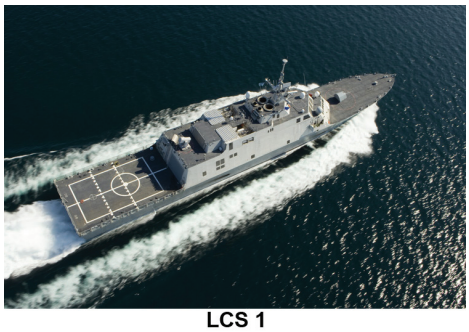
Littoral Combat Ship (LCS)

Executive Summary

- The draft revision of the Littoral Combat Ship (LCS) Test and Evaluation Master Plan (TEMP) currently being proposed by the Navy will require additional revisions to be approved by DOT&E. In particular, the TEMP must incorporate phased operational testing of all increments of mission module capability to be deployed for use in combat.
- The Navy commenced a Quick Reaction Assessment (QRA) of the gun systems on LCS 1 in June 2012. Results from the QRA revealed performance, reliability, and operator training deficiencies for both the 30 mm and 57 mm guns.
- The Navy conducted testing of the MH-60S Block 2 Airborne Mine Countermeasures (AMCM) System, which is intended to support LCS mine countermeasures. Testing indicated shortfalls in performance:
  - The Navy determined the MH-60S helicopter cannot safely tow the AN/AQS-20A Sonar Mine Detecting Set (AQS-20A) or the Organic Airborne Sweep and Influence System (OASIS) because the helicopter is underpowered for these operations. The MH-60S helicopter will no longer be assigned these missions operating from any ship, including LCS.
  - Preliminary evaluation of test data collected during operational assessment (OA) of the MH-60S Block 2 Airborne Laser Mine Detection System (ALMDS) indicates that the system does not meet Navy requirements for False Classification Density and has low reliability.
- DOT&E agreed to defer the Total Ship Survivability Trials (TSSTs) from LCS 1 and 2 to LCS 3 and 4, which affords the Navy time to complete pre-trial damage scenario analysis.
- DOT&E also agreed to defer the Shock Trials from LCS 3 and 4 to LCS 5 and 6, resulting in a one-year delay, due to significant seaframe and system design changes expected. LCS 5 and 6 will be most representative of the class for purposes of the Shock Trials.



LCS 1

LCS 2

System

- The LCS is designed to operate in the shallow waters of the littorals where larger ships cannot maneuver as well. It 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 Mine Countermeasure (MCM), Surface Warfare (SUW), and Anti-Submarine Warfare (ASW) mission packages.
- The Navy is procuring two ship (seaframe) variants:
  - USS *Freedom* (LCS 1, 3, 5, and follow-on ships) is a semi-planing monohull design constructed of steel (hull) and aluminum (deckhouse) with a combined diesel and gas turbine main propulsion system.
  - USS *Independence* (LCS 2, 4, 6, and follow-on ships) is an aluminum trimaran design driven by four independent steerable water jets.
- Common design specifications:
  - Sprint speed in excess of 40 knots, draft of less than 20 feet, and unrefueled range in excess of 3,500 nautical miles at 14 knots
  - Accommodations for up to 76 personnel (air detachment personnel, mission module personnel, and a core crew of no more than 40)
  - 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),

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 RAM (11-cell) launcher integrated with the Close-In Weapons System (Mk 15) search and fire control radars (called SeaRAM), and Sea Star SAFIRE Electro-Optical/Infrared systems for 57 mm gun fire control.
- Multiple individual programs of record involving sensor and weapon systems and off-board vehicles make up the individual mission modules. Mission modules provide offensive capability.
  - SUW Mission Package:
    - Gun Mission Module (two Mk 46 30 mm guns) (Increment 1)
    - Aviation Module (embarked MH-60R and VTUAV) (Increment 1)
    - Maritime Security Module (small boats) (Increment 2)
    - Surface-to-Surface Missile system intended to provide limited "interim" SUW capability in response to an urgent operational need (Increment 3)
    - Longer range Surface-to-Surface Missile (Increment 4)
  - MCM Mission Package:
    - Remote Minehunting System (RMS), consisting of the Remote Multi-Mission Vehicle (RMMV) and the AQS-20A sonar system (Increment 1)
    - MH-60S Block 2A/B 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 AQS-20A sonar system and OASIS are no longer being developed for use in the AMCM System) (Increment 1)
    - AMNS Pre-Planned Product Improvement (P3I) Program for neutralization of near-surface mines and Coastal Battlefield Reconnaissance and Analysis Block I (COBRA Blk I) system 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 2)
    - 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 3)
    - COBRA Block II system, 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 (Increment 4)
  - ASW Mission Package:
    - Torpedo Defense and Countermeasures Module (Light Weight Tow torpedo countermeasure) (Increment 2)
    - ASW Escort Module (Multi-Function Towed Array and Variable Depth Sonar) (Increment 2)
    - Aviation Module (embarked MH-60R and two VTUAVs) (Increment 2)
- The Navy plans to acquire a total of 55 LCSs. In early FY11, the USD(AT&L) authorized the procurement of hulls 3 through 22 (10 of each ship design), subject to Congressional appropriations.

Mission

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

Major Contractors

- *Freedom* Variant (LCS 1, 3, 5, 7, and follow-on 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 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 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

Seaframe

- *Freedom* Variant (LCS 1):
  - The Navy completed the first phase of the Post-Shakedown Availability (PSA), which commenced in 3QFY11, on LCS 1. During sea trials following this event, the ship developed a shaft seal leak and subsequently reentered dry-dock for six weeks to repair.
  - The Navy's Board of Inspection and Survey (INSURV) graded LCS 1 as fit for service during special trials in May 2012 following the emergent dry-docking.
  - The Navy continued developmental testing of the 57 mm gun system on LCS 1.
  - The Navy's Commander, Operational Test and Evaluation Force (COTF) commenced a QRA on LCS 1 in support of FY13 early deployment. Part I (57 mm gun assessment) of the QRA began in 3QFY12. Part II (Information Assurance and Maritime Interdiction Operations assessments) will take place on LCS 1 during 1QFY13.
  - The Navy started the second PSA in July 2012 on LCS 1 in San Diego, California.
- *Independence* Variant (LCS 2):
  - The Navy commissioned LCS 2 in January 2010 and began MCM mission module developmental testing in Mobile, Alabama, after commissioning.
  - LCS 2 departed the east coast and arrived in San Diego, California, in May 2012.
  - The Navy commenced the first phase of the nine-month PSA in September 2012 in San Diego, California.
- *Freedom* Variant (LCS 3):
  - INSURV evaluated LCS 3 as satisfactory during acceptance trials in April 2012.
  - The Navy commissioned LCS 3 in Galveston, Texas, in September 2012.

SUW Module

- COTF tested the 30 mm gun on LCS 1 during the QRA in June and July 2012 in accordance with the DOT&E-approved data collection plan. The Navy continued developmental testing of the 30 mm gun system on LCS 1.

MCM Module

- The Navy conducted testing of the MH-60S Block 2 AMCM System, which is intended to support LCS MCM.
  - COTF completed testing of the MH-60S Block 2A AMCM System with the AQS-20A sonar system in 4QFY11 in accordance with the DOT&E-approved test plan. DOT&E issued an OA report in June 2012.
  - COTF commenced Phase A (Shore-based and Training Phase) of the planned OA of the MH-60S Block 2 AMCM System with the ALMDS in 2QFY12; testing completed in 4QFY12, and was conducted in accordance with the DOT&E-approved test plan. DOT&E expects to issue a formal test report in 2QFY13. The Navy postponed conduct of Phase B (LCS Ship-based Phase) of the planned OA due to the unavailability of an LCS seaframe to facilitate conduct of MCM mission module testing. The Navy intends to conduct the LCS ship-based phase of the planned ALMDS and AMNS OAs in conjunction with the LCS Technical Evaluation scheduled to occur in FY14.
- The RMS program completed reliability growth testing (developmental testing) of RMMV version 4.1 in 1QFY12.
- The Navy commenced a ship-based phase of MCM mission module developmental testing (DT-B2) in 1QFY12; testing completed in 4QFY12.

LFT&E

- The Navy revised the survivability requirements for LCS 3 and beyond to describe the ships' survivability requirements in terms of class-specific LCS Vulnerability Levels:
  - LCS Vulnerability Level I – Operate emergency and damage control systems/equipment to provide for an orderly abandon ship.
  - LCS Vulnerability Level II – All of the capabilities of LCS Vulnerability Level I, plus the capability for mobility to exit the immediate area, electrical power and other required services to operate vital systems, exterior communications to support contact with the operational commander, and small-to-medium caliber weapons or equivalent capability to prevent boarding from small craft.
  - LCS Vulnerability Level III – All of the capabilities of LCS Vulnerability Level II, plus retain some critical mission capability as defined in Conditions for Total Ship Survivability Analyses, Test, and Evaluation for Susceptibility and Vulnerability/Recoverability.
- DOT&E agreed to defer the TSST from LCS 1 and 2 to LCS 3 and 4. This delay affords the Navy enough time to complete the needed pre-trial damage scenario analyses. The TSST is currently scheduled to be conducted on LCS 3 in December 2013 and on LCS 4 in August 2014.
- DOT&E also agreed to defer the Shock Trials from LCS 3 and 4 to LCS 5 and 6, resulting in a one-year delay. With significant seaframe and system design changes expected, LCS 5 and 6 will be most representative of the respective class for purposes of Shock Trials. LCS 5 and 6 will also be the first ships to include shock-qualified equipment.
- DOT&E reviewed drafts of the Navy's Detail Design Integrated Survivability Assessment Reports for LCS 1 and 2. The Navy is working to address DOT&E's comments and finalize these reports.
- The Navy is planning surrogate tests to address knowledge gaps related to the vulnerability of an aluminum ship structure to weapon-induced blast and fire damage. These tests will be conducted during FY13 and FY14.
- DOT&E approved the 57 mm ammunition LFT&E Management Plan, which details the test and evaluation necessary to evaluate the lethality of the 57 mm ammunition. The Navy is coordinating with the Finnish Navy to use their operational equipment to conduct an effectiveness test exercise in September 2013.

- DOT&E approved the 30 mm ammunition LFT&E Management Plan, which details the test and evaluation necessary to evaluate the lethality of the 30 mm ammunition.
- The Navy will submit the Surface-to-Surface Missile LFT&E Management Plan, which details the test and evaluation necessary to evaluate the lethality of the missile, for approval in FY13.
- Fire insulation testing was successfully conducted on a flight deck section of LCS 2 (referred to as grillage test) on the Ex-USS *Shadwell* in March 2012. The test article exceeded performance requirements for a fully intact insulated flight deck. Weapon-induced blast and fire damage will be addressed in surrogate testing planned for FY13 and FY14.

Assessment

This assessment is based on information from DOT&E's observations of selected events and operations. The program offices have issued limited developmental test results and have not been able to provide developmental test data for independent analysis. No formal at-sea operational tests were conducted.

Program

- The draft revision of the LCS TEMP currently being proposed by the Navy will require additional revisions to be approved by DOT&E. In particular, the TEMP must incorporate phased operational testing of all increments of mission module capability to be deployed for use in combat.

Seaframe

- *Freedom* Variant (LCS 1 and 3):
  - As reported in the FY11 Annual Report, the Navy discovered cracks in the hull and superstructure of LCS 1 that required interim repairs as well as design changes. The Navy made production changes to reduce cracking on LCS 3; cracking has not been observed to date.
- *Independence* Variant (LCS 2):
  - As noted in the FY11 Annual Report, the Navy completed interim repairs on LCS 2 because of aggressive galvanic corrosion in the vicinity of water jets. The Navy is installing a system to prevent corrosion on LCS 2 during the current PSA. An Impressed Current Cathodic Protection system is planned for the water jet tunnels on LCS 4.
  - The Navy continued to work through problems associated with the Twin Boom Extensible Crane on LCS 2. Limited testing to date precludes further assessment of this variant.
- Both variants:
  - Crew size can limit the mission capabilities of the ship. Core crew size provides little flexibility to support more than one operation at a time; unplanned manning losses and corrective maintenance further exacerbate the problem. The Navy is reviewing manning levels and installing 20 additional bunks in LCS 1 for flexibility during its deployment, but is not changing the final manning levels.
  - Ship operations at high speeds cause vibrations that make accurate use of the 57 mm gun very difficult. Insufficient operator training and proficiency also appear to have contributed to the poor performance of the 57 mm gun.

SUW Module

- Both variants:
  - The Navy has not finalized how the ships will be utilized with the SUW mission module. Additionally, the Navy has not completed the revised capabilities document defining the incremental approach to fielding mission modules.
  - The 30 mm guns and associated combat system exhibit reliability problems. The Navy established a Failure Review Board to identify and correct deficiencies in 30 mm gun performance.
- *Freedom* Variant: Performance deficiencies with COMBATSS-21 and TRS-3D affect tracking and engagement of contacts.

MCM Module

- Testing of the MH-60S Block 2 AMCM System revealed significant shortfalls in performance.
  - The MH-60S helicopter with the AQS-20A sonar is not operationally effective or suitable because the helicopter is underpowered and cannot safely tow the sonar under the variety of conditions necessary. The Navy cancelled the MH-60S helicopter mission to tow the AQS-20A and OASIS. The cancellation of the OASIS mission creates a gap in LCS organic mine sweeping capability that the Navy intends to address with the implementation of UISS in Increment 3 of the MCM mission module.
  - As observed during the OA and developmental testing, the AQS-20A does not meet some Navy requirements. Contact depth localization errors exceeded Navy limits in all AQS-20A operating modes. False contacts also exceeded Navy limits in two of three search modes. The Navy has implemented modified tactics intended to mitigate these deficiencies; however, those tactics limit platform-level productivity (Area Coverage Rate Sustained). Additionally, the Navy is developing a P3I program to correct these deficiencies.
  - The analysis of test data collected during Phase A of the OA of the MH-60S and ALMDS is still in progress. Preliminary evaluation of data collected during the OA suggests that the ALMDS does not meet Navy requirements for False Classification Density or reliability. DOT&E expects to issue a formal test report in 2QFY13. The Navy has implemented modified tactics intended to mitigate this deficiency; however, those tactics limit platform-level productivity (Area Coverage Rate Sustained). Additionally, the Navy is developing a P3I program to correct this deficiency. Phase B testing was originally intended to provide early operational testing insight into the operational effectiveness and suitability of AMCM systems when operating from an

LCS, and to identify risk to the successful completion of IOT&E. However, the Navy's postponement of Phase B testing will eliminate these intended benefits.

- As reported by the Navy, the reliability of RMMV version 4.1 grew as predicted by the program's reliability growth curve. However, the observed growth is predicated on limited test data collected in a minimally stressing operational environment. The limited scope of testing prevents any meaningful conclusions about operational availability of the RMS.
- As observed and reported by the Navy, during developmental testing (DT-B2), launch and recovery of the RMS was problematic due to material deficiencies with launch and recovery systems, manpower and training deficiencies, and compatibility with the operating environment.

LFT&E

- LCS is not expected to be survivable in that it is not expected to maintain mission capability after taking a significant hit in a hostile combat environment. This assessment is based on a review of LCS design requirements, which do not require the inclusion of the survivability features necessary to conduct sustained operations in its expected combat environment. DOT&E's review of the Navy's draft Detail Design Integrated Survivability Assessment Reports has not changed this assessment.

Recommendations

- Status of Previous Recommendations. The Navy has partially addressed one FY09 recommendation to develop an LFT&E program with the approval of the LFT&E Management Plan; however, the recommendation will not be fully addressed until the details of the surrogate testing and the lethality testing are developed. The Navy has partially addressed the FY10 recommendations to implement all recommendations from DOT&E's Combined Operational and Live Fire Early Fielding Report. Significant remaining recommendations from the Early Fielding Report include enhancing sensors and improving capability of gun systems. With respect to FY11 recommendations, the Navy is adjusting tactics and increasing funding to address deficiencies with the AQS-20A and ALMDS. The FY11 recommendation for the Navy to continue to report vulnerabilities during live fire tests remains valid.
- FY12 Recommendations. The Navy should:
  1. Complete the revised capabilities document defining the incremental approach to fielding mission modules.
  2. Publish the concept of operations for all the mission modules.
  3. Complete manning level studies and finalize manning prior to LCS IOT&E.
  4. Correct gun reliability issues identified during QRA. These problems need to be addressed prior to completion of the LCS SUW Mission Package IOT&E.
  5. Conduct LCS ship-based phases of the planned OA of the MH-60S Block 2 and ALMDS as well as an OA of the MH-60S Block 2 and AMNS MCM systems in FY13 to reduce risk to the LCS MCM Mission Package IOT&E.
  6. Investigate and correct material deficiencies with mission module launch and recovery systems, and manpower and training deficiencies that prevent safe and effective shipboard launch and recovery of the RMS.