

Ballistic Missile Defense System (BMDS)



Executive Summary

- No Homeland Defense intercept flight testing occurred in FY16. Hence, previous assessments that the Ballistic Missile Defense System (BMDS) demonstrates a limited capability to defend the U.S. Northern Command (USNORTHCOM) area of responsibility from small numbers of simple intermediate-range or intercontinental ballistic missile threats (greater than 3,000 km range) launched from North Korea or Iran remain unchanged.
- The Regional/Theater BMDS demonstrates a limited capability to defend the U.S. Pacific Command (USPACOM), U.S. European Command (USEUCOM), and U.S. Central Command (USCENTCOM) areas of responsibility for small numbers of medium- and intermediate-range ballistic missile threats (1,000 to 4,000 km), and a fair capability for short-range ballistic missile threats (less than 1,000 km range).
- The Flight Test, Operational-02 (FTO-02) Event 1a flight test demonstrated an Aegis Ashore remote engagement capability with Standard Missile-3 (SM-3) Block IB Threat Update (TU) guided missiles using data from an AN/TPY 2 Forward-Based Mode (FBM) radar. This was an important demonstration of the European Phased Adaptive Approach (EPAA) Phase 2 BMDS capability. The FTO-02 Event 2a flight test demonstrated a layered BMDS with multiple combat systems

- sharing common defended areas and shot opportunities against two threat-representative ballistic missiles.
- The Missile Defense Agency (MDA) conducted a non-intercept Homeland Defense flight test (Ground-based Midcourse Controlled Test Vehicle-02+ (GM CTV-02+)) during which the MDA demonstrated the Capability Enhancement-II (CE-II) Exo-atmospheric Kill Vehicle (EKV) Alternate Divert Thrusters (ADTs) in an operationally realistic environment. The ADTs turned on and off as commanded and performed nominally, but the EKV experienced an anomaly unrelated to the new ADT system. The MDA collected extensive phenomenology data for discrimination improvements.
- The MDA completed the BMDS Capability Increment 6 System Requirements Review. Capability Increment 6 includes the Re-designed Kill Vehicle, Long Range Discrimination Radar, and discrimination improvements.
- Since FY10, DOT&E has assessed and reported annually that the lack of accreditation of models and simulation for performance assessment have limited DOT&E's use of these data for quantitative evaluations. This assessment remains unchanged for FY16. The MDA should increase

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the development priority and associated funding for a BMDS high-fidelity, end-to-end, digital modeling and statistically significant simulation capability.

- The MDA also conducted several wargames and exercises designed to enhance Combatant Command ballistic missile defense (BMD) readiness and increase Service member confidence in the deployed elements of the BMDS.

System

The BMDS is a federated and geographically distributed system of systems that relies on element interoperability and warfighter integration for system-level operational effectiveness and efficient use of guided missile/interceptor inventory. BMDS includes five elements: four autonomous combat systems and one sensor/command and control architecture.

- Autonomous combat systems – Ground-based Midcourse Defense (GMD), Aegis BMD/Aegis Ashore Missile Defense System (AAMDS), Terminal High-Altitude Area Defense (THAAD), and Patriot
- Sensors – COBRA DANE radar, Upgraded Early Warning Radars (UEWRs), Sea Based X band (SBX) radar, AN/TPY 2 (FBM) radar, Aegis AN/SPY 1 radar aboard an Aegis BMD ship, and the Space-Based Infrared System (SBIRS)
- Command and control – Command and Control, Battle Management, and Communications (C2BMC)

Mission

- USNORTHCOM, USPACOM, USEUCOM, and USCENTCOM employ the assets of the BMDS to defend

the United States, deployed forces, and allies against ballistic missile threats of all ranges.

- The U.S. Strategic Command synchronizes operational-level global missile defense planning and operations support for the DOD.

Major Contractors

- The Boeing Company
 - GMD Integration: Huntsville, Alabama
- Lockheed Martin Corporation
 - Aegis BMD, AAMDS, and AN/SPY-1 radar: Moorestown, New Jersey
 - C2BMC: Huntsville, Alabama, and Colorado Springs, Colorado
 - SBIRS: Sunnyvale, California
 - THAAD Weapon System and Patriot Advanced Capability-3 Interceptors: Dallas, Texas
 - THAAD Interceptors: Troy, Alabama
- Northrop Grumman Corporation
 - GMD Fire Control and Communications: Huntsville, Alabama
- Orbital ATK
 - GMD Booster Vehicles: Chandler, Arizona
- Raytheon Company
 - GMD EKV and SM-3/6 Interceptors: Tucson, Arizona
 - Patriot Weapon System including Guidance Enhanced Missile-Tactical interceptors, AN/TPY-2 radar, COBRA DANE radar, SBX radar, and UEWRs: Tewksbury, Massachusetts

Activity

- The MDA conducted all testing in accordance with the DOT&E-approved Integrated Master Test Plan.
- The BMDS Operational Test Agency and the MDA conducted the FTO-02 Event 2a flight test in November 2015 at Wake Island and the broad-ocean area surrounding it. The primary test objective was to assess Aegis BMD system capability to prosecute a ballistic missile threat engagement in the presence of non organic post intercept debris, while simultaneously conducting anti-air warfare. The THAAD combat system, using Lot 4 interceptors for the first time, generated a non-organic post-intercept debris scene for Aegis BMD.
- The BMDS Operational Test Agency and the MDA executed the FTO-02 Event 1a flight test in December 2015 at the Pacific Missile Range Facility (PMRF) on Kauai, Hawaii. The test objective was to demonstrate the operational capability of the EPAA Phase 2 BMDS, anchored by the Aegis Ashore combat system, to defend Europe against medium-range ballistic missiles (MRBMs). The test was the first target intercept by the AAMDS and the first flight for the SM-3 Block IB TU guided missile.
- No Homeland Defense intercept flight testing occurred in FY16. The MDA conducted a non-intercept GM CTV 02+ flight test in January 2016 using GMD, the AN/TPY-2 (FBM) radar, the SBX radar, and C2BMC. This test was a demonstration of the CE-II EKV ADT and a discrimination phenomenology data collection.
- During FY16, the MDA conducted four system-level ground tests.
 - The Ground Test, Distributed-06 (GTD-06) Part 1 ground test, in October 2015, assessed BMDS-level theater/regional capabilities in USEUCOM's and USCENTCOM's area of responsibility in a distributed test environment.
 - The Ground Test, Integrated-06 (GTI-06) Part 2 ground test, in May 2016, assessed BMDS-level strategic and theater/regional capabilities in USNORTHCOM's and USPACOM's area of responsibility in an integrated test environment.
 - The Ground Test, Integrated-Israel (GTI-ISR) (16) ground test, in July 2016, assessed the interoperability of Israeli and U.S. BMDS systems in an integrated test environment.
 - The GTD-06 Part 2 ground test, in September 2016, assessed BMDS-level strategic and theater/regional capabilities in USNORTHCOM's and USPACOM's areas of responsibility in a distributed test environment.

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- The MDA completed the BMDS Capability Increment 6 System Requirements Review in May 2016. Capability Increment 6 includes the Redesigned Kill Vehicle, Long Range Discrimination Radar, and discrimination improvements.
- The MDA also conducted several wargames and exercises designed to enhance Combatant Command BMD readiness and increase Service member confidence in the deployed elements of the BMDS.

Assessment

- The MDA, in collaboration with DOT&E, updated the Integrated Master Test Plan to incorporate BMDS element maturity, program modifications, and fiscal constraints.
- The FTO-02 Event 2a flight test demonstrated a layered BMDS with multiple combat systems sharing common defended areas and shot opportunities against two threat-representative ballistic missiles.
 - C2BMC software version S6.4-2.2.0 managed the AN/TPY-2 (FBM) radar, executed track reporting of sensor data to Link 16, and forwarded track data between the Aegis BMD and THAAD systems for subsequent engagements.
 - The THAAD combat system with version 2.7 software and using Lot 4 interceptors for the first time, intercepted a complex short-range ballistic missile target.
 - The Aegis BMD engaged an MRBM target. The Aegis Baseline 9.C1 destroyer operating in Integrated Air and Missile Defense radar priority mode engaged the target on remote track data from the AN/TPY-2 FBM CX-2.1.0 radar at Wake Island, and launched an SM-3 Block IB TU guided missile against the target. A faulty G-switch in the SM-3's guidance section failed early in the missile's flight, preventing a midcourse intercept. The malfunctioning G-switch precluded the separation of the missile's second stage from the first stage. A failure review board determined that the G-switch malfunctioned due to mechanical failure from abnormally high sticking in the component's lubricant. The program addressed the problem by implementing improved testing and screening of the G-switch before acceptance for installation. The new process changes were implemented and successfully flown in a controlled test flight.
 - Concurrently, the Aegis BMD ship successfully engaged a cruise missile surrogate target with an SM-2 Block IIIA guided missile.
 - THAAD also engaged the MRBM target and intercepted it.
- In FTO-02 Event 1a, sailors in the Aegis Ashore Missile Defense Test Facility at PMRF engaged an air-launched MRBM target using data from an AN/TPY-2 (FBM) CX 2.1.0 radar located at PMRF. This was an important demonstration of MRBM defense capability relevant to the EPAA Phase 2 BMDS and increased capability for theater/regional BMD. C2BMC relayed AN/TPY-2 (FBM) target track data to Aegis Ashore. Aegis Ashore fired an SM-3 Block IB TU guided missile on the remote track data, and intercepted a target for the first time. The firing assets consummated the engagement using local AN/SPY-1 radar data, rather than that of the AN/TPY-2 (FBM) radar. Although ground testing and unaccredited high-fidelity modeling and simulation have demonstrated all aspects of Aegis BMD's remote engagement capability, the lack of a flight test demonstration or data produced by accredited models reduces certainty in this capability.
- In both FTO-02 events, previously seen system network, radar track management, object discrimination and debris mitigation algorithms, and/or launch event association inaccuracies were noted again. The classified European Phased Adaptive Approach Phase 2 Operational Test and Evaluation Report and the 2015 Assessment of the BMDS report have additional assessment details and recommendations.
- During GM CTV-02+, the MDA demonstrated the CE-II EKV ADTs in an operationally realistic environment. The ADTs turned on and off as commanded and performed nominally, but the EKV experienced an anomaly unrelated to the new ADT system. See the GMD article for additional details. The MDA collected extensive phenomenology data for discrimination improvements.
- In GTD-06 Part 1, the MDA demonstrated interoperability between Aegis Ashore, Aegis BMD, THAAD, the AN/TPY-2 (FBM) radars, C2BMC, and SBIRS in scenarios against theater/regional threats in USEUCOM and USCENTCOM areas of responsibility. The MDA exercised the new capabilities of Aegis BMD software versions BL9.B1/C1, including new engagement planning functionality and an expanded threat set. These test data support the evaluation of BMDS and element-level interoperability and performance against SRBM and MRBM threats.
- In the GTI-06 Part 2 and GTD-06 Part 2 ground tests, the MDA demonstrated interoperability of the GMD GFC software version 6B3.1 with the SBIRS, UEWRs, C2BMC, AN/TPY-2 (FBM) radar, Aegis AN/SPY-1 radar in its long-range surveillance and track mode, the SBX radar, and Patriot Advanced Capability-3. The MDA evaluated a number of GMD software upgrades, including the discrimination logic, SBX tasking, and GFC salvo logic. These test data support the evaluation of GMD system performance against an expanded strategic threat set.
- BMDS-level integrated training capabilities for warfighter and interoperability functions remain limited. See the classified DOT&E European Phased Adaptive Approach Phase 2 Operational Test and Evaluation Report for additional assessment detail.
- The "integrated BMDS" refers to the full complement of BMDS combat systems that have a defensive capability for a given defended area, operating in a fully integrated fashion for the efficient use of the available interceptor inventory. The MDA has not yet demonstrated such an integrated BMDS capability. The MDA has demonstrated a basic BMDS combat capability that includes non-automated engagement planning and execution across the four threat classes (short-range, medium-range, intermediate-range, and intercontinental ballistic missiles) and in multiple phases of flight, but a

considerable amount of development is still necessary to field a robust, reliable, and fully integrated BMDS.

- In FY10, DOT&E reported, “the MDA began execution of its revamped Integrated Master Test Plan to collect the data needed to accredit the models and simulations used for assessing performance and effectiveness of the BMDS.” Since then, DOT&E has assessed and reported annually that the lack of accreditation of models and simulation for performance assessment have limited DOT&E’s use of these data for quantitative evaluations. This assessment remains unchanged for FY16.

Recommendations

- Status of Previous Recommendations. The MDA has addressed most previous BMDS recommendations. The following recommendations remain outstanding. The MDA should:
 1. Continue to address recommendations made in the DOT&E FTO-01 assessment found in the classified DOT&E February 2014 BMDS Annual Report, Appendix E.
 2. Increase the development priority and associated funding for the BMDS simulation-based performance assessment capability. The ability to produce high-fidelity and statistically significant BMDS level performance assessments is critical (FY14 Recommendation).
 3. Include Patriot in system-level operational flight test events in order to assess interoperability and integration between all of the BMDS combat systems and sensors. The MDA has completed initial design for flight tests in FY17-19 and

has identified additional flight tests in FY20-22 to address this FY15 recommendation.

- FY16 Recommendations. The MDA should
 1. In conjunction with the Services, develop and implement integrated BMDS-level training in formal warfighter certification plans.
 2. Assess the performance of the BMDS in both flight and ground testing using realistic Link 16 loading and network configurations.
 3. Include the situational awareness tools used by the fire coordination and link management officers in their assessment of BMDS performance and ensure that warfighter involvement in testing is reflective of Combatant Command operations.
 4. Publish a comprehensive BMDS cybersecurity document that delineates the strategy for effective cybersecurity, achievable milestones for implementing the strategy, and stakeholder roles and responsibilities.
 5. Include reliability, maintainability, availability, and supportability data collectors for all participating elements in operationally realistic flight and ground test events to ensure that sufficient reliability, maintainability, availability, and supportability data are collected to allow for an assessment of operation suitability for all BMDS elements and sensors.
 6. Use targets with threat-representative reactive payloads in some future flight testing to improve the evaluation of lethality, sensor loading, battle management, and kill assessment.