Littoral Combat Ship (LCS) and Associated Mission Modules

Executive Summary

- In the report to Congress required by the National Defense Authorization Act (NDAA) for FY15, DOT&E concluded that the now-planned use of the Littoral Combat Ship (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.
- This same report also concluded that the ability of LCS to successfully execute significant aspects of its envisioned concept of operations (CONOPS) depends on the effectiveness of the mission packages. To date, the Navy has not yet demonstrated effective capability for either the Mine Countermeasures (MCM) or Anti-Submarine Warfare (ASW) mission packages. The Surface Warfare (SUW) mission package has demonstrated a modest ability to aid the ship in defending itself against small swarms of small boats, and the ability to conduct maritime security operations.
- During FY15, the Navy conducted developmental testing of the *Independence* variant LCS seaframe and Increment 1 MCM mission package aboard USS *Independence* (LCS 2). Although the Navy intended to complete that testing by June 2015 and conduct the operational test from July to September, it extended developmental testing through the end of August because of seaframe failures and MCM mission system reliability shortfalls. The Navy subsequently decided in October 2015 to postpone the first phase of IOT&E of the MCM mission package until sometime in 2016, at the earliest.
- The Navy chartered an independent program review of the Remote Minehunting System (RMS), including an evaluation of potential alternative MCM systems, in September 2015.
- DOT&E concluded in a November 2015 memorandum to the USD(AT&L) and the Navy, based on all testing conducted to date, that an LCS employing the current MCM mission package would not be operationally effective or operationally suitable if the Navy called upon it to conduct MCM missions in combat and that a single LCS equipped with the Increment 1 MCM mission package would provide little or no operational capability to complete MCM clearance missions to the levels needed by operational commanders. The following summarize the primary reasons for this conclusion:
  - Critical MCM systems are not reliable.
  - The ship is not reliable.
  - Vulnerabilities of the Remote Multi-Mission Vehicle (RMMV) to mines and its high rate of failures do not support sustained operations in potentially mined waters.
  - RMMV operational communications ranges are limited.
  - Minehunting capabilities are limited in other-than-benign environmental conditions.
  - The fleet is not equipped to maintain the ship or the MCM systems.
  - The Airborne Mine Neutralization Systems (AMNS) cannot neutralize most of the mines in the Navy's threat scenarios; an Explosive Ordinance Disposal Team or other means provided by another unit must be used.
- During the MCM mission package Technical Evaluation (TECHEVAL), the Navy demonstrated that an LSC could detect, classify, identify, and neutralize only a fraction of the mines in the Navy's mine clearance scenarios while requiring extraordinary efforts from shore support, maintenance personnel, and contractors.
- The Navy also conducted both developmental and operational testing of the *Independence* variant LCS seaframe with the Increment 2 SUW mission package aboard LCS 4. Operational testing of the seaframe and Increment 2 SUW mission package is not yet complete because of pending changes to the ship's air defense system, Sea Rolling Airframe Missile (SeaRAM), and other elements of the ship's combat system and networks. A second phase of operational testing of the Increment 2 version of the SUW mission package and *Independence* variant seaframe is scheduled to occur in 3QFY16.

***Freedom* Variant (LCS 1)**

***Independence* Variant (LCS 2)**

- While equipped with the Increment 2 SUW mission package, LCS 4 participated in three engagements with small swarms of Fast Inshore Attack Craft (FIAC). Although all of the attacking boats were ultimately defeated, an attacker managed to penetrate the "keep-out" range in two of the three events. In all three events, however, the ship expended a large quantity of ammunition from the seaframe's 57 mm gun and the two mission package 30 mm guns, while contending with repeated network communication faults that disrupted the flow of navigation information to the gun systems as well as azimuth elevation inhibits that disrupted or prevented establishing firing solutions on the targets. LCS 4's inability to defeat this relatively modest threat beyond the "keep-out" range routinely under test conditions raises questions about its ability to deal with more challenging threats that could be present in an operational environment.
- In comparison to other Navy ships, the LCS seaframes have relatively modest air defense capabilities that cannot be characterized fully until planned tests on LCS 7 and LCS 8 and the Navy's unmanned self-defense test ship provide data for the Navy Probability of Raid Annihilation (P_{RA}) high-fidelity modeling and simulation analyses. The Navy plans to begin those tests in FY17. In FY15, DOT&E learned that the Program Executive Office for Integrated Warfare Systems (PEO IWS) stopped work on the P_{RA} Test Bed for the *Freedom* variant because a high-fidelity model of the ship's AN/SPS-75 radar was not being developed. Development of an acceptable radar model requires intellectual property rights that the Navy does not hold and is not actively seeking. Although less critical because of the combat system architecture of the *Independence* variant, the Navy has also been unable to develop a high-fidelity model of that ship's AN/SPS-77 radar for the same reason. In an August 2015 memorandum, DOT&E advised Navy officials that the lack of these radar models threatens the viability of the Navy's strategy for evaluation of LCS air defense capabilities and suggested alternative strategies specific to each seaframe variant. The Navy has not decided what course of action it wants to pursue.
- In August 2015, the Navy conducted the first shipboard live firing of the ship's SeaRAM system. The demonstration was not designed to be an operationally realistic test of the ship's capability. The aerial drone's flight profile and configuration were not threat representative.
- Test activities in FY15 allowed the collection of reliability, maintainability, availability, and logistics supportability data to support evaluation of the operational suitability of the *Independence* variant seaframe. Although incomplete, the data collected to date show that many of the *Independence* variant seaframe systems have significant reliability problems. During developmental testing, the LCS 4 crew had difficulty keeping the ship operational as it suffered repeated failures of the ship's diesel generators, water jets, and air conditioning units. LCS 4 spent 45 days over a period of 113 days without all 4 engines and steerable water jets operational. This includes a 19-day period in May when 3 of the 4 engines were degraded or non-functional. During the five-month MCM mission package TECHEVAL period, LCS 2 seaframe failures caused the ship to return to, or remain in, port for repairs on seven occasions. Similar to LCS 4, the ship's core systems, such as the air defense system, SeaRAM, the MK 110 57 mm gun, the electro-optical/infrared sensor (Sea Star Shipboard Airborne Forward-Looking Infra-Red Equipment (SAFIRE)) used to target the gun, and the ship's primary radar, experienced failures, leaving the ship with no air or surface defense capability for more than one-half of the test period. LCS 2 was unable to launch and recover RMMVs on 15 of the 58 days underway because of 4 separate propulsion equipment failures involving diesel engines, water jets, and associated hydraulic systems and piping.
- The Navy conducted the first of four periods of cybersecurity testing on the *Independence* variant while the ship was moored in Pensacola, Florida, during a comprehensive maintenance availability. The test comprised a Cooperative Vulnerability and Penetration Assessment (CVPA) of the seaframe and embarked Increment 1 MCM mission package. The CVPA details are classified but indicate that, like the *Freedom* variant seaframe, the *Independence* variant seaframe has cybersecurity deficiencies that significantly degrade operational effectiveness. Plans for the remaining period of the cybersecurity testing in LCS 2 are on hold pending a Navy decision on the readiness of the Increment 1 MCM mission package and *Independence* variant seaframe for MCM operational testing. The Navy delayed the two periods of cybersecurity testing in LCS 4 until after it completes an upgrade of the ship's networks designed to enhance cybersecurity and correct known issues.
- DOT&E does not expect either LCS variant to be survivable in high-intensity combat because the design requirements accept the risk that the crew would have to abandon ship under circumstances that would not require such action on other surface combatants. Although the ships incorporate capabilities to reduce their susceptibility to attack, previous testing of analogous capabilities demonstrates it cannot be assumed LCS will not be hit in high-intensity combat.
- The LCS 3 Total Ship Survivability Trial (TSST) revealed significant deficiencies in the *Freedom* variant design. Much of the ship's mission capability would have been lost because of damage caused by the initial weapons effects or 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.

System

Seaframes

- The LCS is designed to operate in the shallow waters of the littorals that can constrain the ability of larger ships to maneuver.
- The Navy originally planned to acquire 55 LCSs, but reduced the planned procurement to 52 ships in 2013. In a February 24, 2014 memorandum, the Secretary of Defense announced that no new contract negotiations beyond 32 ships would go forward and directed the Navy to submit

alternative proposals to procure a more capable and lethal small surface combatant, generally consistent with the capabilities of a Frigate. Further discussion of the small surface combatant variant (now called a Frigate) is in a separate article in this annual report.

- The Navy is currently procuring two variants of LCS seaframes:
  - The *Freedom* variant (odd-numbered ships) is a semi-planing monohull design constructed of steel (hull) and aluminum (deckhouse) with two steerable and two fixed-boost water jets driven by a combined diesel and gas turbine main propulsion system.
  - The *Independence* variant (even-numbered ships) is an aluminum trimaran design with two steerable water jets driven by diesel engines and two steerable water jets driven by gas turbine engines.
- Common design specifications include:
  - Sprint speed in excess of 40 knots, draft of less than 20 feet, and an un-refueled range in excess of 3,500 nautical miles at 14 knots
  - Accommodations for up to 98 personnel
  - A common Mission Package Computing Environment (MPCE) for mission package control using Mission Package Application Software (MPAS) installed when a mission package is embarked
  - A Multi-Vehicle Communications System to support simultaneous communications with multiple unmanned off-board vehicles
  - Hangars sized to embark MH-60R/S and Vertical Take-Off Unmanned Aerial Vehicles (VTUAVs)
  - MK 110 57 mm gun (BAE/BOFORS)
- The designs have different core combat systems to provide command and control, situational awareness, and self-defense against anti-ship cruise missiles (ASCMs) and surface craft.
  - *Freedom* variant: COMBATSS-21, an Aegis-based integrated combat weapons system with a TRS-3D (AN/SPS-75) air and surface search radar (ASR) (Airbus, France), Rolling Airframe Missile (RAM) system supported by elements from the Ship Self-Defense System (Raytheon) (one 21-cell launcher), a Terma Soft Kill Weapon System (Denmark), and a DORNA EOD gunfire control system with an electro-optical/infrared sensor (Navantia, Spain) to control the MK 110 57 mm gun.
  - *Independence* variant: Integrated Combat Management System (derived from the Thales TACTICOS system (The Netherlands) with a Sea Giraffe (AN/SPS-77) ASR (SAAB, Sweden), one MK 15 Mod 31 SeaRAM system (Raytheon) (integrates the search, track, and engagement scheduler of the Phalanx Close-in Weapon System with an 11-round RAM launcher assembly), ALEX (Automatic Launch of Expendables) System (off-board decoy countermeasures) (Sippican, U.S.), and SAFIRE (FLIR, U.S.) for 57 mm gun fire control.

Mission Packages

- LCS is designed to host a variety of individual warfare systems (mission modules) assembled and integrated into interchangeable mission packages. The Navy currently plans to field MCM, SUW, and ASW mission packages. A mission package provides the seaframes with capability for a single or "focused" mission. Multiple individual programs of record involving sensor and weapon systems and off-board vehicles make up the individual mission modules. Summarized below is the current acquisition strategy for the incremental development of each mission module. However, the Navy recently began an effort to revise its plan, including the possibility of developing different components rather than some upgrades.

SUW Mission Package

- Increment 1 includes:
  - Gun Mission Module (two MK 46 30 mm guns)
  - Aviation Module (embarked MH-60R)
- Increment 2 adds:
  - Maritime Security Module (small boats)
- Increment 3 is expected to add:
  - Surface-to-Surface Missile Module Increment I, employing the AGM 114L Longbow Hellfire missile
  - One MQ-8C Fire Scout VTUAV to augment the Aviation Module
- Increment 4, if fielded, will add:
  - Surface-to-Surface Missile Module Increment II (replacing Increment I) to provide a longer range surface engagement capability

MCM Mission Package

- Increment 1 includes:
  - Remote Minehunting Module, consisting of two RMMVs (version 6.0 (v6.0)) and three AN/AQS-20A sensors. The Navy plans to incorporate an improved sensor (AN/AQS-20C) in a future increment.
  - Near Surface Detection Module, consisting of two Airborne Laser Mine Detection Systems (ALMDS). The Navy plans to incorporate improvements in a future increment.
  - Airborne Mine Neutralization Module, consisting of two AMNS units. In Increment 1, the AMNS does not include a near surface mine neutralization capability.
  - Aviation Module consisting of an MH-60S Block 2B or subsequent Airborne Mine Countermeasures (AMCM) Helicopter outfitted with an AMCM system operator workstation and a tether system.
- Increment 2 is expected to add:
  - Coastal Mine Reconnaissance Module, consisting of the Coastal Battlefield Reconnaissance and Analysis (COBRA) Block I system and one MQ-8B VTUAV for daytime unmanned aerial tactical reconnaissance to detect and localize mine lines and obstacles in the beach zone.

- Increment 3 is expected to add:
  - Unmanned Mine Sweeping Module, consisting of the Unmanned Influence Sweep System (UISS) to actuate/detonate acoustic-, magnetic-, and combined acoustic/magnetic-initiated volume and bottom mines in shallow water.
  - Airborne Mine Neutralization (Near-Surface) Module
- Increment 4 is expected to add:
  - COBRA Block II system, which retains Block I capability and adds nighttime minefield and obstacle detection capability and day/night detection capability in the surf zone.
  - Buried Minehunting Module, consisting of the Knifefish Unmanned Undersea Vehicle, a battery-powered, autonomous underwater vehicle, employing a low-frequency, broadband, synthetic aperture sonar to detect, classify, and identify volume and bottom mines in shallow water.

ASW Mission Package (only Increment 2)

- Torpedo Defense and Countermeasures Module (Lightweight Tow torpedo countermeasure)
- ASW Escort Module (Multi-Function Towed Array and Variable Depth Sonar)
- Aviation Module (embarked MH-60R and MQ-8B Fire Scout VTUAV) (inclusion of Fire Scout is reportedly being deferred because of fiscal constraints.)

Mission

- The Maritime Component Commander will employ LCS to conduct MCM, ASW, or SUW tasks depending on the mission package installed in the seaframe. Because of capabilities inherent to the seaframe, commanders can employ LCS in a maritime presence role in any configuration. With the Maritime Security Module, installed as part of the SUW mission package, the ship can conduct Maritime Security Operations, including Visit, Board, Search, and Seizure of ships suspected of transporting contraband.
- The Navy can employ LCS alone or in company with other ships. The Navy's CONOPS for LCS anticipates that the ship's primary operational role will involve preparing the operational environment for joint force assured access to critical littoral regions by conducting MCM, ASW, and SUW operations, possibly under an air defense umbrella as determined necessary by the operational commander. However, the latest CONOPS observes, "The most effective near-term operational roles for LCS to support the maritime strategy are theater security cooperation and MSO [Maritime Security Operations] supporting deterrence and maritime security."

Major Contractors

- *Freedom* variant (LCS 1, 3, 5, 7, and follow-on odd-numbered ships)
  - Prime: Lockheed Martin Maritime Systems and Sensors – Washington, District of Columbia
  - Shipbuilder: Marinette Marine – Marinette, Wisconsin
- *Independence* variant (LCS 2, 4, 6, 8, and follow-on even-numbered ships)
  - Prime for LCS 2 and LCS 4: General Dynamics Corporation Marine Systems, Bath Iron Works – Bath, Maine
  - Prime for LCS 6 and follow-on even numbered ships: Austal USA – Mobile, Alabama
  - Shipbuilder: Austal USA – Mobile, Alabama
- Mission Packages
  - Mission Package Integration contract awarded to Northrop Grumman – Los Angeles, California

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Activity

LCS Program

- In February 2014, the Secretary of Defense curtailed the planned Flight 0+ LCS procurement at 32 ships and required the Navy to submit alternative proposals for a capable small surface combatant that is more lethal and survivable than the current LCS design. In December 2014, the Secretary of Defense approved the Navy's proposal to procure a small surface combatant based on an upgraded Flight 0+ LCS with minor modifications.
- In January 2015, the Secretary of the Navy announced that the modified small surface combatant LCS would be designated a Frigate and noted that the Navy would consider re-designating earlier LCS variants as Frigates if/when they receive similar modifications. The Navy began work on a Capabilities Development Document in 2015, and plans to complete Joint Staffing of the requirements document in FY16. Additional information about the small surface combatant (now called a Frigate) modification to the LCS is provided in a separate article in this annual report.
- In February 2015, DOT&E provided the Secretary of the Navy certification that only one of each mission module is needed to support operational testing in compliance with Section 122 of the NDAA for FY15.
- In February 2015, DOT&E responded to the reporting requirement in Section 124 of the FY15 NDAA, which directed DOT&E to report on the Test and Evaluation Master Plan (TEMP) for LCS seaframes and mission modules.
- In April 2015, DOT&E provided USD(AT&L) an assessment of the capabilities and limitations of LCS ships and mission packages to support USD(AT&L)'s FY15 LCS Deep Dive and annual review of the program. That report summarized DOT&E's current assessment of both variants,

including an evaluation of the seaframes' cybersecurity, air defense, surface self-defense, reliability, and availability, and known survivability shortfalls. The report also summarized the most significant concerns for each of the mission packages in advance of the planned operational testing of both the SUW and MCM mission packages intended to occur in FY15.

- Also in April 2015, DOT&E submitted a report to Congress and the Secretary of Defense responding to Section 123 of the FY15 NDAA, which directed DOT&E and the Navy to address the current CONOPS and expected survivability attributes of each of the seaframes. This report included a review of the survivability testing, modeling, and simulation conducted to date on the two seaframes, and an assessment of the expected survivability of LCS in the context of its planned employment as described in the CONOPS.
- The Navy began efforts to revise the LCS TEMP in 4QFY15. The current version of the TEMP was only approved for the testing on the first increment of the MCM mission package, the second increment of the SUW mission package, and the initial ASW mission package. An update is now required since testing of the Increment 3 SUW mission package is expected to occur in FY16. Uncertainty in the Navy's plans for the mission packages as well as the uncertainty in ship availability in the out years is slowing the TEMP's development. The FY16 NDAA directed the Navy to submit a current TEMP for the LCS mission modules, approved by DOT&E, which includes the performance levels expected to be demonstrated during developmental testing for each component and mission module prior to commencing the associated operational test phase.
- In August 2015, DOT&E advised Navy officials of concerns that the Navy's current lack of access to the intellectual property needed to develop high-fidelity models of the AN/SPS-75 and AN/SPS-77 radars for use in the P_{RA} modeling and simulation test bed will preclude adequate evaluation of LCS air defense capabilities. The memorandum detailed alternative test strategies involving additional live testing that might be acceptable should the Navy be unable to obtain the necessary data rights.
- In December 2015, DOT&E published an assessment of the results of operational testing of the *Freedom* variant seaframe and SUW mission package (Increments 1 and 2).

Seaframes

- *Freedom* variant:
  - The Navy conducted a TSST in USS *Fort Worth* (LCS 3) from September 29, 2014 through October 3, 2014, in accordance with the DOT&E-approved trial plan.
  - In November 2014, LCS 3 deployed for extended operations in the Western Pacific with an Increment 2 SUW mission package and an aviation detachment that included an MH 60R helicopter and an MQ-8B Fire Scout VTUAV. The Navy expects LCS 3 to return to her homeport in 3QFY16.
  - In November 2015, the Navy placed USS *Milwaukee* (LCS 5) in commission.
- *Independence* variant:
  - In October 2014, USS *Independence* (LCS 2) hosted a scheduled phase of developmental testing focused on integrated seaframe and Increment 1 MCM mission package operations.
  - In January 2015, the Navy conducted developmental testing, including gunnery events, using LCS 2. The ship then sailed from San Diego, California, to the Gulf of Mexico, arriving in Pensacola, Florida, on February 17. Following installation and grooming of the Increment 1 MCM mission package, LCS 2 conducted crew training in MCM operations in preparation for TECHEVAL of the *Independence* variant LCS and Increment 1 MCM mission package.
  - From May through August 2015, the Navy conducted developmental testing, including TECHEVAL, of the *Independence* variant seaframe and Increment 2 SUW mission package aboard LCS 4. This TECHEVAL integrated the test objectives of both the developmental and operational test communities. DOT&E and the Navy's Commander, Operational Test and Evaluation Force (COTF) are using the resulting data to supplement data collected during a subsequent operational test. DOT&E approved an operational test supplement to the developmental test plans, and DOT&E personnel observed the testing aboard LCS 4.
  - In June and July 2015, COTF conducted the cybersecurity CVPA phase of Operational Test C2 (OT-C2) of the *Independence* variant LCS and the Increment 1 MCM mission package aboard LCS 2 while the ship was moored in Pensacola, Florida. The operational testing was conducted in accordance with the test plan approved by DOT&E. COTF plans to complete the final phase of LCS 2 and MCM mission package operational cybersecurity testing and all other OT-C2 events during FY16.
  - In August 2015, the Navy conducted the first shipboard live firing of the ship's SeaRAM system against a subsonic aerial drone. The Navy had attempted to conduct the test event in June, but had to postpone the event due to seaframe equipment failures. The Navy had originally planned to conduct non-firing tracking runs against aerial drones, but these events were canceled because of the range safety restrictions for a manned ship that preclude conducting such test events with realistic geometries. The live fire demonstration was not designed to be an operationally realistic test of the ship's capability. The aerial drone flight profile and configuration were not threat representative.
  - In August and September 2015, the Navy conducted the first phase of operational testing of the *Independence* variant seaframe and Increment 2 SUW mission package (Operational Test C4) aboard LCS 4. Operational testing

was conducted in accordance with a DOT&E-approved test plan. That testing consisted of an examination of the seaframe's electronic warfare capability; several surface self-defense events against small boats (without the mission package); seaframe evaluations of endurance, sprint speed, and small boat launch and recovery for Visit, Board, Search, and Seizure missions of state. The testing also examined the ship's ability, when equipped with an Increment 2 SUW mission package, to combat a small swarm of FIAC.

- Because of changes to the ship's air defense system, SeaRAM, and additional modifications to the ship's combat system and networks, a second phase of operational testing of the Increment 2 version of the SUW mission package and *Independence* variant seaframe will occur in 3QFY16, which will examine the air warfare capabilities of the seaframe, cybersecurity upgrades, and the remaining SUW events.
- USS *Jackson* (LCS 6) completed acceptance trials in June 2015; the Navy accepted delivery in August 2015 and placed the ship in commission in December 2015.

SUW Mission Package

- During 3Q and 4QFY15, the Navy conducted developmental testing of the Increment 2 SUW mission package aboard LCS 4.
- In August and September 2015, the Navy conducted operational testing of the Increment 2 SUW mission package aboard LCS 4. This phase of the operational test examined the *Independence* variant's self-defense capability against small swarms of high-speed boats and its effectiveness for Maritime Security Operations requiring the crew to intercept and board a vessel suspected of transporting contraband when equipped with the Increment 2 SUW mission package. The testing was conducted in accordance with a DOT&E-approved test plan.
- COTF conducted a shore-based Quick Reaction Assessment of an MQ-8B Fire Scout VTUAV equipped with the AN/ZPY-4(1) radar in May and June 2015. The Navy's original plans for the Increment 2 MCM mission package called for the MC-8B VTUAV, but those plans are now in doubt. The Navy plans to embark the larger MQ-8C VTUAV with the SUW mission package starting with Increment 3, but initial plans do not call for the aircraft to be equipped with radar. COTF conducted a land-based operational assessment of the MQ-8C in November 2015, the results of which are not yet available.

MCM Mission Package

- During 1QFY15, the Navy completed the last scheduled phase of the Increment 1 MCM mission package developmental test DT-B2 aboard LCS 2.
- Having completed the land-based phase of an operational assessment of the AMNS in 3QFY14 with the MH-60S helicopter operating from Naval Air Station, Oceana, Virginia, the Navy conducted the ship-based phase of the operational assessment aboard LCS 2 in 1QFY15 during Increment 1 MCM mission package developmental testing. The ship-based phase focused on shipboard integration and the system's operational suitability, but was also able to collect limited effectiveness data.
- The Navy also completed the ship-based phase of an Airborne Laser Mine Detection Systems (ALMDS) operational assessment in 1QFY15 aboard LCS 2 during Increment 1 MCM mission package developmental testing. The test collected limited data to examine system effectiveness and the shipboard suitability of the MH-60S helicopter equipped with the ALMDS.
- The Navy canceled a scheduled operational assessment of Coastal Battlefield Reconnaissance and Analysis (COBRA) Block I after a NASA Antares rocket exploded just after lift-off from the Wallops Island, Virginia, launch pad on October 28, 2014. Although all test preparations had been completed, both MQ-8B Fire Scout VTUAVs that were to host the COBRA system during the test suffered shrapnel damage from the rocket explosion. In December 2014, DOT&E returned the Navy's revised COBRA Block I TEMP for rework, noting that the schedule, test strategies, funding profile, and planned resources no longer reflected the state of the program following cancelation of the operational assessment.
- The Navy conducted shore-based developmental testing (DT-B1) of the RMS, consisting of the v6.0 RMMV and AN/AQS-20A/B from the contractor's facility at West Palm Beach, Florida. The Navy commenced testing in December 2014 with an upgraded version of the sensor, designated AN/AQS-20B, but in January 2015, the Navy determined the new sensor was not yet sufficiently mature and elected to complete testing with the AN/AQS-20A sonar. The Navy subsequently suspended testing in January 2015 to investigate RMMV reliability problems and complete corrective maintenance. The Navy resumed and completed testing in March 2015.
- From April through August 2015, the Navy conducted TECHEVAL of the *Independence* variant LCS and Increment 1 MCM mission package aboard LCS 2. Although the Navy originally planned to conduct the test from April through June 2015, problems with failures of seaframe and MCM systems caused the testing to be extended. The Navy chose to extend the testing further, conducting another evolution of the MCM scenario, in order to provide confidence in the capabilities of the ship and mission package prior to entering the operational test period. Although this testing was developmental in nature, the test was designed to integrate the objectives of both developmental and operational test communities. DOT&E personnel observed the testing aboard LCS 2. If the Navy elects to continue with the same system hardware and software configurations, DOT&E and COTF will use the resulting data to supplement data collected during the operational test. If the Navy decides to go forward to operational testing with a new system, integrated test data collected in FY15 may not be representative of the system the Navy intends to field, and the Navy might need to repeat

some portions of previous tests to provide the requisite data. Although the Navy planned to complete operational testing of the Increment 1 MCM mission package in FY15, only the cybersecurity CVPA was completed. The Navy has delayed the remaining OT-C2 events, and they are unlikely to be conducted before the spring of 2016, at the earliest.

- In an August 2015 memorandum, DOT&E advised the USD(AT&L) that the reliability of the RMS and its RMMV poses a significant risk to the planned operational test of the *Independence* variant LCS and the Increment 1 MCM mission package and to the Navy's plan to field and sustain a viable LCS-based minehunting and mine clearance capability prior to FY20. DOT&E recommended that the acquisition strategy for these systems be reexamined to ensure that sufficient testing is performed to inform the procurement of additional vehicles and cautioned that continued development of this program without a fundamental change would be unlikely to result in a system that is effective and suitable.
- In September 2015, the Navy chartered an independent program review of the RMS, including an evaluation of potential alternative MCM systems. Their report is due in late 1QFY16. Additionally, USD(AT&L) delayed its review to consider approval to restart RMS low-rate initial production until at least 3QFY16.
- In November 2015, DOT&E provided the USD(AT&L), the Assistant Secretary of the Navy for Research Development and Acquisition, and the Program Executive Officer for Littoral Combat Ships a classified assessment of the performance of the *Independence* variant seaframe and Increment 1 MCM mission package. DOT&E based the assessment on the data collected during the TECHEVAL and earlier periods of development and operational testing.
- Also in November 2015, DOT&E provided comments to the Joint Staff on the Navy's draft Capability Production Document for the "Phase 1" (formerly Increment 1) MCM mission package.

ASW Mission Package

- The Navy did not conduct any at-sea testing of the ASW mission package in FY15 due to limited ship availability and changes to the system's design. The Navy continued its efforts on a weight reduction program for the components of the mission package, including the handling system and support structures for the variable depth sonar and multi-function towed array.

Assessment

This assessment is based on information from post-delivery test and trial events, fleet operations, developmental testing, results provided by the Navy Program Offices, operational assessments of MCM mission systems, operational testing of the *Independence* variant seaframe with the Increment 2 SUW mission package, and operational cybersecurity testing conducted in LCS 2. A summary of DOT&E's December 2015 report on the *Freedom* variant equipped with the Increment 2 SUW mission package is also provided below.

Program

- The Navy intends to field LCS capabilities incrementally as mission package systems mature and become ready for fleet use. Since the Navy expects each increment to deliver significant increases in mission capability, the approved TEMP calls for an appropriately-designed phase of OT&E on all delivered mission package increments on each seaframe variant. However, because the content of the later increments is not yet final, the details of the testing to be accomplished for later increments of mission package capability are yet to be planned.
  - Initial phases of operational testing were completed in FY14 for the *Freedom* variant seaframe and Increment 2 SUW mission package and partially completed in FY15 for the *Independence* variant seaframe and Increment 2 SUW mission package embarked on that variant. The final phases of operational testing will not be completed until the full mission package capability is available. The Navy expects to complete those final phases of operational testing in the FY18 timeframe, depending on the decision whether to pursue an Increment 4 of the SUW mission package. It is unknown when either the MCM mission package or ASW mission package operational test programs will be complete.
  - The Navy is finding it difficult to follow the plan 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. Decisions to include the ships in major fleet exercises and to press for establishment of a continuous, multi-LCS presence overseas in FY17 are also reducing the number of ships available to participate in the test program. The Navy is challenged 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.
- Additionally, the Navy directed changes to the seaframe designs based on the results of early developmental testing and operations. The Navy has indicated that the seaframe designs will be stabilized in the third ship of each variant (LCS 5 and LCS 6).

Seaframes

- In the report to Congress responding to the FY15 NDAA, DOT&E noted that the envisioned missions, use of unmanned vehicles, and operating environments have shifted relative to the original LCS vision. DOT&E concluded that the use of LCS as a forward-deployed combatant, where it might be involved in intense naval conflict as now intended, appears to be inconsistent with its inherent survivability in those same environments. The ability of LCS to successfully execute significant aspects of the envisioned CONOPS depends on the effectiveness

of the mission packages. To date, the Navy has not yet demonstrated effective capability for either the MCM or the ASW mission package. The Increment 2 SUW mission package has demonstrated some modest ability to aid the ship in defending itself against small swarms of FIAC, and the ability to conduct maritime security operations.

- While both seaframe variants are fast and highly maneuverable, they are lightly armed and were not designed to provide any significant offensive capability without the planned Increment 4 SUW mission package or the Increment 2 ASW mission package. In comparison to other Navy ships, the LCS seaframes have relatively modest air defense capabilities that cannot be characterized fully until planned tests on LCS 7 and LCS 8 and the Navy's unmanned self-defense test ship provide data for the Navy P_{RA} high-fidelity modeling and simulation analyses. The Navy plans to begin those tests in FY17. In FY15, DOT&E learned that PEO IWS stopped work on the P_{RA} Test Bed for the *Freedom* variant because the high-fidelity model of the ship's AN/SPS-75 radar was not being developed. Development of an acceptable radar model requires intellectual property rights that the Navy does not hold and is not actively seeking. Although less critical because of the combat system architecture of the *Independence* variant, the Navy has also been unable to develop a high-fidelity model of that ship's AN/SPS-77 radar for the same reason. In an August 2015 memorandum, DOT&E advised Navy officials that the lack of these radar models threatens the viability of the Navy's strategy for evaluation of LCS air defense capabilities and suggested alternative strategies specific to each seaframe variant. The alternative test strategies suggest additional live testing that might be acceptable. Near-term resolution will be required to avoid delaying P_{RA} Test Bed analyses needed to finalize DOT&E's evaluation of LCS air defense effectiveness. The Navy has not decided what course of action they want to pursue.
- Neither LCS variant has been operationally tested to evaluate its effectiveness against unmanned aerial vehicles and slow-flying aircraft. Although the Navy had planned to test the *Independence* variant's capability to defeat such threats in FY15, the testing was canceled because of range safety requirements that would have precluded operationally realistic testing. DOT&E concurred with this decision because proceeding with an unrealistic test would have been a needless waste of resources.
- The seaframes include no systems designed to counter torpedo attacks or detect and avoid mines without the appropriately configured mission packages installed.
- Crew size limits the mission capabilities, combat endurance, maintenance capacity, and recoverability of the ships. The Navy continues to review LCS manning to determine appropriate levels and has added 20 berths to all seaframes. The increased berthing supports small increases in the size of the core crew, mission package and aviation detachments, but still leaves the ships heavily dependent on Navy shore organizations for administrative and maintenance support.
- *Freedom* Variant Seaframe (LCS 1 and 3):
  - Although not all aspects of operational effectiveness and suitability could be examined during the 2014 operational test, that testing identified shortcomings in cybersecurity, air defense, surface self-defense, reliability, maintainability, speed and endurance, air operations, and other operations.
  - **Cybersecurity.** Cybersecurity testing conducted aboard LCS 3 uncovered significant deficiencies in the ship's capability to protect the security of information and prevent malicious intrusion. Many of these deficiencies were previously discovered during the 2012 Quick Reaction Assessment that COTF conducted in USS *Freedom* (LCS 1). Although the Navy is developing plans to modify the network architecture in the *Freedom* variant ships to enhance cybersecurity, the severity of the cybersecurity problems will degrade the operational effectiveness of *Freedom* variant seaframes until the problems are corrected.
  - **Air Defense.** Aircraft tracking events conducted during operational testing aboard LCS 3 demonstrated that the crew was unable to detect and track some types of air threats well enough to engage them. The inability to engage these air threats leaves the ship without an effective air defense in some situations. As expected, tracking performance improved significantly when the LCS received tracking information via datalink from a nearby Aegis destroyer. Since the radar had demonstrated significantly better tracking performance during the Navy's TECHEVAL, when subject matter experts were embarked to advise and train the crew, it is possible that the crew's lack of proficiency in the use of the radar's controls during the initial test contributed to the poor performance.
  - The lack of integration between the WBR-2000 Electronic Support Measures (ESM) system and the RAM system limits the ship's capability to make best use of its limited RAM inventory. The inability to provide electronic signal measurements to RAM can reduce the likelihood that some of the missiles fired will acquire and home on the target, thus reducing the probability that the ship will be able to defeat an incoming raid of ASCMs.
  - **Surface Self Defense.** LCS 3 demonstrated the seaframe's core capability for self-defense against a small boat during two trials conducted under favorable conditions, but the operational test did not include enough trials to determine whether a *Freedom* variant LCS can defeat such a threat with regularity. Testing was not conducted in a realistic cluttered environment where identification of threats will be more challenging. Although the Navy attempted to collect additional data on the core seaframe's performance from swarm presentations, DOT&E determined that the data were

invalid. The 57 mm gun failed to achieve a mission kill during one swarm presentation, and the target killed by the 57 mm gun during a second swarm presentation had previously been engaged by the SUW mission package's 30 mm guns. The 57 mm gun itself performed reliably during the operational test, but the DORNA EOD system used to target the gun experienced numerous laser faults that interrupted some engagements and reduced the ship's effectiveness against attacking small boats. An inopportune fault could allow an attacker to close within his weapon range. The LCS 3 crew did not attempt to use the ship's AN/SPS-75 ASR for gun targeting during the operational test.

- **Missions of State.** Operational testing confirmed earlier observations that, except for the ships' lack of fuel endurance, the *Freedom* variant is suited for Maritime Security Operations. LCS 3 readily demonstrated the capability to position, launch, and recover the 11-meter boats included in the SUW mission package when the launch, recovery, and handling system is operational.
- **Speed and Endurance.** During operational testing, LCS 3 did not demonstrate that it could achieve the Navy requirement for fuel endurance (operating range) at the prescribed transit speed or at sprint speed. Based on fuel consumption data collected during the test, the ship's operating range at 14.4 knots (the ship's average speed during the trial) is estimated to be approximately 1,960 nautical miles (Navy requirement: 3,500 nautical miles at 14 knots) and the operating range at 43.6 knots is approximately 855 nautical miles (Navy requirement: 1,000 nautical miles at 40 knots). 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. The Navy's report from calm water trials suggests that the ship can achieve an endurance range of 3,500 nautical miles at an average (but not constant) speed of 14 knots by using a more economical propulsion configuration (two propulsion diesel engines and two steerable water jets). The ship cannot attain a speed of 14 knots in this configuration when fully loaded with fuel.
- **Aircraft Operations.** The *Freedom* variant LCS has sufficient aviation facilities and meets Navy requirements to safely launch, recover, and handle the MH-60R helicopter while operating in up to Sea State 4 conditions. However, the ship frequently had trouble establishing and maintaining a Tactical Common Data Link (TCDL) with the aircraft during the FY14 operational test. The crew's efforts were hampered by an antenna failure and the lack of technical documentation on the operation and maintenance of the datalink. The TCDL is the primary conduit for sharing tactical information, including voice reports, radar tracks, and radar and electro-optical and infrared (EO/IR) sensor video between the MH-60R helicopter and the LCS.
- **Other Operations.** COTF exercised LCS 3 and her crew in a variety of other shipboard evolutions during an operational test, including anti-terrorism/force protection, damage control, mooring and unmooring, navigation, refueling at sea, vertical replenishment, man-overboard recovery, and communications. These evolutions yielded no quantitative data; COTF evaluated the ship's performance qualitatively. Except as noted below, DOT&E observers reported that the ship's performance during the observed evolutions was consistent with the Navy's expectations for any surface combatant.
  - The anchoring system could not securely anchor the ship in an area with a bottom composed of sand and shells. On several occasions, the ship was unable to set the anchor despite repeated efforts. It appears that the anchor and chain are too light and there is too much friction along the anchor chain's internal path from the chain locker to the hawse pipe to allow the anchor and chain to pay out smoothly. Inability to anchor the ship securely could force the ship to remain at sea when anchoring would be preferred and could hazard the ship if it loses power in coastal waters or encounters other circumstances where anchoring is required.
  - The fenders designed to guide the 11-meter Rigid Hull Inflatable Boats included in the SUW mission package during launch and recovery are fragile and occasionally sheared off when impacted by the boats during operational testing. Although the fenders had undergone several redesigns, they were not yet strong enough to sustain such impacts. Loss of one or more of the fenders could delay or preclude boat launch and recovery needed to support Visit, Board, Search, and Seizure operations.
- **Operational Suitability.** The *Freedom* variant LCS seaframe is not operationally suitable because many of its critical systems supporting ship operations, core mission functions, and mission package operations are unreliable; and the ship's crew does not have adequate training, tools, and technical documentation to diagnose failures or correct them when they occur. By design, the ship's small crew does not have the capacity to effect major repairs. Instead, the Navy's support concept depends on the use of remote assistance in troubleshooting problems and the use of Navy repair organizations and contractors for repair assistance. However, the Navy's limited stock of repair parts for LCS systems, many of which were sourced from offshore vendors, can result in long logistics delays and occasionally forces the Navy to resort to cannibalization of another ship in order to expedite repairs.
  - The FY14 operational test did not yield sufficient evidence to report whether the mission critical components were individually meeting the Navy's reliability thresholds; the combined data for all of

the components revealed the aggregate reliability of Propulsion and Maneuvering and Navigation and Ship Control functional areas were extremely low.
  - The aggregate reliability of the components that comprise the core mission area (e.g., total ship computing environment, air search radar, electro-optical tracking system, and electronic support measures) was also poor. Based on the operational test results, the probability of successfully completing a 30-day mission without a critical failure of a core mission subsystem that reduces the ship's full mission capability is less than 5 percent.
  - The aggregate reliability of the mission package support functional area (mission package support systems, mission package computing environment, waterborne mission equipment, and airborne mission equipment) was somewhat better than that of other functional areas but, at 0.38, still well below the Navy's reliability threshold (0.9).
  - Low reliability, maintenance challenges, and logistics delays reduced LCS 3's operational availability for Mobility (Propulsion and Maneuvering), Total Ship Computing Environment (TSCE), Seaframe Sensors and Controls, Communications, and Mission Package Support to below the Navy's threshold requirement (0.85). Failures of the Propulsion and Maneuvering subsystems and the TSCE, which are fundamental to ship operations, caused the ship to return to port for repairs or reduced readiness while at sea for 42 and 36 days, respectively. The demonstrated availability of six other mission-critical subsystems was above the Navy's threshold: Engineering Controls, Navigation and Ship Control, Electrical Power Generation and Distribution, Auxiliary Systems, Damage Control, and Seaframe Engagement Weapons. The LCS 3 seaframe was partially or fully mission capable just over 60 percent of the time in Air Warfare and nearly 85 percent of the time in Surface Warfare, but partial mission capability can result in a significant reduction in operational effectiveness.
- *Independence* Variant Seaframe (LCS 2 and 4):
  - DOT&E is still analyzing data on the performance of the *Independence* variant seaframe. During the period under review, LCS 2 underwent developmental testing and TECHEVAL with the Increment 1 MCM mission package embarked, as well as the first phase of operational cybersecurity testing (CVPA). Additionally, LCS 4, with the Increment 2 SUW mission package embarked, underwent developmental testing, TECHEVAL, and the first phase of planned operational testing. Observer reports and preliminary data analyses provide sufficient evidence of numerous *Independence* variant seaframe deficiencies that significantly degrade the ships' operational effectiveness and suitability. Many of these deficiencies are detailed below.
  - **Air Defense.** The *Independence* variant ships are the first to use the SeaRAM air defense system. Although SeaRAM has never been operationally tested, it shares many components with the Phalanx Close-In Weapon System, which is widely installed in the fleet as a secondary or tertiary close-in self-defense system. The Navy completed the first at-sea demonstration of the SeaRAM system in LCS 4 in 2015 during an engagement against a non-maneuvering, subsonic aerial target (BQM-74) with radio frequency and infrared augmentation that were not consistent with the characteristics of realistic threats. Because SeaRAM is a self-contained system that integrates the Phalanx radar, track processing, and ESM receiver it should provide an air defense capability on par with other RAM-equipped ships in the fleet as long as the AN/SPS-77 ASR radar can detect the incoming threat(s) and the crew can maneuver the ship to place the threat(s) in SeaRAM's engagement zone. However, as with the *Freedom* variant, the ship's air defense effectiveness will remain unproven until live operational testing is conducted on a manned ship, on the unmanned self-defense test ship, and using an appropriately designed P_{RA} Test Bed. That testing is scheduled to begin in 3QFY16 aboard the self-defense test ship and 1QFY17 aboard LCS 8. The Navy plans to complete testing utilizing the P_{RA} Test Bed in FY18, but those plans are in doubt due to issue with the radar modeling explained earlier in this report.
  - Upon learning that the Navy planned to upgrade the SeaRAM system installed in LCS 4 to bring it to the same configuration as the system being installed in Aegis destroyers, and that those upgrades and other combat system upgrades were to be installed in 1QFY16 and 3QFY16, DOT&E recommended that some of the *Independence* variant air warfare operational testing planned to complete in FY15 be delayed so it could be conducted with the ship in its deployment configuration. The Navy accepted the recommendation and now plans to conduct the air warfare tracking events in late FY16. The Navy plans to complete live SeaRAM testing on LCS 8 in FY17.
  - The Program Office conducted several developmental test events to evaluate the ship's capability to detect, track, and engage so-called Low Slow Flyers (LSF) (unmanned aerial vehicles, slow-flying fixed-wing aircraft, and helicopters) in mid-2015. The only sensor used to provide tracking information for engaging LSFs with the 57 mm gun is the SAFIRE EO/IR system. The test events demonstrated that SAFIRE was unable to provide reliable tracking information against some targets. Furthermore, the safety standoff requirements on Navy test ranges were so severe as to preclude meaningful live fire shooting engagements. Because of these constraints, the program decided to cancel all subsequent live fire events, conceding that

the *Independence* variant is unlikely to be successful consistently when engaging some LSFs until future upgrades of SAFIRE can be implemented. Live firing events planned during operational testing were also canceled, as the results from developmental testing were sufficient to conclude that the *Independence* variant will not likely be effective in these scenarios against some LSFs. Future testing against LSFs will not be possible until the Navy finds a solution to the severe safety constraints that preclude engaging realistic targets.

- **ESM Testing.** While most air warfare testing was delayed to FY16, COTF completed testing of the *Independence* variant's ES-3601 ESM system during the FY15 operational test. COTF used Lear aircraft equipped with ASCM seeker simulators to represent the ASCM threats. Although DOT&E analysis of the test data is not complete, DOT&E observed that the ES-3601 detected the presence of the ASCM seekers in most instances but did not reliably identify certain threats.
- **Surface Self-Defense.** The *Independence* variant seaframe's surface self-defense effectiveness was tested during developmental, integrated, and operational test firing events in 2015. These events tested the crew's capability to defeat a single small boat using the seaframe's 57 mm gun. DOT&E considered three of the developmental test events as sufficient to provide data for the operational effectiveness determination, in addition to the two dedicated operational test events for surface self-defense. Prior to these five events, the Navy also conducted three additional developmental test events, which revealed gun faults and fuzing errors. The program corrected these problems before proceeding to the integrated and operational test events. LCS 4 successfully defeated the attacking boat with the seaframe's MK 110 57 mm gun system during four of the five presentations considered either integrated or operational test events. The firing presentations were judged successful if a "mission kill" or "mobility kill" was achieved before the attacker could approach within the effective range of its weapon(s) – the prescribed "keep-out" range. Since, in the test environment, the attacker was the only boat in the area, it was easily classified as a threat well beyond the effective range of the ship's weapons. The Navy has not conducted any testing to determine how well the ship will perform when faced with an attack in a realistic cluttered maritime environment including both neutral and hostile craft; the Navy has also not conducted operational testing to determine how well the ship (without the SUW mission package) will perform against multiple attacking boats.
  - Two of the surface self-defense failures were caused by MK 110 57 mm gun malfunctions. During the first presentation, the gun operator's panel displayed multiple fault indications, and the operator was unable to change the fuze setting from proximity mode to the recommended point detonation (impact) mode. Technicians subsequently determined that a gun component had failed, and the gun was repaired on July 7, 2015. The second presentation on July 18 resulted in failure when the 57 mm gun loading mechanism jammed while the operator was attempting to reload the gun. With the assistance of a civilian gun system technician, the crew downloaded the remaining ammunition, cleared the jam, and restored the gun to "single-sided" operation in about 4 hours by consolidating good components. Until repaired on August 7, 2015, the gun was limited to firing 60 rounds before reloading. Technical issues with SAFIRE performance, including inability to track small surface craft automatically once acquired (auto-track), low targeting update rate, poor bearing accuracy, and unwieldy operator interface as well as persistent problems with gun system accuracy resulted in excessive ammunition consumption to achieve these modest results. The testing revealed that although successful in most of these events, had the ship been required to engage multiple small boats, the crew would be forced to reload the gun, which could interrupt engagements. Thus, the *Independence* variant seaframe will be challenged to defeat threat-representative boat swarms in an operational environment and could exhaust its supply of 57 mm ammunition if faced with multiple engagements.
  - LCS 4 found it necessary to supplement the watch team with an additional watchstander just to operate SAFIRE, leaving management of the gun to a second operator, even though the staffing plan calls for one operator to handle both functions. The small LCS crew does not include enough trained operators to maintain this watch arrangement for any appreciable length of time.
  - Gun accuracy problems have been observed in both LCS 2 and LCS 4, with the 57 mm gun consistently firing short of the target when shooting to port and beyond the target when shooting to starboard. The Navy has not yet identified the root cause of the problem but has reduced the error such that the operator can compensate using normal procedures.
  - On one occasion, the shock caused by firing the 57 mm gun unseated a network card, disabling the steering controls on the bridge and forcing the crew to steer the ship from an alternate location. On another occasion, gunfire shook network cables loose, disabling several combat systems, including the AN/SPS-77 ASR and the 57 mm gun. While the ship was able to recover from this failure within a few minutes and continue the engagement, these interruptions prolonged the ship's exposure to the advancing threat and reduced the crew's situational awareness during the repair. Failures of this nature demonstrate the need for full ship shock trials, which are currently planned to be conducted on LCS 6.

- **Missions of State.** LCS 4 completed six mock Missions of State during OT-C4 requiring the launch and recovery of two 11-meter Rigid Hull Inflatable Boats. LCS 4 met the 60-minute launch requirement, but on average was not able to meet the 60-minute recovery requirement. Faults in the Twin-Boom Extensible Crane (TBEC) and problems with the Surface Tow Cradle were responsible for the time delays during recovery operations. The cumbersome multi-step boat launch/recovery process has several 'single points of failure' that increase the likelihood of delays and the possibility of mission failure, including the Surface Tow Cradle, TBEC, the Mobicon straddle carrier, and a forklift. The failure of any of these components can halt boat operations and could leave a boat stranded at sea.
- **Endurance at transit speed.** LCS 4 demonstrated that the *Independence* variant seaframe's fuel endurance at a transit speed of 14 knots exceeds the Navy requirement. Assuming that all of the ship's "burnable" F-76 fuel could actually be consumed, LCS 4 demonstrated a fuel endurance of 5,345 nautical miles at 14 knots based on an hourly consumption rate of 421 gallons during a 6-hour trial. In reality, no ship would ever plan to consume all of its fuel during a transit because of the need to maintain a reserve for contingencies. If a 20 percent of fuel buffer were maintained, the ship's endurance would be 4,242 nautical miles.
- **Sprint speed and endurance.** COTF reported that LCS 4 demonstrated an average sprint speed of 37.9 knots during a 3-hour trial on September 10 (Navy requirement: 40 knots). Based on the fuel consumption rate and the amount of practically available fuel, an *Independence* variant ship would be able to travel nearly 1,000 nautical miles in 25 hours at this speed (Navy requirement: 1,250 nautical miles at 40 knots). COTF noted that the ship was unable to maintain the correct trim during the trial because the interceptors (components of the ride control system designed to assist with trim control) were inoperative and that the crew had to change five fuel oil pre-filters during the trial to keep the gas turbine engines on line. LCS 4 has long-standing problems with her ride control system hardware, including interceptors, fins, and T-Max rudders, that affect her maneuverability. The ship also had reported recurring problems with frequent clogging of the gas turbine engine fuel oil conditioning module pre-filters and coalescers, and found it difficult to maintain high speed for prolonged periods. The three-hour trial conducted on September 10 was reportedly the longest period of sustained high-speed operations in the ship's history.
- **Aircraft Operations.** Observers reported difficulties with the establishment and maintenance of the Tactical Common Data Link (TCDL), an encrypted point-to-point datalink. When available, the TCDL allows transmission of video, data, and voice communications between the aircraft and the LCS. However, like LCS 3, LCS 4 lacked adequate documentation on the operation and maintenance of TCDL equipment. Flight operations were disrupted by two failures of the ship's only JP-5 (F-44) fuel pump that precluded refueling any embarked aircraft for long periods. In addition to problems with TCDL, systems that support flight operations, such as the Advanced Stabilized Glide Slope Indicator, tactical air navigation system, and the wind-speed measurement system were frequently degraded or inoperative. These failures had little impact during the operational test because weather conditions were generally favorable, but in more challenging conditions, their failure could severely limit flight operations.
- **Other Operations.** COTF also exercised LCS 4 and her crew in a variety of other shipboard evolutions during OT-C4, including anti-terrorism/force protection, damage control, mooring and unmooring, refueling at sea, vertical replenishment, man-overboard recovery, communications, and receiving a tow. DOT&E observers reported that the ships performed as expected during the observed evolutions.
- **Cybersecurity.** In the only phase of operational testing completed to date in LCS 2, COTF conducted a CVPA of the seaframe and embarked Increment 1 MCM mission package in June and July 2015 while the ship was moored in Pensacola, Florida, during a comprehensive maintenance availability. COTF's cybersecurity team assessed all shipboard and mission package systems that were in scope except the MH-60S helicopter, SeaRAM, and software-defined radios. The CVPA details are classified but indicate that, like the *Freedom* variant seaframe, the *Independence* variant seaframe has cybersecurity deficiencies that significantly degrade the ship's operational effectiveness. Plans for the last phase of the cybersecurity operational testing, an Adversarial Assessment, are on hold pending a Navy decision on the readiness of the Increment 1 MCM mission package and *Independence* variant seaframe for MCM operational testing. As noted earlier, all OT-C4 cybersecurity testing in LCS 4 has been delayed until the Navy completes upgrades to the ship's networks designed to enhance its cybersecurity and correct known issues.
- **Limitations on Watercraft Launch and Recovery.** Because of structural defects in LCS 2 and LCS 4 identified during rough water trials aboard LCS 2, the Navy has established a limit on the maximum allowable dynamic loading of the Twin-Boom Extensible Crane (TBEC) used to launch and recover the RMMV and other watercraft. Sea conditions that would have caused the limit to be exceeded precluded RMS operations on several occasions during the MCM mission package TECHEVAL aboard LCS 2. Additionally, the design of the *Independence* variant seaframe and the ship's watercraft launch, handling, and recovery system used with the TBEC, coupled with the turbulent wake

produced by the water jets, make launch and recovery of the RMMV and other watercraft complex and somewhat risky evolutions, requiring the ship's crew to exercise great care.

- **Operational Suitability.** COTF collected reliability, maintainability, availability, and logistics supportability data to support evaluation of the operational suitability of the *Independence* variant seaframe throughout the last half of FY15 and plans to continue that effort when MCM OT-C2 begins on LCS 2 and when OT-C4 resumes on LCS 4. Although incomplete, the data collected to date show that essential *Independence* variant seaframe systems have significant reliability problems. During developmental testing, the LCS 4 crew had difficulty in keeping the ship operational as it suffered repeated failures of the ship's diesel generators, water jets, and air conditioning units. Some of the failures proved to be problems with communications between the systems and the Engineering Control System, which forced the crew to place key systems into 'local' mode to resume operation. As a temporary expedient, this was generally effective, but because the reduced size of the crew was predicated on extensive use of automation, the added labor involved in monitoring and controlling these systems individually stretches the limits of the crew's ability to operate and maintain the ship's systems. In addition, because of the planned reliance on shore-based contractor support, in many cases the LCS crew lacks the documentation, training, test equipment, and tools required to troubleshoot and repair serious problems as they emerge. Lack of documentation and training contributed to recurring issues with the TSCE, integrated combat management system (ICMS) software, and communications systems.
- **LCS 2 Reliability and Availability.** LCS 2 equipment failures left the ship with limited mission capability throughout the 176-day data collection period and with no mission capability on two occasions. Many of the failures disrupted MCM operations, and caused the ship to return to, or remain in, port for repairs. The ship had to call for shore-based assistance to repair nearly all significant failures. The following are the most significant seaframe equipment problems observed during the data collection period.
  - LCS 2 had no Secret Internet Protocol Router Network (SIPRNET) connectivity for a period of four days at the beginning of the period because of a hard drive failure that had occurred the previous month. Lack of SIPRNET connectivity impedes the flow of classified information between the ship and the operational commander.
  - Failure of the navigation attitude server deprived critical combat systems of roll and pitch information for six days during the period and limited the capability of ICMS, SeaRAM, and the AN/SPS-77 ASR.
  - SeaRAM experienced four failures, leaving the ship with no air defense capability for a total of 120 days (68 percent of the period).
  - The MK 110 57 mm gun was inoperative for 114 days because of damage caused when gun components overheated, rendering the ship incapable of any defense against an LSF threat and leaving only crew-served machine guns for defense against surface threats.
  - SAFIRE was inoperative for a period of 25 days until the turret could be replaced, but this outage occurred while the 57 mm gun was inoperative, a period when the ship already had little capability to defend against a surface or LSF threat.
  - The AN/SPS-77 ASR had multiple outages of short duration (3 to 30 minutes) that required the crew to reboot an interface device and was restricted to limited use because of a failing antenna turntable gearbox for a period of 3 weeks until it could be repaired by a SAAB technician.
  - Failure of a power conversion unit that supplied 400 Hertz power to the mission bay deprived the ship of MCM mission capability for 20 days while the ship was in port undergoing repairs. The Naval Sea Systems Command was forced to locate a functional replacement because the failed unit was obsolete and could no longer be supported with repair parts.
  - The ship also lost the capability to supply 400 Hertz power to the aircraft hangar, where it is needed to conduct pre-mission checks on the MH-60S and AMCM systems. The ship was provided portable power units to fill the gap until the ship's power converter could be repaired. The Navy never determined the cause of the near-simultaneous failures of the two power conversion units, although technicians considered them related.
  - LCS 2 experienced multiple air conditioning equipment failures and was unable to supply enough cooling to support the ship's electronics on several occasions. One or more of the ship's 3 chilled water units was either inoperative or operating at reduced capacity for 159 days (90 percent of the period).
  - A Mobicon straddle carrier failure left the ship unable to conduct waterborne MCM operations for a period of four days until a technician could travel from Australia to diagnose the problem and make needed adjustments. This episode demonstrated the crew's paucity of documentation, training, and diagnostic equipment.
  - The boat davit failed while launching the lifeboat (7-meter RHIB) and forced the ship to accompany the boat into port. The ship remained in port with no usable mission capability for five days because the lifeboat is safety equipment and essential for operations at sea.

  - The ship experienced several Ship Service Diesel Generator failures during the period, but was never without at least two of four generators operable (sufficient to power all combat loads, but limited maximum propulsion speed).
  - LCS 2 was unable to launch and recover RMMVs on 15 days because of 4 separate propulsion equipment failures involving diesel engines, water jets, and associated hydraulic systems and piping. These failures would also have limited the ship's capability to use speed and maneuver to defend itself against small boat threats.
  - LCS 2 was unable to launch and recover RMMVs on 10 additional days because of 3 TBEC failures.
- LCS 4 Reliability and Availability. LCS 4 exhibited equipment failures that limited its operational availability and left the ship with limited mission capability at various points throughout the data collection period (113 days). The ship was fully mission capable less than 40 percent of that time. The following are the most significant seaframe equipment problems observed during the data collection period.
  - LCS 4 spent 45 days during this period without all 4 engines and steerable water jets operational. This includes a 19-day period in May when 3 of the 4 engines were degraded or non-functional. Since LCS relies on speed to augment its combat effectiveness and survivability, the loss of any engine (especially a gas turbine) can degrade the ship's effectiveness.
  - LCS 4 experienced multiple air conditioning equipment failures and was unable to supply enough cooling to support the ship's electronics for a two week period in May. One or more of the ship's 3 chilled water units was either inoperative or operating at reduced capacity for 56 days.
  - JP-5 fuel pump failures left the ship with no capability to refuel the embarked helicopter for 11 days.
  - A TBEC failure left the ship unable to recover an 11-meter RHIB until the day after it was launched. Once the RHIB was recovered, the TBEC remained in a degraded state for 23 days.
  - The 57 mm gun was either inoperative or operating in a degraded condition for 35 days.
  - SeaRAM, the ship's primary defense against ASCMs, was inoperative or degraded for 15 days.
  - The ship's ride control system, used for high-speed maneuvering, did not appear to be fully functional at any time during developmental or operational testing in FY15.
  - Similar to problems seen on LCS 2, the AN/SPS-77 ASR had multiple outages of short duration (3 to 30 minutes) that required the crew to reboot an interface or the radar itself.
  - Numerous interruptions in the flow of navigation data were noted during live fire events in September, seriously degrading the ship's combat effectiveness. Both combat and navigation systems require frequent updates about the ship's heading, roll, and pitch to operate correctly. Without this information, the ASR, SeaRAM, and ESM system cannot correctly determine the relative orientation of targets to the ship, and more critically, the 57 mm gun cannot fire. Even a momentary interruption of navigation data to these systems forces 57 mm operators to reestablish a track on the target via SAFIRE (a laborious process) and disrupts the crew's situational awareness.

SUW Mission Package

- In FY14 operational testing, LCS 3 (*Freedom* variant) and an embarked Increment 2 SUW mission package demonstrated the capability to defeat a small swarm of FIACs under the specific conditions detailed in the Navy requirement; however, the crew received extensive hands-on training that might not be available to crews on other ships. Testing conducted to date has not been sufficient to demonstrate LCS capabilities in more stressing scenarios consistent with existing threats or to demonstrate with high confidence that the *Freedom* variant LCS can defeat even small swarms with regularity when equipped with the Increment 2 SUW mission package.
- While equipped with the Increment 2 SUW mission package, LCS 4 participated in three engagements with small swarms of FIACs. The engagements used the same "keep-out" criteria as the single target self-defense engagements. Although all of the attacking boats were ultimately defeated, an attacker managed to penetrate this "keep-out" range in two of the three events. In all three events, however, the ship expended a large quantity of ammunition from the seaframe's 57 mm gun and the two mission package 30 mm guns, while contending with repeated network communication faults that disrupted the flow of navigation information to the gun systems as well as azimuth elevation inhibits that disrupted or prevented establishing firing solutions on the targets. The SAFIRE performance issues described in the seaframe section also presented the crew with challenges during the swarm engagements. LCS 4's failure to defeat this relatively modest threat routinely under test conditions raises questions about its ability to deal with more realistic threats certain to be present in theater.
- In the past, the 30 mm Gun Mission Modules have been prone to jams caused by separation of ammunition links and accumulation of spent cartridges in the ejection path. Although they can typically be cleared in a few minutes, ammunition jams interrupt firing and can be sufficiently disruptive to cause the ship to lose valuable time in a fast-moving engagement. FY14 testing conducted in LCS 3 showed the Navy's concerted effort to improve ammunition belts has had some positive effect, but the problem has not been eliminated. LCS 4 experienced numerous instances of link separation during FY15 developmental testing, but DOT&E observers report that modified ammunition can lids

introduced before the operational test have largely mitigated that problem.

- LCS 4 experienced a large number of azimuth elevation inhibits during FY15 developmental and operational tests, which momentarily interrupted 30 mm gun firing engagements. The azimuth elevation inhibit is designed to prevent the gun from firing when the pointing of the gun sight and gun are not in reasonable agreement. Observers reported that the inhibits occur with annoying frequency (a dozen or more times during a live fire engagement), severely impairing the flow of the engagement. The crew reported that the cause of the frequent inhibits was to have been corrected in a software patch, but the patch was either not installed or not effective.

MCM Mission Package

- DOT&E concluded in a November 2015 memorandum to the Secretary of Defense and the Navy, based on the testing conducted to date, that an LCS employing the current MCM mission package would not be operationally effective or suitable if it were called upon to conduct MCM missions in combat and that a single LCS equipped with the Increment 1 MCM mission package would provide little or no operational capability to complete MCM clearance missions to the levels needed by operational commanders. The primary reasons for this conclusion are:
  - Critical MCM systems are not reliable.
  - The ship is not reliable.
  - Vulnerabilities of the RMMV to mines and its high rate of failures do not support sustained operations in potentially mined waters.
  - RMMV operational communications ranges are limited.
  - Mine hunting capabilities are limited in other-than-benign environmental conditions.
  - The fleet is not equipped to maintain the ship or the MCM systems.
  - The AMNS cannot neutralize most of the mines in the Navy's threat scenarios; an Explosive Ordinance Disposal Team or other means provided by another unit must be used.
- During the MCM mission package TECHEVAL, the Navy demonstrated that an LSC could detect, classify, identify, and neutralize only a fraction of the mines in the Navy's mine clearance scenarios while requiring extraordinary efforts from shore support, maintenance personnel, and contractors.
- During developmental testing, the Navy has not demonstrated that it can sustain LCS-based mine reconnaissance and mine clearance rates necessary to meet its strategic mine clearance timelines. Following TECHEVAL, DOT&E identified seaframe reliability and availability, poor reliability of MCM components—particularly the RMS/RMMV—system integration problems, and subsystem limitations as critical shortcomings that have substantially limited MCM effectiveness. In addition to the seaframe problems discussed earlier in this LCS report, this section discusses specific mission package shortcomings that, unless corrected, will continue to prevent the Navy from achieving its LCS MCM objectives, including the required timelines for large-scale mine clearance operations.
- As stated in the November 2015 DOT&E memorandum to the Secretary of Defense and the Navy, testing continues to show that employing these LCSs with the Increment 1 MCM mission package would require an exorbitant and costly shore infrastructure to make an insignificant contribution to the mine area clearance needs of operational commanders. In the pre-test work-ups and the TECHEVAL, the crew had to request on-site or remote assistance 33 times. The RMMVs during this same period required 291 shore-based actions necessitating 4,123 man-hours of effort to accomplish 107.7 hours of minehunting. The Navy significantly increased the shore-based support above their original support concept to complete the TECHEVAL.
- **Inability to Sustain Timely MCM Operations.** LCS MCM mission package testing since 2011 has shown that MCM mission-critical systems are often not available when needed and frequently fail after only short periods of operation, making it impossible for the *Independence* variant LCS to sustain timely MCM activities over long periods. Problems with seaframe support systems (discussed above), the Remote Minehunting Module, and MH-60S and AMCM modules have all contributed to lost MCM productivity. During TECHEVAL, in FY15, the Navy devoted approximately 80 of 132 test days to seaframe, RMS, and AMCM repair actions rather than minehunting operations. These TECHEVAL corrective maintenance demands prevented LCS 2 from demonstrating that it could provide rapid and sustained mine reconnaissance and mine clearance.
  - **RMS.** Severe RMS reliability problems continued to persist throughout FY15 testing. The table below provides a summary of RMMV and RMS reliability data collected that shows the reliability of the RMMV and RMS are consistently below the 75 hours Mean Time Between Operational Mission Failure (MTBOMF) prescribed by the Navy requirements.

RMS and v6.0 RMMV Reliability in 2014-2015 Testing

Test Event	Test Period	System Operating Time (Hours)	RMMV OMFs	RMMV MTBOMF (Hours)	RMS OMFs	RMS MTBOMF (Hours)
LCS MCM MP DT-B2 Ph4 Pd2	Sept 11 – Oct 20, 2014	139.0	3	46.3 *(20.8-126.1)*	6	23.2 *(13.2-44.1)*
DT-B1	Jan 13 –Mar 25, 2015	163.4	7	23.3 *(13.9-42.0)*	8	20.4 *(12.6-35.1)*
LCS MCM MP TECHEVAL	Apr 7 – Aug 30, 2015	265.7	15	17.7 *(12.5-25.8)*	17	15.6 *(11.3-22.2)*
All	***Sep 11, 2014 – Aug 30, 2015***	***568.1***	***25***	***22.7 (17.4-30.1)***	***31***	***18.3 (14.4-23.6)***

Note: Values in parentheses represent 80 percent confidence intervals.
MCM – Mine Countermeasures; MP – mission package; TECHEVAL – Technical Evaluation; RMMV – Remote Muti-Mission Vehicle; OMF – Operational Mission Failure; MTBOMF – Mean Time Between Operational Mission Failure

- As DOT&E indicated in an August 2015 memorandum to USD(AT&L), without changes, RMMV and RMS reliability problems threaten the Navy's capacity to field and sustain a viable LCS-based MCM capability. Since the RMS is critical to achieving the Navy's sustained area coverage rate requirement, this annual report also includes a separate article on the RMS that provides additional detail.
  - During TECHEVAL, four RMMVs and six AN/AQS-20As operated off-board LCS for 226 hours and conducted 94 hours of minehunting (employing the sonar to actively search for mines, revisit contacts, and identify bottom objects). On six occasions, an RMMV could not be recovered aboard LCS 2 and had to be towed to port by test support craft and then shipped to the remote operating site (simulating an in-theater depot-level maintenance activity) or prime contractor site (original equipment manufacturer intermediate- and depot-level repair facility) for repairs. On average, the LCS 2 completed a total of 5 hours of RMS minehunting per week (1.25 hours per week per RMMV), and an RMMV had to be towed to port for every 16 hours of RMS minehunting.
  - The pace of RMS operations demonstrated by one LCS with 4 RMMVs is less than 10 percent of the operating tempo for a single ship shown in the Navy's Design Reference Mission Profile for Increment 1 bottom-focused minehunting (shallow-water) operations. Based on the demonstrated pace of operations during TECHEVAL, all of the RMMVs the Navy plans to acquire to outfit 24 MCM mission packages would be required to search the area that the Navy originally projected a single LCS and MCM mission package could search.
  - Although the Navy considers one of the two RMMVs in the Increment 1 mission package an embarked spare that permits continued RMS operations even after one unit fails, LCS 2 averaged just 3.5 days underway before losing all RMS capability, that required a call for outside RMS repair assistance, or necessitated a return to port. LCS 2 was underway for more than one week with at least one mission-capable RMS embarked only once during TECHEVAL. On five occasions, LCS 2 operated for less than two days before encountering an RMS problem that required assistance from shore-based intermediate-level maintenance personnel to continue operations. In three cases, an RMMV was recovered without collecting minehunting data. These problems resulted in the RMMV returning to LCS 2 with at least some fraction of the expected mission data in only 15 of 24 launches (63 percent).
  - Mishaps also severely damaged two RMMVs, causing them to be returned to the contractor for extensive repairs.
  - Despite underway periods that were short relative to the expectations of the LCS Design Reference Mission Profile, both RMMVs embarked at the beginning of an underway period were unavailable to conduct minehunting missions six times during TECHEVAL.
  - On 3 occasions, totaling 19 days, all four v6.0 RMMVs in the Navy's inventory were unavailable to execute minehunting missions.
  - The Navy completed TECHEVAL with one of four RMMVs operational. However, post-test inspections revealed that the sonar tow cable installed in that unit was no longer functional.
- **AMCM.** During TECHEVAL, the MH-60S and its associated AMCM mission kit and mission systems also experienced problems that interrupted or delayed LCS MCM activities.
  - Nine MH-60S AMCM problems interrupted or delayed MCM missions. These problems included MH-60S rotor blade delamination, an MH-60S power distribution unit failure, a broken relief valve on an MH-60S hydraulic reservoir, multiple AMCM mission kit failures that required the MH-60S to return to port for repairs, and an AMNS neutralizer that failed to launch when commanded. The launch failure would have required the aircrew to jettison the launch and handling system if live rounds (operational assets)

been employed. As a result, LCS 2 demonstrated sustained MH-60S operations lasting more than one week just once during TECHEVAL.
  - On eight occasions, LCS 2 conducted MH-60S operations for two days or less before needing repairs that in many cases required the ship or helicopter to return to port for spare parts or repairs. In one case, after returning to port, the Navy elected to replace a helicopter embarked aboard LCS and in need of repairs rather than repair it.
  - In total, during 132 days of TECHEVAL, the LCS 2 Aviation Detachment employed two MH 60S helicopters for 141 flight hours.
  - Considering only the 58 days underway, LCS 2 was ALMDS-mission capable for 16 days, AMNS-mission capable for 26 days, and not capable of conducting the planned AMCM mission for 16 days primarily because of helicopter and mission kit problems. Nearly all the lost AMCM mission days occurred in the AMNS configuration. This is not surprising given that the AMNS mission is more stressing on the MH-60S and its AMCM mission kit because of the need to lower the loaded AMNS launch and handing system into the water and retrieve it at least once per sortie.
  - The MH-60S aircrew employed 2 ALMDS pods to search for mines for 33 hours and 3 AMNS launch and handling systems to launch 107 inert neutralizers against 66 targets.
  - Since the MH-60S AMCM capability is critical to achieving the Navy's sustained area coverage rate requirement, this annual report also includes a separate article on the MH-60S that provides additional detail.
- **Communications between LCS and its Unmanned Vehicles.** Two significant communications shortcomings limit the effectiveness of the current LCS MCM mission package system-of-systems. One centers on the limited range of high data rate communications between an off-board RMMV and the host LCS and the other is related to the persistent difficulty with establishing and maintaining the existing line-of-sight (LOS) and over-the-horizon (OTH) communications channels. The former limits the reach and productivity of LCS MCM operations, and the latter results in frequent mission delays and the potential loss of an RMMV with which the LCS is unable to communicate. Unless these problems are solved, the LCS and its MCM mission package will never be able to fulfill its wartime MCM missions within the timelines required.
- Although the RMMV can search autonomously while operating OTH from the LCS, it can only conduct Electro-optical Identification operations to reacquire and identify bottom mines when operating within LOS communications range of the LCS. This limitation will complicate MCM operations in long shipping channels, and will make it necessary to clear a series of LCS operating areas to allow the ship to follow MCM operations as they progress along the channel. The cleared operating areas must be close enough to the intended search area to maintain LOS communications and large enough to enable LCS operations, including ship maneuver to facilitate launch and recovery of the RMMV and MH-60S helicopter. The additional time required to clear these areas will increase the demand for mine clearance. Although a May 2012 Navy briefing proposed development of an airborne relay and a high frequency ground wave radio capability, along with other upgrades, to make the Increment 1 MCM mission package "good enough" for IOT&E, the Navy has not yet fielded either of those capabilities. Had LCS 2 been required to clear its operating areas during the 2015 TECHEVAL and the Area Coverage rate Sustained remained unchanged, the time required to complete MCM operations in the test field would have increased nearly three-fold. In the May 2012 briefing cited above, the Navy reached a similar conclusion regarding the operational consequences of limited RMMV communications ranges.
- During TECHEVAL, LCS 2 had frequent problems establishing initial communications between the ship and an RMMV using existing OTH and LOS channels and maintaining those communications links once established. These problems frequently delayed the start of RMS missions and periodically terminated missions prematurely. On one occasion, loss of communications during an attempt to launch an RMMV caused the ship to return to port with the RMMV suspended from the TBEC because the crew was unable to complete the launch or bring the vehicle back into the mission bay. On another occasion, loss of LOS communications resulted in extensive damage to an RMMV that required months of depot-level repair at the contractor's facility when the ship attempted to recover it using OTH communications. On a third occasion, an abrupt loss of power led to loss of communications with an RMMV, making it necessary for a test support craft to take the RMMV under tow. In addition to these incidents, the LCS crew routinely found it necessary to seek help from shore-based technicians to resolve communications problems. During the latter portion of TECHEVAL, the program manager embarked a team of subject matter experts to monitor LCS – RMMV communications, assist with troubleshooting, and collect diagnostics. Shortly after the TECHEVAL, the Program Office established a task force to analyze the communications problems and propose solutions. The task force has since recommended a multi-faceted approach that includes improving operating and troubleshooting documentation for the communications system-of-systems, enhancing crew training in initialization of communications links and fault troubleshooting, and, longer term, a reexamination of the communications architecture.
- **Potential Attrition of RMMVs When Employed in Mined Waters.** The combination of acoustic radiated

noise, frequent RMMV failures that prevent recovery aboard LCS, and the probability the vehicle and its sensor will get entangled with mines or other hazards all pose a risk to losing the RMS. Given the limited existing inventory of RMMVs (four v6.0 vehicles, four vehicles awaiting upgrades to v6.0, and two vehicles designated for training use only), any RMMV attrition would severely degrade the Navy's ability to conduct LCS-based MCM operations.

- RMMV acoustic radiated noise measurements, last collected during developmental testing in 2007/2008, indicated that existing RMMVs might be vulnerable to some mines. The RMS Program Office has not assessed radiated noise following recent vehicle configuration changes and has requested a waiver to deploy the system even through it did not previously meet its acoustic radiated noise specification. If RMMV radiated noise continues to exceed acceptable limits, systems could be lost during LCS-based minehunting and mine clearance operations depleting the Navy's limited inventory of assets. The magnetic signature of the v6.0 RMMV has not been measured.
- As noted earlier, only 18 of 24 RMMVs launched from LCS 2 ended with an RMMV recovery aboard LCS 2 during TECHEVAL. Frequent RMMV failures that preclude vehicle recovery aboard LCS might result in lost RMMVs and expose personnel who attempt to recover RMMVs in open waters to air, surface, and mine threats. Because of the number of incidents in which an RMMV could not be recovered, the Navy is now considering options that would provide LCS with additional support to recover RMMVs that it cannot recover otherwise. On four occasions during TECHEVAL, RMMV failures precluded LCS 2 from controlling the movements of an off-board RMMV. If similar failures occur during operations, the RMMV could become disabled in the minefield or drift into a minefield before salvage or support craft arrive to recover it.
- Even though test minefields are deliberately planned to reduce the risk of RMS striking a mine target or becoming entangled in its mooring cable, the RMS has snagged several tethered mines, and other surface and underwater objects during testing. These incidents often cause damage to the vehicle or its deployed sonar that leaves the system inoperable. In some cases, divers embarked on test support craft have entered the water to assist in recovery of assets following a snag. Although the Navy is still developing CONOPS to handle these situations during operations in a threat minefield, it is clear that if these incidents occur during wartime operations they will pose a risk to vehicles and potential recovery personnel. Furthermore, the repeated occurrence of these incidents presents both a tactical and a system design challenge for the Navy to resolve as it tries to minimize attrition when the system is operationally employed.
- In FY15, the Navy also disclosed that the AN/AQS-20 does not trail directly behind the RMMV when deployed to tactical minehunting depths. Instead, the sensor tows to starboard of the RMMV path. This offset causes the RMS to behave like a mine sweeping system as the sonar and its tow cable passes through the water, thereby increasing the risk of snagging a tethered mine.

- **System Minehunting Performance in Less Than Optimal Conditions.** Testing has revealed several shortcomings that, unless corrected, will delay completion of LCS-based mine reconnaissance and mine clearance operations.
  - The ALMDS does not meet Navy detection/classification requirements in all depth bins or the Navy's requirement for the average probability of detection and classification in all conditions over a region of the water column that extends from the surface to a reduced maximum depth requirement. When the system and operator detect and classify a smaller percentage of mines than predicted by fleet planning tools, the MCM commander will likely underestimate the residual risk to transiting ships following clearance operations. To account for this uncertainty, the Navy might find it necessary to conduct minesweeping operations. However, the Navy does not plan to include the mechanical minesweeping capability that would be required in the MCM mission package. In some conditions, the ALMDS also generates a large number of false classifications (erroneous indications of mine-like objects) that can delay near-surface minehunting operations until conditions improve or slow mine clearance efforts because of the need for additional search passes to reduce the number of false classifications. In favorable environmental conditions, the Navy's new multi-pass tactic has been successful in reducing false classifications to the Navy's acceptable limits at the cost of requiring more search and identification time.
  - The RMS program has not yet demonstrated that the AN/AQS-20A operating in its tactical single pass modes can meet its detection and classification requirements against deep water targets moored near the ocean bottom, near-surface moored mines that are not detected by the ALMDS, or stealthy bottom mines. Unless corrected, these problems will likely adversely affect the quality of LCS-based minehunting and mine clearance operations in some threat scenarios. As an alternative, additional RMS search passes could be employed with the sensor at other depths, but this will further slow minehunting and mine clearance operations.
  - The results of developmental and integrated testing to date continue to show that the RMS's AN/AQS-20A sensor does not meet Navy requirements for contact depth localization accuracy or false classification

density (number of contacts erroneously classified as mine-like objects per unit area searched). Contact depth localization problems complicate efforts to complete identification and neutralization of mines. False classifications, unless eliminated from the contact list, require identification and neutralization effort, result in the expenditure of limited neutralizer assets, and negatively affect the LCS sustained area coverage rate. To mitigate the problem of false classifications, the Navy has implemented tactics and software designed to compare the results of multiple search passes over the same area to "prune out" most false classifications and minimize the number conveyed for identification/neutralization. Under some conditions, the Navy has demonstrated these pruning tactics reduce false classification densities to the Navy's acceptable limits. However, as observed during developmental testing in 1QFY15, these new procedures do not reduce false classification densities appreciably in all operationally relevant conditions. The continued need for additional passes to "prune out" excessive classifications will prevent the LCS MCM mission package from achieving the Navy's predictions for Sustained Area Coverage Rates that were based on the expectation that RMS would be a "single-pass" system.

  - The Navy is developing AN/AQS-20 pre-planned product improvements (P3I) as a longer-term solution to improve probability of correct classification, reduce false classifications, and resolve contact localization accuracy problems. In early FY15, the Navy was optimistic that it could produce a mature P3I system prior to the first phase of LCS MCM operational testing then planned in late FY15. The Program Office now expects the P3I system to enter operational testing in FY18.
  - Developmental testing of the RMS in 2008 revealed that the system had problems reacquiring bottom objects for identification in deeper waters. Although the Navy implemented fixes in the v6.0 RMMV designed to correct this deficiency, the Navy has not yet conducted sufficient testing to evaluate the efficacy of its fix.
  - During an AN/AQS-20A operational assessment in 2012, operators had difficulty identifying bottom objects in areas with degraded, but operationally relevant, water clarity. Unless system performance in this environment improves, degraded water clarity will delay MCM operations.

- **Limited Mission Package Neutralization Capability.** The current increment of the MCM mission package cannot neutralize moored mines above the AMNS operating ceiling; an Explosive Ordinance Disposal Team or other means provided by another unit must be used. Unfortunately, this limitation will preclude neutralizing most of the mines expected in some likely threat scenarios. Within its operating range, AMNS performance is frequently degraded by the loss of fiber-optic communications between the aircraft and the neutralizer. The system has experienced loss of fiber-optic communications in a wide range of operationally relevant operating conditions, including those that are relatively benign. Although the Program Office has stated that it intends to develop an improved AMNS to extend its depth range and potentially improve performance in coarse bottom conditions and higher currents, none of these efforts are funded. The Navy is also considering other alternatives.
  - AMNS Increment 1 cannot neutralize near surface mines because of safety interlocks designed to protect the helicopter and crew from exposure to fragments, surge, and blast that might result from mine detonation; an Explosive Ordinance Disposal Team or other means provided by another unit must be used.
  - During the shore-based phase of an operational assessment completed in 2014, the system and its operators were unable to achieve the Navy's requirement for mine neutralization success in realistic conditions. Frequent loss of fiber-optic communications between the aircraft and the neutralizer was the primary cause of unsuccessful attack runs. The Navy attributed the failures to the bottom composition even though the bottom conditions experienced in the test area were not significantly different from those expected in some potential operating areas.
  - Following developmental testing in high-current environments in 2013, Navy Air Test and Evaluation Squadron Twenty One (HX-21) concluded that the AMNS destructor, as currently designed, is ineffective in swift water currents. Although the Navy completed additional developmental testing in 2015, the Navy's testing has not characterized system performance under operationally realistic conditions in even moderate currents that might be encountered in potential operating areas.
  - **Inability to Maintain Systems.** An earlier section of this LCS report noted that, consistent with the CONOPS, the LCS is reliant on shore-based support for assistance with diagnosis and repair of seaframe equipment problems and that the ship could be more self-reliant if the sailors were provided with better maintenance training, technical documentation, test equipment, and tools and a more extensive stock of spares. This holds true for the MCM mission systems as well, because the mission package detachment is also not equipped to handle anything beyond relatively uncomplicated preventive maintenance and minor repairs. For example, the Navy's records show that shore-based RMMV maintenance personnel completed more than 4,000 hours of RMMV maintenance over 6 months of TECHEVAL work-ups and testing to support approximately 108 hours of RMS minehunting. Not only is this level of support, 38 hours of maintenance per hour of minehunting, far beyond the capability of the embarked crew, it is also not sustainable for wide-area LCS MCM operations that must be completed quickly.

- **Problems with Developmental MCM Systems.** Two problems observed during early developmental testing of COBRA Block I, if not subsequently corrected, could adversely affect the operational effectiveness and suitability of the system and the Increment 2 MCM mission package.
  - During early developmental testing of the COBRA Airborne Payload System (CAPS) on a UH-1 helicopter, the system suffered multiple power losses because of an unstable power supply voltage to the power distribution assembly (PDA) caused by a bad reference ground. The PDA subsequently shut down CAPS as a precautionary measure, resulting in the loss of imagery.
  - During dynamic conditions, such as roll and pitch maneuvers, the COBRA Integrated Gimbal (IG) was unable to maintain the correct step-stare sequence to acquire a complete dataset. During flight operations, the IG must continuously look at a single spot (stare) while the system records multiple images. The IG must also adjust its look angle to step to the next spot to optimize its imagery acquisition. The inability to maintain the correct step-stare sequence can result in gaps in the imagery of the target area.

ASW Mission Package

- Although the Navy did not conduct any ASW mission package testing in FY15, problems observed in early developmental testing, if not corrected, could adversely affect the operational effectiveness and suitability of the mission package during a future operational test. In particular, the mission package exceeds the LCS mission package weight allowance. The weight of the Variable Depth Sonar and its handling system is a major contributor, and the Navy is pursuing weight reduction initiatives.

LFT&E

- Neither LCS variant is expected to be survivable in high-intensity combat because the design requirements accept the risk that the ship must be abandoned under circumstances that would not require such an action on other surface combatants. Although the ships incorporate capabilities to reduce their susceptibility to attack, previous testing of analogous capabilities in other ship classes demonstrates it cannot be assumed LCS will not be hit in high-intensity combat. As designed, the LCS lack the redundancy and the vertical and longitudinal separation of equipment found in other combatants. Such features are required to reduce the likelihood that a single hit will result in loss of propulsion, combat capability, and the ability to control damage and restore system operation.
- LCS does not have the survivability features commensurate with those inherent in the USS *Oliver Hazard Perry* class Guided Missile Frigate (FFG 7) it is intended to replace. The FFG 7 was designed to retain critical mission capability and continue fighting if need be after receiving a significant hit.
- The LCS 3 TSST revealed significant deficiencies in the *Freedom* variant design. Much of the ship's mission capability would have been lost because of damage caused by the initial weapons effects or from the ensuing fire. The weapons effects and fire damage happened before the crew could respond, and the ship does not have sufficient redundancy to recover the lost capability. Some changes could be made to make the ship less vulnerable and more recoverable without major structural modifications. Examples include providing separation for the water jet hydraulic power units, redesigning the Machinery Plant Control and Monitoring System, and reconfiguring the chilled water system into a zonal system with separation for the air conditioning (chilled water) plants.
- DOT&E is analyzing the initial internal blast test findings recently provided by the Navy. The Navy delayed completion of the planned fire testing and final internal blast tests until the spring of 2016 because of other Navy testing priorities.

Recommendations

- Status of Previous Recommendations.
  - The Navy partially addressed one FY09 recommendation to develop an LFT&E program with the approval of the LFT&E Management Plan; however, the lethality testing of the new surface-to-surface missile still needs to be developed.
  - The Navy partially addressed the FY10 recommendations to implement recommendations from DOT&E's Combined Operational and Live Fire Early Fielding Report and plans to address other recommendations in future ships.
  - With respect to FY11 recommendations regarding AN/AQS-20A and ALMDS, the Navy is adjusting tactics and, for the AN/AQS-20A, funding improvements to address deficiencies. The FY11 recommendation for the Navy to continue to report vulnerabilities during live fire tests remains valid.
  - For FY12 recommendations:
    - The Navy partially addressed the recommendations to complete the revised capabilities document defining the incremental approach to fielding mission packages.
    - The Navy has released requirements letters for Increments 1 and 2 SUW and Increment 1 MCM mission packages only; however, the requirements have not been codified in approved Capabilities Production Documents. The Navy published the LCS Platform Wholeness Concept of Operations Revision D in January 2013.
    - The Navy has not published the concept of employment for all the mission packages, but advises that it has completed initial manning level studies. The Navy has adjusted ship and mission package manning levels and is continuing studies to determine the final manning levels.
    - The Navy has stated that gun reliability problems identified during the Quick Reaction Assessment conducted aboard LCS 1 have been resolved based on limited testing conducted in October 2012. Subsequent testing has demonstrated that the gun reliability has indeed improved.

- The Navy conducted LCS-based phases of the planned operational assessments of the MH-60S Block 2/3 and ALMDS and the MH-60S Block 2/3 and AMNS MCM systems in 1QFY15.
- Throughout FY13/14, the Navy focused on correction of material deficiencies with seaframe launch and recovery systems, and procedural and training deficiencies that prevented safe shipboard launch and recovery of the RMS. Although the Navy has retired some problems, LCS 2 continued to experience some damage to equipment during RMMV launch and recovery in low to moderate sea states.
- The Navy should still address the FY13 recommendation to provide a surface-to-surface missile LFT&E Management Plan for DOT&E approval for the recently selected surface-to-surface missile.

- For FY14 recommendations:
  - The Navy continues to monitor the reliability of LCS systems and, when warranted by available data, incorporates system changes to improve reliability and other aspects of performance as funding permits.
  - The Navy has planned corrective actions for the cybersecurity deficiencies identified during operational testing of the *Freedom* and *Independence* variants of LCS but installation of upgrades will be done in FY16. The Navy completed a CVPA in LCS 2 with the MCM mission package in FY15, but the schedule for the follow-on Adversarial Assessment has not been determined. The Navy should consider scheduling the Adversarial Assessment after the planned upgrade to the ship's cybersecurity configuration as was done for the LCS 4 with the SUW mission package, whose testing will now be done in 2QFY16 when it expects to complete its first phase of cybersecurity upgrades.
  - The Navy has not yet altered its plan for live fire swarm engagements during testing of the SUW mission package; testing conducted in LCS 4 duplicated that completed in LCS 3 in FY14. Nor has the Navy developed plans for testing Increments 3 and 4 of the SUW mission package.
  - Although the Navy has identified potential solutions, DOT&E is not aware of any funded effort to provide the OTH communication needed for RMS electro-optical identification operations.
  - Although the Navy is continually working to improve mission system (RMMV, ALMDS, AMNS, AMCM mission kit, AN/AQS-20A) reliability, FY15 testing showed that reliability, maintainability, and availability problems continue to prevent timely and sustained MCM operations and require extensive reliance on shore-based support.
  - The Navy made minor modifications to the AMNS system and trained operators to maintain forward neutralizer motion to reduce the risk of cutting the fiber-optic cable, but the system continued to have problems with early termination of fiber-optic communications during TECHEVAL. The Navy should continue to monitor AMNS operations to identify uncorrected causes of fiber breaks.
  - The Navy reported that a technical group is reviewing the ventilation lineup during condition ZEBRA, (the highest condition of material readiness) in the *Freedom* variant LCS to determine if the system is operating as intended.
  - The Program Office reports that the contractor is investigating problems with the Machinery Plant Control and Monitoring System fire alarm system in the *Freedom* variant LCS.

- FY15 Recommendations. The Navy should:
  1. Shift to a performance-based test schedule rather than continuing a schedule-driven program to provide the LCS program ample time and resources needed to correct the numerous serious problems that repeatedly have been identified before operational testing occurs.
  2. Accelerate efforts to obtain the intellectual property rights needed to develop high-fidelity digital models of the AN/SPS-75 and AN/SPS-77 radars for the P_{RA} Test Bed, or present plans to enhance air warfare testing aboard the self-defense ship for DOT&E to review.
  3. Improve the shock resistance of mission-critical electronics in the *Independence* variant LCS to improve continuity of operations during 57 mm gun engagements and other shock-inducing activities/events.
  4. Work with the vendor to develop SAFIRE changes needed to improve the human-machine interface, reduce the time required to develop a new track, improve tracking, and correct other performance issues noted in FY15 testing in order to enhance the *Independence* variant seaframe's effectiveness against surface and LSF threats.
  5. Investigate and correct the causes of *Independence* variant seaframe problems that disrupt gunnery engagements and other operations, including loss of navigation information to combat systems, 30 mm gun azimuth-elevation inhibits, and the 57 mm gun's azimuth-dependent range errors.
  6. Re-engineer the Multi-Vehicle Communication System, RMMV, and/or other essential system-of-systems components to improve interoperability and enable reliable LOS and OTH communications between LCS and RMMVs.
  7. Develop a safe method to realistically test the ships' ability to counter LSF threats.
  8. Provide LCS crews with better training, technical documentation, test equipment, and tools, along with additional spares to improve the crews' self-sufficiency and enhance LCS and mission package maintainability.
  9. Acquire additional organic U.S. Navy expertise in LCS systems to reduce the reliance on equipment vendors and other contractors, particularly those located overseas.
  10. Continue to investigate options to re-engineer the recovery of watercraft in order to reduce risk, delays, crew workload, and the likelihood of failures.
  11. Develop tactics to mitigate system vulnerabilities to mines, mine collision, and entanglement hazards, and other surface and underwater hazards.