

Mk 54 Lightweight Torpedo

Executive Summary

- The Navy's Fifth Fleet issued an Urgent Operational Need Statement (UONS) in March 2010 requesting solutions to address an emerging submarine threat. The Navy identified the Mk 54 Block Upgrade (BUG) software as a solution.
- In August to September 2011, for the Quick Reaction Assessment (QRA), the fleet fired 22 Mk 54 BUG torpedoes against a Steel Diesel Electric Submarine surrogate target and against U.S. attack submarine targets. Based on preliminary results of this test, the Navy scheduled an additional phase of in-water QRA in November 2011 and delayed the planned early fielding until January 2012.
- The Navy did not complete adequate in-water or modeling and simulation developmental testing of the Mk 54 BUG. As the program office shifted resources to demonstrate that the Mk 54 BUG has a capability against the UONS emerging submarine threat, testing focused on the UONS threat scenarios vice the operational scenarios for which the Mk 54 BUG was originally intended.

System

- The Mk 54 Lightweight Torpedo is the primary Anti-Submarine Warfare weapon used by U.S. surface ships, fixed-wing aircraft, and helicopters.
- 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. An Mk 46 torpedo and Mk 50 torpedo can be converted to an Mk 54 via an upgrade kit.
- The Mk 54 sonar processing is an expandable open architecture system. It combines algorithms from the Mk 50 and Mk 48 torpedo programs with the latest commercial off-the-shelf technology.
- The Navy designed the Mk 54 sonar processing to operate in shallow-water environments and in the presence of sonar countermeasures.
- 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 High-Altitude Anti-submarine Warfare Weapons Capability program will provide an adapter kit to permit long-range, high-altitude, GPS-guided deployment of the Mk 54 by a P-8A Maritime Patrol Aircraft.
- The Mk 54 BUG is a software upgrade to the Mk 54 baseline torpedo designed to correct deficiencies identified during the 2004 Mk 54 IOT&E.
- The Navy is planning a series of near-term improvements to the Mk 54, including an improved sonar array and block upgrades to the tactical software.

Mission

The Navy surface and air elements employ the Mk 54 torpedo as their primary anti-submarine weapon:

- For offensive purposes, when deployed by Anti-Submarine Warfare 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 Contractor

- Raytheon Integrated Defense Systems – Tewksbury, Massachusetts

Activity

- The Navy's Fifth Fleet issued an UONS in March 2010 requesting solutions to address an emerging submarine threat. The Navy identified the Mk 54 BUG software as a solution. In February 2011, the Navy tasked the Commander, Operational Test and Evaluation Force (COTF) to conduct a QRA to support the early fielding of the Mk 54 BUG to address the emerging threat.
- COTF observed and analyzed the results of program office and fleet in-water Mk 54 exercises and developmental testing from January to September 2011. In addition, COTF conducted a modeling and simulation assessment using the Weapons Analysis Facility located at the Naval Undersea Warfare Center, Newport, Rhode Island, to examine Mk 54 BUG performance in baseline warfare scenarios.

- In August to September 2011, for the QRA, the fleet fired 22 Mk 54 BUG torpedoes against a Steel Diesel Electric Submarine surrogate target and against U.S. attack submarine targets. Based on preliminary results of this test, the Navy scheduled an additional phase of in-water QRA in November 2011 and delayed the planned early fielding until January 2012. The Navy also changed to Mk 54 BUG software to correct some identified performance problems.
 - In August 2011, DOT&E directed the Navy to submit for approval Operational Test Authority-developed test plans for QRAs planned to support a fielding decision for programs on the DOT&E oversight list.
 - DOT&E is assessing the Mk 54 BUG torpedo's performance as the developmental testing, fleet training, and QRA events are completed. DOT&E plans to submit an Early Fielding Report in early 2012 once all available test data are analyzed.
 - The Navy is drafting a Test and Evaluation Master Plan revision for Mk 54 BUG. The revision includes additional testing to address the UONS emerging threat and to address major deficiencies identified during the 2004 IOT&E.
 - The Navy developed a Submarine Launched Countermeasure Emulator to support torpedo testing. The emulator enables the Navy to conduct realistic torpedo operational testing against threat submarine surrogates that can employ mobile countermeasures. The Navy also developed a Steel Diesel Electric Submarine surrogate to evaluate torpedo performance against stationary submarine threats in limited operational scenarios.
 - The Mk 54 was placed on LFT&E oversight for lethality in January 2010. The lethality strategy is currently under development and will focus on the Technology Insertion 1 hardware upgrade and BUG software capabilities that were not tested during the FY11 QRA. The QRA did not have any lethality testing elements.
 - In September 2010, the Navy conducted a single Mk 54 firing under the Lightweight Data Gathering Program (LDGP). The objective of the LDGP was to validate arming capability, and verify exploder performance in both impact and proximity modes. The Navy conducted the test as a set-to-hit firing against the Expendable Influence Target on an instrumented range in Nanoose, British Columbia. The weapon impacted the target and demonstrated both impact and magnetic influence fuzing. The tested weapon was a modified fleet exercise weapon running baseline software, not the BUG software.
- additional submarine target types, and assessing the torpedo's final terminal homing and impact of the target (set-to-hit).
- Since safety concerns prevent using manned submarines for set-to-hit testing, the Navy developed an unmanned Steel Diesel Electric Submarine target. The Navy is using this surrogate for both set-to-hit and set-not-to-hit testing. The Steel Diesel Electric Submarine target has different signature characteristics than the UONS emerging threat, thus this surrogate is of limited utility in assessing torpedo operational performance for the UONS. However, completing set-to-hit terminal homing testing may address some unresolved test scenarios identified in the IOT&E. Mk 54 BUG performance in these previously unresolved test areas will affect the overall effectiveness and suitability of the torpedo against other submarine threats.
 - The Navy did not complete adequate in-water or model and simulation developmental testing of the Mk 54 BUG. As the program office shifted resources to demonstrate that the Mk 54 BUG has a capability against the UONS emerging submarine threat, testing focused on the UONS threat scenarios vice the operational scenarios for which the Mk 54 BUG was originally intended.
 - To date, the Navy's emerging threat test scenario execution was structured and attacking crews had perfect knowledge of the target's location. Also, the Navy conducted testing in a relatively benign area where torpedo interactions with the bottom or false contacts were minimized. Testing in these structured scenarios indicates the Mk 54 BUG likely has a limited capability against the Steel Diesel Electric Submarine surrogate target. The Mk 54 BUG performance in other environmental areas and against operationally realistic target scenarios is unresolved.
 - The Navy is using a 1995 Operational Requirements Document, supplemented with sponsor clarification letters, as the reference to develop improvements and to test the Mk 54 torpedo upgrades. These documents are out of date and do not reflect the current threats, the current threat capabilities, or the current or desired torpedo performance. The Navy should update the Mk 54 requirements to identify the capabilities needed.
 - The single LDGP test event demonstrated successful impact and influence fuzing and full detonator functionality. The bulk explosive components were not demonstrated.

Assessment

- The Navy originally planned the Mk 54 BUG software to improve Mk 54 classifier and tracker performance and to resolve IOT&E Mk 54 deficiencies. The UONS emerging threat provided the incentive for the Navy to accelerate the development and fielding of the Mk 54 BUG software.
- The operational profile of the UONS emerging threat and the resulting changes to the torpedo's final homing software and exploder requires further testing to confirm Mk 54 performance, to include additional target operational scenarios,

Recommendations

- Status of Previous Recommendations. The Navy is making progress in addressing the five previous recommendations. The unresolved IOT&E of the Mk 54 terminal homing is superseded by changes to the Mk 54 BUG software; thus, the updated terminal homing software will require a set-to-hit testing evaluation to resolve torpedo effectiveness.
- FY11 Recommendations. The Navy should:
 1. Continue conducting Mk 54 BUG OT&E during 2012. The testing should include scenarios against representative surrogates employing current threats, tactics, and torpedo countermeasures.

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2. Obtain an operationally realistic set-to-hit target and complete the terminal homing testing of the Mk 54 torpedo.
3. Generate a new Capability Development Document for future Mk 54 hardware and software upgrades
4. The Navy should continue to develop a lethality strategy that includes the firing of the MK 54 against appropriate targets.
5. The Navy should expand the LDGP to include weapons upgraded to address the UONS scenario.

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