

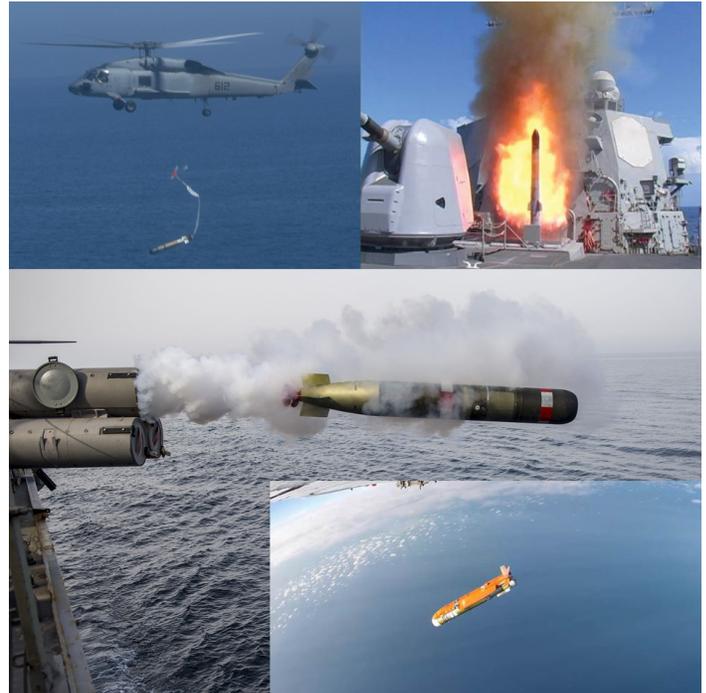
MK 54 Lightweight Torpedo and Its Upgrades Including High Altitude Anti-Submarine Warfare Capability

Executive Summary

- The Navy continued development of hardware and software updates to the MK 54. The new version, designated the MK 54 Mod 1 torpedo, is scheduled to begin OT&E in FY20.
- The Navy started the MK 54 Mod 1 development in FY07 and in-water developmental testing in November 2015. The Navy has completed 16 of the planned 80 MK 54 Mod 1 developmental test firings and obtained valid test data from 11. In February 2016, the Navy paused the second of six in-water developmental test events to search for two lost test torpedoes. The Navy updated its developmental test plans and resumed the in-water developmental test program in October 2016.
- In February 2016, the Navy completed a Milestone C acquisition decision for the MK 54 Mod 1 without a Navy-approved Capability Development Document or an approved Test and Evaluation Master Plan (TEMP). The Navy approved the MK 54 Mod 1 Capability Development Document on September 26, 2016.
- 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, began initial contractor flight testing and initial P 8A Poseidon Flight Clearance safety testing in FY16. The Navy has not approved a requirements document yet for the HAAWC.
- Based on data collected in the Navy's scaled MK 54 warhead tests executed in FY16, it is assessed the MK 54 will remain not effective even with the Mod 1 fixes. Details supporting this assessment will be provided in a classified LFT&E report that will be issued in FY17.

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 interoperate and be compatible with the analog or digital combat control systems and software variants installed on all ASW fixed-wing and helicopter aircraft, and on the 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 and enhance false target rejection as well as correct previously identified deficiencies.
- The HAAWC will provide an adapter wing-kit to permit 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 is expected to be added in a later program phase. In-flight updates will not be available in the baseline HAAWC kit.

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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

- During FY16, the Navy continued development of new MK 54 Mod 1 torpedo front-end hardware and tactical software to address the performance shortfalls identified with the MK 54 (BU). The Navy plans to begin the MK 54 Mod 1 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's developmental test plan called for firing 80 MK 54 torpedoes in 6 separate test events covering both deep and shallow water scenarios, between September 2014 and May 2016. During the November 2015 test event, the Navy fired 10 MK 54 Mod 1 torpedoes in deep water scenarios and obtained valid test data from 8 torpedoes. During the February 2016 test event, the Navy fired 6 of the 10 planned MK 54 Mod 1 torpedoes before pausing the in-water test event to search for two lost test torpedoes. The Navy updated its developmental test plans and resumed the in water developmental test program in October 2016.
- In February 2016, the Navy completed a Milestone C acquisition decision for the MK 54 Mod 1 without a Navy-approved Capability Development Document or an approved TEMP. DOT&E continues to work with the Navy's Operational Test and Evaluation Force and the Program Office to develop an adequate MK 54 Mod 1 operational test program within the constraints of the available test target surrogates. The Navy approved the MK 54 Mod 1 Capability Development Document on September 26, 2016, but that document did not address the HAAWC program that has started testing. The Navy is developing a separate requirements document to address that program.
- In FY15, DOT&E participated in the Navy's Torpedo Target Strategy Working Group to identify and develop test target surrogates for the MK 54. The Navy proposed a short-term strategy that utilizes three separate torpedo targets, each appropriate for specific limited scenarios. However, the Navy did not fund the short-term strategy and has not developed a long-term target strategy.
- In FY15 and FY16, DOT&E funded and 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 project is intended to improve the WAF for developing and testing torpedoes by improving the modeling of the ocean environment and improving target models.

- In FY16, Boeing continued contractor testing of the HAAWC wing kits for employing the MK 54 torpedo from the P-8A at medium to high altitudes. The Navy started initial integration testing and initial flight clearance safety testing of the HAAWC into the P-8A Poseidon aircraft.
- As a result of increased HAAWC program cost estimates and reduced funding, the Navy transferred sponsor organizational responsibilities within the Navy staff and is revising performance thresholds, which it is documenting in a draft HAAWC Capabilities Production Document.
- The HAAWC program has not yet developed a comprehensive test strategy and does not have an approved TEMP. The HAAWC program is scheduled to begin OT&E in FY19. DOT&E continues to work with the Navy to develop an adequate operational test strategy.
- In September 2015, the Navy conducted a small-scale test of the warhead to characterize hull deformation as a function of weapon standoff. The Navy has not delivered the final report on this test series. The results of the small-scale test were used to plan a large-scale test executed in late FY16, which the Navy performed at Aberdeen Test Center, Underwater Explosion Test Facility, using a scaled MK 54 warhead against a threat-representative target. The primary objective of this testing was to demonstrate weapon lethality by quantifying the extent of damage and hull rupture to the target hull.

Assessment

- In FY14, DOT&E assessed that the MK 54 torpedo is not operationally effective as an offensive ASW weapon. During operationally challenging and realistic scenarios, the MK 54 (BU) demonstrated below threshold performance and exhibited many of the same failure mechanisms observed during the IOT&E. Torpedo mission kill performance against targets

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employing operationally realistic evasion tactics was below requirement thresholds. Performance was further degraded when considering crew performance for targeting and employing the MK 54 (BU) and the Navy's assessment of the warhead. The Navy designed the MK 54 Mod 1 upgrade to improve the MK 54's hit performance in these test scenarios.

- DOT&E also reported the MK 54 (BU) torpedo was operationally suitable and met the same reliability and availability requirements as the baseline torpedo. However, MK 54 (BU) operational testing identified shortfalls with the employing platforms' tactics and tactical documentation, and interoperability problems with some platform fire control systems. The Navy initiated immediate actions to address these shortfalls and has reported the training and tactics shortfalls are fixed for the MK 54 (BU). DOT&E plans to evaluate the effectiveness of the employing platforms' tactics, documentation, and interoperability during the MK 54 Mod 1 OT&E.
- Some MK 54 (BU) operational realistic scenarios were not assessed 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 and test articles. Because of these test limitations, the Navy will not be able to assess MK 54 Mod 1 performance in all important operationally realistic scenarios. DOT&E plans to conduct set-not-to-hit testing with manned submarines and limited set-to-hit testing with available target surrogates to assess if the MK 54 Mod 1 improves hit performance and corrects MK 54 (BU) shortfalls. These test limitations will result in an upper bound estimate of MK 54 hit performance but are acceptable for Mod 1 testing given past performance shortfalls. However, the Navy must fund efforts to resolve these test limitations.
- The Navy intends the MK 54 Mod 1 to improve MK 54 (BU) effectiveness with a new 112-element hydrophone front end, new processors, and new software designed to improve detection, classifier, and tracker performance. Completed developmental testing demonstrated performance results similar to the MK 54 (BU); however, to date, the Navy has conducted most developmental testing using simple structured 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.
- Based on data collected in the Navy's scaled MK 54 warhead tests executed in FY16, it is assessed the MK 54 will remain

not effective even with the Mod 1 fixes. Details supporting this assessment will be provided in a classified LFT&E report that will be issued in FY17.

Recommendations

- Status of Previous Recommendations. The following previous recommendations remain outstanding. The Navy still needs to:
 1. Conduct operationally realistic mobile target set-to-hit testing scenarios. The Navy has not developed a mobile target surrogate for set-to-hit testing. The Navy investigated possible surrogates; however, the proposals are unfunded.
 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. The Navy should evaluate and incorporate the 11 recommendations in DOT&E's 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 and 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.
- FY16 Recommendations. The Navy should:
 1. Complete the development and approval of the HAAWC requirements and TEMP.
 2. 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.
 3. Initiate recommendations that will be provided in the FY17 MK 54 LFT&E report.

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