MK 54 Lightweight Torpedo and High-Altitude Anti-Submarine Warfare Capability (HAAWC)

Executive Summary

- The Navy continued development of hardware and software updates to the MK 54 Lightweight Torpedo. The new version, designated the MK 54 Mod 1 torpedo, is scheduled to begin OT&E in FY20.
- The Navy began MK 54 Mod 1 development in FY07 and started in-water developmental testing in November 2015. The Navy has shot 43 of the 84 MK 54 Mod 1 torpedoes in accordance with the developmental test plan. Testing is behind schedule due to poor weather, the loss of target services, and test torpedoes. The remainder of the developmental test events are planned for FY18 and FY19.
- The High-Altitude Anti-Submarine Warfare Weapons Capability (HAAWC) program, designed to deliver the MK 54 torpedo from the cruising altitude of a P-8A aircraft, completed initial contractor flight testing and is scheduled to complete safe separation testing of HAAWC from the P-8A in 2017. Initial integration testing began in 2016 and continued in 2017 with the first test release of a HAAWC from a P-8A planned for December 2017. The Navy has not approved a Test and Evaluation Master Plan (TEMP) for the HAAWC program. The Navy completed a HAAWC Milestone C acquisition decision in December 2017 without conducting an independent operational assessment.
- The LFT&E assessment of this weapon remains unchanged from 2016. The Navy should outline an evaluation plan that provides a more detailed assessment of the lethality criteria being used by the program.

System

- The MK 54 Lightweight Torpedo is the primary anti-submarine warfare (ASW) weapon used by U.S. surface ships, fixed-wing aircraft, and helicopters. The MK 54 must be compatible with analog or digital combat control systems and software variants installed on all ASW fixed- and rotary-wing aircraft and on surface ship combat control system variants used for torpedo tube or ASW rocket-launched torpedoes.
- The MK 54 combines the advanced sonar transceiver of the MK 50 torpedo with the legacy warhead and propulsion system of the older MK 46. MK 46 and MK 50 torpedoes are converted to an MK 54 via an upgrade kit.
- The Navy designed the MK 54 to operate in shallow-water environments and in the presence of countermeasures. The MK 54 sonar processing uses an expandable, open architecture system. It combines algorithms from the MK 50 and MK 48 torpedo programs with commercial off-the-shelf technology.
- The Navy has designated the MK 54 torpedo to replace the MK 46 torpedo as the payload section for the Vertical

Launched Anti-Submarine Rocket for rapid employment by surface ships.

- The MK 54 Block Upgrade (BU) was a software upgrade to the MK 54 baseline torpedo designed to provide a small, shallow draft target capability and to correct deficiencies identified during the 2004 MK 54 IOT&E.
- The Navy is developing the MK 54 Mod 1. The MK 54 Mod 1 hardware upgrades the torpedo's sonar array from 52 to 112 elements, providing higher resolution. Associated software upgrades are designed to exploit these features to improve target detection, enhance false target rejection, and correct previously identified deficiencies.
- The HAAWC marries an adapter wing-kit to an MK 54 torpedo to allow long-range, high-altitude, GPS-guided deployment of the MK 54 by a P-8A Multi-mission Maritime Aircraft. A follow-on capability to receive in-flight targeting updates via Link 16 from the P-8A may be added in a later program phase. In-flight updates will not be available in the baseline HAAWC kit.

Mission

Commanders employ naval surface ships and aircraft equipped with the MK 54 torpedo to conduct ASW:

- For offensive purposes, when deployed by ASW aircraft and helicopters
- For defensive purposes, when deployed by surface ships
- In both deep-water open ocean and shallow-water littoral environments

- Against fast, deep-diving nuclear submarines and slow-moving, quiet, diesel-electric submarines

Major Contractors
- Raytheon Integrated Defense Systems – Tewksbury, Massachusetts
- Progeny Systems Corporation – Manassas, Virginia
- Boeing Company – St. Charles, Missouri
- Northrop Grumman – Annapolis, Maryland

Activity

MK 54 Mod 1
- During FY17, the Navy continued development of new MK 54 Mod 1 torpedo sonar section hardware and tactical software to address the performance shortfalls identified in the MK 54 (BU). The Navy plans to begin OT&E of the MK 54 Mod 1 in FY20.
- The Navy began MK 54 Mod 1 development in FY07 and started in-water developmental testing in November 2015. The Navy's developmental test plan calls for shooting 84 MK 54 Mod 1 torpedoes in 6 separate test events covering both deep- and shallow-water scenarios. The Navy only shot 43 torpedoes and is behind schedule due to poor weather and the loss of target services and test torpedoes. The Navy intends to complete the remainder of the developmental test events in FY18 and FY19. The Navy completed the following MK 54 Mod 1 developmental testing in FY17:
  - Four of four planned MK 54 Mod 1 events in shallow and deep water in October 2016.
  - Four of nine planned shallow-water test events in December 2016. The Navy halted testing due to poor weather.
  - Four of 10 planned shallow- and deep-water test events in April 2017. The Navy halted testing due to poor weather.
  - The six events delayed from April 2017 in June 2017. During the test, the Navy did not recover one test torpedo.
  - Nine of nine planned shallow-water test events in July 2017.
- The Navy completed a Milestone C acquisition decision in February 2016 for the MK 54 Mod 1 without an approved TEMP. The Navy approved the MK 54 Mod 1 Capability Development Document on September 26, 2016. The Navy approved the HAAWC requirements in a capability production document in June 2017. In FY17, the Program Office made progress in developing the MK 54 Mod 1 and the HAAWC TEMPs; however, neither document is ready for approval.
- In August 2017, the Navy intended to conduct a Surface Weapons Test (SWT) to test the MK 54 safety, arming device fuzing, and warhead reliability. Due to a series of target acoustic source failures, the Navy canceled the SWT.
- In FY17, DOT&E participated in two Resource Enhancement Program projects to develop critical assets for torpedo operational testing. One project develops the Submarine Launched Modular 3-inch Device (SLAM-3D) as a threat-representative surrogate torpedo countermeasure. The second project is an update to the Weapons Assessment Facility (WAF) hardware-in-the-loop modeling and simulation testbed located at the Naval Undersea Warfare Center in Newport, Rhode Island. The Navy intends for the project to improve the WAF for developing and testing torpedoes by improving target models and modeling of the ocean environment.
- In September 2015, the Navy conducted small-scale testing to characterize the warhead as a function of weapon standoff. The Navy delivered the final report in July 2017. In late FY16, the Navy conduced scaled warhead testing to assess the lethality of this weapon against operationally representative targets.

HAAWC
- In October and December 2016, Boeing continued contractor testing of HAAWC wing kits on a surrogate aircraft at Eglin AFB. In October 2016, the Navy started P-8A/HAAWC integration testing with P-8A ground and captive carriage flight tests to collect data from the P-8A weapons systems and evaluate the operator machine interface. The Navy continued integration testing and safe separation testing of the HAAWC on the P-8A aircraft in FY17. Safe separation testing is scheduled for completion in December 2017.
- In March 2017, the Navy's Commander Patrol and Reconnaissance Group canceled and withdrew the endorsement for the Navy's P-8A High-Altitude ASW Concept of Operations.
- The Navy is planning the first MK 54 HAAWC All-Up-Round (AUR) test from a P-8A in December 2017. During this developmental test, the Navy plans to launch four HAAWC AURs with Ballistic Air Test Vehicles (BATV). The Navy completed a HAAWC Milestone C acquisition decision in December 2017 without conducting an independent operational assessment. Integrated testing is planned for summer 2018, when the Navy plans to test in the final software configuration with a mix of HAAWC AURs with MK 54 Mod 0 exercise torpedoes and BATVs. Operational testing is planned for FY19.

Assessment
- In FY14, DOT&E assessed that the MK 54 (BU) torpedo is not operationally effective as an offensive ASW weapon.

- Some MK 54 (BU) operationally realistic scenarios were not assessed in previous testing due to the unavailability of target surrogates and the Navy's safety regulations for shooting against manned submarine targets. Due to resource constraints, the Navy has not developed adequate set-to-hit surrogate targets. Because of these test limitations, the Navy cannot adequately assess all components of the MK 54 Mod 1 kill chain. The Navy plans to conduct set-not-to-hit testing with manned submarines and limited set-to-hit testing with available static target surrogates to assess if the MK 54 Mod 1 improves performance and corrects MK 54 (BU) shortfalls. Despite test limitations, the Navy may be able to estimate an upper bound of MK 54 performance, but the test will not resolve performance knowledge gaps identified in previous testing for many operationally realistic scenarios.
- Completed developmental testing of the MK 54 Mod 1 demonstrated performance results similar to the MK 54 (BU); however, to date, the Navy has conducted most developmental testing using simple scenarios where the MK 54 previously demonstrated satisfactory performance. These simple developmental test scenarios are good regression testing that yield significant recorded test data; however, little data were obtained to assess MK 54 performance in challenging, operationally realistic scenarios. The Navy is planning additional in-water developmental testing to assess more challenging operational scenarios.
- The LFT&E assessment of this weapon remains unchanged from 2016.

Recommendations
- Status of Previous Recommendations. The following previous recommendations remain outstanding. The Navy should still:
  1. Conduct operationally realistic mobile target set-to-hit testing and minimize test limitations. The Navy has not developed a mobile target surrogate for set-to-hit testing. The Navy investigated possible surrogates, but the proposals are unfunded. The Navy should fund efforts to minimize these test limitations.
  2. Propose alternatives to minimize or eliminate the test and safety limitations that minimize operational realism in MK 54 testing.
  3. Complete development of the MK 54 Mod 1 TEMP.
  4. Evaluate and incorporate the 11 recommendations in the DOT&E MK 54 (BU) OT&E report to improve the effectiveness of the MK 54. Significant unclassified recommendations include:
     - Improve the target detection, localization, and track performance of ship and aircraft crews that employ the MK 54. While improving the sensor system capability on ships and aircraft is a longer range goal, updating the MK 54 employment tactics, training, and documentation could immediately improve overall crew proficiency and ASW effectiveness. The Navy has reported it has made progress in updating its tactics and documentation, but there has been no testing yet to verify the deficiencies have been resolved.
     - Improve the MK 54's effective target search and detection capability. The MK 54 should be able to effectively search the area defined by typical fire control solution accuracy, crew employment, and placement errors.
     - Reduce the complexity of the MK 54 employment options and required water entry points in existing tactical documentation. The Navy has reported it has made progress in updating its tactics and documentation, but there has been no testing yet to verify the deficiencies have been resolved.
  5. Complete the development and approval of HAAWC TEMP.
  6. Utilize developmental test scenarios that stress the MK 54 Mod 1 in scenarios where improvements are desired. When possible, these scenarios should be operationally realistic.
- FY17 Recommendation.
  1. The Navy should outline an evaluation plan that provides a more detailed assessment of the lethality criteria being used by the program.