# Director, Operational Test and Evaluation redacted/unclassified input for the report required by Section 123 of H.R. 3979, National Defense Authorization Act for Fiscal Year 2015 (Update from FY14 Input)

**Reporting Requirements**

The FY15 National Defense Authorization Act (NDAA), Section 123 of H.R. 3979 extends the requirement in the Conference Report (113-66) accompanying H.R. 3304, the FY14 NDAA, for the Director, Operational Test and Evaluation (DOT&E) to coordinate with the Navy to submit a report on the Littoral Combat Ship (LCS). That reporting requirement stated:

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

DOT&E submitted an input to the FY14 NDAA report requirement in April 2014. It is attached for reference. Since the submission of that report:

- The Navy has updated their submission with additional content to answer the original reporting requirements;
- The Navy conducted an extensive study of small surface combatant alternatives, which DOT&E also reviewed and reported on to the Secretary of Defense;
- The Navy has conducted some additional testing providing some additional insight into the current performance of the LCS Mission Packages;
- The Navy has drafted (but not issued) an update to the LCS Concept of Operations.

Much of DOT&E's FY14 NDAA submission is still relevant and much of DOT&E's assessment has not changed. So as not to be redundant with the FY14 submission, this year's DOT&E submission for the NDAA reporting requirement provides updates to the attached FY14 submission and is tailored to address any changes pertinent to address the above mentioned topics.

**LCS Concept of Operations**

The DOT&E response to the FY14 NDAA reporting requirement provided a broad, comprehensive history of the Navy's evolving thinking about LCS, its capabilities, and how it might be used. That report stated simply that "The Navy's thinking about what the Littoral Combat Ship (LCS) would be and how it would be employed has evolved since its inception." This is expected, as much of the original vision for offboard sensors has not materialized and the Navy has gained additional insight into the capabilities and limitations of the seaframes and mission packages through experimentation, testing, and operations. The majority of the content from the previous DOT&E report input remains germane. The Navy is now working to develop an updated version of the Concept of Operations (CONOPS), called Revision C, which at the



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time of this document, is not yet approved by Navy leadership. DOT&E's response to the FY15 NDAA reporting requirements (this document) provides some amplifying information on that draft document. In general, DOT&E's primary conclusion remains the same: even as the envisioned missions, use of unmanned vehicles, and operating environments have shifted in the Navy's thinking, the use of LCS as a forward-deployed combatant, where it might be involved in intense Naval conflict, appears to be inconsistent with its inherent survivability in those same environments. Furthermore, the ability of LCS to successfully execute significant aspects of the envisioned CONOPS will depend on the success in developing operationally effective and suitable mission packages; the current and draft CONOPS are based on the expected capabilities of these mission packages in the future, and not on the demonstrated or desired performance of the earlier increments of those mission packages.

***High-Intensity Operations Deemphasized, Independent Operations Unlikely, and Air Defense Help Required***

When the Navy announced the LCS program in 2001, they were looking for a "*survivable, capable, near-land platform to deal with threats of the 21st century.*" Envisioned for use primarily in major combat operations, LCS was intended to be a self-sufficient combatant designed to fight and win in shallow-water and near-land environments, often independently, without risking larger combatants in constricted areas. It was to achieve these capabilities primarily through the use of offboard and largely unmanned systems, which would allow engagement of threats at some distance from the seaframe. Earlier versions of the CONOPS documents referred to LCS delivering focused mission capabilities to "kick in the door," and "sprinting ahead" of the Carrier Strike Group. The concepts included groups of LCSs, or even individual LCSs, operating independently of a strike group, at least in the initial stages of a crisis. This would potentially place multiple LCSs within range of shipborne and shore-based anti-ship threats before they have been neutralized or suppressed, implying that at the time, the Navy could have envisioned the LCS as being survivable in such a regime.

More recent descriptions of the LCS CONOPS have moderated that vision and now emphasize the use of LCS in less stressing missions or in less stressing threat environments. Revision B of the LCS Warfighting CONOPS, approved in 2011, acknowledges that "*although LCS can operate in high density, multi-threat littoral environments independently or as part of a SG (Strike Group), a lone LCS in one of the three focused mission configurations brings to the fight limited warfighting capability. The effective execution of combat missions involving LCS typically necessitates multiple LCS operating in a coordinated SAG (Surface Action Group) fashion for mutual support and usually ahead of the strike force's arrival to the operating area.*" That same CONOPS discusses LCS sprinting ahead of a strike group "to assist in preparing the operational environment for joint force assured access to critical littoral regions by conducting MCM [Mine Countermeasures], ASW [Anti-Submarine Warfare], and SUW [Surface Warfare] operations – under an air defense umbrella as determined by the operational commander." The units providing that dedicated air defense support would have to be stationed very near the protected units to have a reasonable chance of defeating Anti-Ship Cruise Missiles (ASCMs) launched in the littorals. Such a concept appears contradictory to the ship design, which is meant

to provide high sprint speeds; how LCS is to capitalize on its sprint speed when it must be protected by slower air defense ships is unclear.

***Vision of Unmanned/Offboard Sensors Largely Unrealized***

For each of the primary missions, the Navy desired to achieve the LCS vision through unmanned and offboard sensors and weapons. The engagement of small boats in the SUW mission was intended to occur remotely and at some distance from the LCS, using unmanned aerial vehicles (UAVs) with surface radar and high-rate-of-fire guns and missiles, as well as unmanned surface vehicles (USVs) to lay sensors or act as floating magazines. Early versions of the CONOPS discuss the (anticipated) stealthy and covert nature of the LCS MCM package, which would *reduce the need for escorts and significantly reduce the need for local air and maritime superiority*. This was to be achieved through a combination of the low observable nature of the offboard unmanned systems coupled with what the Navy envisioned as a stealthy and survivable platform.

Today's LCS has few of the features envisioned by the early CONOPS. It employs no unmanned offboard vehicles with the SUW mission package. The first increment of the MCM package includes two unmanned Remote Multi-Mission Vehicles (RMMVs), but their reach is limited to line-of-sight communications when conducting mine identification operations, a far cry from the original vision of keeping LCS far from the threat areas. Additionally, as currently configured, LCS can only operate one RMMV at a time.

The Navy plans to add a Fire Scout Vertical Takeoff and Landing Unmanned Aerial Vehicle (VTUAV) equipped with an electro-optical/infrared (EO/IR) sensor to the aviation module for each of the mission packages and has recently deployed LCS 3 with one Fire Scout (prior to operational testing). The future addition of a Longbow Hellfire surface-to-surface missile (SSM) mission module should provide additional reach, but still within the horizon; realization of the original desire for over-the-horizon missile engagements will have to wait until a future date. The Navy is considering an over-the-horizon SSM, and conducted an initial proof of concept firing in September 2014. When and if this will become part of the SUW mission package for LCS remains to be determined. An SSM system is also being considered for the new Small Surface Combatant (SSC) frigate.

***Newest CONOPs Draft Continues the Trends DOT&E Noted Previously***

Revision C of the LCS Warfighting CONOPS is awaiting approval by U.S. Fleet Forces Command. The draft of that document reviewed by DOT&E, which reflects lessons learned from the 2013 deployment of USS *Freedom* (LCS 1) and information derived from testing and war games, continues the moderating trend noted in last year's report. Nonetheless, rather than reflecting current capabilities, the CONOPS continues to describe the *projected capabilities of the mission packages that will be available in 2020 rather than the current capabilities*. Although it states that LCS is designed to work with other ships or *in support of* a strike group, it assumes that LCS will not normally be assigned to a strike group. It also assumes that LCS can perform a range of surface combatant roles under an air defense umbrella. The most definitive

statement of the envisioned use of LCS, relative to strike group operations, and the acknowledged need for air defense protection, is the following:

> *"LCS provides a 'first response' and extended forward-deployed presence, operating primarily in a SAG [Surface Action Group] construct detached from the strike group, with the capability to assure joint force access through littoral SUW [Surface Warfare], MCM [Mine Countermeasures] and ASW [Anti-Submarine Warfare]. Under these circumstances, LCS must operate under an appropriate AD [Air Defense] umbrella as determined by the operational commander and may be absorbed into the strike group for protection as necessary."*

Graphical depictions of the operational concept in the document, especially MCM, show a DDG or CG operating as part of the LCS SAG to provide the air defense cover; such a depiction reveals that the Navy considers this coupling of Aegis combatants to LCS SAGs a likely scenario in order to conduct MCM operations.

Earlier CONOPS discussed the possibility that LCS could perform missions in addition to those supported by the three planned mission packages if appropriate mission packages were developed. Those missions included Special Operations Force (SOF) support, Search and Rescue (SAR), Combat Search and Rescue (CSAR), Freedom of Navigation (FON) operations, Non-combatant evacuation operations (NEO), Theater Security Cooperation (TSC) operations, Global Fleet Station (GFS), Maritime Law Enforcement Operations (LEO), Maritime Security Operations (MSO), and Irregular Warfare (IW). Revision C notes that LCS has an inherent capability to perform these missions and others but cautions that the extent to which LCS with a SUW, MCM, or ASW mission package can conduct such secondary missions is assumed to be limited because of the ship's manning and limited space.

The draft CONOPS stresses the limitations imposed by the need to maintain connectivity with manned and unmanned systems during MCM operations, which will draw LCS closer to harm's way in order to perform its intended missions. Most notably, the need to remain within line-of-sight communications (no more than 10 miles) of the RMMV when investigating bottom contacts to identify whether they are mines is a particularly short tether. During operations to clear long, narrow channels or sea lines of communication (SLOCs), the need for line-of-sight communications will make it necessary to clear a series of operating "boxes" to accommodate the MCM forces, their air defense escort(s), and support vessels. Clearance of these operating boxes will impose additional "overhead" workload and slow the progress of MCM operations. The draft CONOPS notes that, although the Fire Scout VTUAV could be equipped with a communications relay capability, development of that capability is not funded.

The draft CONOPS notes that upon retirement/decommissioning of *Avenger* class mine countermeasure ships and MH-53E helicopters, LCS with the MCM mission package will be the primary U.S. Navy platform, but acknowledge that, as DOT&E has previously reported, the Navy will continue to rely on underwater MCM (UMCM) forces, explosive ordnance disposal mobile units, Navy divers, unmanned underwater vehicle (UUVs) and Naval Oceanography Mine Warfare Center UUV platoons because of projected gaps in LCS MCM capability.



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***Modularity is a Double-Edged Sword***

One aspect of LCS that has remained constant from the earliest thinking to the most recent CONOPS is the idea of a focused mission platform achieved through modularity and the use of mission packages. The concept documents have also been consistent in identifying the primary mission packages, and therefore the priority missions of LCS, as MCM, ASW, and SUW, with a particular focus in the latter case on defense against high-density small boat attacks. The Navy has continually touted the benefits of modularity as the means to achieve flexibility to address operational needs in theater.

Whether the concept to provide multi-mission capability through modularity is the most cost-conscious method for ship design is beyond the scope of DOT&E's review. However, modularity, even if the Navy demonstrated seamless reconfiguration, presents unique challenges to naval warfighting. Since each LCS is capable of only a single mission, operational planners will need to carefully consider how to pair multiple LCSs together in SAGs to ensure that multiple missions can be conducted in an area of operations. Because an LCS equipped with the SUW mission package has no ASW capability, for example, many areas of operation where multiple threats are present will require multiple LCSs to work together for mutual protection against threats, or for the likely multi-mission character of many Navy warfare scenarios. Such grouping of two or three LCSs with disparate mission packages is in addition to the now-acknowledged need for destroyer/cruiser support for air defense in some scenarios. The CONOPS, therefore, acknowledges the difficulty of planning LCS SAGs because of the inherent lack of multi-mission capabilities, making three or four ships (three LCSs plus one air defense platform) sometimes necessary to enable mission accomplishment and ensure survivability. The same mission scenarios could be accomplished with 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.

Modularity could be desirable and beneficial if the non-modular ship must give up some capabilities to retain multiple missions. If a frigate, for example, being inherently a multi-mission ship, had to accept less ASW capability because it is restricted in space and weight to retain full SUW or air defense capabilities, then modularity would be a desired trait in the design of a new ship. However, the Navy has already shown that multi-mission ships can be built without giving up capabilities in any one mission. The benefits of retaining a modular mission design must be carefully weighed in light of the Navy's often multi-mission deployments, the increased logistics burden, and more complicated concept of operations. The Navy has suggested that modularity enables an easier integration of as yet unknown mission packages; while this is a possible benefit, it has not yet been realized, nor are there any proposed mission packages beyond the three currently in development. Moreover, whether these other mission packages would require physical modifications to the seaframe will depend on the specific components and cannot be assumed to easily plug in to existing seaframes.

The Navy conducted one demonstration of a mission package reconfiguration in preparation for the 2014 Rim of the Pacific (RIMPAC) exercise when an Increment 1 MCM

mission package was removed from LCS 2 and replaced with an Increment 2 SUW mission package. Navy testers and DOT&E were not present and do not have data on the success or timing of that demonstration. While it is possible that a reconfiguration was successful stateside, it remains unclear whether in-theater mission package exchanges are feasible or desirable given the timeliness and anticipated logistics burden. The draft CONOPS also notes that "The required lead times to support an MP [mission package] exchange and the actual mechanics of the swapout process are under development by various working groups and Commander Naval Surface Forces." At a minimum, the envisioned exchange will occur in approximately 4 days followed immediately by a 7-10 day work-up period to integrate LCS and mission package crews (especially the air detachment). This two-week period for an exchange assumes no difficulties are encountered in the mission package embarkation, that all of the equipment is available at the exchange site (requiring advance teams to deploy to the site for preparations at least 30-60 days ahead of time according to the document), and that all crew training and certifications are complete.

The CONOPS discussed both tactical exchanges and strategic exchanges, with the latter being unplanned and conducted on short notice. "Tactical modularity or "swapability" takes into account the manning, training, and equipment issues required to enable rapid exchanges of mission packages, on the order of days or weeks, while strategic modularity can take months to years to fully execute."

**LCS Contribution to Core Navy Missions**

DOT&E's report input for the FY14 NDAA reporting requirements provided the details on LCS's contribution to the maritime strategy outlined in the October 2007 edition of "A Cooperative Strategy for 21st Century Seapower." The assessment for each core Navy mission has not changed. The draft Revision C of the LCS CONOPS reiterates the observation contained in the 2011 CONOPS that "The most effective near-term operational roles for LCS to support the maritime strategy are theater security cooperation (TSC) and MSO (maritime security operations) supporting deterrence and maritime security." Although the draft CONOPS reflects increasing confidence in the projected capabilities of the mission packages, DOT&E agrees with the stated view that the ship's sea control and power projection capabilities should be considered ***limited*** until demonstrated as each mission package becomes operational. It accurately notes that while components of the SUW mission package have been tested and deployed, development and testing of the MCM and ASW mission packages are incomplete. Testing conducted in 2013 and 2014 demonstrated that a *Freedom* class LCS equipped with an Increment 2 SUW mission package has a modestly enhanced capability for self-defense. The ship's capability to use its SUW resources to protect other ships has not been tested. The Navy plans to test the SUW mission package in an *Independence* class LCS later this year.

The MSO mission includes actions to mitigate threats short of war, including piracy, terrorism, weapons proliferation, transportation of contraband, and other illicit activities. Testing has demonstrated that the *Freedom* class LCS is capable of Maritime *Interdiction* Operations, including activities that the Navy now describes as approach, assist, and visit (AAV), in a low-threat environment when equipped with the Increment 2 SUW mission package, which includes

a Maritime Security Module comprising two 14-meter Rigid Hull Inflatable Boats (RHIBs), boarding party equipment, and additional berthing. (In previous versions of the CONOPS, this capability was described as Visit, Board, Search, and Seizure (VBSS)). The *Freedom* class LCS has also demonstrated the capability to deliver warning and disabling fire when required to support MSO. The *Independence* variant's MSO capability has not yet been tested.

As noted in DOT&E's 2014 report, *Freedom* demonstrated her capability to render Foreign Humanitarian Assistance (FHA), Foreign Disaster Relief, and Humanitarian and Civic Assistance (HCA) when she delivered 10 pallets of supplies to the Armed Forces of the Philippines in the wake of Typhoon Haiyan using the ship's embarked helicopter and a helicopter from USS *Cowpens* (CG 63).

In March 2015, the Navy issued a significant revision to the maritime strategy, which no longer defines the Navy's capacity in terms of core capabilities (to which the LCS CONOPS still refers). The new version describes five essential functions, which are used as building blocks to support accomplishment of seven naval missions. The connection between essential functions and naval missions is shown in Figure 1.

| | Essential Functions | | | | |
|---|---|---|---|---|---|
| Naval Missions | All Domain Access | Deterrence | Sea Control | Power Projection | Maritime Security |
| Defend the Homeland | X | X | X | X | X |
| Deter Conflict | X | X | | X | |
| Respond to Crises | X | | | X | |
| Defeat Aggression | X | | X | X | |
| Protect the Maritime commons | X | | | | X |
| Strengthen partnerships | X | X | X | | X |
| HA/DR | X | | | X | |

**Figure 1. Essential Functions Required to Support Naval Missions**

***All Domain Access***

The March 2015 version of the strategy introduces the All Domain Access function. This function supports all naval missions and is defined as assuring appropriate freedom of action in

any domain—the sea, air, land, space, and cyberspace, as well as the electromagnetic (EM) spectrum. This function has five components: battlespace awareness, assured command and control, cybersecurity operations, electromagnetic maneuver warfare, and integrated fires.

LCS sensors, weapons, and command and control suites limit the ship's capability to support battlespace awareness, assured command and control, or integrated fires. The LCS CONOPS readily admits that LCS cannot serve as a command and control hub for Navy operations given the limited space and lack of capability inherent to its combat system.

The *Freedom* class LCS has serious flaws in its cybersecurity posture, making its ability to function in all domains questionable. Cybersecurity testing conducted during the operational test aboard LCS 3 in FY14 uncovered significant vulnerabilities in the ship's onboard networks and systems. The details of these vulnerabilities are classified.

***Deterrence***

The revised strategy does not include LCS among those ships and forces capable of supporting the deterrence function: SSBNs, Carrier Strike Groups with airwing, surface and subsurface combatants with precision attack weapons, expeditionary Marine units deployed from amphibious ships, U.S. Coast Guard units, and ships capable of Ballistic Missile Defense.

***Sea Control/Power Projection/Maritime Security***

These essential functions appear to be very similar to the core missions discussed in DOT&E's FY14 report input. DOT&E's assessment of LCS's contributions to these functions is unchanged.

**Comparison of Combat Capabilities**

DOT&E's FY14 report provided a detailed comparison of LCS capabilities to those of the systems that LCS is expected to replace, including *Oliver Hazard Perry* (FFG 7) class frigates, *Cyclone* (PC 1) class coastal patrol ships, *Avenger* (MCM-1) class mine countermeasures ships, and MH-53E Sea Dragon helicopters and their associated MCM systems. As noted in last year's report, that comparison was challenging because many aspects of LCS capability remained unknown, DOT&E had never evaluated the effectiveness and suitability of some of the legacy systems, and none had been evaluated in recent years. Thus the provided comparison was based largely on an examination of the combat system suites of the respective ships and aircraft. Except as noted in the following updates on LCS capabilities, DOT&E has received no information that would alter the views expressed in last year's report.

Table 1 provides a visual aid for discussing the differences in capabilities between LCS and the ships it is expected to replace. The colors are an indication of LCS capabilities relative to the ship indicated in each row: green means LCS is more capable than the indicated ship class; red, less capable. Yellow is an indication that LCS is likely neither more nor less capable or the assessment is mixed (better in some and worse in other areas). In general, as DOT&E has stated before, unless LCS is equipped with the relevant mission package, its capabilities for that mission are either non-existent or severely degraded relative to the modern frigate or MCM class ships. Even when LCS is equipped with a mission package, its overall capabilities are less than a

multi-mission frigate, assuming that a frigate built today would include modernized air defense capabilities. A detailed discussion of each mission area is provided below.

**Table 1. Comparison of Capabilities between LCS and Other Ships**

| | Air Defense | SUW | ASW | MCM |
|---|---|---|---|---|
| Core LCS capability relative to FFG7 | | | No capability | N/A |
| LCS with SUW mission package relative to FFG7 | | Unclear without data | No capability | N/A |
| LCS with ASW mission package relative to FFG7 | | | | N/A |
| Core LCS capability relative to PC ships | | | N/A | N/A |
| LCS with SUW mission package relative to PC | | Unclear without data | N/A | N/A |
| Core LCS capability relative to MCM ships | | | N/A | No capability |
| LCS with MCM mission package relative to MCM ship | | | N/A | |

***Air Defense***

DOT&E's assessment of LCS's air warfare capabilities compared to the ships it will replace has not changed relative to the details provided in the FY14 NDAA report input. Additional details were provided in DOT&E's report on the SSC task force study. Air defense testing has not been completed for either LCS variant, nor have the air defense capabilities of the legacy ships been evaluated using current operational testing approaches, which rely on the self-defense test ship, live testing aboard a production-representative ship, and a robust modeling and simulation test bed. The Navy has also not tested the concept of using Aegis combatants to provide the air defense umbrella while LCS is conducting operations in the littorals, a clear need given the trends highlighted above in LCS CONOPS documents. Nevertheless, it is important to note that LCS's Probability of Raid Annihilation requirement was predicated on the notion that area air defense provided by Aegis combatants had already reduced the size of the ASCM raid. To argue that an Aegis combatant will defend LCS double counts the contribution of Aegis area defense.

The legacy MCM ships have no air defense systems. The PC coastal patrol ships similarly have little air defense capability, making LCS clearly superior to those ships.

A comparison of LCS's current air defense capabilities to the FFG 7 is not straightforward, however. The FFG 7 was never equipped with modern air defense systems,

making any direct comparison to LCS arguably inappropriate given the differences in the combat systems across three decades of development and improvements, and the Navy's choice not to modernize FFGs in recent years. As currently equipped, FFGs can only employ the Close-In Weapon System (CIWS) and soft-kill measures (electronic attack and countermeasures), making it possible that LCS air defense capabilities exceed those of the current FFG 7, but comparative test data would be required to make that determination.

At the height of its capabilities and given the less capable ASCM threats of the 1980s and 1990s, the FFG 7's combat system and employment of SM-1 missiles arguably gave the ship a credible area air defense (beyond the ability to conduct local air warfare or self-defense against ASCMs). Understandably, given the advancement in ASCM technology and proliferation, those capabilities translated to today would not provide an area air defense capability relative to Aegis destroyers. Although an FFG 7 does not have an area air defense capability relative to today's threat, an FFG constructed today would not be limited to the combat system of the 1980s. Upgraded versions of the ship's radar, Nulka, SLQ-32, Standard Missile (e.g., SM-2), or Evolved SeaSparrow Missile (ESSM) would likely give an FFG 7 a credible air defense capability relative to today's standards.

The most important difference between the LCS combat system and the FFG 7's is layered defense. FFG 7, originally, had four layers of defense – SM-1, Nulka countermeasures, active electronic support measures (SLQ-32), and CIWS. The FFG's SLQ-32 variant enabled some electronic attack capability (ability to jam older ASCM seekers), whereas LCS does not have that capability. Nulka has been shown in testing to be more effective against some threats than chaff, which is the only soft-kill countermeasure that LCS employs currently. Both LCS variants have only two layers of defense – Rolling Airframe Missile (RAM) and chaff. Therefore, relative to the FFG at the height of its capabilities, the LCS's combat system is arguably less capable. The improved capabilities against some specific threats through the use of RAM likely do not overcome the limitations imposed by having only two layers of defense. Furthermore, RAM has other known limitations that likely degrade LCS's capability relative to FFG 7's. Had the Navy continued to modernize FFGs, LCS's capabilities by comparison would have clearly been deficient.

Ultimately, DOT&E assesses LCS as having less or nearly equivalent capability to the LPD 17 air defense systems, which also employ RAM but have a more capable combat system. In a March 2011 report, DOT&E assessed that the LPD 17 class ships are not operationally effective against several modern classes of ASCMs. Therefore, it is unlikely that the *Freedom* class LCS will be able to meet the Navy's requirements for air defense based on the results available from LPD testing.

The Navy has reported that the SeaRAM system, which is employed on the *Independence* class and is being considered for backfit on *Freedom* class ships, forward-fit on the future SSC, and backfit on some destroyers, has successfully demonstrated a full "detect-to-engage" sequence in a recent naval exercise. DOT&E has not been provided the data from those events and cannot comment on the extent of the realism, the scope of the testing, or the accuracy of the results. In general, the SeaRAM system, to date, is largely untested. At the time of this report,

the SeaRAM system has never launched a missile from any ship, let alone been fired against an actual realistic threat; it has only been fired once in a land-based developmental test. The Navy plans to deploy USS *Coronado* (LCS 4) before SeaRAM has been fired against even the least challenging ASCM stream raid.

***Surface Self-Defense Comparison***

DOT&E's FY14 NDAA report noted that LCS has less capability for defense against small boat attacks when the SUW mission package is not embarked than FFG 7 class ships and PCs, which have more extensive weapon suites. In that configuration, the LCS capability to defend against small boat attacks is limited to one 57mm gun paired with an electro-optical sensor and/or air and surface search radar and four crew-served .50 caliber machine guns. Its capability when the SUW mission package is embarked is discussed in a later section. FFG 7 class ships are equipped with a radar-guided 76mm gun, a 25mm Mk 38 Mod 2 machine gun system that includes an integrated electro-optical gunfire control system, a 20mm CIWS, and .50 caliber machine guns. FFG 7s are normally deployed with one or two SH-60B helicopters, which could be armed with Hellfire missiles and machine guns. PCs have one Mk 38 Mod 2 machine gun system and an Mk 96 weapon system, which includes a 25mm machine gun, a 40mm grenade launcher, and an electro-optical fire control system on the same stabilized platform. The Navy has also installed a Griffin short-range SSM system on forward-deployed PCs. MCM 1 class ships have only six short-range, crew-served machine guns and two 40mm grenade launchers for self-defense. None of the ships has a long-range surface-to-surface weapon.

The multiple defensive layers inherent in some ship designs also provide redundancy to protect against system failures. During the period of data collection aboard LCS 3 in FY14, Mk110 57mm gun and DORNA EO/IR failures left the ship with only short-range, crew-served weapons for self-defense on several occasions. A single gun failure aboard a frigate, which has more than one organic gun system available, would not hinder the ship as much as it did on LCS when its 57mm gun failed. On the *Freedom* class, if the DORNA system fails, the ship might be able to engage small boats using the ship's air and surface search radar to provide targeting information to the gun system; however, that capability was not examined during the operational test, and it is not clear that the use of the radar would be a feasible alternative since DORNA also comprises the gunfire control system.

**Updates to DOT&E's assessment of LCS Surface Self-Defense**

Two test events completed on USS *Fort Worth* during FY14 demonstrated that the ship has the core capability to defeat a single small boat beyond the Navy's required keep-out range. The tests did not examine whether the LCS could defeat a larger number of boats with the seaframe's core weapons. The electro-optical gunfire control sensor, DORNA Electro-Optical Device, experienced occasional laser faults that interrupted Mk110 57mm gun firing during the single small-boat engagement and small-boat swarm engagements discussed in a subsequent section.

The surface self-defense capability of the *Independence* class LCS is still being evaluated in developmental testing. While they use the same Mk110 57mm gun as the *Freedom* class LCS, the ships have experienced problems with combat system integration and gun accuracy. The Navy conducted two 57mm gun system development tests aboard LCS 2 in January 2015. In a gun system accuracy test using a stationary towed target, the system exhibited poor accuracy. The Navy is investigating the cause of the accuracy problems.

The Navy had planned to conduct the second test as an integrated test to provide data for a future operational test, but cancelled those plans because of unresolved concerns about gun system performance. However, during the test, LCS 2 successfully defeated a single boat, but only after several attempts. Before firing the last salvo, the crew changed the muzzle velocity and made height adjustments using an unverified feature of the gun fire control system. Although the ship hit the target during this salvo, the ad-hoc nature of the adjustments raises questions about the repeatability of that performance.

The Navy plans to resume developmental testing in May 2015 and expects to complete an operational test aboard USS *Coronado* (LCS 4) before the end of the fiscal year. The ship will embark an Increment 2 SUW mission package for the test.

**Self-Defense against Torpedoes and Mines**

As DOT&E stated in the FY14 NDAA report input, LCS will have no capability to detect or defend against torpedoes unless the ASW mission package is embarked, unlike FFG 7 class ships that have some inherent capability to detect threat torpedoes and can employ a torpedo countermeasure system. Even with the LCS ASW mission package embarked, LCS will not have any automated torpedo detection capability. The PC 1 class ships also have no capability against torpedoes.

LCS has no effective capability to detect and avoid mines along its path, whereas MCM-1 and FFG 7 class ships have an inherent capability for such in-stride mine avoidance. Although the effectiveness of the MCM-1's mine-avoidance capability is unknown, the low magnetic and acoustic signatures of MCM ships reduce their susceptibility to influence mines. In contrast, both LCS seaframes, FFG 7s, and PC 1 class ships are considered susceptible to magnetic and acoustic influence mines.

Like its predecessor, the draft Revision C CONOPS notes that the LCS does not have a requirement for acoustic and magnetic signature reduction and cites the lack of signature information for use by Navy Component Commanders to evaluate the risk posed to LCS by susceptibility to mines or torpedo attacks. The draft CONOPS recommends that the LCS program office "conduct acoustic and magnetic signature measurements and work design requirements to reduce signatures." Until that work has been completed, Navy Commanders will have only the results of mine susceptibility testing conducted using an unloaded aluminum hull high speed vessel (USNS *Swift*) and unvalidated and unaccredited modeling and simulation to assess the risk to LCS posed by acoustic and magnetic influence mines when operating in shallow regions of the littorals. Those results indicate that the steel-hull *Freedom* class LCS, which has a degaussing system to control its magnetic signature, and the aluminum-hull

*Independence* class LCS, which has no degaussing system, will be at risk in shallow waters. The modeling and simulation, despite not yet being validated, have indicated that the *Freedom* class ships are somewhat less susceptible than *Independence* class ships.

***Surface Warfare***

The SUW mission package is designed to enhance LCS SUW capability. When equipped with an SUW mission package, the LCS SUW weapons include those organic to the seaframe (57mm gun and an electro-optical fire control system) and those included in the mission package. The weapon systems in the Increment 1 and Increment 2 SUW mission packages include two Mk 46 30mm guns with electro-optical fire control systems and an MH-60R helicopter, which can be armed with a machine gun and Hellfire missiles. The Navy plans to include the Fire Scout VTUAV and an SSM mission module in future increments.

Although the SUW weapons installed in LCS and the ships being replaced vary significantly in caliber, range, and rate of fire, DOT&E's FY14 NDAA Report concluded that there is no evidence that LCS is significantly more or less capable against the small boat threat than the other ships. DOT&E has no test data on the performance of FFG 7 class frigates and PC 1 class coastal patrol ships against the small boat threat to enable a quantitative comparison of their capabilities with those of an LCS equipped with an SUW mission package. However, the LCS has a speed advantage over the other two ships, which offers multiple benefits when defending against an attacking swarm, including slowing the attackers' closure rate and thereby gaining additional engagement time. With sufficient alertment, an armed helicopter gives both LCS and FFG 7 a detection and classification advantage over the PCs and provides an additional layer of defense. FFG 7's capability to embark two helicopters increases the likelihood that one will be available when needed. The additional helicopter coupled with a more extensive gun suite makes FFG arguably at least as capable as LCS; but given its lack of the speed advantage that LCS enjoys in these engagements, any comparison of capability between the LCS and the FFG is difficult to justify without actual test data.

**Updates to DOT&E's assessment of LCS Surface Warfare Capabilities**

The *Freedom* class LCS and its Increment 2 SUW mission package achieved mixed results against small boat swarms during FY14 testing. In a developmental test completed in October 2013, USS *Fort Worth* (LCS 3) successfully defeated a small swarm beyond the prescribed keep out range. One of the boats became airborne while crossing LCS 3's wake at high speed, suffered damage when it slammed back to the surface, and eventually sank. The remaining boats were defeated with gunfire. In a second developmental test in February 2014, LCS 3 was not successful in defeating all of the boats beyond the keep-out zone. Following intensive remedial training to hone the crew's tactics, ship-handling, and gunnery, LCS 3 successfully defeated a small swarm in an operational test conducted in April 2014. The embarked helicopter assisted with early detection, tracking, and classification of the attacking boats but did not employ any weapons during the tests. Although the tests demonstrated that the *Freedom* class LCS has the capability to defeat a small swarm under relatively benign conditions, they provided insufficient data for DOT&E to determine with confidence whether the probability of success meets the Navy's requirement.

The Navy has not yet completed testing of the SUW mission package in an *Independence* class LCS. Developmental testing completed in FY14 disclosed integration problems between the seaframe's Integrated Combat Management System and the mission package. Additionally, the problems with inaccurate 57mm gunfire described earlier will detract from the ship's overall SUW performance if not resolved. The Navy plans to resume developmental testing in May 2015 and expects to conduct an operational test in USS *Coronado* (LCS 4) before the end of FY15.

***Mine Countermeasures***

DOT&E's response to the FY14 NDAA reporting requirements contained a detailed assessment of LCS MCM performance based on available data from developmental and early operational testing and a comparison of LCS and legacy MCM force capabilities. The following sections update that information to incorporate the results of additional testing conducted in late FY14 and early FY15. While DOT&E's earlier comparison between LCS and legacy systems is still germane, this year's report provides additional details derived from a review of the CONOPS and the updated LCS test results.

**Updates to DOT&E's assessment of LCS MCM Capability**

DOT&E's FY14 NDAA report indicated that the Navy had not yet demonstrated through end-to-end testing under operationally realistic conditions that an LCS equipped with an MCM mission package could orchestrate the complete sequence of steps necessary to find and neutralize mines without significant delays and interruptions. One area that has continually hampered successful and timely MCM operations is the launch and recovery of the RMMV. After the Navy made changes to hardware and procedures and conducted more extensive crew training, the Navy was successful in demonstrating improved launch and recovery tempo during a developmental test in 1QFY15. The crew completed 16 launches and 14 recoveries during the test period. Prior to this phase of testing, the Navy had imposed restrictions if wave action was expected to exceed certain parameters (a function of wave height and period). Even though the recent test was conducted within these parameters and marine conditions were generally favorable, several instances of equipment damage delayed or prevented recovery of an offboard RMMV.

In addition to launch and recovery problems, DOT&E's FY14 NDAA report discussed the Remote Minehunting System's (RMS) reliability problems even after the Navy had concluded a reliability growth effort directed by the Undersecretary of Defense (USD) for Acquisition, Technology, and Logistics (AT&L) following the program's Nunn-McCurdy breach in 2009. Since that report, the Navy has implemented additional RMS upgrades and conducted additional developmental and integrated testing in preparation for the planned LCS operational test in FY15. In the recent phase of LCS developmental testing (1QFY15) mentioned above, and in the recent phases of shore-based RMS developmental and integrated testing (1-2QFY15), RMS reliability problems persisted. These problems include the inability to align the system's inertial navigational unit, intermittent communications, a lube oil pump failure that caused a mission abort, capture latch impairment that precluded shipboard recovery of the RMMV, degraded electro-optic identification capability resulting in a mission abort and replacement of

the AN/AQS-20A towed body, tow cable damage following several snags on underwater objects or mooring cables, and multiple incidents of stuck AN/AQS-20A fins or fin actuation faults.[1] Following LCS developmental testing in 1QFY15, DOT&E determined that RMS reliability (mean time between operational mission failures) was no more than 20 hours and that statistical analysis of all existing data does not yet support the Navy's assertions of improving RMS reliability. Although the Navy continues to report reliability improvements, test data from the more recent RMS developmental testing are not yet available to update this assessment.

During the 1QFY15 developmental test, fleet operators were unable to execute operationally realistic, end-to-end mine reconnaissance and clearance without intervention by testers with knowledge of ground truth target positions. As a result, LCS 2, equipped with the Increment 1 MCM mission package, only partially covered shallow- and deep-water operating areas in three weeks of testing. Because the end-to-end mission was truncated artificially and more time would have been required to identify all mine-like contacts (including many that were erroneous, i.e., false classifications) to achieve the required clearance percentage, these test outcomes suggest that operationally realistic coverage rate results for this test period would have been less than the Navy's already reduced Increment 1 mission package requirements. Testing also continued to reveal problems when Sailors use RMS to revisit search areas in an attempt to prune AN/AQS-20A sonar's false classifications, a necessary step to minimize follow-on efforts to identify these contacts.

Although the RMMV can search autonomously while operating over the horizon from the LCS, it can currently only conduct operations to reacquire and identify bottom mines within the range of line-of-sight Ultra High Frequency communications. As noted earlier, this limitation will complicate MCM operations in long shipping channels, and may make it necessary to clear a series of LCS operating areas to allow MCM operations to progress along the channel. These cleared operating and maneuvering areas are a byproduct of LCS CONOPS that aim to keep the LCS and its crew out of mined waters while conducting RMS identification operations. The additional effort required to clear LCS operating areas will increase demand for mine clearance and delay attainment of strategic objectives. Although this limitation is not new to the RMS, it did not become operationally significant until the Navy decertified the MH-60S helicopter for towing MCM devices, including the AN/AQS-20A sensor. Lacking the option to use a helicopter-towed AQS-20A, the LCS currently has no capability to conduct identification operations beyond the horizon. The Navy has not yet identified a solution to this problem.

DOT&E's earlier assessment indicated that mission package minehunting systems (AN/AQS-20A and Airborne Laser Mine Detection System) had not demonstrated the detection/classification and localization capabilities needed for an LCS equipped with an Increment 1 MCM mission package to meet its required sustained area coverage rate. The Navy had planned to correct AN/AQS-20A deficiencies prior to the FY15 operational test of the Increment 1 MCM mission package by shifting to an improved version of the sensor

[1] In some cases, tow cable snags rendered the system inoperable in the assigned mission until a replacement tow cable could be installed with the assistance of shore-based support.

(AN/AQS-20B) and integrating the improved sensor into the MCM mission package. Following delays in the delivery of AN/AQS-20B prototypes and problems discovered in early characterization testing, the Navy chose to defer introduction of the AN/AQS-20B and plans to proceed to operational testing in FY15 with the AN/AQS-20A. Although AN/AQS-20A sonar performance is unchanged, the Navy reports that recent testing of the RMMV v6.0 and AN/AQS-20A show improved horizontal contact localization accuracy following system software changes. The Navy also implemented software changes designed to improve the system's probability of reacquiring bottom objects. Test data needed to confirm contact localization improvements and reassess reacquisition performance have not yet been provided to DOT&E. The Navy has also not yet identified a schedule for testing and introduction of the AN/AQS-20B in a subsequent increment of the mission package.

The Navy is also working on pre-planned product improvements to enhance Airborne Laser Mine Detection System (ALMDS) detection performance and reduce the frequency of receiver failures, but does not expect to integrate these changes into the first increment of the MCM mission package. Last year, the Navy completed an experimental deployment of the existing system to the 5th Fleet to assess the system's performance in theater. Although commanders reported that the system offered some unquantified detection and classification capability, they also identified a number of planning and evaluation shortcomings and indicated that the system "did not necessarily improve current MCM capability." During the experimental deployment and developmental testing aboard LCS 2, frequent receiver failures continued to reduce ALMDS functional search width (requiring more time than expected to complete high-confidence searches for near-surface mines). Furthermore, the first increment of the LCS MCM mission package still requires placing Explosive Ordnance Disposal personnel in the minefield for some mines.

DOT&E's FY14 NDAA report noted that the Navy had not yet completed operational testing of the Airborne Mine Neutralization System (AMNS). During a shore-based operational assessment of the AMNS in FY14, the system was unable to achieve the Navy's requirement for mine neutralization success except under limited conditions not generally expected during combat. Failures of the host MH-60S aircraft's systems and its associated Airborne Mine Countermeasures (AMCM) Mission Kit limited AMNS mission availability. The primary cause of unsuccessful attack runs was frequent loss of fiber-optic communications between the aircraft and the neutralizer. Although the Navy subsequently attributed the failures to the bottom composition (sand and shells), DOT&E is not satisfied that the root cause of these failures has been determined. However, even if the bottom composition was actually the root cause, it is important to note that the bottom composition in the test areas was representative of realistic operating areas and would likely be encountered in actual MCM operations. Reliability and fiber-break problems negatively affect the timeliness of LCS-based AMNS operations and will likely reduce the ship's sustained area coverage rate, since additional helicopter sorties and significantly more neutralizers will be needed to clear the mines. Following the FY14 operational assessment, the Navy developed a plan to reduce the likelihood of failures of the fiber-optic communications; however, the Navy does not expect to fully implement these system changes until FY16. Furthermore, the Navy has not yet mitigated system performance

deficiencies identified during developmental testing in moderate-to-swift current, another challenge that the system would face during littoral MCM operations. In the interim, the Navy plans to proceed to the first phase of LCS MCM operational testing with the existing system in an area where current is not expected to be a problem.

***Comparison of LCS and Legacy MCM Performance***

MCM performance is measured by the ability to detect/classify, identify, and eliminate mines in sustained and timely operations over large areas. Thus, LCS and legacy MCM performance are compared on the basis of two criteria: (1) detection, classification, identification, and neutralization success against a range of likely mine threats and (2) the sustained area clearance rate or timeliness of meeting objectives (i.e., time to clear). The assessments and supporting analyses in the following sections will show:

- LCS equipped with the first increment of the MCM mission package will likely provide detection, classification, and identification performance that is similar to legacy performance against most threats. LCS does not currently have the mine clearance (or neutralization) systems to match legacy system capabilities against near-surface and beach zone threats. Neither legacy nor LCS systems provide sufficient MCM capability to accomplish the Navy's campaign objectives for timely mine clearance.
- Even if LCS MCM area clearance rates equal area clearance rates of legacy systems, current LCS limitations and CONOPS require LCS to clear more area, and hence make LCS less efficient than legacy systems, when both are tasked to clear transit lanes through potentially mined waters. In the most challenging scenario for LCS, the additional LCS workload significantly increases the time required relative to legacy.
- Although LCS limitations do not impose the same workload demands in all scenarios, the small number of LCS MCM mission packages that might be available to deploy before FY20 will not contribute significantly to the Navy's MCM capability.
- Even if all MCM mission packages expected to be available at full operational capability are embarked in the LCS fleet, the Navy will be unable to meet key campaign scenario objectives with LCS alone. The Navy's strategic timelines for mine clearance will remain at risk unless LCS MCM performance ultimately exceeds the Navy's current expectations.

**Mine Detection, Classification, Identification, and Neutralization**

Figure 2 provides a qualitative assessment of the performance of legacy systems and LCS with the Increment 1 MCM mission package and the final MCM mission package in various phases of the detect-to-engage sequence. The legacy and Increment 1 assessments are based on DOT&E's review of available data, whereas the final LCS/mission package assessment reflects

the Navy's view as of 2012.[2] Figure 2 shows that DOT&E does not expect the LCS MCM concept to deliver significant performance gains in the near term. Available data suggest the Increment 1 mission package will include detection, classification, and identification systems that provide performance similar to legacy systems against most threats and mine clearance (or neutralization) systems that provide no capability to match legacy systems' capability against near-surface and beach zone threats. Although limited by environmental conditions, the ALMDS is expected to provide some capability to detect and classify near-surface mines that does not exist in the legacy fleet. However, whereas legacy systems are capable of clearing near-surface mines, the first increment of the MCM mission package does not include an organic capability to identify or neutralize near-surface mines. As indicated by the rightmost column under each phase of the MCM sequence, the Navy is hopeful that the final (Increment 4) mission package will deliver greatly improved performance that allows it to achieve intended MCM operational capability against most threats. However, a recent program review presentation to USD (AT&L) characterized achievement of many of the final increment performance requirements as high risk. Additionally, as indicated above in the LCS performance update, the Navy has not yet identified a near-surface neutralization solution that will allow the LCS to replace legacy mechanical sweeping capability augmented by EOD units.

| Mine Type | Detect/Classify | | | Identify | | | Neutralize | | |
|---|---|---|---|---|---|---|---|---|---|
| | Legacy | LCS (Inc 1) | LCS (Final) | Legacy | LCS (Inc 1) | LCS (Final) | Legacy | LCS (Inc 1) | LCS (Final) |
| Anti-Landing and Beach Zone | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Near Surface | ● | ● | ● | ● | ● | ● | ● | ● | TBD |
| Drifting | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Volume | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Close-Tethered / Rising | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Bottom | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Bottom Stealth | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Buried | ● | ● | ● | ● | ● | ● | ● | ● | ● |

● Required Operational Capability

● Partial Operational Capability (poor performance in some conditions)

● No Operational Capability

**Figure 2. Comparison of Legacy and LCS MCM Capabilities by Mine Type**

[2] OPNAV N952 briefing charts, "Legacy to LCS MCM Transition," 21 May 2012.

**Sustained Coverage/Clearance Rate and Timeliness**

The time required to counter the large-scale employment of sea mines altered war plans during Operation Desert Storm and motivated renewed focus on improving the Navy's MCM capabilities. A classified study of clearance efforts following Desert Storm quantitatively estimated the legacy MCM systems' area clearance rate.[3] A subsequent Mission Needs Statement (MNS) for MCM (M042-85-93) (October 1993) recognized the timeliness of MCM operations as the primary shortfall in this mission area. The MNS cited required MCM capabilities that included (1) rapid reconnaissance and assessment of the mine threat, and (2) clearance of the sea mine threat through detection, neutralization, or sweeping, including rapid breakthrough of chokepoints. The Navy developed requirements for the new systems it now expects to field with LCS based on similar criteria.

More than 20 years later, the capability gap cited in the MNS above has not been mitigated; aging legacy forces are being decommissioned, and the Navy continues to develop a suite of MCM systems that it expects to field as an LCS mission package capable of replacing legacy systems. As a result, MCM capacity has declined because the Navy has been unable to field the expected LCS MCM capability to replace 12 MHC-51 class ships and three MCM-1 class ships decommissioned since 2006. Moreover, as recently as 2012, the Navy resource sponsor indicated the combined clearance rate of one MCM-1 ship and 1 MH-53E helicopter (the legacy unit considered comparable to one LCS) was less than one-third of the legacy capability demonstrated in the early 1990s.[4] Despite recent investments to improve legacy performance, test-quality data continue to be unavailable to support a quantitative assessment of current legacy coverage/clearance rates.

Although the Navy asserts that the first increment of the MCM mission package would make LCS at least as capable as existing legacy MCM assets, Navy expectations (requirements) for LCS MCM performance continue to change. Table 2 in DOT&E's classified version of this report provides a summary of LCS Flight 0+ Capability Development Document (CDD) threshold requirements. In 2008, when the CDD was written, the Navy expected to deliver a mission package capable of meeting these requirements before FY13.[5] In February 2013, the Navy issued, for the first time, interim performance requirements applicable to the first increment of the LCS MCM mission package, a fraction of the final desired area clearance rates. As noted above in the LCS update, testing has not yet demonstrated that an LCS equipped with the first increment of the MCM mission package will achieve these already-reduced requirements. These conclusions suggest LCS performance has not yet reached parity with legacy performance cited by the Navy in 2012.

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3 CNA Document CRM 93-86 (June 1993), "Effectiveness of U.S. and UK Mine Countermeasures Operations in the Persian Gulf Following Desert Storm."

4 OPNAV N952 briefing charts, "Legacy to LCS MCM Transition," 21 May 2012.

5 Section 5.4.4 of Flight 0+ CDD. Increment 4 is analogous to the baseline Spiral Alpha MCM mission package identified in the CDD.

**Table 2. Summary of Key Flight 0+ Performance Thresholds**
REDACTED

The LCS incremental performance requirements letter deferred all other MCM capabilities, including attainment of full CDD requirements for shallow- and deep-water minehunting and clearing, to later increments of the mission package. More recently, the Navy acknowledged significant risk in its strategy to deliver the full MCM mission package capability that includes improved shallow- and deep-water minehunting and clearing, beach zone/surf zone and very shallow water coverage, and mine sweeping capabilities.[6] The same briefing indicated the Navy eventually expects its LCS MCM capability to achieve shallow- and deep-water clearance rates comparable to the clearance rate achieved by legacy systems nearly 25 years earlier; thus, the 1993 Mission Needs Statement would remain unmitigated and the timeliness of MCM operations would continue to be a potential shortcoming in future campaigns.

In addition, even if LCS MCM area clearance rates were equal to area clearance rates of legacy systems, current limitations require LCS to clear more area and make it less efficient than legacy systems when both are tasked to clear transit lanes through potentially mined waters (particularly in shallow waters). In the most demanding case, additional MCM workload to provide the required LCS maneuvering space significantly increases the time to clear mines relative to the legacy case. In other cases, such as clearance of large operating areas, LCS limitations do not increase workload since the area cleared for LCS to maneuver coincides with tasking effort. These results are a byproduct of the LCS CONOPS that aim to keep the man out of the minefield by using offboard systems, the limited range of high-data-rate communications necessary for shipboard operators to employ the RMS to identify bottom objects (in shallow waters only), and the need to clear the large maneuvering areas required for LCS to launch and recover RMMVs and the MH-60S helicopter.

The operational implications of LCS limitations are further illustrated by considering the Navy's "What It Takes To Win" (WITTW) criteria for one important Major Combat Operations (MCO) scenario. WITTW criteria are classified, making a quantitative comparison of LCS and legacy clearance rates and clearance demands impossible for this redacted report. Please see DOT&E's classified report for these details.

**Table 3. Clearance Demand in the Sea Lines of Communication Portion of WITTW Scenario**
REDACTED

**Table 4. Clearance Demand in Full WITTW Scenario**
REDACTED

In addition to the workload imposed by efforts to provide LCS maneuvering areas that are cleared of mines, the combined results provided in Tables 3 and 4 of the classified version of

[6] LCS Program Defense Acquisition Board In-Process Review (DAB IPR), 8 April 2015.

this report show that independent surface action groups consisting of legacy MCM ships or LCSs will still be significantly challenged to meet the Navy's needs. Details are discussed in the classified version of this report.

Furthermore, even if the first increment of the MCM mission package reaches initial operational capability as planned in FY15/16, total LCS MCM capability, in the near-term, will be limited by the number of available updated (v6.0) RMMVs. The Navy has upgraded four RMMVs to the v6.0 configuration and plans to upgrade three additional units by FY17. Although each Increment 1 MCM mission package includes two RMMVs, the LCS mission modules program office indicates two additional shore-based back-ups are required to support testing and training. If a similar logistics concept were employed during operations, seven or eight v6.0 RMMVs would support no more than two Increment 1 MCM mission packages until at least FY20 when the Navy expects new RMMVs to become available. Thus, Tables 5 and 6 provided in the classified report suggest LCS will contribute little to the Navy's campaign scenarios in the near-term. DOT&E classified report provides estimates of the LCS force structure and other supporting units needed to fulfill the WITTW scenarios.

**Table 5. LCS Time to Clear the Sea Lines of Communication Portion of WITTW Scenario**
REDACTED

**Table 6. LCS Time to Clear in WITTW Scenario**
REDACTED

Coordination amongst LCS assets or between LCS and legacy assets may also limit any significant LCS involvement in potential near-term operational scenarios. Without the ability to exercise multiple LCSs equipped with the MCM mission package, it is unclear whether the Navy can demonstrate successful command and control over multiple LCSs with multiple offboard assets, resolve frequency conflicts between RMMVs, or share contact information between platforms to maximize employment of available assets. Operational testing will be necessary to determine the Navy's ability to complete MCM timelines and execute these new concepts of operations unique to LCS.

***Anti-Submarine Warfare***

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 currently plans to move that testing, scheduled in FY16 in the Test and Evaluation Master Plan (TEMP), to FY18 for the *Freedom* class, and will likely postpone the operational test to FY19 or later on the *Independence* class. The primary causes for these delays are higher testing priorities and the availability of ships; the pressure for forward deployments and the need to complete other development and test events have reduced the pool of available ships for even the initial stages of developmental testing.

The Navy did conduct an at-sea test of an Advanced Development Model (ADM) of the Variable Depth Sonar (VDS) in September 2014 aboard USS *Freedom* (LCS 1). The primary focus of that test was to examine the integration of the VDS and TB-37 Multi-Function Towed

Array (MFTA) with the LCS platform; however, data were collected to evaluate the sonar's detection performance of submarines under highly-structured scenarios.

The ADM VDS sonar transmitter coupled with the MFTA sonar receiver showed promising sensor performance in one environment. The operators were highly-cued, however, since they were provided prior knowledge of the target submarine's position. Moreover, the target operated in a non-stressing low-contact environment (few likely false detection opportunities), and did not execute evasion tactics that are expected of any submarine that can hear the sonar transmissions of the VDS. These types of limitations are typical of such early testing, but preclude DOT&E from providing any assessment regarding the expected effectiveness of the ASW Mission Module in a real-world combat scenario at this time.

With regard to comparing the capability to legacy systems, the LCS's sonar system is specifically optimized for deep water and is not suitable for operations in some very shallow-water environments. Contrast this with the FFG, which has little long-range deep-water active sonar capability like the LCS ASW mission package, but does have some limited capability in shallow waters since the active sonar array is hull-mounted. In terms of detection capability, provided the ASW mission package engineering challenges can be overcome, it theoretically should have greater capability in deep-water environments than the FFG, but will remain less capable in very shallow-water environments for detecting submarines. A continuously active sonar that can be deployed below the surface sonic layer is clearly an advantage in those environments over a hull-mounted pulsed sonar array, like that aboard an FFG. However, testing has consistently revealed that active sonars, whether a VDS or hull-mounted, while offering the potential for long-range detections, can suffer from high numbers of false alarms, which can be debilitating and offset any advantage gained from increased detection ranges. Whether the ASW mission package suffers from the same problem in any of these acoustic environments remains to be seen.

With respect to the ability to engage a submarine once detected, LCS is less capable than the FFG. 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 (at least one is more likely to be available), or use the over-the-side torpedo launchers to engage nearby targets immediately.

As previously stated, an LCS that is not equipped with an ASW mission package has no capability to detect submarines, nor any capability to defend against them, making that configuration of an LCS clearly deficient relative to the multi-mission FFG, unless a second LCS, equipped with the ASW mission package, or an Aegis combatant is operating nearby and can provide the needed protection.

**Assessment of LCS Survivability**

DOT&E's assessment of LCS's survivability is unchanged from previous reports. The LCS is not expected to be survivable in high-intensity combat in that it is not designed to maintain mission capability after receiving a significant hit. DOT&E's assessment is based on a review of LCS survivability design requirements and the results of early survivability testing,

modeling and simulation, and analysis of threats LCS might encounter when operating ahead of the Strike Group as described in the CONOPS.

These conclusions highlight a potential mismatch between the anticipated LCS operating environment and the ship's limited survivability. The latest 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 SAGs, 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 in a hostile combat environment.

During DOT&E's review of the work completed by the Navy's Small Surface Combatant Task Force, it became clear that LCS does not have the survivability features commensurate with those inherent in the USS *Oliver Hazard Perry* Class Guided Missile Frigate (FFG 7) it is intended to replace. The FFG 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.

**Status of Operational Testing and the Test and Evaluation Master Plan (TEMP)**

On February 18, 2015, in response to the reporting requirements of Section 124 of the NDAA for FY15, DOT&E provided Congress with a detailed report on the status of operational testing and the Navy's progress in completing the test program prescribed by the LCS TEMP. A thorough description of each test event, completion status, reason for delays, and recent changes to the test program is provided in that report.

The Navy is finding it difficult to fulfill the plan detailed in the approved TEMP. The integration of concurrently developed components into the MCM mission package has not been as easy as originally planned, and the Navy has appropriately decided to conduct additional developmental testing after making system changes in an attempt to correct the identified problems with subsystem performance. Several test periods have been postponed – some by multiple years – most often because the LCS seaframes have not been and are not expected to be available when needed to support the test schedule prescribed in the TEMP. Some delays can be attributed to the early seaframes' lack of maturity at delivery and the resulting requirements for unplanned repairs and modifications. Decisions to include the ships in major fleet exercises and to press for establishment of a continuous, multi-LCS Presence in Singapore in FY17 are

reducing the pool of ships available to participate in the test program. This deficit is exacerbated by the demands of the Navy's 3:2:1 ship/crew rotation plan, which is designed to permit three crews to staff two ships, one of which is continuously forward-deployed. The forward-deployed ship is obviously not available to participate in testing, but the availability of the non-deployed ship is also affected by this policy because it must support the training of the non-deployed crews. Thus, the Navy is finding it difficult to meet the simultaneous demands for LCS fleet operations, both forward-deployed and in home waters, as well as mission package development and the necessary developmental and operational testing. One example of these conflicting priorities is the push to delay air warfare testing to future hulls, which has also been compounded by the lack of production-representative systems. Despite the first ship's commissioning in 2009, the *Independence* variant's air defense capabilities will not be operationally tested until FY17, when LCS 8 is available. The *Freedom* variant's air warfare testing will shift to LCS 7 and is currently planned to occur in late FY16, also nearly 8 years after its commissioning.

The Navy recently completed the operational testing of the *Freedom* variant's seaframe (core capabilities testing) and the first phase of operational testing for the SUW mission package, but only for the increment installed on the *Freedom* variant. The Navy has not yet completed testing of the *Independence* seaframe, has not completed testing of the MCM mission package, and has not completed operational testing of any other package aboard either of the seaframes. DOT&E's report on OT-C1, the first phase of operational testing of the SUW mission package, will be an interim assessment, and will be available in 3QFY15. In that report, DOT&E expects to assess the Flight 0+ *Freedom* class seaframe's core capabilities in surface self-defense and in the conduct of routine shipboard evolutions. The test will also allow DOT&E to assess the endurance of the ship's small crew during a protracted period of medium-intensity operations and to assess the reliability and availability of the seaframe. DOT&E will also use the results from OT-C1 and the earlier integrated test events to provide an updated evaluation of the performance of the Increment 2 SUW mission package when installed in a *Freedom* class seaframe. Although the combined events will include only three defensive operations against small boat swarms, the additional data are expected to bolster DOT&E's earlier assessment of that capability.

The Navy has scheduled 15 additional phases of LCS operational testing to accommodate their plan to field the LCS mission capabilities incrementally as the mission systems mature. DOT&E will also be participating in multiple LCS-related test events to monitor the development of these mission systems. According to the latest schedule, the next two operational tests will evaluate *Independence* seaframes with the Increment 1 MCM mission package and Increment 2 SUW mission package in FY15. The Navy has also scheduled integrated developmental and operational test events designed to provide a limited assessment of the LCS seaframe's air defenses; DOT&E's assessment of LCS air defenses cannot be completed until the Navy conducts more thorough "lead ship" air warfare testing on LCS 7 and 8, completes the planned self-defense test ship testing of the combat system, and completes the robust modeling and simulation studies planned for the FY18-19 timeframe. DOT&E is currently monitoring the conduct of the MCM mission package workup period, and final developmental test period for the Remote Minehunting System. Since DOT&E plans to obtain



**Redacted Version**

many of the data needed for an adequate assessment of the MCM package from integrated test periods (combined developmental and operational test events), DOT&E is closely monitoring those test periods and will observe the final technical evaluation just prior to the operational test of that mission package.

Since the current LCS TEMP contains only scant details on the out-year tests, the Navy plans to flesh out those plans in the next TEMP update. That update was expected to be completed before the end of 2015 but is now delayed, primarily because the Navy has not yet provided the details on its plans to finish development of the components of the future increments. Initial plans for completing testing of the follow-on increments of the mission packages as well as completing seaframe evaluations not yet conducted (e.g., full ship shock trial is now planned for FY16), are discussed in DOT&E's classified FY15 NDAA report. The Navy expects to complete all phases of LCS Initial Operational Test and Evaluation for the final increments of each of the mission packages by FY20.

**Completed Survivability Testing, Modeling, and Simulation**

Much of the survivability-related testing conducted to date has focused on the demonstration of compliance with design requirements. This type of testing can provide useful information to the Live Fire Test and Evaluation (LFT&E) process, but it is not sufficient to answer the critical issues delineated in the LFT&E Management Plan. The majority of the findings from the completed events are summarized in the DOT&E FY14 NDAA report submission.

The Navy has concluded 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). Studies on aluminum structure integrity are of particular importance for the *Independence* class, which is constructed primarily from aluminum, not steel, like other Navy combatant ships. Furthermore, the *Freedom* class' superstructure is also aluminum. The Navy has not yet assessed the likelihood of major structural damage from a weapon-induced fire, which is the larger concern for combatants that are expected to operate in combat environments where anti-ship cruise missile hits could cause internal fires. Internal blast effects can damage fire insulation and suppression systems that would normally be available to mitigate the fire effects in an undamaged compartment. Data from the multi-compartment aluminum structure blast and fire tests, which will be conducted later this year, are needed before DOT&E can credibly assess the likelihood of major structural damage from a weapon-induced fire. It is, therefore, premature to draw any other conclusions about the structural integrity of the LCS hull, at the time of this report.

Since the FY14 NDAA report was submitted, the Navy has conducted a Total Ship Survivability Trial (TSST) on the *Freedom* variant. DOT&E's report on that testing is expected to be completed in the near future; the following discusses preliminary conclusions and findings.

The Navy completed a TSST in October 2014 aboard USS *Fort Worth* (LCS 3) in the Southern California operating area. The TSST is an at-sea damage scenario-driven trial with the ship in a near "full-up" status. 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. A similar trial for the *Independence* variant USS *Coronado* (LCS 4) will not be conducted until early FY16.

For LCS, the TSST shotlines were originally planned to be based on analyses performed for the Detail Design Integrated System Assessment Report (DDISAR). Because the Navy did not complete the DDISAR analyses, the trial team had to select TSST shotlines prior to having a full understanding of the expected damage and before the potential for mission recovery was fully developed. The lack of fully developed and documented shotline analyses hindered the ability to ensure that the selected scenarios were recoverable. Recoverable shotlines are typically chosen for the TSST, but because of LCS's low damage tolerance, not all shotlines were recoverable for the LCS 3 trial. Once the pre-trial damage predictions were completed, the Navy determined that three of the four scenarios would be non-recoverable. Since the LCS design requirements do not require retention of primary mission following most weapon encounters, the focus of the trial was on damage control and containment; the recovery actions the crew could take to reconstitute mission capability were therefore limited.

A summary of the ship's post-hit capability is provided in Table 7 in the classified version of this report. The LCS 3 TSST highlighted the existence of significant vulnerabilities in the *Freedom* class design. Much of the ship's mission capability was 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 of the systems could be redesigned or reconfigured to make the ship less vulnerable and more recoverable without requiring major structural modifications.

There are insufficient analytical and test and trial data to determine if the *Freedom* variant will meet its survivability design requirements. However, some general observations are made in DOT&E's classified version of this report using the limited analyses that have been completed.

DOT&E plans to issue a full TSST report later this fiscal year. That report will contain additional detail and discussion of the results and will also include a list of ship design recommendations to improve the vulnerability and recoverability of future *Freedom* variant LCSs and *Freedom*-based frigates.

**Table 7. LCS 3 TSST Results**
**REDACTED**

**Assessment of LCS Endurance**

DOT&E's FY14 report input noted that the Navy had measured the fuel endurance (unrefueled operating range) of LCS 2 and LCS 3 during calm water trials conducted in 2013 and that preliminary reporting indicated that both seaframes meet the Navy's requirement to transit a

distance of 3,500 nautical miles at 14 knots with a full mission package payload without refueling at sea. DOT&E's FY14 report also stated that LCS 2 reportedly has excess fuel capacity but cannot fill all storage tanks to capacity when loaded with a complete mission package without exceeding the ship's full load displacement design limit.

However, during operational testing completed in 2014, LCS 3 ***did not*** demonstrate that it could achieve the Navy requirement for fuel endurance at the prescribed transit speed or at sprint speed. Information provided by the Navy indicated that between 91 and 92 percent of the ship's total diesel fuel (F-76) tank capacity would actually be available for use since some room must be left for expansion when the tanks are filled, a portion of the tanks' volume is filled with piping and structural members, and a small amount of fuel remains inaccessible when the tanks are emptied. Based on fuel consumption data collected during the test, the ship's operating range at 14.4 knots is estimated to be approximately 1,960 nautical miles and the operating range at 43.6 knots is approximately 855 nautical miles (Navy requirement: 1,000 nautical miles at 40 knots).[7] In an emergency, the ship could use its aviation fuel (F-44) to extend the transit and sprint ranges by 360 and 157 nautical miles, respectively. The shortfall in endurance may limit the flexibility of the ship's operations in the Pacific and place a heavier than anticipated demand on fleet logistics.

It is not entirely clear why the operational testing of endurance resulted in differing conclusions from the Navy's calm water trials, from which they assess LCS as meeting the endurance requirements. The Navy has not yet issued the reports from either LCS variant's endurance trials, making any study of differing conditions between the two tests impossible. However, differences in sea and wind conditions during the trials, differing assumptions about the quantity of fuel available, differences in ship displacement, and inaccuracies in the measurement of fuel consumption could account for some of the differences. During the LCS Program Defense Acquisition Board In-Process Review (DAB IPR) on April 8, 2015, the LCS program office reported that LCS 3's fuel endurance is 3,405 nautical miles (nmi) and that LCS 2's endurance is 4,285 nmi. The draft CONOPS provided lower endurance estimates for planning battle group operations and states that experience during RIMPAC 2012 showed that LCS 1 needed fuel every day when operating with a carrier to maintain the desired minimum fuel level onboard and notes that the ship will require fuel every four or five days when operating at the slowest speed to keep its fuel level above these same desired minimums.

The Navy plans to evaluate the fuel endurance of the *Independence* class LCS in USS *Coronado* (LCS 4) during an operational test scheduled in 4QFY15.

Table 8 provides a comparison of endurance and speed capabilities between LCS, the anticipated SSC frigate and the FFG 7.

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[7] The Navy Operational Test Agency did not explain the reason for the excess transit and sprint speeds during the 2014 test.

**Table 8. Comparison of Endurance Features**

| Capability | LCS Flight 0+ Requirement | LCS *Freedom* Variant OT Results | Modified LCS SSC | FFG 7 Flight 4 |
|---|---|---|---|---|
| Endurance Range (nmi)/ Speed (knots) | 3,500 nmi / 14 knots | 1960 nmi / 14.4 knots | 2,600 nmi / 14 knots | 4,000 nmi / 20 knots |
| Stores Endurance (days) | 14 | 14 | 14 | 30 |
| Sustained Speed (knots) | 40 | 43.6 | *Freedom*: 31<br>*Ind.*: 34 | 29+ |

DOT&E's FY14 report also noted that equipment failures and the repair capacity of LCS crews may limit LCS's ability to maintain full mission capability for protracted periods at sea. Equipment failures caused *Fort Worth* to abort operations and return to port for repairs on several occasions in FY14, including repairs to propulsion and maneuvering systems and the Total Ship Computing Environment that resulted in 42 and 36 days of downtime during the period of operational test data collection. Crew fatigue may also limit the ships' endurance during periods of high-intensity operations.

**Manning Plan Assessment**

DOT&E's report input to the FY14 NDAA requirements provided a detailed discussion of LCS manning, and DOT&E is not aware of any subsequent changes to the LCS manning plan. The draft Revision C CONOPS acknowledges the employment considerations that are driven by the limitation of a small crew, noting that although LCS is expected to participate in Phase II operations and beyond, the increased operating tempo and work load risk will have to be weighed against maintenance requirements and crew fatigue.

**LCS Casualty Reports**

The Navy input to the FY15 NDAA reporting requirements provides an updated tally of equipment casualty reports (CASREPs) by ship and severity and offers explanations for the growth in numbers of CASREPs. DOT&E has no other data.

It is important to note, however, that experience has shown that the number of CASREPs is not a reliable indicator of equipment reliability and availability. Although originally designed to notify the chain of command about the failure of critical equipment and the concomitant limitations on a ship's capabilities as well as the need for assistance and repair parts, CASREPs now often serve primarily to justify and expedite repair assistance and high priority parts requisitions. Today's ships have much more expedient and less formal methods for informing their chain of command about mission-limiting equipment casualties, including email and satellite voice communications. DOT&E has observed cases where a clear operational mission failure has occurred, requiring a part replacement to correct, but no CASREP has been issued. Similarly, DOT&E has observed many CASREPs issued to ensure part demand remained high, or a request for help is expedited through that system, but with no corresponding severe failure to mission capability aboard the ship.

For the sake of completeness in characterizing LCS's reliability and availability, Table 9 describes the operational mission failures that occurred during the period of data collection for the operational test conducted aboard LCS 3 in FY14. More than 150 equipment malfunction events were recorded during the period of about 180 days, but only those in Table 9 caused a loss of some essential mission functionality. Thirteen of the listed failures were documented in CASREPs (those that are marked with an asterisk in the table), but twelve others were not (particularly those that the crew was able to restore without assistance). The ship filed a total of 47 CASREPs during this same period; the majority of those failures were not considered operational mission failures.

**Table 9. Operational Mission Failures (OMFs)**

| OMF Number * =assoc. CASREP exists | Date Discovered | System Affected (Category) | Area Affected | OMF Description | Downtime (hours) (Excludes time in CNAV and PMAV) |
|---|---|---|---|---|---|
| 1 | Pre-existing failure at start of data collection on 30-Sep-13 (Not included in reliability analysis) | Link-16 (Comms) | Core Mission | Unable to establish datalink with other platforms because of failed signal message processor. Repair completed 27 Oct 13 with technical assistance and part(s). Satisfactory test on 11 Nov 13. | 648 |
| 2 | 3-Oct-13 | Boat Ramp (WMZ) | Mission Package Support | Hydraulic power unit overheated stopping operations to reposition launch ramp to launch/recover boats. Repair method not recorded. | 1 |
| 3 | 8-Oct-13 | NAVDDS (TSCE) | Core Mission | Failed NDS 2 circuit card disrupted navigation inputs to combat systems including TRS-3D, TACAN, SHF SATCOM, and 57mm GFCS. Corrected by cannibalization of circuit card from NDS 1 on 11-Oct-13 and assistance from prime vendor and OEM. | 83 |
| 4 | 8-Oct-13 | Port Shaft (Propulsion) | Seaframe Operations | Leakage of lubricating oil from line shaft bearing forced ship to return to port with locked shaft. Corrected by replenishing oil supply. Cause of leakage not reported. | 11 |
| 5* | 11-Oct-13 | SPS 75 Radar (Sensors) | Core Mission | Unable to track air targets because of failed Doppler processor. Corrected on 11/9/13 by installation of replacement power supply. | 704 |
| 6 | 12-Oct-13 | LHRS (WMZ) | Mission Package Support | Failed circuit breaker rendered crane inoperative. Corrected by cannibalization of circuit breaker from another location. | 3 |
| 7 | 12-Oct-13 | Boat Ramp/ Door (WMZ) | Mission Package Support | WMZ boat ramp and stem door could not be operated. Neither cause nor corrective action was recorded. | 3 |

| OMF Number * agreed, CASREP exists | Date Discovered | System Affected (Category) | Area Affected | OMF Description | Downtime (hours) (excludes time in CMAV and PMAV) |
|---|---|---|---|---|---|
| 8 | 16-Oct-13 | WBR-2000 (Sensors & Controls) | Core Mission | System elements removed to lab to correct persistent interface faults and unreliable operation. Corrected on 10/25/13 with use of a substitute hard drive provided by OEM or ISEA. | 240 |
| 9 | 17-Oct-13 | 30mm GMMs | SUW Mission Package | Both 30mm GMMs inoperative. Loose MT-301 stripper cover plate caused feed jam and MT-302 lost video because of failed "Magic-1" Video Computer and Sensor Array Frame Grabber. | 7 |
| 10 | 19-Oct-13 | VMS (Navigation) | Seaframe Operations | Server fault caused total loss of Voyage Management System (VMS) functionality. Corrected by resetting XNS server. | 1 |
| 11 | 19-Oct-13 | Mk 110, 57mm (Seaframe Weapons) | Core Mission | Faulty main power switch (S-14) caused gun to lose power during firing event. Corrected on 11/1/13 by installation of repaired switch. | 219 |
| 12* | 22-Oct-13 | VMS (Navigation) | Seaframe Operations | Failure of 2nd of 2 VMS computers rendered the system inoperative. (One computer had been described as degraded at start of data collection.) Both computers were reportedly restored by 11/21/13, but Casualty Correction report was not sent until 12/11/13. | 624 |
| 13* | 18-Nov-13 | LHRS (WMZ) | Mission Package Support | Bent overhead track rail rendered LHRS crane inoperative. Repaired with industrial assistance during CMAV that commenced 12/2/13. | 336 |
| 14* | 21-Nov-13 | RDDS (TSCE) | Core Mission | Bent pins on TSCE circuit card assembly for the Radar Data Distribution System (RDDS) caused loss of raw and processed video for SPS 75 radar in MCC. Corrected on 1/22/14 with ISEA assistance. | 1,224 |
| 15* | 22-Nov-13 | Starboard Steerable Waterjet (Propulsion) | Seaframe Operations | Loss of hydraulic oil from loose fitting on the outboard hydraulic ram caused ship to terminate operations and return to port with starboard shaft locked. Corrected on 1/14/14 with industrial assistance. | 1,008 |
| 16* | 9-Jan-14 | Platform Lift (MP Support) | Mission Package Support | Broken rollers caused lift to fail during offload operations. Corrected on 2/7/14 with industrial assistance. | 718 |
| 17* | 21-Jan-14 | Port Splitter Gear Oil Cooler (Propulsion) | Seaframe Operations | Squadron commander directed ship to return to port for preemptive repairs after crew reported detecting oil in seawater side of cooler. Cooler replaced with industrial assistance. | 154 |

| OMF Number * asterisk indicates CASREP exists | Date Discovered | System Affected (Category) | Area Affected | OMF Description | Downtime (hours) (includes time in CMAV and PMAV) |
|---|---|---|---|---|---|
| 18* | 29-Jan-14 | SPS 75 (Sensors) | Core Mission | Failure of power supply caused loss of air tracks and radar sweep. Corrected on 1/30/14 with part obtained from LCS 1. | 71 |
| 19* | 30-Jan-14 | DORNA (Sensors) | Core Mission | Ship observed that laser was providing inaccurate range measurements. Laser replaced on 2/7/14 with part cannibalized from LCS 1. | 95 |
| 20 | 11-Feb-14 | LHRS (MP Support) | Mission Package Support | Crane failed to operate when required for RHIB launch. Corrected by repairing failed electrical connectors. | 2 |
| 21* | 15-Feb-14 | DORNA (Sensors) | Core Mission | Laser was providing inaccurate range measurements because of faulty pedestal power unit. Restored on 2/24/14 by replacing power unit. | 208 |
| 22 | 16-Feb-14 | LHRS (MP Support) | Mission Package Support | Loss of power interrupted RHIB recoveries on two occasions. Repair method not recorded. | 1 |
| 23* | 24-Feb-14 | Link 16 (Comms) | Core Mission | Unable to establish datalink because of Low Volume Terminal (LVT) failure. Repaired with ISEA assistance by replacing LVT chassis on 3/4/14. | 176 |
| 24* | 4-Mar-14 | SPS-75 radar (Sensors) | Core Mission | Radar inoperative; electrical fault damaged amplifier, antenna motor, and power cable. Repaired with OEM and prime vendor assistance on 3/17/14. | 304 |
| 25* | 20-Mar-14 | Starboard Steerable Waterjet (Propulsion) | Seaframe Operations | Ship returned to port for repairs after failed feedback cable caused loss of starboard steering control. Repaired with industrial assistance on 3/25/14. | 130 |

**Small Surface Combatant Study and Follow-on Frigate**

Although not part of the reporting requirements for the FY15 NDAA, the Navy discusses its plans for the future variants of the LCS, referred to as the small surface combatant (SSC), or its most recent designation: a follow-on frigate. Given its close connection to the LCS program, it is worthwhile to comment on the capabilities and limitations of that ship, at least as it is currently proposed.

***Background***

In February 2014, the Secretary of Defense directed the Navy to submit proposals for a capable small surface combatant to follow the first 32 LCSs. The Navy established a Small Surface Combatant Task Force (SSCTF) which examined not only ship alternatives, but also proposed a variety of what the Task Force calls Capability Concepts to survey the possible defensive and offensive capabilities of a frigate-like ship. The study also examined differing

levels of vulnerability/recoverability (survivability) to threats that overcome the ships' defensive capabilities. The Task Force did not make a final recommendation of what ship design is best for the Navy's needs or cost constraints; rather it laid out the range of possibilities for a small surface combatant. Navy leadership then proposed, and the Secretary approved in December 2014, an LCS with relatively minor modifications (e.g., no hull redesign or extension) as the top-level design concept for the follow-on small surface combatant.

Prior to this decision, the Secretary tasked DOT&E, Cost Assessment and Program Evaluation, and AT&L to also provide an assessment of the SSCTF study to aid his decision. DOT&E provided a written report to the Secretary in October 2014. A brief summary of DOT&E's conclusions from this study are provided below. The full report is also included in DOT&E's classified version of this report.

***SSC Study Conclusions***

The SSCTF assessed what it calls Capability Concept 5D as meeting most, but not all, of the Fleets' desires for a frigate-like ship and developed top-level requirements for this concept. Concept 5D requirements include fully self-contained (that is, not provided by removable and replaceable modules or larger mission packages) multi-mission combat capabilities in each warfare area listed above, as well as the ability to survive a hit by non-overmatching threat weapons and retain primary combat mission capabilities. The Task Force determined that only a new design ship could fully satisfy Concept 5D requirements, although major modifications to the existing LCS design could provide ships satisfying most of the Concept 5D top-level requirements. Therefore, by extension, the minor-modification to the LCS, which the Navy has chosen to pursue, does not satisfy many of the aspects of a modern multi-mission and survivable frigate as desired by the Fleet.

Compared to Concept 5D, the follow-on frigate, or SSC(X), provides capability in each warfare area, but relies in some cases on removable/replaceable modules (but not entire mission packages, as in LCS) to provide full capability; thus, an SSC(X) deploying with full combat capabilities in one mission area would sacrifice some capability in another, but not as much as LCS. It is ***not a true multi-mission frigate***, however. For example, an SSC(X) configured with the full SUW capability, would retain only an acoustic towed array and towed torpedo countermeasures to provide the ship some limited submarine detection capability and a torpedo defense capability. While such a configuration is clearly more capable than an LCS equipped with the SUW-mission package, it does not enable the SSC(X) to conduct full ASW missions, thereby not making it a true multi-mission platform. The embarked helicopter would likely not be configured with the dipping sonar necessary for ASW prosecution, and it is unclear whether the helicopter, being configured primarily to conduct SUW, could be quickly reconfigured to carry and employ torpedoes. Furthermore, the SSC(X), again configured for SUW, would not enjoy the full active sonar capability envisioned for the ASW mission package. Therefore, the SSC(X), while having elements of a multiple missions, primarily to enable some additional defensive capability, would not be a multi-mission frigate.

### SSC Survivability

With respect to survivability, most of DOT&E's analysis is classified and redacted from this report. Table 10 and Table 11, in the classified version, compare the vulnerability of the LCS baseline designs, SSC(X), and FFG 7 class based on the ships' vulnerability reduction features. The vulnerability reduction features included in the FFG 7 class make it significantly more survivable than the LCS and SSC(X). The SSC(X) high-level requirements do not address the most likely causes of ship and mission loss against certain threats. With respect to susceptibility reduction features, testing has demonstrated that while such capabilities 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 SSC(X) would not eliminate the possibility of being hit, and would, therefore, not provide significant improvement in SSC(X)'s overall survivability relative to LCS.

**Table 10. Vulnerability Reduction Features Comparison**
REDACTED

**Table 11. Threat-based Vulnerability Comparison**
REDACTED

### Air Warfare

With respect to air warfare capabilities, the Navy plans to change the primary radar on LCS, change the electronic support system, and add the Nulka countermeasure to augment its soft-kill system (flares). However, the missile system will remain the same as on the *Independence* class LCS ships (SeaRAM). Currently, DOT&E has no data on the efficacy of the envisioned radar or new electronic support system, which is designated Surface Electronic Warfare Improvement Program (SEWIP) lite. It is possible that both the radar and SEWIP lite systems would be an improvement over the currently installed systems aboard LCS, but operational testing will be needed to make such a determination. Regardless of these changes, the envisioned air warfare suite will be similar to that currently employed on LPD 17 class ships, which also employ RAM (only) and Nulka combined with a primary surface search radar and electronic support system.

Therefore, the self-defense systems envisioned for the SSC are unlikely to be significantly more capable than the self-defense systems employed on LPD 17, which DOT&E has already assessed as not effective against some threats. Test results for the LPD 17 are provided in DOT&E's classified version of this report. Thus, while it is certainly useful to employ these self-defense systems, it cannot be assumed they will prevent the ships on which they are installed from being hit.

As discussed above, the FFG 7 was never equipped with modern air defense systems, making any direct comparison to SSC particularly difficult, and arguably inappropriate given the differences in the combat systems across three decades of development and improvements. At the height of its capabilities and given the less capable ASCM threats of the 1980 and 1990s, the

FFG 7's combat system and employment of SM-1 missiles arguably gave the ship a credible area air defense (beyond the ability to conduct local air warfare or self-defense against ASCMs). Understandably, given the advancement in ASCM technology and proliferation, those capabilities translated to today would not provide an area air defense capability relative to Aegis destroyers. Although an FFG 7 does not have an area air defense capability relative to today's threat, an FFG constructed today would not be limited to the combat system of the 1980s. In any case, it would be an inaccurate comparison to claim that SSC (or LCS) class ships are more capable than the FFG 7, since the FFG 7 never had a modern combat system for a meaningful comparison. Assuming that modern systems and missiles would be installed on the FFG 7 were it around today, it would also benefit from a stronger layered defense than the SSC. As discussed above for LCS, the FFG had (or would have) four layers of defense, whereas the SSC is only envisioned with two layers.

**Surface Warfare**

With respect to surface warfare capabilities, the Navy plans to add to the LCS SUW mission package capabilities and core seaframe capabilities (helicopter armed with hellfire missiles, two 30mm guns, and the 57mm gun), and two additional 25mm guns, the Harpoon missile for an over-the-horizon surface-to-surface capability, and make permanent the Longbow Hellfire vertical launch missile planned for small boat defense. The FFG 7 employs a different gun suite, with a larger 76mm gun and only one 25mm gun, but also employs CWIS, which SSC would not have. A quantitative comparison of gun performance for these two configurations against the variety of threats they would be used against is impossible without a credible side-by-side comparison test, however. FFG also can employ Harpoons for over-the-horizon surface warfare missions, making the SSC similar in that respect.

Assuming the integration of all these systems aboard the SSC is successful, which is not guaranteed, these systems would make the SSC on par with or even more capable (against some threats) than the FFG 7 surface warfare capabilities. Such a statement is only true with the SUW-configured SSC – elimination of several of these systems when the ship is configured for ASW, for example, calls into question its capability relative to the FFG.

The question of SSC's surface warfare capability is not so much whether it is superior to the FFG or PC class ships, but whether it will be effective against the actual anticipated threats. Specific threats and SSC's likely success against them are discussed in the classified version of this report. A thorough and realistic test to examine the mission area is needed before any statement of true capability is made.

**Anti-Submarine Warfare**

With respect to ASW, the SSC would employ the same capabilities as the LCS Flight 0+ baseline when all are in the ASW configuration (i.e., ASW mission package/mission module embarked). That version of the combat system would enable an SSC to have long-range detection capability, but only in deep-water environments and moderately shallow environments (which is most, but not all, of the anticipated operating areas of threat submarines). That detection capability is likely greater than that expected with a hull-mounted sonar, which is what

the FFG 7 employs. However, because all but one of the ship alternatives identified by the SSCTF would not have a hull-mounted sonar, the Navy's proposed SSC would have minimal capability in very shallow-water environments where the variable-depth sonar cannot be employed.

The envisioned SSC includes only one helicopter. This is in contrast to the FFG 7, which employs two helicopters and shipboard torpedo launchers. The additional helicopter that exists on FFG 7 enables a more persistent ASW search and attack capability. Therefore, although the SSC (and LCS) will likely enjoy a more capable detection capability, the ability to capitalize on those detections is diminished relative to the FFG, since the SSC employs only one helicopter.

It is important to note that the SSC will still retain a modular ASW capability. Although providing some detection capability with the passive acoustic towed array and torpedo defense through a towed countermeasure system, when the ASW module is removed to make room for the SUW mission module components, the SSC does not retain a robust ASW capability relative to the FFG. FFGs can continue to conduct both ASW and SUW without reconfiguration, whereas the SSC would retain a limited capability to only detect and avoid submarines.

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OPERATIONAL TEST
AND EVALUATION

APR 2 9 2015

The Honorable William M. "Mac" Thornberry
Chairman
Committee on Armed Services
United States House of Representatives
Washington, DC 20515-6035

Dear Mr. Chairman:

Section 123 of H.R. 3979, National Defense Authorization Act (NDAA) for Fiscal Year 2015 (FY15) required DOT&E and the Navy to provide a report on the Littoral Combat Ship (LCS) addressing the current concept of operations and expected survivability attributes of each of the seaframes. I have enclosed my unclassified redacted input to that report, which is an update to the same requirement in the NDAA for FY14. A more complete classified version of this report was provided to you on April 15, 2015. Much of my FY14 NDAA submission is still relevant and my assessment has not changed; I include that unclassified report for reference. The following are my conclusions for the majority of the topics required by the NDAA:

**LCS Concept of Operations**

- Even as the envisioned missions, use of unmanned vehicles, and operating environments have shifted in the Navy's thinking, the use of LCS as a forward-deployed combatant, where it might be involved in intense Naval conflict, appears to be inconsistent with its inherent survivability in those same environments. Furthermore, the ability of LCS to successfully execute significant aspects of the envisioned Concept of Operations (CONOPS) will depend on the success in developing operationally effective and suitable mission packages; the current and draft CONOPS are based on the expected capabilities of these mission packages in the future, and not on the demonstrated or desired performance of the earlier increments of those mission packages.

- The Navy is now working to develop an updated version of the CONOPS, called Revision C, which at the time of this document, is not yet approved by Navy leadership. The newest CONOPS continues the trends DOT&E noted previously and emphasizes the use of LCS in less stressing missions or in less stressing threat environments. It more clearly acknowledges the lack of organic air defense capabilities and the likely need to provide multiple LCSs with a dedicated air defense umbrella for forward-deployed operations in some environments.

- Since each LCS is capable of only a single mission and lacks the capability for self-defense against some threats, operational planners will need to carefully consider how surface action groups are composed to ensure that multiple missions can be conducted in an area of operations.

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.

**LCS Contribution to Core Navy Missions**

- LCS's contribution to Navy missions focuses around the three primary mission packages for Surface Warfare (SUW), Anti-Submarine Warfare (ASW), and Mine Countermeasures (MCM). While components of the SUW mission package have been tested and deployed, development and testing of the MCM and ASW mission packages are incomplete. Testing has demonstrated, and the Navy's CONOPS observes, that the *Freedom* class LCS is ideally suited for Maritime Interdiction Operations, which include activities that the Navy now describes as approach, assist, and visits (AAV) to mitigate threats short of war, including piracy, transportation of contraband, and other illicit activities. These operations are conducted in a low-threat environment and when LCS is equipped with the Increment 2 SUW mission package. The *Independence* variant's Maritime Security Operations (MSO) capability has not yet been tested.

**Comparison of Combat Capabilities**

- As noted in last year's report, a comparison of LCS to *Oliver Hazard Perry* (FFG 7) class frigates, *Cyclone* (PC 1) class coastal patrol ships, and *Avenger* (MCM-1) class mine countermeasures ships is challenging because many aspects of LCS capability remain unknown, DOT&E does not have test quality data for most of the legacy systems, and none have been evaluated in recent years. Thus, the provided comparison was based largely on an examination of the combat system suites of the respective ships and aircraft.

- I assess LCS as having less or nearly equivalent capability to the LPD 17 air defense systems, which I assessed in 2011 to be not operationally effective against several modern classes of Anti-Ship Cruise Missiles (ASCMs).

    - The legacy MCM ships have no air defense systems. The PCs similarly have little air defense capability, making LCS clearly superior to those ships.

    - A comparison of LCS's current air defense capabilities to the FFG 7 is not straightforward, however, since the FFG 7 was never equipped with modern air defense systems. As currently equipped, FFGs, can only employ the Close-In Weapon System (CIWS) and soft-kill measures (electronic attack and countermeasures), making it possible that LCS air defense capabilities exceed those of the current FFG 7, but comparative test data would be required to make that determination. The most important difference between the LCS combat system and the FFG 7's is layered defense. The FFG 7, at the height of its capabilities, had four layers of defense via multiple hard- and soft-kill systems; the LCS has two layers, the Rolling Airframe Missile (RAM) and chaff. Had the

Navy continued to modernize FFGs, LCS's capabilities by comparison would have been less.

- When the SUW mission package is not installed, the ship's capability to defend against small boat attacks is limited to one 57mm gun coupled to an electro-optical gunfire control system and four .50 caliber machine guns. FFG 7 class ships and PCs have more extensive weapon suites, which in addition to providing redundancy (more than one gun available should a failure occur) are also organic to the ship regardless of the mission being performed. LCS will have no capability to detect or defend against torpedoes unless the ASW mission package is embarked, unlike FFG 7 class ships that have some inherent capability to detect threat torpedoes and can employ a torpedo countermeasure system. LCS has no effective capability to detect and avoid mines along its path, whereas MCM-1 and FFG 7 class ships have an inherent capability for such in-stride mine avoidance.

- The SUW weapons installed in LCS and the ships being replaced vary significantly in caliber, range, and rate of fire. LCS has a speed advantage over the other two ships, which offers multiple benefits when defending against an attacking swarm. However, the ability to employ two helicopters (vice one) coupled with a more extensive gun suite could be advantageous for the FFG. Absent test data, I cannot provide a definitive comparison between the LCS and the FFG when conducting SUW.

- Although test-quality data continue to be unavailable to support a precise assessment of current legacy system MCM performance, it is clear that the Navy does not now possess the MCM capacity to achieve its wartime objectives. Nor will LCS's Increment 1 MCM mission package significantly improve the Navy's MCM capability, even if the Increment 1 MCM mission package achieves its interim requirements. Based on my current estimates of LCS's mine clearance capabilities, 2 LCSs with Increment 1 MCM mission packages (all that the Navy will likely be able to field and support through about 2020) would not fulfill the Navy's "What It Takes To Win" (WITTW) scenario.

    - Even if LCS MCM area clearance rates were equal to legacy systems, LCS, with the current limitations of the Increment 1 mission package, will take several times longer to complete the mission objective than the legacy systems. This result is a byproduct of: (1) LCS CONOPS that aim to keep the man out of the minefield by using offboard systems, (2) the limited range of high-data-rate communications necessary for shipboard operators to employ the Remote Minehunting System (RMS) to identify bottom objects, and (3) the need to clear the large maneuvering areas required for LCS to launch and recover Remote Multi-Mission Vehicles (RMMVs) and the MH-60S helicopter.

- 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. That sonar system is specifically optimized for deep-water environments. Contrast this with the FFG, which has little long-range deep-water active sonar capability, but does have some limited capability in shallow waters since the active sonar array is hull-mounted. In terms of

detection capability, provided the ASW mission package engineering challenges can be overcome, LCS theoretically should have greater capability in deep-water environments than the FFG, but will remain less capable in very shallow-water environments for detecting submarines. A continuously active sonar that can be deployed below the surface sonic layer is clearly an advantage in those environments over a hull-mounted pulsed sonar array, like that aboard an FFG. However, testing has consistently revealed that active sonars, whether variable-depth or hull-mounted, while offering the potential for long-range detections, suffer from high numbers of false alarms, which can be debilitating and offset any advantage gained from increased detection ranges. Whether the ASW mission package suffers from the same problem in any of these acoustic environments remains to be seen. With respect to the ability to engage a submarine once detected, LCS is less capable than the FFG, since the LCS must rely on a single helicopter to deliver torpedoes, whereas the FFG has the capacity to launch two helicopters or use its over-the-side torpedo launchers.

**Assessment of LCS Survivability and Summary of Completed Survivability Testing**

- The LCS is not expected to be survivable in high-intensity combat in that it is not designed to maintain mission capability after receiving a significant hit. Although the CONOPS anticipates providing additional warships for LCS protection, such allocations mean stretching already limited air defense assets, and risking reduced protection for the battle group. 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 improve its survivability after receiving a significant hit.

- LCS does not have the survivability features commensurate with those inherent in the USS *Oliver Hazard Perry* Class Guided Missile Frigate (FFG 7) it is intended to replace. The FFG is designed to retain critical mission capability and continue fighting if need be after receiving a significant hit.

- Since the FY14 NDAA report was submitted, the Navy has conducted a Total Ship Survivability Trial (TSST) on the *Freedom* variant. As an element of the Live Fire Test and Evaluation (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 highlighted the existence of significant vulnerabilities in the *Freedom* class design. Much of the ship's mission capability was 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 of the systems could be redesigned or reconfigured to make the ship less vulnerable and more recoverable without requiring major structural modifications.

**Status of Operational Testing and the Test and Evaluation Master Plan (TEMP)**

- This report contains a summary of progress in completing the test program prescribed by the LCS TEMP; however, a more detailed report on this topic was provided separately in response to the reporting requirements of Section 124 of the NDAA for FY15. The Navy recently completed the operational testing of the *Freedom* variant's seaframe (core capabilities testing) and the first phase of operational testing for the SUW mission package, but only for the increment installed on the *Freedom* variant. The Navy has not yet completed testing of the *Independence* seaframe, has not completed testing of the MCM mission package, and has not completed operational testing of any other package aboard either of the seaframes. In general, I have little insight into the capabilities and limitations of the *Independence* class LCS, as it remains largely untested more than six years after the Navy accepted delivery of USS *Independence* (LCS 2).

**Small Surface Combatant Study and Follow-on Frigate**

- Although not part of the reporting requirements for the FY15 NDAA, the Navy discusses its plans for the future variants of the LCS, referred to as the small surface combatant (SSC), or most recently its new designation: a follow-on frigate. Given its close connection to the LCS program, my full report on the SSC Task Force study, which I also provided to the Secretary in October 2014, is included in DOT&E's classified version of this report for your information. That report concludes the SSC recommended by the Navy will be significantly less survivable than a frigate and will not provide the multi-mission capabilities of a frigate. In particular, the SSC(X) high-level requirements do not address the most likely causes of ship and mission loss against certain threats. And, the susceptibility reduction features to be incorporated in the SSC(X) would not eliminate the possibility of being hit, and would, therefore, not provide significant improvement in SSC(X)'s overall survivability relative to LCS.

J. Michael Gilmore
Director

Enclosure:
As stated

cc:
The Honorable Adam Smith
Ranking Member