multi-LCS MCM operations that must be completed quickly, let alone during combat at sea.

In September 2016, the Navy released new plans to change the LCS crewing structure. The Navy now 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, but 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 some of the problems observed in the previous testing of both variants.

Air Defense Capabilities of LCS

Air defense testing has not yet been completed for either LCS variant. The Navy has not conducted any of the planned live-fire air defense test events or the modeling and simulation studies necessary to definitively determine the ship's ability to defend itself against ASCMs. Despite the dearth of testing, DOT&E has compared the capabilities of LCS's air defense system to other ships in the Navy. I assess that LCS likely has less or nearly equivalent capability to the LPD 17 air defense systems, which also employ Rolling Airframe Missile (RAM) but have a more capable combat system. In 2011, I assessed the LPD 17 class ships are not operationally effective against several modern classes of ASCMs. Therefore, it is unlikely that LCS will be able to meet the Navy's requirements for air defense based on the results available from LPD testing. More recently, limitations in the SeaRAM system (currently installed on *Independence* variants) revealed some significant classified concerns.

For the *Freedom* variant, DOT&E learned in fiscal year 2015 (FY15) that the Navy stopped work on the air defense modeling and simulation test bed because it did not have the intellectual property rights and detailed technical information for the ship's air defense radar (AN/SPS-75). The lack of intellectual property for these foreign radars has been a problem for both variants of LCS, making it difficult for engineers to develop high-fidelity models and understand the capabilities and limitations of these radars or effect changes when problems are found. I proposed alternative test strategies to overcome this difficulty; however, in 2016, the Navy decided it is not satisfied with the *Freedom* variant's radar and RAM system for defense against ASCMs. The Navy now plans to replace the RAM system with SeaRAM, which is the system installed on the *Independence* variant. Because of this decision, the Navy does not plan to test (at all) the existing *Freedom*-variant air defense systems installed on LCS 1 through 15. This is 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. Although the Navy has conducted some training events where a single subsonic drone is shot down in non-stressing, operationally *unrealistic* conditions (not emulating actual threats), the fact remains that no end-to-end operationally realistic live-fire testing has been conducted. The crews of these ships will remain unaware of any problems with their air defense systems that might have been discovered during testing, and will likely discover these problems at the worst possible time: when under attack. The need for this testing is all the more acute given the recent ASCM attacks against Navy ships off the coast of Yemen.

For the *Independence* variant, air defense testing continues to be delayed and its completion is now in doubt as well because of higher priority testing of the CVN 78 air defense systems. Additionally, the Program Executive Office for LCS sent a letter to the Navy's Surface Warfare Director (N96) stating that *Independence* variant air warfare testing cannot be executed at current funding levels. The Navy had planned to conduct the first of the planned operationally realistic live-fire 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. Based on the Navy's most recent plans, 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 testimony is not anticipated before FY20.

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 December 2015, the Navy-conducted a 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 make best use of the available resources and ensure that LCS's air defense testing reflects the capabilities of deploying LCSs.

The Navy has also successfully completed some non-firing air defense tests that provide some initial insights into the capabilities and limitations of components of the air defense systems. For the *Freedom* variant, these tests revealed that because of the limited capabilities of the air defense radar, the crew was unable to detect and track some types of air threats well enough to engage them. The lack of integration between the WBR-2000 Electronic Support Measures (ESM) system and the RAM system limited the ship's capability to make best use of its limited RAM inventory. For the *Independence* variant, although the ships relies on the SeaRAM system, the ship's air surveillance radar provided LCS crews with only limited warning to defend itself against ASCMs in certain situations. The *Independence* variant's ESM system is able to detect the presence of the ASCM seekers in most instances but did not reliably identify certain threats, and in some cases did not provide LCS crews with adequate warning to defend itself.

Finally, with respect to air defense, the ship is expected to struggle to defend itself against low, slow-flying aircraft such as unmanned aerial vehicles, helicopters, and small planes. In the Navy's developmental test events, we learned that the electro-optical system used to target the seaframe's gun 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 of these threats until future upgrades of the tracking system can be implemented.

Cybersecurity

Much of my assessment of the two seaframes' cybersecurity posture and capabilities is classified and covered in detail in my recent operational test reports. However, I will state that the testing conducted in FY14 on LCS 3, testing conducted in 2015 on LCS 2, and finally the most recent test aboard LCS 4 have revealed significant deficiencies in the ship's ability to protect the security of information and prevent malicious intrusion. Although the Navy is developing plans to modify the network architecture in the both *Freedom* and *Independence* variants to enhance cybersecurity, the severity of the cybersecurity problems discovered on LCS will degrade the operational effectiveness of either variant until the problems are corrected.

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. The Navy designed and implemented the IA remediation program to mitigate or eliminate some of the vulnerabilities found during the 2015 test aboard LCS 2 and was successful in eliminating some of the deficiencies that placed the ship at risk from cyber-attacks conducted by nascent (relatively inexperienced) attackers.

Unfortunately, because of numerous limitations, the Navy's testing aboard 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.

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 plans a second phase of IA remediation to correct additional network deficiencies; however, DOT&E is unaware of the plans to install or test these changes on future ships, or whether these changes will correct the problems observed during the LCS 4 test. Nevertheless, routine and thorough cybersecurity assessments of each ship, and each configuration of mission packages, particularly those being deployed, should be a core strategy for LCSs as well as all Navy ships. The inadequacies in test execution and poor performance discovered in recent LCS cybersecurity testing strongly suggest that the Navy must undertake a more concentrated and focused effort to improve cybersecurity for these ships.

Self-Defense against Surface Threats

Both variants of LCS rely exclusively on the seaframe's MK 110 57 mm gun and a gunfire control system that is fed by an electro-optical/infrared sensor to defend the ship against attacking surface threats, such as a small fast boat. Unless the SUW mission package is installed, this one gun is the ship's only defense against these targets (as well as low, slow-flying targets). Too few data exist on the *Freedom* variant to provide a definitive evaluation of that ship's ability to defend itself with only the 57 mm gun. Furthermore, the test that was conducted was limited to a single target boat attacking LCS and the events were not conducted in a realistic cluttered environment where identification of threats will be more challenging.

On the *Independence* variant, however, the Navy conducted seven test events, each consisting of a single attacking small boat. LCS failed to defeat the small boat in two of these events, because of gun failures that have since been corrected. Overall, 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 are 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 have not been determined definitively.

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.

Self-Defense against Subsurface Threats

As I have stated in multiple reports, LCS will have no capability to detect or defend against torpedoes unless the ASW mission package is embarked, specifically the lightweight tow countermeasure. This is in contrast to the USS *Oliver Hazard Perry* Class Frigates (FFG), which had some inherent capability to detect threat torpedoes and could employ a torpedo countermeasure system. The lack of capability implies that a submarine could launch an attack on an LCS, without the crew knowing that they were under attack, and successfully hit the ship.

Because an LCS equipped with the SUW mission package has no ASW capability, nor any torpedo defense capability, many areas of operation where multiple threats are present will require multiple LCSs to work together for mutual protection, or for the likely multi-mission character of many Navy warfare scenarios. Such groups of two or three LCSs with disparate single-mission packages is in addition to the now-acknowledged need for destroyer/cruiser support for air defense in some scenarios. The Navy's CONOPS documents acknowledge the difficulty of planning LCS surface action groups because of the inherent lack of multi-mission capabilities, making three or four ships sometimes necessary to enable mission accomplishment and ensure survivability. The same mission scenarios might be accomplished by fewer ships, provided those ships had multi-mission capabilities. The original vision, therefore, of a nimble, mission-focused ship has been overcome by the realities of the multi-mission nature of naval warfare combined with the multiple threat environments of high-intensity naval conflicts.

Survivability

As I have previously reported, neither of the LCS designs includes survivability features necessary to conduct sustained operations in a combat environment. Furthermore, during DOT&E's review of the work completed by the Navy's Small Surface Combatant Task Force in 2014, it became clear that LCS does not have the survivability features commensurate with those inherent in the FFG it is intended to replace. The FFG is designed with shock-hardened mission and propulsion systems. It has redundancy and separation of major combat and engineering systems and equipment. These design features are meant to enable the ship to not only exit the area once hit by significant threat weapons, but also to retain critical mission capability and continue fighting if need be. LCS is not designed to do so.

The LCS CONOPS acknowledges LCS vulnerabilities to some air, surface, and subsurface threats and suggests that LCS is best suited for missions such as Theater Security Cooperation and Maritime Security Operations. At the same time, the LCS CONOPS states that LCS is expected to spend the majority of its time operating independently or in surface action groups, ahead of the strike group, preparing the environment for joint force access to critical littoral operating areas. Such operations could expose LCS to the full spectrum of potential threats, and the CONOPS acknowledges that the limited air defense and survivability capabilities of LCS will necessitate an appropriate defense plan provided by the very forces LCS is supporting. Providing additional warships for LCS protection means stretching already limited battle group air defense assets. Furthermore, the presence of such air defense ships to aid LCS does not guarantee the susceptibility to these attacks will be reduced to zero or its survivability improved, given the potential threats that LCS might encounter as one of the first assets present in a hostile combat environment.

Aluminum Ship Vulnerability

The Navy has not yet adequately assessed the LCS aluminum hull and deckhouse fire vulnerability; however, this is an obvious survivability concern for these ships. Aluminum structure is vulnerable to melting and loss of structural integrity during shipboard fires. This is not a problem for steel hulled ships. Battle damage and collision incidents involving ships with aluminum superstructures, such as USS *Stark* and USS *Belknap*, highlighted these survivability concerns for the Navy. The Navy's Survivability Review Group concluded in the 1980s that aluminum ship structure was highly vulnerable to fire spread and loss of strength, which was codified in the 1985 edition of the General Specifications for Ships of the United States Navy, section 150a, by requiring deckhouses and superstructure to be steel. This policy was reversed for LCS. More recently, an aluminum ship, HSV *Swift*, suffered extensive structural damage from blast and fire when she was hit by a missile off the coast of Yemen. This recent attack serves as a grim reminder of the increased risk inherent in the *Independence* variant, which is constructed primarily from aluminum.

The Navy has not yet assessed the likelihood of major structural damage from a weapon-induced fire on LCS. These assessments have not been done because the Navy was not equipped with the analytical tools necessary to model this problem. The LCS LFT&E program included tests to gather data for model development and validation, but that process is still ongoing. The *Independence*-variant survivability assessment report that is due in FY17 will not include comprehensive analysis of fire induced structural damage potential.

Based on testing of fire insulation conducted by the LCS program, the Navy reported that it is unlikely that major structural damage will occur to aluminum structures from an internal fire in an undamaged compartment (i.e., all fire suppression systems are operable and fire insulation is intact). This nuanced reporting did not address the fact that internal blast effects can damage fire insulation and suppression systems that would normally be available to mitigate the fire effects in an undamaged compartment. It is, therefore, premature to draw any other conclusions about the structural integrity of the LCS hull.

Shock Trials

This year, the Navy conducted reduced severity shock trials on the *Independence*-variant USS *Jackson* (LCS 6) and the *Freedom*-variant USS *Milwaukee* (LCS 5). I approved the reduced severity trial geometries for LCS 6 because of serious concerns about the potential for damage to non-shock hardened mission critical equipment and ship structure. There was also concern about the damage tolerance of the ship's hull structure relative to steel hulled ships. Unlike other surface combatants the combat systems on LCS are not shock hardened. Also, the main propulsion system on the *Independence* variant is not shock hardened. The Navy argued that the reduced severity approach was necessary because they lacked specific test data and a general understanding of how the non-Grade A systems (Grade A systems must remain functional after shock) would respond to shock. To further mitigate potential equipment damage and personnel injury, some mission systems were removed, other equipment was modified to improve shock resistance, and construction deficiencies were corrected.

LCS 6 was tested in June and July 2016. The trial consisted of three shots of increasing severity, ending at 50 percent of the required shock design level. At these reduced levels, most non-Grade A components and systems, including electrical power generation systems and the SeaRAM 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. The Navy is still analyzing the structural response data.

Based on the LCS 6 shock trial lessons learned and limited equipment damage, I directed the Navy to conduct a traditional three shot shock trial for LCS 5, with the final shot at two-thirds the required shock design level. The Navy conducted the first two shots from August 29 through September 23, 2016, starting the trial at the same shock severity as other modern surface combatants. 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 viewed the third LCS 5 trial as not worthwhile because the Navy was concerned shocking the ship at the increased level of that trial would significantly damage substantial amounts of non-hardened equipment, as well as damage, potentially significantly, the limited amount of hardened equipment, thereby necessitating costly and lengthy repairs. The Navy view is that its modeling could be used to confidently conclude what would occur if the third shot were conducted based on the results of the first two shots. I disagree and maintain that the third LCS 5 shot is needed: the Navy's models have not correctly predicted important aspects of the response of the LCS 6 and LCS 5 seaframes to the shock events that were conducted; nor have those models accurately predicted the responses of the equipment installed and integrated onto the ships.

As planned and conducted, neither shock trial resulted in catastrophic damage, yet both shock trials exposed critical shock deficiencies, which I will detail in an upcoming classified report. These deficiencies, which were only identified in the shock trial, can now be specifically addressed and corrected by Navy engineers to make the ships more survivable.

Total Ship Survivability Trials (TSST)

As an element of the LFT&E program, the TSST is the primary source of recoverability data and is intended to provide a damage scenario-based engineering assessment of the ability of the ship's crew to utilize the installed firefighting and damage control systems to control damage, reconfigure, and reconstitute mission capability after combat damage.

The LCS 3 TSST revealed significant deficiencies in the *Freedom*-variant design. Much of the ship's mission capability would have been lost because of damage caused by the initial weapons effects or from the ensuing fire. The weapons effects and fire damage happened before the crew could respond, and the ship does not have sufficient redundancy to recover the lost capability. Some changes could be made to make the ship less vulnerable and more recoverable without major structural modifications. Examples include providing separation for the water jet hydraulic power units, redesigning the Machinery Plant Control and Monitoring System, and reconfiguring the chilled water system into a zonal system with separation for the air conditioning (chilled water) plants. The Navy has not yet made any plans to make such changes in future ships, however.

The LCS 4 TSST, conducted in January 2016, exposed weaknesses in the *Independence*-variant design. While the shock-hardened auxiliary bow thruster would have provided limited post-hit propulsion, much of the ship's mission capability would have been lost because critical support systems such as chilled water are not designed for reconfiguration and isolation of damage caused by the initial weapons effects or from the ensuing fire and flooding. There were many survivability improvements identified by the trial team that could be implemented in the *Independence*-variant ships, for example, outfitting the rescue and assistance locker with additional damage control gear to make it a third damage control locker, and modifying the damage control and chill water systems to increase the ability to reconfigure and isolate damaged sections.

Mission Packages

The ability of LCS to perform the bulk of its intended missions (SUW, MCM, and ASW) depends on the effectiveness of the mission packages. To date, despite LCS having being in service since 2008, the Navy has not yet demonstrated effective capability for LCSs equipped with the MCM, SUW, or ASW mission packages. The Increment 2 SUW mission package is the only fielded system on LCS seaframes; it 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, such as launching an recovering boats and conducting pirate interdiction operations.

Surface Warfare (SUW)

The Navy has now conducted one operational test of the Increment 2 SUW mission package installed aboard a *Freedom* variant and one operational test of the mission package installed aboard an *Independence* variant. The ship's organic 57 mm gun is augmented with two 30 mm guns and an MH-60R helicopter, which can be armed with a machine gun and HELLFIRE missiles.

For the *Freedom* variant, the Navy conducted three live-fire engagements aboard LCS 3 consisting of a small swarm of fast-inshore attack craft (small boats) under the specific conditions detailed in the Navy's reduced and interim requirement. LCS 3 achieved mixed results against these small swarms during FY14 testing. In the first developmental test, the ship successfully defeated a small swarm beyond the prescribed keep out range. In the second developmental test, LCS 3 was not successful. Following intensive remedial training to hone the crew's tactics, ship-handling, and gunnery, LCS 3 repeated the test and was successful in the one operational test event. Although the tests demonstrated that the *Freedom* variant could defeat a small swarm under benign conditions, there is little evidence that such results are repeatable under these same conditions as well as other less favorable conditions. Moreover, the Navy does not have in place intensive training programs for small boat defense that enabled the crew to be successful in the last test event, nor has the Navy taken my recommendation to develop a shore-based operator-in-the-loop team trainer, which has the potential to alleviate some of the uncertainty in LCS SUW performance, enable more adequate testing of the ship's capabilities in these scenarios where test resources are scarce, and potentially examine other conditions (such as varying sizes of swarms and interfering traffic).

In 2015, LCS 4, similar to LCS 3, participated in three engagements with small swarms of 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, these operational test results confirmed 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. 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 my November 2016 classified report. In it, I also detail my recommendations for improving performance and tactics so that these ships might be effective in these scenarios.

The Navy has begun work on developing and testing the Surface-to-Surface Missile Module (SSMM), the core component of the Increment 3 mission package. Although early developmental testing has shown the Longbow HELLFIRE missile employed from the SSMM has the needed lethality to defeat some of these small boat threats, operational testing in 2015 and 2016 revealed some potential limitations in the targeting capability of the ship. 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 LCS requirements for SUW swarm defense during operational testing of the Increment 3 mission package in FY18. These tests will be the first time that the Navy will have investigated LCS's ability to defend ships other than itself.

Mine Countermeasures (MCM)

In 2009, the Navy recognized that its legacy MCM capabilities, particularly *Avenger*-class and *Osprey*-class surface ships and MH-53E Sea Dragon helicopters, were aging while the worldwide mine threat continued to modernize.[2] In response to the advancing mine threat abroad and planned retirement of legacy assets at home, the Navy articulated an overarching vision for 21st-century mine warfare hailing the LCS as the "keystone" of the future MCM force.[3] The principal objective of the Navy's MCM vision was "to decrease significantly the time required to conduct countermeasures operations, while ensuring low risk to naval and commercial vessels, and to remove the man from the minefield." The plan was based on the premise that a suite of MCM systems, deployed from an LCS stationed outside the minefield, could replace and outpace legacy capabilities that put sailors in harm's way.

After initially setting high expectations for LCS MCM performance, the Navy continues to temper its outlook. As the Navy embarked on efforts to transform its MCM vision to reality, analysts employed performance modeling to estimate the area clearance rates of each LCS equipped with a package of MCM systems in a variety of operational scenarios, including large-scale scenarios requiring operations of multiple LCSs for sustained periods. These modeling estimates formed the basis for the MCM requirements the Navy documented in the LCS Flight 0+ Capabilities Development Document (CDD) approved in 2010. In the CDD, the Navy also postulated that remaining development and integration of the systems needed to complete the fully capable MCM mission package could be accomplished quickly, indicating that "delivery of the first baseline Spiral Alpha MCM mission package is on schedule for FY12."[4] As it became clear that this optimistic goal would not be met, the Navy developed a plan to test and field three "increments" of partial Spiral Alpha capability before achieving full Spiral Alpha capability in a fourth and final increment. In doing so, the Navy asserted that an LCS equipped with the first partial Spiral Alpha MCM mission package (or Increment 1 MCM mission package) would replace aging legacy systems and improve clearance rates by a factor of two.

The Navy has not yet delivered on the promise of its 21st-century MCM vision, even at reduced expectations. The Navy has not yet demonstrated in end-to-end testing that the sustained area clearance rate of an LCS equipped with the current MCM mission package

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2 Legacy MCM capabilities also include Explosive Ordnance Disposal Units and Marine Mammals.

3 "Ensuring Global Access and Commerce – 21st Century U.S. Navy Mine Warfare," PEO(LMW) / OPNAV N85 Mine Warfare Primer, June 2009.

4 In Annex A Section 5.4 of the LCS Flight 0+ CDD, the Navy further defined baseline mission packages as "those that will contain the full set of Spiral Alpha systems and achieve all Spiral Alpha performance attributes contained in this CDD." More recently, the Navy described the Increment 4 MCM mission package as the configuration expected to achieve LCS Flight 0+ CDD requirements.

exceeds its own estimates of legacy clearance rate, nor has it demonstrated that an LCS could meet the Navy's Increment 1 requirements for area clearance rate. The Navy has also not yet demonstrated the capability of an LCS to conduct efficient MCM operations in an operationally realistic shipping channel. Given the currently ineffective and limited line-of-sight communications between LCS and off-board vehicles, an LCS is forced to clear a series of operating areas that allow the ship to follow MCM operations as they progress along the channel while remaining within operational range of its off-board systems. This alone has the negative effect of vastly increasing mission timelines regardless of the effectiveness of the minehunting and clearing systems LCS employs. In addition, the performance demonstrated during LCS developmental testing that has been completed since 2014 provides ample evidence that the small number of LCSs equipped with the current MCM mission package that the Navy might be able to muster before FY20 would not provide an operational capability to complete MCM clearance missions at the levels needed by operational commanders. Even under the best conditions the Navy might hope to experience, the technical evaluation in 2015 revealed that an LCS with the current MCM mission package would deliver less than half the Increment 1 requirements, which themselves are a fraction of the full Spiral Alpha requirements.

In a June 2016 early fielding report, based exclusively on the testing conducted before 2016, I concluded 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. In the same early fielding report, I concluded that the current versions of the individual systems that comprise the current MCM mission package -- specifically the RMS (consisting of the RMMV and AN/AQS-20A) and the MH-60S Airborne MCM (AMCM) helicopter equipped with the Airborne Laser Mine Detection System (ALMDS) or the AMNS -- would not be operationally effective or operationally suitable if called upon to conduct MCM missions in combat.

The Navy has conducted limited operational testing of the individual systems it expected to field in the Increment 1 MCM mission package and has not initiated any operational testing of an LCS equipped with an integrated MCM mission package, other than a preliminary cybersecurity assessment. The lack of progress in developing, operationally testing, and fielding a credible, LCS-based MCM capability contrasts sharply with the timeline and performance expectations the Navy conveyed in the LCS Flight 0+ CDD. As the Navy attempts to fill capability gaps left by canceled programs and correct shortfalls in the performance of the original Spiral Alpha systems still in development, it is increasingly likely that the Navy will not *complete* Initial Operational Test and Evaluation (IOT&E) of either LCS variant equipped with the final (fully capable, Spiral Alpha) MCM mission package until at least 2023, more than a decade after the optimistic schedule set forth in the CDD.[5] Moreover, it is not clear that any future version of the mission package will meet the MCM requirements the Navy established in the LCS Flight 0+ CDD. Not surprisingly, I understand the Navy is now considering changes that would reduce some requirements for the so-called Spiral Alpha (or final) MCM mission package. Although such reductions may ultimately prove necessary to realign expectations with technical reality, the operational implications of lower clearance rates include longer clearance timelines and more LCSs equipped with MCM mission packages, as scenario geometry permits.

In October 2015, the Navy delayed operational testing of the *Independence*-variant LCS equipped with the first increment of the MCM mission package pending the outcome of an independent program review, including an evaluation of potential alternatives to the RMS. The Navy chartered the review in response to an August 21, 2015, letter from Senators John McCain and Jack Reed, Chairman and Ranking Member of the Senate Committee on Armed Forces expressing concerns about the readiness to enter operational testing given the significant reliability problems observed during a technical evaluation in 2015, a topic I have repeatedly reported on in previous years. In early 2016, following the completion of the independent review, among other actions, the Navy canceled the RMS program, halted further RMMV procurement, abandoned plans to conduct operational testing of individual MCM mission package increments, and delayed the start of LCS MCM mission package IOT&E until at least FY20. After canceling the RMS program, the Navy also announced its intention to evaluate alternatives to the RMS such as the unmanned surface craft towing improved minehunting sensors, and an improved version of the Knifefish unmanned undersea vehicle (UUV). However, the Navy has not yet fully funded these potential alternatives.

Ironically, the Navy's mine warfare resource sponsor (OPNAV N852) identified a multi-function LCS unmanned surface vessel (USV) as a "game changer" and potential RMMV

[5] Since 2010, the Navy has canceled the RMMV, OASIS, and RAMICS programs and discontinued use of the MH-60S in towing missions (thereby eliminating its employment of the AN/AQS-20A).

replacement in 2012.[6] In the years that followed, however, Navy officials touted RMMV reliability improvements that never materialized and funded additional RMMV development, but did not prioritize development of a multi-function USV capable of integrating with the RMS's AN/AQS-20 sonar.[7] These choices could leave the Navy without a viable means of towing improved AN/AQS-20C sonars when the contractor delivers initial production units next year and could delay realistic testing and fielding of the system. By accepting objective analysis of RMMV performance and committing to the USV sooner, the Navy could have avoided this unfortunate position and saved millions in RMMV development costs.

The Navy is developing the AN/AQS-20C sonar with upgrades designed to correct RMS and AN/AQS-20A minehunting performance shortfalls observed in combined developmental and integrated testing. Unless corrected, AN/AQS-20A shortfalls will delay completion of LCS-based mine reconnaissance and mine clearance operations. Although the Navy has demonstrated the AN/AQS-20A can find some mines when employed in ideal conditions, the sonar does not meet its detection and classification requirements over the prescribed depth regimes and simultaneously provide adequate coverage against all threats spanning a representative range of operationally realistic conditions. In addition, testing has repeatedly shown that AN/AQS-20A sensor does not meet Navy requirements for contact depth localization accuracy or false classification density (number of contacts erroneously classified as mine-like objects per unit area searched). Contact depth localization problems complicate efforts to complete identification and neutralization of mines. False classifications, unless eliminated from the contact list, require identification and neutralization effort, result in the expenditure of limited neutralizer assets, and negatively affect the LCS sustained area coverage rate.

Because of funding constraints, the Navy is struggling to implement many of the independent review team's recommendations. Although the Navy now plans to employ the Common Unmanned Surface Vehicle (CUSV) and AN/AQS-20C as the primary replacement for

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6 OPNAV N852 MIWIP 2012 briefing

7 See Statement of the Honorable Sean J. Stackley, Assistant Secretary of the Navy (Research, Development, and Acquisition) and Vice Admiral Richard Hunt, Director, Navy Staff before the Subcommittee on Seapower and Projection Forces of the House Armed Services Committee, July 25, 2013 and Statement of the Honorable Sean J. Stackley, Assistant Secretary of the Navy (Research, Development, and Acquisition), Vice Admiral Joseph P. Mulloy, Deputy Chief of Naval Operations for Integration of Capabilities and resources, and Lieutenant General Kenneth J. Glueck, Jr., Deputy Commandant, Combat Development and Integration and Commanding General, Marine Corps Combat Development Command before the Subcommittee on Seapower and Projection Forces of the House Armed Services Committee, March 26, 2014.

the RMS, even by its own optimistic schedule the Navy will not complete IOT&E of the system until at least FY21. In addition, the program does not appear to have sufficient funding to compare the capabilities of the AN/AQS-24 (currently operated in 5th Fleet) to the AQS-20, nor to examine different configurations of MCM mission packages with the two sonars. .

Many of the Navy's recent decisions regarding the future composition of the MCM mission package have focused on improving surface and subsurface MCM capabilities, but the suite of LCS-based airborne MCM systems, which the Navy plans to Initial Operational Capability (IOC) in FY17, is not without problems requiring attention. For example, developmental and operational testing of the MH-60S with either the ALMDS or the AMNS has shown that the reliabilities of MH-60S and its AMCM mission kit do not support sustained operations at a high tempo. Although the ALMDS pods themselves have not been the primary source of mission downtime, at least during stateside testing, the associated equipment for conducting missions with ALMDS, including the helicopter and AMCM mission kit, together experience a high failure rate (approximately once every 12 flight hours), making sustained LCS-based operations difficult. Similarly, the combined results of MH-60S, AMCM mission kit, and AMNS reliability suggest that the integrated AMCM system experiences one operational mission failure every 7 neutralizer launches and 5.9 flight hours, on average, during AMNS operations. By any measure, system reliability precludes timely and sustained operations.

The ALMDS does not meet Navy detection/classification requirements, except in particularly benign conditions such as those observed during the technical evaluation in 2015. Earlier testing revealed that the system does not meet the Navy's detection requirement in all depth bins or Navy's requirement for the average probability of detection and classification across a specified depth band. When the system and operator detect and classify a smaller percentage of mines than predicted by fleet planning tools, the MCM commander will likely underestimate the residual risk to transiting ships following clearance operations. In favorable conditions, tactics, techniques, and procedures, specifically a multiple-pass technique, has been successful in reducing false classifications (erroneous indications of mine-like objects) to the Navy's acceptable limits. However, in other conditions, the system generates a large number of false classifications that can delay near-surface minehunting operations until conditions improve or slow mine clearance efforts because of the need for additional search passes to reduce the number of false classifications. In 2016, the Navy reportedly reallocated funding intended to support near-term development of ALMDS pre-planned product improvements, to correct some of the detection and classification limitations and improve false classification rates. The Navy also reported that the improved system would not be available to the LCS MCM mission package until at least FY21.

The current increment of the AMNS cannot neutralize mines that are moored above the system's prescribed safe operating ceiling, which will preclude neutralizing most of the mines expected in some likely threat scenarios. In addition to this fundamental limitation which precludes the system's use against many threat mines, AMNS performance is frequently degraded by the loss of fiber-optic communications between the aircraft and the neutralizer. The system often experiences loss of fiber-optic communications in a wide range of operationally relevant operating conditions, including those that are relatively benign, and has not demonstrated the ability to neutralize mines in even moderate water currents. Although the Program Office has stated that it intends to develop an improved AMNS to extend its depth range and potentially improve performance in coarse bottom conditions and higher currents, none of these efforts are funded. The Navy is now considering the Barracuda Mine Neutralization System as a potential alternative to the AMNS, but does not expect to commence Barracuda developmental testing until at least FY22. In the meantime, legacy forces will be needed in all MCM missions requiring clearance of near-surface mines.

The Navy is continuing to develop the Coastal Battlefield Reconnaissance and Analysis (COBRA), Knifefish UUV, and Unmanned Influence Sweep System (UISS), but has not yet conducted any 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, LCS-based communications and launch and recovery problems observed in earlier testing of the RMS are likely to affect the upcoming phases of Knifefish and UISS operational testing. Thus, it is critically important that developmental and operational testing of these systems include end-to-end operations encompassing multiple sorties and realistic conditions and communications ranges to identify additional problems that must be corrected prior to fielding.

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. Without improvements, the capability of the current system will likely be limited in some operationally realistic threat scenarios and will not provide the capability needed to satisfy LCS MCM requirements for minehunting in the surf zone and beach zone. The Navy expects the COBRA Block II system to include surf zone capability, improved beach zone detection capability against small mines, and nighttime capability. The Navy expects these improvements to provide the capability needed to meet LCS MCM requirements in the surf zone and beach zone and expects the Block II system to reach IOC in FY22.

Knifefish contractor testing in September 2016 identified a significant problem with Knifefish watertight integrity that will require a redesign of components that will likely delay the start of operational testing. During testing in October 2016, an engineering development model Knifefish UUV broke in half as contractor personnel attempted to launch it into the water from a shore base. The Navy and contractor have suspended further testing pending the outcome of a root cause investigation of the latest failure. Although billed as another potential game changer following cancelation of the RMS program, pre-planned product improvements to Knifefish are currently unfunded.   In fact, the entire Knifefish program is in jeopardy pending funding decisions.   The program is currently examining the possibility of delaying Milestone C indefinitely until additional funding can be provided, which also places the delivery of a full MCM mission package in jeopardy on the timelines described above.

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 essential.   The UISS program, similar to Knifefish, is also facing the potential of significant delays to the delivery of capability, because of funding shortfalls.

Anti-Submarine Warfare (ASW)

The Navy has not yet conducted any operational testing of the planned ASW mission package since it is still in the early stages of development. The Navy planned an IOC for the mission package in FY16 following operational testing in FY15. Now, however, the earliest the LCS program might achieve IOC for the ASW mission package is FY19 for the *Freedom* variant and FY20 for the *Independence* variant. The primary causes for these delays are higher testing priorities of the other mission packages and the lack of availability of ships, which in recent years have been affected by the push for deployments. Additionally much work has gone into a weight reduction program for the sonar and handling system, and a re-compete of the variable depth sonar. The Navy recently downselected from three vendors, selecting the variable depth sonar and handling system, and will begin ship integration efforts in the coming year. IOT&E is now planned for 2019.

The Navy did conduct an at-sea test of an advanced development model of the variable depth sonar in September 2014 aboard LCS 1, albeit that test was conducted with a different sonar than was selected in the Navy's recent decision. Those tests showed promising sensor performance in one acoustic environment, and demonstrated the potential of a variable depth sonar, which several other foreign navies already employ from their frigates. The operators were highly-cued in that test, since they were provided prior knowledge of the target submarine's position, and the submarine did not execute evasion tactics. Given the significant departures from operational realism in that test and given the Navy has now chosen to go with a different design and vendor, I cannot provide any assessment of the expected effectiveness of the ASW mission package in a real-world combat scenario at this time.

LCS's sonar system is specifically optimized for deep water and will not be suitable for some very shallow-water environments such as in the littorals. Its limitations in shallow water are yet to be determined, however, and operational testing against diesel-electric submarines will be essential for understanding the ship's capabilities. Nevertheless, in deep water environments, the ASW mission package has the potential to provide LCSs with comparable or enhanced detection capability relative to other surface ships that employ hull-mounted sonars. LCS will face challenges that other ships do not, particularly the need to tow two systems behind the ship reliably.

The Navy is developing a torpedo countermeasure as part of the ASW mission package, which will provide LCSs equipped with that system to counter some, but not all, threat torpedoes. The lightweight tow countermeasure is still in development, but the Navy has completed some initial testing of prototypes. Most recently the Navy has determined that LCS seaframes will need to be modified for the employment of this system; these changes will be implemented on LCS 7, LCS 10, and all future seaframes planned to receive an ASW mission package. The Navy has not yet addressed the plan for backfitting these changes in earlier seaframes. Nor is there any plan to outfit other LCSs equipped with MCM or SUW mission packages with torpedo defense capabilities, making those ships reliant on protection from a second LCS, equipped with the ASW mission package, or an Aegis combatant that is operating nearby.

With respect to the ability to engage a submarine once detected, LCS will be less capable than Navy frigates or other ASW-capable surface ships. LCS has no organic capability to engage submarines and must rely on a single embarked helicopter to deliver torpedoes, whereas FFGs have the capacity to launch two helicopters (meaning at least one is more likely to be available), or use over-the-side torpedo launchers to engage nearby targets immediately. LCS, along with other Navy units, will suffer from the limitations of the Mk 54 torpedo's effectiveness and lethality recently discovered in testing; these problems affect LCS, DDGs, P-8, P-3, and helicopter effectiveness in ASW missions, and warrant a concerted effort to correct as soon as possible.

LCS-Frigate Design

In December 2015, the Secretary of Defense curtailed the buy of LCSs from 52 to 40, citing that a rebalancing of capability is needed to "reverse the trend of prioritizing quantity over lethality" and "reduce the number of LCS available for presence operations," a need that will be met by other high-end ships. The Secretary's decision is supported by the results of operational testing and the lack of lethality demonstrated by LCS to date. Of those 40, the Navy now plans to build the last 12 as a modified version of LCS that is more frigate-like. I have reported multiple times on the anticipated capabilities and limitations of the envisioned LCS-frigate; my most comprehensive assessment was provided in recent Congressionally-directed reporting requirements and in the assessment the Secretary requested of my office when the Small Surface Combatant Task Force was stood up in late 2014. I summarize some of my observations here from that and other recent reports.

The Navy's Small Surface Combatant Task Force identified that only major modifications to the existing LCS design could provide the Navy the survivability and lethality characteristics of past frigates desired for the future Small Surface Combatant. Because of the Navy's decision to keep the LCS seaframe, any future small combatant will, by and large, inherit the limited survivability characteristics inherent to the LCS design as well as the limitations in space, weight, power, and cooling.

The Joint Staff recently approved a CDD for the LCS-Frigate. The CDD requires that the modified LCS be multi-mission capable, more lethal, and more survivable. Its primary missions will be ASW and SUW, but is also required to be capable of launching an over-the-horizon missile, albeit without a clearly specified means of target designation. Because of the space, weight, power, and cooling limitations inherent in the current LCS design, the LCS-frigate most likely will <u>not</u> meet all of the requirements specified in the CDD simultaneously; this was a finding from the Navy's Small Surface Combatant Task Force. It will most likely require swapping mission modules or components of the modules to provide either the full mission capability for SUW or ASW, but not all of the capabilities of both mission sets simultaneously. In my estimation, the LCS-frigate will, therefore, not be a true multi-mission frigate. For example, the LCS-frigate configured with full SUW capability, would likely only retain an acoustic towed array and towed torpedo countermeasure to provide the ship some limited submarine detection capability and a torpedo defense capability, but not an active sonar. While such a configuration is clearly more capable than an LCS equipped with the SUW-mission package alone, it does not enable the LCS-frigate to conduct full ASW missions with an active sonar and act as an effective escort to high-value naval units.

Moreover, the ship's ability to simultaneously be equipped to conduct these missions plus others such as land-attack, anti-ship warfare, or provide local air defense to other Navy units (a traditional frigate role) are likely infeasible given the limitations imposed by this design. The Navy's Small Surface Combatant Task Force identified that if a true multi-mission SUW, ASW, and local area defense air warfare capability (for the frigate to be able to act as an escort) are desired, then a major design change to the LCS seaframes or a new design would be required.

I have previously expressed my concern that the CDD relegates all mission performance measures, other than the two measures for force protection against surface and air threats, to Key System Attributes rather than Key Performance Parameters, which permits the combat capabilities desired in these follow-on ships to be traded away as needed to remain within the cost constraints. As a result, the new LCS-frigate could, in the extreme, be delivered with less mission capability than desired and with limited improvements to the survivability of the ship in a combat environment. In fact, the LCS-frigate could meet all its KPPs without having any mission capability.

The vulnerability reduction features proposed for the LCS-frigate, while desired and beneficial, provide no significant improvement in the ship's survivability. Notwithstanding potential reductions to its susceptibility due to improved electronic warfare system and torpedo defense, minor modifications to LCS (e.g., magazine armoring) will not yield a ship that is significantly more survivable than LCS when engaged with threat missiles, torpedoes, and mines expected in major combat operations. The vulnerability reduction features included in the FFGs the Navy has deployed in the past made them significantly more survivable than an LCS. The LCS-frigate requirements do not address the most likely causes of ship and mission loss against certain threats. Specifically, the current LCS seaframes do not have sufficient separation and redundancy in their vital systems to recover damaged capability. Because the LCS-frigate design is not substantially different from the LCS Flight 0+ baseline and will not add much more redundancy or greater separation of critical equipment or additional compartmentation, it will be less survivable than the Navy's previous frigate class.

The Navy does plan several susceptibility reduction features to offset the above-described limitations of the seaframes. Testing has demonstrated that while the proposed susceptibility reduction features are clearly desirable, they do not reduce susceptibility to being hit to a value at all close to zero. Therefore, the incorporation of these features does not allow the assumption the ships will not be hit in high-intensity combat. The susceptibility reduction features to be incorporated in the LCS-frigate would not eliminate the possibility of being hit, and would, therefore, not provide significant improvement in the ship's overall survivability relative to the current LCS.

Finally, while the Navy is examining methods to reduce weight, it is anticipated the LCS-frigate, because of the simultaneous employment of ASW and SUW equipment, will be significantly heavier than the existing LCS resulting in a lower maximum sprint speed and less fuel endurance. The loss of sprint speed will therefore affect its success in small boat swarm defense, and its ability to keep up with a carrier strike group.

At a recent Surface Navy Association national symposium, the Secretary of the Navy redesignated LCS as a frigate, stating that LCS can "deploy with a carrier strike group," has "robust anti-mine and anti-submarine warfare capabilities" and "is capable of putting the enemy fleet on the bottom of the ocean." [8] None of these claims appear to be supported by the current capabilities demonstrated in testing, and instead describe a ship that is not yet built and under current Navy plans may never be built. Current LCSs do not have the endurance to deploy with a carrier strike group, its ASW and MCM mission packages do not yet exist, LCS has no anti-ship weapon to sink enemy combatants, and only a limited capability to sink a few small fast attack craft as I previous described. Some subset of these capabilities may yet come to fruition in the coming years; however, currently, LCS's limited lethality make these ships a shadow of the abilities of modern navy frigates.

Future Test and Evaluation Plans

In response to conditions that the FY16 National Defense Authorization Act placed on the availability of LCS program funding, the Navy successfully completed a partial update of the LCS Test and Evaluation Master Plan (TEMP) to support future OT&E of the seaframes and mission packages. Congress required the update to support planning of the needed testing of the Increment 3 SUW mission package, the ASW mission package, to reflect the significant changes to the program's air defense plans, as well as MCM mission package development and composition. I approved the change pages to the TEMP in March 2016. Additional updates are now required to complete a revision to the TEMP, including developmental and integrated testing plans, changes to reflect the Navy's evolving plans for the MCM mission package, air

8 See also the Senate Armed Services Committee letter to Secretary Mabus and Chief of Naval Operations Admiral Richardson dated February 5, 2016.

defense testing of the seaframes, and plans for providing seaframes with an over-the-horizon missile capability.

In closing, I would like to emphasize that operational, live-fire, and operationally-realistic developmental testing have been essential in identifying the significant problems that need to be overcome for this program to be successful. Although I had predicted the poor performance in my earlier reporting on the MCM mission package, it was only in testing of the full mission package, at sea, and aboard the ship with a trained crew that the Department was able to discover the significant problems and shortfalls that crews would face in MCM missions. In fact, the Navy's independent review team emphasized that a reliance on shore-based metrics and shore-based testing "provided a false sense of [system] maturity". Similarly, only in operationally-realistic testing of the SUW mission package were the inaccuracies of the gun, the limitations of the ship's maneuvering and tactics, and the deficient training revealed, and the overall effectiveness of the ship in those missions characterized. Testing should not be limited to only self-defense scenarios (as has been suggested by a narrow reading of the requirements), but should examine the LCS's ability to escort other ships, as a frigate would. I continue to recommend to the Navy that adequate developmental and operational testing be funded and conducted to ensure that the future capabilities envisioned for LCS are adequately characterized, and problems discovered and fixed prior to deployment and future procurements.