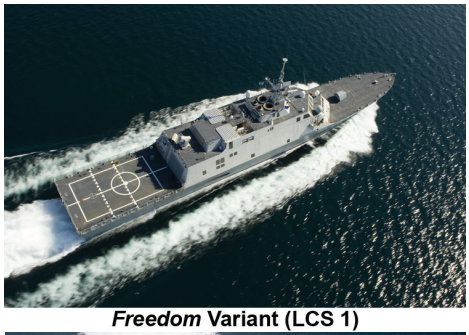
Littoral Combat Ship (LCS)

Executive Summary

- DOT&E approved a revision to the Littoral Combat Ship (LCS) Test and Evaluation Master Plan (TEMP) in August 2013, and issued an Early Fielding Report in December 2013 providing an assessment of the LCS seaframes and mission packages.
- The Navy has not yet conducted comprehensive operational testing of the LCS but has scheduled some initial operational test events in FY14.
- The Navy completed the second phase of a Quick Reaction Assessment (QRA) of the capabilities and limitations of the *Freedom* variant seaframe and Increment II Surface Warfare (SUW) mission package on LCS 1 in December 2012.
  - Results from the QRA revealed performance, reliability, and operator training deficiencies for both the 30 mm and 57 mm guns. Developmental tests of the SUW mission package in October 2013 show improvement over past performance.
  - The *Freedom* variant demonstrated a capability to conduct maritime interdiction operations when the mission module is embarked.
- The core combat capabilities of the *Independence* variant seaframe remain largely untested. Developmental testing focused on evaluating the performance of the seaframe and the Mine Countermeasures (MCM) mission package.
- Analysis of data from an operational assessment of the Airborne Laser Mine Detection System (ALMDS) conducted in FY12 showed that the system does not meet the Navy's desired probability of detection over the required depth zone and produces many false contacts. These deficiencies will increase the time required for the LCS to complete MCM operations. LCS has yet to demonstrate whether the first increment of MCM capability will meet the Navy's reduced expectations for mine clearance. Even if this MCM package meets all of its final increment requirements, legacy systems will be needed to perform the full range of mine clearance operations.
- LCS is not expected to be survivable in high-intensity combat because its design requirements do not require the inclusion of survivability features necessary to conduct sustained combat operations in a major conflict as expected for the Navy's other surface combatants.
- Equipment reliability problems have degraded the operational availability of LCS 1 and LCS 2. The Navy reports that recent reliability improvements made to the affected seaframe components have led to improved operational availability; however, no formal developmental or operational testing has occurred to verify and quantify any improvement.



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

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

System

Seaframes

- The LCS is designed to operate in the shallow waters of the littorals where larger ships cannot maneuver as well.
- The Navy plans to acquire a total of 52 LCSs.
- The Navy is procuring two (seaframe) variants of the LCS:
  - USS *Freedom* (LCS 1, 3, 5, and follow-on 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.
  - USS *Independence* (LCS 2, 4, 6, and follow-on 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 unrefueled range in excess of 3,500 nautical miles at 14 knots
  - Accommodations for up to 76 personnel
  - A Common Mission Package Computing Environment for mission package control

  - Hangars sized to embark MH-60R/S and Vertical Take-Off Unmanned Aerial Vehicles (VTUAVs)
  - 57 mm Bofors Mk 3 gun
- The designs have different core combat systems to provide command and control, situational awareness, and self-defense against anti-ship cruise missiles and surface craft.
  - *Freedom* Variant: COMBATSS-21, an Aegis-based integrated combat weapons system with a TRS-3D air/surface search radar, Ship Self-Defense System Rolling Airframe Missile (RAM) system (one 21-cell launcher), TERMA Soft Kill Weapon System, and a DORNA electro-optical/infrared system for Mk 110 57 mm gun fire control.
  - *Independence* Variant: Integrated Combat Management System (derived from Dutch TACTICOS system) with a Sea Giraffe air/surface search radar, one Mk 15 Mod 31 SeaRAM launcher mount (which integrates the search, track, and engagement scheduler of the Close-in Weapon System with an 11-round RAM launcher assembly), ALEX (Automatic Launch of Expendables) System (off-board decoy countermeasures), and Sea Star SAFIRE electro-optical/infrared systems for 57 mm gun fire control.

Mission Packages

- LCS is intended to accommodate a variety of individual warfare systems (mission modules) assembled and integrated into interchangeable mission packages. The Navy currently plans to field MCM, SUW, and Anti-Submarine Warfare (ASW) mission packages. Mission modules provide the seaframes with mission capability.
- Multiple individual programs of record involving sensor and weapon systems and off-board vehicles make up the individual mission modules.

SUW Mission Package

  - Increment 1
    - Gun Mission Module (two Mk 46 30 mm guns)
    - Aviation Module (embarked MH-60R)
  - Increment 2
    - Maritime Security Module (small boats)
  - Increment 3
    - Surface-to-Surface Missile system intended to provide limited "interim" SUW capability in response to an urgent operational need
    - Aviation Module (two VTUAVs)
  - Increment 4
    - Longer range Surface-to-Surface Missile

MCM Mission Package

  - Increment 1
    - Remote Minehunting System (RMS), consisting of the Remote Multi-Mission Vehicle (RMMV) and the AN/AQS-20A sonar system
    - MH-60S Block 2A/B Airborne Mine Countermeasures (AMCM) System, consisting of an AMCM system operator workstation, a tether system, and the two MCM systems currently under development – ALMDS for detection and classification of near surface mines, and the Airborne Mine Neutralization System (AMNS) for identification and neutralization of in volume and bottom mines (the AN/AQS-20A sonar system and Organic Airborne Sweep and Influence System are no longer being developed for use in the AMCM System)
  - Increment 2
    - Coastal Battlefield Reconnaissance and Analysis (COBRA) Block I system (and VTUAVs) for unmanned aerial tactical reconnaissance to detect and localize minelines and obstacles in the daylight in the beach zone and partially in the surf zone
  - Increment 3
    - Unmanned Influence Sweep System (UISS) to activate acoustic-, magnetic-, and combined acoustic/magnetic-initiated volume and bottom mines in shallow water so they self-destruct
  - Increment 4
    - COBRA Block II system (and VTUAVs), which has Block I capability with the addition of night-time minefield and obstacle detection capability and full detection capability in surf zone; and Knifefish Unmanned Undersea Vehicle, a self propelled, untethered, autonomous underwater vehicle, employing a low-frequency broadband sonar sensor 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 two VTUAVs)

Mission

- The Maritime Component Commander will employ LCS to conduct MCM, ASW, or SUW tasks depending on the mission package fitted into the seaframe. Commanders can employ LCS in a maritime presence role in any configuration because of capabilities inherent to the seaframe. With the Maritime Security Module, installed as part of the SUW mission package, the ship can conduct Visit, Board, Search, and Seizure maritime interception operations.
- The Navy can employ LCS alone or in company with other ships. The Navy is still developing the concept of employment for these ships in each of the mission areas.

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, LCS 8, and follow-on even numbered ships: Austal USA – Mobile, Alabama
  - Shipbuilder: Austal USA – Mobile, Alabama
- Mission Packages
  - Future Mission Package Integration contract awarded to Northrop Grumman – Los Angeles, California

---

Activity

LCS Program

- DOT&E approved a revision to the LCS TEMP in August 2013. The TEMP governs test and evaluation of both LCS seaframe and mission package programs through FY15 and has the strategy and resources identified to support completing IOT&E in FY19.
- DOT&E published an Early Fielding Report providing an assessment of the LCS seaframes and mission packages in December 2013.

Seaframe

- *Freedom* Variant (LCS 1):
  - Commander, Operational Test and Evaluation Force (COTF) completed the second phase of a QRA of *Freedom*'s capabilities and limitations in November and December 2012 along with an assessment of the ship's cyber defense and maritime interdiction capabilities in preparation for the ship's overseas deployment to Singapore.
  - The Navy continued developmental testing of the seaframe's 57 mm gun system in November and December 2012 and January 2013.
  - USS *Freedom* (LCS 1) departed San Diego, California, for operations in the Western Pacific in March 2013.
- *Independence* Variant (LCS 2):
  - The Navy completed calm water performance trials in May and June 2013 to evaluate the seaframe's speed, power, fuel consumption, and maneuvering characteristics.
  - The Navy completed acoustic trials in August 2013 to evaluate the radiated and structure-borne noise signatures.
  - The Navy completed a scheduled phase of developmental testing of structural improvements to the RMMV launch, handling, and recovery system, and multi-vehicle communications system (MVCS) upgrades in dockside and at-sea testing in 4QFY13.
- *Freedom* Variant (LCS 3):
  - USS *Fort Worth* (LCS 3) completed initial Combat System Ship Qualification Trial events in November and December 2012.
  - The Navy completed fuel economy trials in September 2013 to evaluate the seaframe's speed, power, fuel consumption, and maneuvering characteristics.
  - The Navy commenced developmental testing of LCS 3 and the Increment II SUW mission package in September 2013.

SUW Mission Package

- The Navy continued developmental testing of the 30 mm gun mission modules on LCS 1 in December 2012 and January 2013.
- The Navy established incremental performance requirements for the Increment II SUW mission package.
- The Navy completed the second phase of a QRA of the capabilities and limitations Increment II SUW mission package on LCS 1 in December 2012.
- The Navy conducted additional developmental testing of the SUW mission package in October 2013.

MCM Mission Package

- DOT&E issued a formal report on the Phase A (shore-based and training phase) operational assessment of the MH-60S Block 2 AMCM System with ALMDS. The Navy intends to conduct Phase B (LCS-based phase) of the ALMDS operational assessment in conjunction with the MCM mission package Developmental Test Phase 4 Period 2 on the *Independence* variant seaframe that is scheduled to occur in 4QFY14-1QFY15.
- The Navy established performance requirements for the Increment I MCM mission package.
- The RMS program completed a second and final phase of reliability growth improvements of the RMMV, and completed 438 hours of in-water contractor testing in 2QFY13.
- The AMNS program completed developmental testing using explosive destructors against moored explosive-filled targets (live-on-live testing) at Aberdeen Test Center, Maryland; explosive destructors against inert targets in the Gulf of Mexico; and training neutralizers against inert targets in the Gulf of Mexico and at the South Florida Test Facility in the Atlantic. COTF plans to conduct an

operational assessment in two phases: shore-based in mid-FY14 and LCS-based in late FY14.
- The Navy continued developmental testing of the RMMV launch, handling, and recovery system, and MVCS interoperability in LCS 2.

LFT&E
- In July 2013, the Navy began 30 mm ammunition lethality testing in accordance with the DOT&E-approved plan at Naval Surface Warfare Center – Dahlgren, Virginia. Testing will continue into FY14.
- Component-level aluminum survivability testing began in June 2013 that will generate data to address the aluminum structural collapse due to fire exposure. Also, the Navy conducted a series of large-panel tearing tests of aluminum structural elements unique to the *Independence* variant of the LCS. Additional surrogate tests to address knowledge gaps related to the vulnerability of the aluminum ship structure to weapon induced blast and fire damage will be conducted during FY14.
- The Navy updated the LCS TEMP with a plan to assess LCS vulnerability against the latest Capability Development Document requirements. The results of this assessment will be included in a Detail Design Survivability Assessment Report that is scheduled for completion in FY16.

Assessment

This assessment is based on information from DOT&E's observations of post-delivery testing and trial events, fleet operations, and developmental test data and results provided by the Navy Program Offices. No formal at-sea operational tests were conducted.

Program
- The Navy intends to field LCS capabilities incrementally as mission package systems mature and become ready for fleet use. 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).
  - Since the Navy expects each increment to deliver significant increases in mission capability, DOT&E is requiring the Navy to conduct an appropriately-designed phase of OT&E on all delivered increments on each seaframe variant.
  - The initial phases of OT&E are scheduled in FY14, but the final phases will not be completed until the FY19 timeframe.

Seaframes
- While both seaframe variants are fast and highly maneuverable, they are lightly armed for ships of this size and possess no significant offensive capability without the planned SUW Increment IV mission package.
  - They have very modest self-defense capabilities; their air defense capabilities cannot be characterized fully until tests on LCS 5 and LCS 6 (the production-representative seaframes) and the Navy's unmanned Self-Defense Test Ship feed the Navy Probability of Raid Annihilation high-fidelity modeling and simulation analyses in FY18.
  - The surface self-defense capability is scheduled to undergo limited testing in the first OT&E events on LCS 2 and LCS 3 in FY14, but the Navy has deferred testing of the ships' capability to defeat unmanned aerial vehicles and slow-flying aircraft until production-representative seaframes are available.
  - The seaframes have no systems designed to detect torpedo attacks or mines without the appropriately configured mission packages installed.
- Results from the QRA revealed performance, reliability, and operator training deficiencies for the 57 mm gun on LCS 1 that prevented the ship from demonstrating it can meet the Navy's SUW performance requirements.
  - The Navy reported that the observed deficiencies have been corrected on LCS 1; and that those corrections were satisfactorily demonstrated during developmental testing in October 2012; however, no data were collected during that testing to facilitate an independent assessment.
  - The preliminary analysis of data collected during recent testing of the 57 mm gun conducted on LCS 3 in October 2013, which was observed by DOT&E, indicates that the gun reliability has improved. DOT&E expects to issue a formal test report in 4QFY14 after the Navy has completed IOT&E of the *Freedom* variant seaframe and Increment II SUW mission package.
- Crew size can limit the mission capabilities and combat endurance of the ship. The Navy continues to review manning to determine appropriate levels. The Navy installed 20 additional berths in LCS 1 for flexibility during its deployment and has stated that additional berths will be installed in all seaframes.
- *Freedom* Variant (LCS 1 and 3):
  - Developmental testing demonstrated that this variant can position, launch, and recover the 11-meter boats included in the SUW mission package as long as the launch, recovery, and handling system is operational. Replacement of the aluminum launch ramp with one constructed of steel allows a boat to be stored on the ramp to reduce the launch time and improve responsiveness. The Navy has not tested the ship's capability to handle, launch, and recover other watercraft.
  - COMBATSS-21 and TRS-3D performance deficiencies have affected target detection and tracking capabilities in developmental testing.
  - The QRA performed by COTF uncovered vulnerabilities in the ship's capability to protect the security of information.
  - Failures of diesel-powered generators, air compressors, and propulsion drive train components have degraded

the seaframe's operational availability. The Navy reports that recent reliability improvements made to the affected seaframe components have led to improved operational availability of the seaframe; however, no formal developmental or operational testing has occurred to quantify that improvement.

- *Independence* Variant (LCS 2):
  - DOT&E has no data to assess the core mission capabilities of the *Independence* variant seaframe.
  - The *Independence* crew encountered multiple problems with the twin-boom extensible crane (TBEC) and other mission package support systems during initial developmental testing of the MCM mission package. Since then, the vendor improved the TBEC and the Navy made RMMV hardware changes. Developmental testing in August 2013 demonstrated the ship's capability to launch and recover the RMMV has improved.
  - Availability of the *Independence* to support testing has been degraded by equipment failures, including problems with operator consoles, power generation equipment, components of the ship's computing and networking equipment, propulsion drive train components, and communications systems. The Navy reports that recent reliability improvements made to the affected seaframe components have led to improved operational availability of the *Independence*; however, no formal developmental or operational testing has occurred to quantify that improvement.

SUW Mission Package

- Results from the QRA revealed performance, reliability, and operator training deficiencies for both the 30 mm guns that prevented the ship from demonstrating that it can meet the Navy's SUW performance requirements. However, as installed in the *Freedom* variant, the Increment II SUW mission package does enhance existing surface self-defense capability and provides additional capability to conduct maritime interdiction operations; it has not been tested in the *Independence* variant seaframe.

MCM Mission Package

- The Navy has not yet demonstrated the interim sustained area coverage rate requirement through end-to-end testing. Developmental testing has focused primarily on integrating the Increment I MCM mission package on the *Independence*. The MCM mission package has not been tested with the *Freedom* variant seaframe.
- During operational assessments completed in 2011 and 2012, the AN/AQS-20A and ALMDS systems that compose the Increment I minehunting sensors demonstrated some capability in favorable benign operating environments, but failed to meet all performance requirements established by the Navy.
  - AN/AQS-20A contact depth localization errors in all operating modes and false contacts in two of the three search modes exceeded Navy limits. ALMDS failed to achieve the desired detection performance over the depth range prescribed by the Navy and the system's false contacts exceeded Navy limits by a wide margin.
  - While the Navy has identified mitigations for some of these deficiencies, they require additional search missions to weed out most of the false contacts. The additional search missions will reduce LCS's search rate.
  - Data from these operational assessments also bring into question the ability of the two minehunting systems to search the full water column; the Navy is conducting additional tests to determine if there are gaps in coverage. The Navy is also developing an improved version of the AN/AQS-20A and expects to begin developmental testing in FY14.
- AMNS, intended to provide identification and neutralization of in-volume and bottom mines, will provide the only mine neutralization capability in the Increment I MCM mission package.
  - Since the Navy has stopped the development of the Rapid Airborne Mine Clearance System (RAMICS), Increment I will not provide near-surface mine neutralization capability.
  - The operational assessment that the Navy planned to conduct in FY13 has slipped to FY14.
  - The Navy plans to develop an improved version of AMNS that will include the capability to neutralize near-surface mines; however, that development is not currently funded. The Navy expects AMNS to achieve initial operating capability (IOC) in FY16.
- The RMS, which is critical to achieving the Navy's sustained area coverage rate requirement, has also experienced developmental delays.
  - The Navy expects RMS to achieve IOC in 4QFY15. Contractor tests completed in FY13 suggest that RMMV reliability has grown since the RMS program emerged from the Nunn-McCurdy review in FY10; however, these tests were not conducted in an operationally realistic manner and the measure used was not operationally relevant resulting in artificially high estimates of reliability. Data from the recent development testing suggest that reliability may not have improved sufficiently to enable an LCS with two RMMVs onboard to complete the desired area search without having to return to port more often than currently planned and desired to obtain replacements. An accurate quantitative assessment of achieved RMMV reliability cannot be evaluated until the RMS is tested in operationally realistic minehunting missions (test conditions not achieved during the contractor testing).
  - The analysis of test data collected during developmental testing of structural improvements for the RMMV and the RMMV recovery system as well as MVCS upgrades is still in progress. The Navy expects to issue a formal test report in 2QFY14.

- Even if this MCM package meets all of its final increment requirements, legacy systems will be needed to perform the full range of mine clearance operations.

LFT&E

- The initial aluminum fire testing focused on the strength degradation of aluminum panels and welds at elevated temperatures. Follow-on testing in FY14 will investigate structural collapse of a multi-compartment aluminum structure due to fire exposure. The tearing tests collected data needed to develop methodologies suitable for the simulation of ductile fracture on the structural scale within the framework of whole-ship finite element analyses. Data analysis continues; the Detail Design Survivability Assessment Report is scheduled to complete in FY16.
- LCS is not expected to be survivable in high-intensity combat because the design requirements do not require the inclusion of survivability features necessary to conduct sustained combat operations in a major conflict as expected for the Navy's other surface combatants.

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 details of the surrogate testing and the lethality testing still need 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. Significant remaining recommendations include enhancing seaframe sensors and improving capability of seaframe and SUW mission package gun systems.
  - 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.
  - The Navy partially addressed the FY12 recommendations to complete the revised capabilities document defining the incremental approach to fielding mission packages.
    - The Navy has released requirements letters for Increments I and II SUW and Increment I MCM mission packages only; however, the requirements have not been codified in an approved Capabilities Production Document. 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 initial manning level studies have been completed. 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 QRA have been resolved based on limited testing conducted in October 2012. Preliminary analysis of additional testing conducted aboard LCS 3 in October 2013, which was observed by DOT&E, indicates that the gun reliability has improved.
    - The Navy intends to conduct LCS ship-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 starting in late FY14.
    - Throughout FY13, the Navy focused on correction of material deficiencies with mission package launch and recovery systems, and manpower and training deficiencies that prevent safe and effective shipboard launch and recovery of the RMS, and can now launch and recover the RMMV without damaging equipment in Sea States 1 and 2. Developmental testing is scheduled to continue in FY14.
- FY13 Recommendation.
  1. The Navy should provide a Surface-to-Surface Missile LFT&E Management Plan for DOT&E approval.