

## Sensors / Command and Control Architecture



**Aegis AN/SPY-1 Radar**



**AN/TPY-2**



**Cobra Dane**



**C2BMC**



**UEWR**



**SBIRS**



**Sea-Based X-band Radar**

**C2BMC - Command and Control, Battle Management and Communications System**  
**SBIRS - Space-Based Infrared System**  
**UEWR - Upgraded Early Warning Radars**

### Executive Summary

- The Missile Defense Agency (MDA) continued to mature the Ballistic Missile Defense System (BMDS) sensors/command and control architecture. During FY16, the MDA used the sensor/command and control architecture in one Ground-based Midcourse Defense (GMD) developmental flight test, two BMDS operational flight tests, and four ground tests. Additionally, the Air Force used the sensor/command and control architecture in one intercontinental ballistic missile (ICBM) reliability and sustainment flight test.
- Many COBRA DANE radar system components and facilities are past the original design lifespan. Options for long-term supportability are diminishing and many of the original equipment manufacturers no longer exist. The Air Force awarded a \$77 Million, 2-year contract to Raytheon for operations, maintenance, and sustainment of the COBRA DANE radar.
- The MDA demonstrated AN/TPY-2 Forward-Based Mode (FBM) radar capabilities, including enhanced tracking; improved debris mitigation and launch complex association algorithms; and updated discrimination and decision control logic.
- The Army continues to transition AN/TPY-2 (FBM) radar operations and maintenance from contractor logistics support to organic soldier operations and maintenance. Training and documentation deficiencies continue to be discovered, most

recently in both Flight Test, Operational-02 (FTO-02) events. Soldiers are now responsible for activities at two of the five deployed radars.

- The MDA demonstrated Command and Control, Battle Management, and Communications (C2BMC) threat assessment, threat evaluation, sensor resource management, sensor track data processing, track reporting, target selection, discrimination and debris mitigation tasking, sensor/weapon access determination, and engagement monitoring during dedicated flight and ground testing as well as when tracking real-world ballistic missile targets-of-opportunity. C2BMC provided Combatant Commanders with timely and accurate information on numerous real-world events.
- The MDA awarded Lockheed Martin a \$784.3 Million contract to develop and operate the Long Range Discrimination Radar.

### System

- The BMDS sensors are systems that provide real-time ballistic missile threat data to the BMDS. The data are used to counter ballistic missile attacks. The sensor systems are operated by the Army, Navy, Air Force, and the MDA.
  - The COBRA DANE radar is a fixed site, single-face, L-band phased array radar operated by the Air Force and located at Eareckson Air Station (Shemya Island), Alaska.

# FY16 BALLISTIC MISSILE DEFENSE SYSTEMS

- The Upgraded Early Warning Radars (UEWRs) are fixed site, multiple-face, ultra-high frequency radars operated by the Air Force and located at Beale AFB, California (two radar faces); Fylingdales, United Kingdom (three radar faces); and Thule, Greenland (two radar faces). The MDA and Air Force Space Command are also upgrading the Early Warning Radars in Clear Air Force Station, Alaska (FY17), and Cape Cod Air Force Station, Massachusetts (FY18).
- The Sea-Based X-band (SBX) radar is a mobile, phased array radar operated by the MDA and located aboard a twin-hulled, semi-submersible, self-propelled, ocean-going platform.
- The AN/TPY-2 (FBM) radar is a transportable, single-face, X-band phased array radar commanded and tasked by the C2BMC, and located at sites in Japan, Israel, Turkey, and the U.S. Central Command (USCENTCOM) area of responsibility.
- The list of BMDS sensors also includes the Aegis AN/SPY-1 radar and the Space-Based Infrared System (SBIRS)/Defense Support Program satellites. See the Aegis Ballistic Missile Defense (BMD) and SBIRS articles (pages 413 and 403, respectively), for reporting on these sensors.
- The C2BMC system is a Combatant Command interface to the BMDS. More than 70 C2BMC workstations are fielded at U.S. Strategic Command, U.S. Northern Command (USNORTHCOM), U.S. European Command (USEUCOM), U.S. Pacific Command (USPACOM), and USCENTCOM; numerous Army Air and Missile Defense Commands; Air and Space Operations Centers; and other supporting warfighter organizations.
  - The current C2BMC provides Combatant Commands and other senior national leaders with situational awareness of BMDS status, system coverage, and ballistic missile tracks by displaying selective BMDS data for strategic/national missile defense and for theater/regional missile defense, utilizing multiple message formats and diverse terrestrial and satellite communications paths.
  - The C2BMC also provides a consolidated upper echelon BMD mission plan at the Combatant Command and component level. BMDS elements (Aegis BMD, GMD, Patriot, and Terminal High-Altitude Area Defense (THAAD)) use their own command and control battle management systems and mission-planning tools for stand-alone engagements.
- The current C2BMC S6.4 suite provides command and control for the AN/TPY-2 (FBM) radar as well as track reporting to support weapon system cueing and engagement operations.
- Using the BMDS Communications Network, the C2BMC forwards AN/TPY-2 (FBM) and AN/SPY-1 tracks to GMD. C2BMC uses the Tactical Digital Information Link-Joint message formats to send C2BMC system track data to THAAD, Patriot, and coalition systems for sensor cueing and for Aegis BMD engagement support.
- The C2BMC S8.2 (projected for FY17-18) is intended to mature and expand S6.4 capabilities as the next major step toward integrated, automated sensor management and engagement coordination.

## Mission

- Combatant Commands use the BMDS sensors to detect, track, and classify/discriminate ballistic missile threats that target the United States and U.S. allies.
- Combatant Commands use C2BMC for deliberate and dynamic planning; situational awareness; track management; AN/TPY-2 (FBM) sensor management and control; engagement support and monitoring, data exchange between C2BMC and BMDS elements; and network management.

## Major Contractors

- COBRA DANE Radar: Raytheon Company, Intelligence, Information, and Services – Dulles, Virginia
- UEWRs: Raytheon Company (Prime), Integrated Defense Systems – Tewksbury, Massachusetts; Harris Corporation/Exelis (Sustainment) – Colorado Springs, Colorado
- SBX, and AN/TPY-2 (FBM) Radars: Raytheon Company, Integrated Defense Systems – Tewksbury, Massachusetts
- C2BMC: Lockheed Martin Corporation, Rotary and Mission Systems – Huntsville, Alabama, and Colorado Springs, Colorado

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## Activity

- The MDA conducted all testing in accordance with the DOT&E-approved Integrated Master Test Plan.
- During FY16, the MDA and the Air Force used the sensor/command and control architecture in nine tests. The MDA executed one GMD developmental flight test, two BMDS operational flight tests, and four ground tests; the Air Force executed one ICBM reliability and sustainment flight test.
  - The FTO-02 Event 2a flight test, in October 2015, assessed a layered BMDS defense with multiple combat systems sharing common defended areas and shot opportunities.
  - 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 areas of responsibility in a distributed test environment.
  - The FTO-02 Event 1a flight test, in December 2015, assessed the operational capability of the regional/theater European Phased, Adaptive Approach Phase 2 BMDS, anchored by the Aegis Ashore Missile Defense System, to defend Europe against medium-range ballistic missiles.

# FY16 BALLISTIC MISSILE DEFENSE SYSTEMS

- The Ground-based Midcourse Controlled Test Vehicle-02+ (GM CTV-02+) flight test, in January 2016, assessed the Capability Enhancement-II Exo-atmospheric Kill Vehicle Alternate Divert Thruster performance in a flight environment while also assessing discrimination data flow through the fire control loop.
- 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 area of responsibility in a distributed test environment.
- The Glory Trip 219 flight test, in September 2016, is an Air Force Minuteman III ICBM reliability and sustainment assessment.
- The MDA used hardware-in-the-loop, training devices, and analytical models of the COBRA DANE radar, Beale UEW, Thule UEW, and Fylingdales UEW during the GTI-06 Part 2 and GTD-06 Part 2 ground tests. In addition, the MDA used the Beale UEW in the GM CTV-02+ flight test. The MDA also developed a COBRA DANE and Thule UEW targets-of-opportunity campaign that will begin in FY17.
- The SBX radar was used in one GMD developmental flight test (GM CTV-02+), one ICBM reliability and sustainment flight test (Glory Trip 219), and two ground tests (GTI-06 Part 2 and GTD-06 Part 2).
- The MDA used the AN/TPY-2 (FBM) radar and C2BMC in one GMD developmental flight test (GM CTV-02+), two BMDS operational flight tests (FTO-02 Event 2a and FTO-02 Event 1a), and four ground tests (GTD-06 Part 1, GTI-06 Part 2, GTI-ISR (16), and GTD-06 Part 2). In addition, the Air Force used C2BMC and the AN/TPY-2 (FBM) radar in one ICBM reliability and sustainment flight test (Glory Trip 219).
- In January 2016, the MDA evaluated C2BMC Spiral 6.4 and AN/TPY-2 (FBM) in an Element Cybersecurity Experiment (ECE) to identify cybersecurity vulnerabilities with participation from Cyber Protection Team 800.
- In October 2015, the MDA awarded Lockheed Martin a \$784.3 Million contract to develop and operate the Long Range Discrimination Radar. The MDA completed the System Requirements Review in February 2016.
- Many COBRA DANE radar system components and facilities are past the original design lifespan. Options for long-term supportability are diminishing, and many of the original equipment manufacturers no longer exist. In December 2015, the Air Force awarded a \$77 Million, 2-year contract to Raytheon for operations, maintenance, and sustainment of the COBRA DANE radar.
- The ground test data showed mixed UEW performance with several new missile threat objects added to the UEW object classification database.
- The MDA demonstrated AN/TPY-2 (FBM) radar software upgrades, including enhanced tracking; improved debris mitigation and launch complex association algorithms; and updated discrimination and decision control logic.
- The MDA and the Army continue working to achieve full materiel release of the AN/TPY-2 (FBM) radar. Of the nine original materiel release conditions the Army created in 2012, the Army closed seven by 2014 and migrated the remaining two to the set of materiel release conditions associated with software version CX-1.2.3\_18. Of the 25 CX 1.2.3\_18 materiel release conditions, the Army closed one prior to 2016 and the Army closed four in 2016. The Army is also in the process of establishing additional materiel release conditions for software version CX-2.1.0.
- The Army continues to transition AN/TPY-2 (FBM) radar operations and maintenance from contractor logistics support to organic soldier operations and maintenance. Training and documentation deficiencies continue to be discovered, most recently in both FTO-02 events. Soldiers are now responsible for activities at two of the five deployed radars.
- In Glory Trip 219, the SBX radar acquired and tracked the Minuteman III ballistic missile through the boost and/or midcourse phases of flight.
- The MDA demonstrated C2BMC threat assessment, threat evaluation, sensor resource management, sensor track data processing, track reporting, target selection, sensor/weapon access determination, and engagement monitoring during dedicated flight and ground testing, as well as during real-world ballistic missile targets-of-opportunity.
  - The system demonstrated dual radar management and track processing/reporting utilizing operational C2BMC suites and communications.
  - The C2BMC engagement planner provided non-real-time performance analysis of the composition and location of U.S. and allied BMD assets, but does not currently provide a system-level capability to coordinate engagement decisions.
  - Software version S6.4-3.0 provided discrimination tasking of the AN/TPY-2 (FBM) radar for long-range threats, multiple-radar discrimination tasking of a threat, and several fixes related to message sequencing and timing.
  - During GM CTV-02+, the MDA used passive links to conduct real-time activities with upcoming C2BMC version S8.2 and to collect data on closed loop fire control, enhanced tracking, post intercept assessment, and discrimination.

## Assessment

- During ground testing, the MDA gathered data to support evaluation of software upgrades and cybersecurity of the COBRA DANE radar, UEWs, and the AN/TPY-2 and SBX radars, including verification that the COBRA DANE radar software upgrades resolved a technical issue related to scan-dependent biases.

- During FTO-02 Event 1a, C2BMC demonstrated support to Aegis BMD Launch on Remote via track processing of AN/TPY-2 data, system track formation, system track selection, and Link 16 track reporting.
  - Flight testing with C2BMC control of two AN/TPY-2 (FBM) radars has yet to occur. However, C2BMC did exercise dual radar management, precision cueing, and system track formation during a dedicated ground test (USEUCOM and USCENTCOM areas of responsibility) and during real-world targets of opportunity (USPACOM and USEUCOM areas of responsibility).
  - C2BMC has not demonstrated real-time engagement direction capabilities.
  - Problems previously discovered during testing, if not corrected, could adversely affect C2BMC effectiveness. These problems, the details of which can be found in DOT&E's classified 2015 Assessment of the BMDS, include:
    - Track management and track processing problems
    - Data management problems
- Recommendations**
- Status of Previous Recommendations. The MDA has addressed all but two previous recommendations for the sensors/command and control architecture. The MDA:
    1. Made progress on sensor/command and control architecture cybersecurity testing by performing basic testing and system scans during GTI-06 Part 2 and one ECE. The MDA should continue to increase the number of components and the fidelity of its cybersecurity assessments.
    2. Has initiated, but not completed, a study on the additional sensor requirements for an effective defense of Hawaii.
  - FY16 Recommendations. The MDA should:
    1. With the Air Force, identify spare and replacement part sources for long-term COBRA DANE radar sustainment.
    2. With the Army, update AN/TPY-2 (FBM) Interactive Electronic Technical Manuals and improve AN/TPY-2 (FBM) radar operator training.
    3. Perform a flight test with multiple AN/TPY-2 (FBM) radars to assess the ability of C2BMC to correctly task and fuse track data from multiple sources observing realistic targets and to assess the ability to disseminate the subsequent system-level data across the BMDS. Additionally, the MDA should evaluate BMDS performance in dual radar missions, particularly Defense of Europe for USEUCOM and Homeland Defense for USNORTHCOM, using the COCOM suite (which can only manage one radar), when the C2BMC Global Engagement Manager is non-mission capable.
    4. Continue C2BMC development efforts to provide an engagement management capability to the BMDS.