

## Aegis Ballistic Missile Defense (Aegis BMD)

### Executive Summary

- Aegis Ballistic Missile Defense (BMD) intercepted three short-range non-separating targets during FY09 flight tests and U.S. Navy Fleet exercises. During a Japanese flight test mission in early FY10, it also intercepted a medium-range separating target. Intercept missions included both midcourse and terminal phase engagements.
- During the first of two Japanese flight test missions, a Standard Missile-3 (SM-3) Block IA interceptor failed to intercept a medium-range target although the shipboard weapon system performed as designed.
- Aegis BMD demonstrated the ability to perform a simultaneous engagement of a short-range ballistic missile target in the terminal phase of flight and an anti-ship cruise missile.
- Aegis BMD demonstrated the ability to send a cue to the Terminal High-Altitude Area Defense (THAAD) system during a THAAD intercept mission.
- Aegis BMD demonstrated the ability to receive a cue from THAAD during an Arrow Weapon System Mission.
- The U.S. Navy conducted two Fleet live firing exercises using Aegis BMD in FY09, which further tested command and control infrastructure and Aegis BMD functionality in an operational setting.
- Fast Contingency Analysis and Activation Team (CAAT) East-Bravo demonstrated the potential of Aegis BMD to contribute to the defense of Israel.

### System

- Aegis BMD is a sea-based missile defense system that employs the multi-mission shipboard Aegis Weapon System, with new radar and missile capabilities to engage ballistic missile threats.
  - Computer program modifications to the AN/SPY-1 radar allow long-range surveillance and track (LRS&T) of ballistic missiles of all ranges.
  - A modified Aegis Vertical Launcher System stores and fires the SM-3 Block IA and modified SM-2 Block IV interceptors.
  - The SM-3 Block IA design delivers a maneuverable kinetic warhead to an intercept point in the upper atmosphere or in space for midcourse engagements.
  - Modified SM-2 Block IV interceptors provide the capability to engage short-range ballistic missile targets in the terminal phase of flight.



- Aegis BMD is capable of autonomous missile defense operations and can send or receive cues to or from other Ballistic Missile Defense System (BMDS) sensors through tactical data links.

### Mission

The Navy can accomplish three missions using Aegis BMD:

- Provide forward-deployed radar capabilities to enhance defense against ballistic missile threats of all ranges
- Provide all short- to long-range ballistic missile threat data to the Command, Control, Battle Management, and Communications (C2BMC) system for dissemination to Combatant Commanders' headquarters to ensure situational awareness
- Defend deployed forces and allies from short- and medium range theater ballistic missiles

### Prime Contractors

- Lockheed Martin Maritime Systems & Sensors, Moorestown, New Jersey
- Raytheon Missile Systems, Tucson, Arizona

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## Activity

- The Missile Defense Agency (MDA) completed a comprehensive review of test requirements for the entire BMDS in FY09. As part of that process, the MDA identified nine Critical Engagement Conditions (CECs) and 11 Empirical Measurement Events (EMEs) for which specific Aegis BMD flight and ground tests are necessary to collect data to validate and accredit the Aegis BMD models and simulations. The 2009 Integrated Master Test Plan (IMTP) revision incorporates these test events. Modifications to the IMTP and its provisions for testing Aegis BMD as a result of the recent plans for a phased, adaptive approach to providing missile defense for Europe are under development.
- In FY09, the Aegis BMD program continued to assess engagement capabilities for midcourse and terminal defense missions during an FOT&E phase of testing. This follows the completed combined Developmental Test/Operational Test phase of testing that supported the transition of the Aegis BMD 3.6 system to the Navy in October 2008.
- The Aegis BMD program conducted five intercept missions: Fleet Exercise “Pacific Blitz,” Japanese Flight Test Mission (JFTM)-2, Fleet Exercise “Stellar Daggers,” Flight Test Mission (FTM)-17 (also known as “Stellar Avenger”), and JFTM-3. The two Fleet exercises, while operationally realistic, did not employ BMDS system-level capabilities. Therefore, they are not included in the BMDS system-level assessment.
  - In November 2008 during “Pacific Blitz,” two Aegis BMD destroyers engaged two short-range ballistic missile targets using SM-3 Block I interceptors which were at the end of their service life. One engagement was successful, but the other failed due to loss of seeker cryo-cooling. The developer hypothesizes that the leak occurred due to an early-on missile manufacturing process of the SM-3 Block I. SM-3 Block IA missiles in the current inventory use improved buildup procedures and are not expected to have similar problems. “Pacific Blitz” was the first U.S. Navy proficiency firing to employ the SM-3 against a ballistic missile target.
  - In November 2008 during JFTM-2, a Japanese Aegis BMD destroyer successfully detected, tracked, and prosecuted an engagement of a medium range separating target. However, the SM-3 Block IA missile failed to hit the target. Investigation as to the cause of the SM-3 Block IA failure is ongoing.
  - In March 2009 during “Stellar Daggers,” an Aegis BMD destroyer performed a simultaneous engagement of a short-range ballistic missile target in the terminal phase of flight (with a modified SM-2 Block IV interceptor) and a cruise missile target (with an SM-2 Block IIIA interceptor). Earlier, Aegis BMD attempted a terminal phase engagement, but the target failed to reach the desired altitude and range. Aegis BMD terminated the engagement, as designed, because the target did not qualify for engagement. “Stellar Daggers” was conducted as FOT&E and was the final test of the Aegis BMD 3.6.1 Sea-Based Terminal capability.
- In July 2009 during FTM-17 “Stellar Avenger,” an Aegis BMD destroyer conducted a midcourse phase engagement of a short-range ballistic missile target using an SM-3 Block IA interceptor. Concurrently, a separate Aegis BMD cruiser conducted the first simulated SM-3 Block IB engagement using a developmental Aegis BMD 4.0.1 software load.
- In October 2009 during JFTM-3, a Japanese Aegis BMD destroyer using an SM-3 Block IA interceptor successfully intercepted a medium range separating target.
- In FY09, Aegis BMD participated in several BMDS system flight and ground tests to assess Aegis BMD functionality and interoperability with the BMDS.
  - Ground Test Other (GTX)-03c in November and December 2008 used hardware-in-the-loop simulations to demonstrate the ability to engage an intermediate-range ballistic missile target using the SM-3 launch-on-remote capability with an AN/TPY-2 radar in Forward-Based Mode (FBM). The test also assessed launch-on-remote capability with another Aegis BMD ship employed as the forward sensor.
  - Flight Test Ground-based Interceptor (FTG)-05 in December 2008 demonstrated Aegis LRS&T functionality in support of the GMD intercept test. Another Aegis ship, positioned down range beyond the target impact area, demonstrated a simulated launch on AN/TPY-2 (FBM) engagement of an intermediate range target.
  - Ground Test Distributed (GTD)-03 in March 2009 demonstrated BMDS operational functionality, connectivity, and interoperability. GTD-03 used simulators on three Aegis BMD ships (dockside) and at the Space and Naval Warfare Systems Center (SPAWAR) in San Diego, California. GTD-03 assessed launch-on-remote functionality with both the AN/TPY-2 and AN/SPY-1 radars as the forward-based sensors.
  - Flight Test THAAD Interceptor (FTT)-10a in March 2009 demonstrated the ability of Aegis BMD to send a cue to THAAD over operational communication links.
  - “Caravan 2” in July 2009, an Israeli Arrow Weapon System test, included a simulated engagement of a medium-range target by Aegis BMD, supported by a cue from AN/TPY-2 (Terminal Mode, or TM) and an examination of the interoperability between Aegis BMD and the Arrow system.
  - Flight Test Other (FTX)-06 Event 1 in July 2009, a tracking exercise, assessed functionality of the new Aegis BMD 4.0.1 software on an Aegis BMD cruiser. Aegis BMD also conducted a simulated engagement.
  - Ground Test Other (GTX)-03e in July 2009 used hardware-in-the-loop simulations to test the interaction between BMDS elements, sensors, and command and control interfaces. GTX-03e evaluated Aegis BMD ability

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to track and support BMDS engagements of updated threat representations.

- Fast CAAT East-Bravo, conducted April to June 2009, was a European theater-centric, hardware-in-the-loop and distributed ground test that provided a system-level assessment of theater data paths.

## Assessment

- In FY09 and early FY10, Aegis BMD flight testing continued to demonstrate the capability to engage short-range non-separating and medium-range separating ballistic missile targets in the midcourse and terminal phases of flight. The terminal phase engagement during “Stellar Daggers” provided additional data for a more thorough assessment of the sea-based terminal engagement capability with modified SM-2 Block IV interceptors.
- Intercept tests have demonstrated the efficacy of the SM-3 Block IA interceptor for some midcourse engagement missions. While flight testing to date has not exercised the highest pulse mode of the SM-3 kinetic warhead divert system, the program has executed seven ground tests to verify full pulse operation. These ground tests, combined with validated modeling and simulation results, give moderate confidence that the full range of pulse modes function correctly.
- The zero-pulse mode of the SM-3 third stage rocket motor also has not been tested in a live intercept event. Zero-pulse functionality is applicable to only a small portion of the overall engagement battlespace, and is nearly impossible to demonstrate safely during flight testing. Results from digital simulations and ground testing are encouraging, and

provide limited confidence in the rocket motor’s zero-pulse functionality.

- FY09 included two SM-3 failures during “Pacific Blitz” and JFTM-2. Aegis BMD has attributed the “Pacific Blitz” failure to manufacturing procedures applicable to the Block I missile that do not apply to current Block IA interceptors. Aegis BMD continues to investigate the cause of the JFTM-2 Block IA interceptor failure.
- Aegis BMD demonstrated LRS&T functionality during FTG-05.
- FTT-10a demonstrated Aegis BMD’s ability to cue THAAD while Aegis BMD and THAAD inter-element data transfer over tactical links continues to mature. Aegis BMD has not yet tested launch-on-remote capability in a live intercept mission, though such a mission is planned for FTM-15 in FY10.
- Command and control and theater engagement capabilities were demonstrated in an operationally-realistic environment during U.S. Navy Fleet exercises.
- Fast CAAT East-Bravo demonstrated the potential of Aegis BMD to contribute to the defense of Israel.

## Recommendations

- Status of Previous Recommendations. The program addressed all of the six recommendations from FY08.
- FY09 Recommendation.
  1. The MDA should revise the IMTP to incorporate operationally realistic testing of Aegis BMD to support the phased, adaptive approach to providing missile defense for Europe.

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