

## Mk 54 Lightweight Torpedo

### Executive Summary

- In August to September 2011, the Navy fired 22 Mk 54 Block Upgrade (BUG) torpedoes against a Steel Diesel Electric Submarine surrogate target and against U.S. attack submarine targets in order to address the March 2010 Navy Fifth Fleet Urgent Operational Need Statement (UONS). Based on the results of this test, the Navy revised the Mk 54 BUG tactical software, conducted an additional phase of in-water developmental testing in November 2011, and completed a limited release of the weapon to the fleet.
- DOT&E issued an Early Fielding report on January 12, 2012. DOT&E reported that based on completed testing, crews employing the Mk 54 have a limited capability against the UONS threat under favorable targeting and environmental conditions. DOT&E also reported that the Navy's testing was completed under best-case scenarios, and the Navy did not have an adequate threat surrogate for the UONS threat. For additional details, see DOT&E's classified report.
- The Navy did not complete adequate in-water or modeling and simulation developmental testing of the Mk 54 BUG as planned. 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.
- The Navy began operational testing on the Mk 54 with BUG software in March 2012.

### 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. The Mk 46 and Mk 50 torpedoes 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

Navy surface ships and aircraft 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 started operational testing of the Mk 54 BUG torpedo in FY12. The operational testing is being conducted with the same version of the torpedo's tactical software that

the Navy early fielded in January 2012 to address the Fifth Fleet UONS threat. Relevant prior activity includes:

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- The Navy developed a Steel Diesel Electric Submarine surrogate to evaluate torpedo performance against stationary submarine threats in limited operational scenarios. The Navy also 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.
- In August to September 2011, the fleet fired 22 Mk 54 BUG torpedoes with software version 42.B.1 against a Steel Diesel Electric Submarine surrogate target and against U.S. attack submarine targets. Based on the results of this test, the Navy issued Mk 54 BUG software version 42.B.2 to correct some identified performance problems, conducted an additional phase of in-water testing in November 2011, and fielded the Mk 54 early for limited use in January 2012.
- DOT&E issued a classified Early Fielding report on January 12, 2012. DOT&E reported that based on completed testing, crews employing the Mk 54 have a limited capability against the UONS threat under favorable targeting and environmental conditions. DOT&E also reported that the Navy's testing was completed under best-case scenarios, and the Navy did not have an adequate threat surrogate for the UONS threat. For additional details, see DOT&E's classified report.
- During FY11 and FY12, the Navy updated the Mk 54 BUG Test and Evaluation Master Plan (TEMP) to address both the new testing required for the UONS threat and the planned correction of major deficiencies identified during the 2004 IOT&E. DOT&E approved the Mk 54 BUG TEMP in December 2012.
- DOT&E approved the Navy's Operational Test Plan on February 24, 2012, to cover the first phase of operational testing. Because Navy testers could not identify the test execution details of all planned future test events, DOT&E approved the test plan for the first event and required it to be updated when the execution details could be defined for the future test events. DOT&E approved an update to the test events on July 31, 2012, and expects a final test plan update to cover the remainder of the operational testing in early FY13. The Navy conducted the first phase of BUG operational testing, designated OT-B1A, off the coast of southern California in March 2012. Three weapons were fired by an *Arleigh Burke* class destroyer and five were dropped by MH-60R helicopters. Another five weapons were intended to be dropped by P-3C aircraft, but those events were cancelled due to aircraft material problems. After the testing, the Navy declared the MH-60R runs invalid due to testing irregularities.
- The Navy conducted the second phase of BUG operational testing off Cape Cod, Massachusetts, in August 2012. The P-8A aircraft delivered eight weapons; MH-60R helicopters dropped another six weapons. Three more planned torpedo runs were not completed.
- The Navy conducted the third scheduled phase of BUG operational testing off Maui, Hawaii, in September 2012. P-8A aircraft delivered eight weapons and SH-60B helicopters dropped four weapons. An additional two runs were not completed.
- The Navy is planning an additional test event to complete the remaining Mk 54 BUG testing in 3QFY13.
- As a result of concerns about warhead performance and changes to the warhead exploder, DOT&E placed the Mk 54 on live fire oversight in 2010. The Navy had completed the Mk 54 BUG exploder modification and testing; therefore, DOT&E agreed to the Navy's proposal to develop a LFT&E plan starting with the Mk 54 Mod 1 version of the torpedo. The Mk 54 Program Office met with DOT&E in July 2012, and held an LFT&E meeting in August 2012 to develop an adequate lethality program for the Mk 54 Mod 1 torpedo. DOT&E is working with the Navy to establish a strategy for LFT&E to support the FY13 Mk 54 Milestone B.
- The Navy plans to continue the Mk 54 program with the Mk 54 Mod 1 torpedo and plans to approve a new set of requirements documents in FY13.
- In September 2012, the Navy conducted the first Mk 54 Service Weapons Test in an attempt to assess the performance of the warhead. The result of the event is under evaluation.

## 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, additional submarine target types, and the assessment of 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 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 so that attacking crews had near perfect knowledge of the target's location. In addition, the Navy conducted UONS testing in a relatively benign area that minimized torpedo interactions with the bottom or false contacts. 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 some operationally realistic target scenarios is being tested in FY12/13.
- 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 operational realism of the Mk 54 BUG testing from fleet platforms suffers from significant test and safety limitations intended to prevent the Mk 54 from hitting the manned submarine target when it is dropped from an aircraft and due to time constraints for completing the testing. The time constraints associated with Mk 54 exercise torpedo

employment and recovery often do not allow sufficient time for fully operationally realistic events.

## Recommendations

- Status of Previous Recommendations. Two previous recommendations remain outstanding.
  1. The unresolved IOT&E of the Mk 54 terminal homing is superseded by changes to the Mk 54 BUG software; however, the updated terminal homing software will require a set-to-hit testing evaluation to resolve torpedo effectiveness.
  2. The Navy should continue to develop a lethality strategy that includes the firing of the Mk 54 against appropriate targets.
- FY12 Recommendations. The Navy should:
  1. Complete Mk 54 BUG OT&E in 2013. The testing should include scenarios against representative surrogates employing current threats, tactics, and torpedo countermeasures.
  2. Obtain an operationally realistic mobile set-to-hit target and complete the terminal homing testing of the Mk 54 torpedo.
  3. Investigate alternatives, such as the use of a portable range, to minimize or eliminate the test and safety limitations that minimize operational realism in Mk 54 testing.

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