

Aegis Ballistic Missile Defense (Aegis BMD)

Executive Summary

- In FY13, the Aegis Ballistic Missile Defense (BMD) program completed most of the combined developmental test (DT)/operational test (OT) and IOT&E flight test program for the Aegis BMD 4.0 system and Standard Missile-3 (SM-3) Block IB guided missile.
- The Aegis BMD program conducted five intercept missions in FY13 and one in early FY14. All but one resulted in successful intercepts.
- During an integrated flight test of the Ballistic Missile Defense System (BMDS), an Aegis BMD 3.6.1 destroyer intercepted an anti-air warfare target using an SM-2 missile and failed to intercept a short-range ballistic missile target using an SM-3 Block IA guided missile.
- Aegis BMD participated in the first system-level operational flight test conducted by the Missile Defense Agency (MDA). During the mission, an Aegis BMD 3.6.2e destroyer intercepted a medium-range ballistic missile target using an SM-3 Block IA guided missile.
- Aegis BMD continued to improve interoperability with other BMDS elements and sensors during flight and ground testing in FY13.
- Hardware-in-the-loop (HWIL) ground testing demonstrated Aegis BMD capability to contribute to theater, regional, and strategic-level defense missions spanning a range of ballistic missile defense scenarios.

System

- Aegis BMD is a sea-based missile defense system that employs the multi-mission shipboard Aegis Weapon System, with improved radar and new missile capabilities to engage ballistic missile threats. Capabilities of Aegis BMD include:
 - Computer program modifications to the AN/SPY-1 radar for long-range surveillance and track (LRS&T) of ballistic missiles of all ranges.
 - A modified Aegis Vertical Launch System, which stores and fires SM-3 Block IA and Block IB guided missiles (on select ships), and modified SM-2 Block IV guided missiles (on select ships).
 - SM-3 Block IA and Block IB guided missiles, which use a maneuverable kinetic warhead to accomplish midcourse engagements of short-, medium-, and intermediate-range ballistic missiles.
 - Modified SM-2 Block IV guided missiles, which provide terminal engagement capability against short-range ballistic missiles and air-breathing threats.



- Aegis BMD is capable of performing autonomous missile defense operations and operations that exploit networked sensor information; it can send or receive cues to or from other BMDS sensors through tactical datalinks.

Mission

The Navy can accomplish three missile defense-related missions using Aegis BMD:

- 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 elements of the BMDS
- Provide all short- to long-range ballistic missile threat data to the Command and Control, Battle Management, and Communications (C2BMC) system for dissemination to Combatant Commanders' headquarters to ensure situational awareness

Major Contractors

- Prime: Lockheed Martin Corporation, Mission Systems and Training – Moorestown, New Jersey
- AN/SPY-1 Radar: Lockheed Martin Corporation, Mission Systems and Training – Moorestown, New Jersey
- SM-3 Missile: Raytheon Company, Missile Systems – Tucson, Arizona

BALLISTIC MISSILE DEFENSE SYSTEMS

Activity

- In FY13, the Aegis BMD program completed most of the combined DT/OT and IOT&E flight test program for the Aegis BMD 4.0 system and SM-3 Block IB guided missiles, in accordance with the DOT&E-approved Integrated Master Test Plan.
- Although the program completed FOT&E for the Aegis BMD 3.6.1 system in FY11, the program continued to use variants of the Aegis BMD 3.6 system (i.e., 3.6.1 and 3.6.2e) in BMDS-level tests in FY13 to assess system-level engagement capability and interoperability.
- The Aegis BMD program conducted five intercept missions in FY13 and one in early FY14; five ballistic missile targets were intercepted, one anti-air warfare target was intercepted, and one ballistic missile target was not intercepted.
 - During Flight Test Integrated-01 (FTI-01) in October 2012, an Aegis BMD 3.6.1 destroyer simultaneously engaged a short-range simple separating ballistic missile target with an SM-3 Block IA guided missile and an anti-air warfare target with an SM-2 missile. The SM-2 missile successfully engaged its intended target, but the SM-3 Block IA guided missile failed to intercept. FTI-01 was the first integrated flight test with multiple firing elements (Aegis BMD, Terminal High-Altitude Area Defense [THAAD], and Patriot) engaging multiple ballistic missile and air-breathing targets in a realistic BMDS-level architecture.
 - In the Flight Test Standard Missile-20 (FTM-20) mission in February 2013, an Aegis BMD 4.0.2 cruiser intercepted a medium-range non-separating ballistic missile target with an SM-3 Block IA guided missile using remote data provided by Space Tracking and Surveillance System – Demonstrators. The FTM-20 intercept was the first performed with an Aegis BMD 4.0 ship's fire control system set up with remote engagements authorized, and the first firing of an SM-3 Block IA guided missile from an Aegis BMD 4.0 ship.
 - During FTM-19 in May 2013, an Aegis BMD 4.0.2 cruiser intercepted a short-range complex separating ballistic missile target with an SM-3 Block IB guided missile. The FTM-19 engagement was the third successful intercept mission conducted with the Aegis BMD 4.0 system with an SM-3 Block IB guided missile, and the second combined DT/OT flight test for that system. In addition to the flight mission, the ship participated in a four-event multi-warfare exercise, including live fire events with an SM-2 against an air-breathing threat and guns against a high-speed maneuvering surface threat, to assess simultaneous BMD radar loading while exercising surface warfare, electronic warfare, undersea warfare, and anti-air warfare capabilities.
 - An Aegis BMD 3.6.2e destroyer participated as a shooter in Flight Test Operational-01 (FTO-01) in September 2013. During the mission, the ship intercepted a medium-range ballistic missile target with an SM-3 Block IA guided missile. FTO-01 was the first system-level operational flight test conducted by the MDA.
- During FTM-21 in September 2013, an Aegis BMD 4.0.2 cruiser intercepted a short-range complex separating ballistic missile target with the first of two salvo-fired SM-3 Block IB guided missiles. This was the first salvo firing of two SM-3 guided missiles against a live ballistic missile target in an Aegis BMD flight test. The FTM-21 engagement was the fourth successful intercept mission conducted with the Aegis BMD 4.0 system and SM-3 Block IB guided missiles, and the first Aegis BMD flight test designated as an IOT&E mission supporting a Full-Rate Production decision for the SM-3 Block IB guided missile.
- In the FTM-22 flight mission in October 2013, an Aegis BMD 4.0.2 cruiser intercepted a medium-range separating target with an SM-3 Block IB guided missile. The FTM-22 engagement was the fifth successful intercept mission conducted with the Aegis BMD 4.0 system with an SM-3 Block IB guided missile, and the second of two IOT&E flight missions. The FTM-22 engagement was the first intercept of a medium-range target with the Aegis BMD 4.0 system and an SM-3 Block IB guided missile.
- In FY13, Aegis BMD ships or HWIL facilities participated in several flight and ground tests to assess Aegis BMD 3.6.1/3.6.2e and 4.0.1/4.0.2 system functionality and interoperability with the BMDS.
 - Ground Test Integrated-04e (GTI-04e) Part 1 in November 2012 tested the engagement capabilities of fielded and to-be-fielded missile defense elements and sensors against ballistic missiles of all ranges in an HWIL environment. Participants included Aegis BMD 3.6.2e and 4.0.2 (laboratory sites); C2BMC, Patriot, THAAD; Space-Based Infrared System (SBIRS), AN/TPY-2 Forward-Based Mode (FBM), Joint Tactical Ground Station, and Arrow.
 - Fast Eagle 2 Increment 2 in February 2013 explored ballistic missile defense capabilities using laboratory and distributed assets for Aegis BMD 3.6.1, AN/TPY-2 (FBM), C2BMC, SBIRS, and Patriot. The event was designed to evaluate the capability of AN/TPY-2 (FBM) and the associated C2BMC to augment existing U.S. Central Command BMDS capability. Also, a primary focus of the test was the development of tactics, techniques, and procedures (TTPs) for Aegis BMD use of AN/TPY-2 (FBM) data and for the provision of AN/TPY-2 (FBM) track data to Aegis, THAAD, and Patriot.
 - Fast Assurance in February 2013 used laboratory assets of Aegis BMD 4.0.2, C2BMC, Ground-based Midcourse Defense (GMD), COBRA DANE, AN/TPY-2 (FBM), and SBIRS to demonstrate the interoperability between Aegis BMD and GMD fire control in relation to the Aegis BMD LRS&T mission.
 - GTI-04e Part 1a runs-for-the-record in October 2013 further explored theater/regional defense capabilities (beyond those tested in GTI-04e Part 1) using updated

BALLISTIC MISSILE DEFENSE SYSTEMS

software builds for AN/TPY-2 (FBM), C2BMC, and THAAD, in addition to Aegis BMD 3.6.2e and 4.0.2.

- An Aegis BMD 4.0.2 cruiser participated in Flight Test Ground-Based Interceptor-07 (FTG-07) in July 2013. The cruiser successfully performed LRS&T duties in support of the GMD engagement against an intermediate-range ballistic missile target. FTG-07 was the first live-target LRS&T mission performed by an Aegis BMD 4.0 ship where the ship's data were used to create GMD's weapon task plan.
 - The FTO-01 System Pre-Mission Test in July 2013 explored integrated engagement capability for Aegis BMD 3.6.2e and THAAD in an operationally relevant architecture using HWIL assets to reduce risks for the FTO-01 flight mission.
 - Aegis BMD participated in the Fast Aim HWIL event in August 2013, which demonstrated the use of the Sea-Based X-band (SBX) radar in strategic defense scenarios. The test included laboratory assets of Aegis BMD, C2BMC, GMD Fire Control, AN/TPY-2 (FBM), SBX, and SBIRS.
 - The MDA conducted a Maintenance Demonstration (M-Demo) in August 2013 using an Aegis BMD 4.0.2 ship to collect reliability, maintainability, and availability data.
 - The MDA performed a set of warfighter simulations in an HWIL environment in August and September 2013 as part of the FTO-01 campaign. The warfighter used the simulations to explore and refine TTPs, and for training of operators for regional/theater engagement scenarios. Participants included Aegis BMD, THAAD, SBIRS, AN/TPY-2 (FBM), and C2BMC.
 - Aegis BMD 3.6.1 participated in the FTI-01 System Post-Flight Reconstruction in September 2013, which was a BMDS HWIL-based event designed to provide data in support of modeling and simulation verification, validation, and accreditation efforts.
- refine TTPs for the transmission and receipt of Aegis BMD track data for use by GMD.
 - With the completion of FTM-21 and FTM-22, the IOT&E flight testing phase for Aegis BMD 4.0 and SM-3 Block IB guided missiles is nearly complete. However, the program needs to complete Flight Test Other-18 (FTX-18) and planned HWIL testing of raid engagement capability and Information Assurance testing using accredited models and simulations in the test runs-for-the-record before an assessment of effectiveness and suitability can be made. Additionally, the program needs to test Aegis-Aegis, Aegis-THAAD, and Aegis-Patriot engagement coordination; only the first of these three types of engagement coordination is planned for live-target testing before the SM-3 Block IB Full-Rate Production decision in 4QFY14.
 - The program has addressed and tested corrections for the SM-3 TSRM problems found in FTM-15 and FTM-16 Event 2.
 - The program re-designed the TSRM cold gas regulator in response to the FTM-15 anomalous TSRM behavior; the new cold gas regulator has now been flight tested five times without incident.
 - To correct the failure exhibited in the FTM-16 Event 2 TSRM energetic event, the program modified the TSRM's inter-pulse delay time; the now greater minimum inter-pulse delay has been exercised without incident in three flight tests and a number of ground-based static firings.
 - During FTM-21, the second of two salvo-launched SM-3 Block IB guided missiles suffered a reliability failure of the TSRM during second pulse operations (the first missile had already achieved a successful intercept). The MDA has established a Failure Review Board to determine the root cause of this failure.
 - A Failure Review Board concluded that the failure to intercept in FTI-01 was caused by a faulty memory chip in the SM-3 Block IA guided missile's Inertial Measurement Unit (IMU). The specific brand of IMU with this problem is confined to a small fraction of fielded SM-3 Block IA guided missiles, and the program and U.S. Navy are working to mitigate any potential impact from those rounds. The faulty chip is not present in the IMU's design for the SM-3 Block IB guided missile.
 - An Aegis BMD 3.6.2e destroyer, using an SM-3 Block IA guided missile, successfully intercepted its medium-range ballistic missile target during FTO-01. A full assessment of FTO-01 test mission data with respect to the effectiveness, suitability, and interoperability of the participating BMDS elements is ongoing.
 - Continued post-deployment system-level ground testing with the Aegis BMD 3.6 system has helped to refine TTPs and overall interoperability of that system with the BMDS. However, the test events routinely demonstrated that inter-element coordination and interoperability are still in need of improvement.

Assessment

- In FY13, Aegis BMD demonstrated the capability to perform end-to-end engagements against complex separating short-range and separating medium-range ballistic missiles with the Aegis BMD 4.0 system and SM-3 Block IB guided missiles.
- Flight testing in FY13 exercised Aegis BMD 4.0 launch-on-remote and demonstrated the capability of the 4.0 system to fire deployed SM-3 Block IA guided missiles.
- Test data from FY13, in combination with data collected during previous flight testing, suggest that overall Aegis BMD 4.0 Weapon System reliability is adequate for the midcourse defense mission against short- and medium-range ballistic missiles. However, the SM-3 Block IB third stage rocket motor (TSRM) has experienced flight test failures that require further investigation and the identification of the underlying root cause(s).
- Aegis BMD 4.0's participation in FTG-07 verified the system's capability to perform LRS&T against long-range targets. However, the test highlighted the need to further explore and

Recommendations

- Status of Previous Recommendations.
 - The program addressed the remaining part of the recommendation from FY11 to demonstrate that the SM-3 TSRM problem that caused the failure in FTM-16 Event 2 has been corrected when it completed the FTM-19, FTM-20, and FTM-21 flight missions with TSRM inter-pulse delays at the revised minimum value.
 - The program addressed the first recommendation from FY12 to conduct further live-target testing of the Aegis BMD 4.0.2 LRS&T capability when it successfully sent track data for use by GMD fire control in FTG-07.
 - The program addressed the second FY12 recommendation to engage a medium-range target before the Full-Rate Production decision for the SM-3 Block IB guided missile to support assessment of midcourse capability when it completed the FTM-22 flight mission.
- FY13 Recommendations. The program should:
 1. Conduct flight testing of Aegis BMD 4.0's remote authorized engagement capability against a medium-range ballistic missile or intermediate-range ballistic missile target using an SM-3 Block IB guided missile.
 2. Conduct operationally realistic testing that exercises Aegis BMD 4.0's improved engagement coordination with THAAD and Patriot.
 3. Continue to assess an Aegis BMD 4.0 intercept mission where the ship simultaneously engages an anti-air warfare target to verify BMD/anti-air warfare capability.
 4. Use the Failure Review Board process to identify the failure mechanism responsible for the FTM-21 second missile failure and determine if there is an underlying root cause common to both the FTM-16 Event 2 and FTM-21 second missile failures.
 5. Deliver sufficient Aegis BMD 4.0 validation data and evidence to support BMDS modeling and simulation verification, validation, and accreditation of the Aegis HWIL and digital models.