Aegis Ballistic Missile Defense (Aegis BMD)

Executive Summary

- The Missile Defense Agency (MDA) conducted five Aegis Ballistic Missile Defense (BMD) intercept flight test events in FY19, successfully intercepting two ballistic missile targets with Standard Missile-3 (SM-3) Block IIA missiles, one cruise missile with an SM-6 missile, and two cruise missiles with SM-2 missiles.
- The MDA conducted additional Aegis BMD non-intercept flight test events in FY19 with live or simulated SM-3/SM-6 missile variants engaging simulated or live ballistic missile targets, respectively.
- The MDA conducted five Ballistic Missile Defense System (BMDS) ground tests with hardware-in-the-loop (HWIL) representations for Aegis BMD that provided data on Aegis BMD interoperability and weapon system functionality in various regional/theater and strategic scenarios.
- The MDA conducted a four-event U.S. Navy fleet exercise that included NATO assets, demonstrating interoperability with NATO partners during cruise missile and ballistic missile engagements.
- The AN/SPY-6(V)1 radar successfully completed its Navy-funded BMD developmental tracking exercise test campaign.

System

- Aegis BMD is a sea- and land-based missile defense system that employs the multi-mission Aegis Weapon System, with improved radar and new missile capabilities to engage ballistic missile and anti-air warfare threats. Aegis BMD includes:
  - Computer program modifications to all Aegis Weapon System elements, including the AN/SPY-1 radar, to support multiple BMDS mission capabilities including long-range surveillance and track, engagement support surveillance and track, and organic engagement with the SM-3, SM-6, or modified SM-2 Block IV missile variants against ballistic missiles
  - A modified Aegis Vertical Launching System, which stores and fires SM-3 Block IA, Block IB, and Block IIA guided missiles, modified SM-2 Block IV guided missiles, and SM-6 Dual I guided missiles
  - SM-3 Block IA, Block IB, and Block IIA guided missiles that use maneuverable kinetic warheads to accomplish midcourse engagements of short-range ballistic missiles (SRBMs), medium-range ballistic missiles (MRBMs), and intermediate-range ballistic missiles (IRBMs)
  - Modified SM-2 Block IV guided missiles that provide Sea-Based Terminal (SBT) capability against SRBMs and MRBMs
  - SM-6 guided missiles that provide SBT capability against SRBMs and MRBMs in their terminal phase of flight, anti-ship cruise missiles, and all types of aircraft
- Aegis BMD ships and Aegis Ashore are designed to conduct missile defense operations, send/receive cues to/from other BMDS sensors through tactical datalinks, and conduct engagements using remote track data from BMDS sensors.
- Aegis Ashore (Baseline 9.B2) (BL 9.B2) is the current land-based version of Aegis BMD, with an AN/SPY-1 radar and Vertical Launching System to enable engagements against MRBMs and IRBMs with SM-3 guided missiles. The operational Aegis Ashore site in Romania is the land-based component of the second phase of the European Phased-Adaptive Approach (EPAA) for the defense of Europe. A second site in Poland, currently undergoing construction, will complete the third phase of the EPAA for the defense of Europe.
- The Navy is developing the AN/SPY-6(V)1 Air and Missile Defense Radar for future Flight III *Arleigh Burke* destroyers. It is a replacement for the AN/SPY-1 radar and is intended to provide increased radar sensitivity, extended detection ranges, and simultaneous sensor support of ballistic missile and air defense missions.

Aegis Cruiser

Aegis Ashore and Vertical Launch System

Mission

Commanders will employ units equipped with Aegis BMD to accomplish three missile defense-related missions:

- Defend deployed forces and allies from short- to intermediate-range theater ballistic missile threats
- Provide forward-deployed radar capabilities to enhance defense against ballistic missile threats of all ranges by sending cues or target track data to other BMDS elements
- Provide ballistic missile threat data to the Command and Control, Battle Management, and Communications system for dissemination to Combatant Commanders' headquarters to ensure situational awareness

Major Contractors

- Aegis BMD Weapon System: Lockheed Martin Corporation, Rotary and Mission Systems – Moorestown, New Jersey
- AN/SPY-1 Radar: Lockheed Martin Corporation, Rotary and Mission Systems – Moorestown, New Jersey
- SM-3, SM-2 Block IV, and SM-6 Missiles: Raytheon Company, Missile Systems – Tucson, Arizona
- AN/SPY-6(V)1 Radar: Raytheon Company, Integrated Defense Systems – Tewksbury, Massachusetts

Activity

- The MDA conducted Aegis BMD testing in accordance with the DOT&E-approved Integrated Master Test Plan.
- The MDA conducted five Aegis BMD intercept flight test events in FY19, successfully engaging two ballistic missile targets and three cruise missiles:
  - During Flight Test Aegis Weapon System-45 (FTM-45) in October 2018, an Aegis destroyer intercepted a simple-separating MRBM target equipped with a high-explosive payload with an SM-3 Block IIA missile. This was the first intercept using a production-representative SM-3 Block IIA missile, and the second Block IIA intercept overall.
  - During Flight Test Integrated-03 (FTI-03) in December 2018, the Aegis Ashore Missile Defense Test Complex (AAMDTC) at the Pacific Missile Range Facility in Kauai, Hawaii, intercepted an air-launched IRBM target using an SM-3 Block IIA missile and the Aegis engage-on-remote (EOR) capability. FTI-03 was the first end-to-end demonstration of EOR.
  - During Formidable Shield-19 (FS-19) Event 1 of the four-event Navy fleet exercise in May 2019, an Aegis destroyer operating in BMD priority mode intercepted a cruise missile with a live SM-2 missile while simultaneously engaging a simulated ballistic missile target with a live SM-3 Block IA missile.
  - During FS-19 Event 4, an Aegis destroyer intercepted a cruise missile target with a live SM-2 missile while tracking a live SRBM target.
  - During FTM-31 Event 2 in August 2019, an Aegis destroyer detected, tracked, and engaged a cruise missile with an SM-6 missile.
- Aegis BMD participated in additional non-intercept flight test events in FY19 with live or simulated SM-3/SM-6 missile variants engaging simulated or live ballistic missile targets, respectively.
- Five BMDS ground tests with HWIL provided information on Aegis BMD interoperability and weapon system functionality in various regional/theater and strategic scenarios.
- The BMDS Operational Test Agency and the Navy Commander, Operational Test and Evaluation Force (OPTEVFOR) accredited all participating Aegis BMD HWIL modeling and simulation (M&S) for the regional/theater and strategic scenarios assessed in FY19 ground testing.

Assessment

- Results from flight testing, high-fidelity M&S, and HWIL testing demonstrate that Aegis BMD can intercept non-separating, simple-separating, and complex-separating ballistic missiles in the midcourse phase of flight. However, flight testing and M&S did not address all expected threat types, ground ranges, and raid sizes.
- FTM-45 demonstrated that Aegis destroyers can organically engage and intercept MRBMs with SM-3 Block IIA missiles. FTI-03 demonstrated, for the first time in an end-to-end test, Aegis BMD's capability to intercept an IRBM using EOR and an SM-3 Block IIA missile.
- OPTEVFOR accredited Aegis BMD high-fidelity M&S tools for many scenarios, but it noted limitations for raid engagements due to the lack of validation data from live fire raid engagements and lack of post-intercept debris modeling.
- During the four events that comprised FS-19, the MDA demonstrated Aegis BMD interoperability with NATO partners over the U.S. European Command Operational Tactical Data Link communication architecture during cruise missile and ballistic missile engagements. An Aegis destroyer twice engaged a simulated MRBM target with live SM-3 Block IA missiles, performed engagement support surveillance and track, organically engaged a live SRBM target with a simulated SM-6 Block 1 guided missile, and organically engaged a lofted SRBM target with simulated SM-3 Block IB (Threat Update) missiles. During the last engagement, the geo-repositioned AAMDTC launched a simulated SM-3 Block IIA guided missile at the target, using track data from the BL 9.C2 ship in an EOR scenario.
- Aegis BMD has exercised rudimentary engagement coordination with Terminal High-Altitude Area Defense firing units, but not with Patriot. MDA ground tests have routinely shown that inter-element coordination and interoperability need improvement to enhance engagement efficiency.
- The MDA has been collaborating with DOT&E and the USD(R&E) to establish an affordable ground testing approach to support assessments of reliability. DOT&E cannot assess SM-3 missile reliability with confidence until the MDA is able to provide additional ground test data that simulates the in-flight environment. In FY19, the MDA identified possible data sources to inform reliability estimates, but the data will not be available until CY21.
- A December 2017 SM-3 Block IB Acquisition Decision Memorandum requires the MDA and DOT&E to ensure periodic flight testing of the Block IB throughout the life of the program in the Integrated Master Test Plan. DOT&E and the MDA agreed that periodic testing would occur at approximately 2 year intervals. The MDA conducted two surveillance firings of the SM-3 Block IB missile in FY18, and two Stockpile Surveillance and Reliability program firings of the SM-3 Block IA missile in FY19.
- AN/SPY-6(V)1 participated in its final Navy-funded BMD developmental test, FTX-34. This tracking exercise was the last of five SPY-6(V)1 BMD tracking exercises at the U.S. Navy's Advanced Radar Development Evaluation Laboratory (ARDEL). ARDEL does not have the most recent Aegis combat system (i.e., BL 10), precluding future integration testing with the AN/SPY-6 radar at that facility.

Recommendations

The MDA should:

1. Provide data from high-fidelity ground test venues in the near term to help inform SM-3 Block IB Threat Upgrade and Block IIA missile reliability estimates.
2. Continue to conduct periodic (approximately every 2 years) SM-3 Block IB firings throughout the life of the program to demonstrate missile reliability.
3. Conduct Aegis BMD flight testing with live fire intercepts of raids of two or more ballistic missile targets to aid in the validation of M&S tools for raid engagements.
4. Improve Aegis BMD high-fidelity M&S tools to incorporate post-intercept debris modeling to better assess engagement performance in raid scenarios.
5. Coordinate with the Navy to fund an Aegis BL10 combat system at ARDEL for use in future combat system integration testing with the AN/SPY-6 radar.