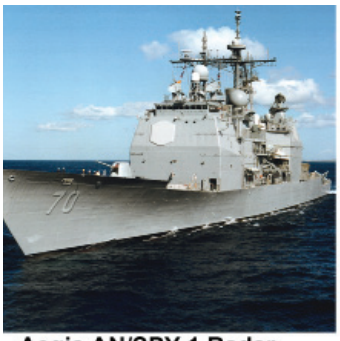
Sensors / Command and Control Architecture

Executive Summary

- The Missile Defense Agency (MDA) continued to mature the Ballistic Missile Defense System (BMDS) sensors/ command and control architecture during 23 flight tests, ground tests, and cybersecurity assessments.
- The MDA delivered the first instantiation of the BMDS Overhead Persistent Infrared Architecture (BOA) and tested an updated version of the BMDS mission planner.
- The MDA completed the final design of the Long-Range Discrimination Radar and initiated the Homeland Defense Radar – Hawaii program.
- The MDA conducted threat-realistic cybersecurity testing on Command and Control, Battle Management, and Communications (C2BMC), AN/TPY-2 radar, and Sea-Based X-band (SBX) radar, improving the ability of these systems to withstand cybersecurity attacks.


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
SBIRS - Space-Based Infrared System
UEWR - Upgraded Early Warning Radars

System

- The BMDS sensors are systems that provide real-time ballistic missile threat data to the BMDS. The Services use the data to counter ballistic missile attacks. The Army, Navy, Air Force, and the MDA operate the sensor systems.
  - The COBRA DANE radar is a fixed site, L-band phased array radar operated by the Air Force and located at Eareckson Air Station (Shemya Island), Alaska.
  - The Upgraded Early Warning Radars (UEWRs) are fixed site, ultrahigh frequency radars, operated by the Air Force located at Beale AFB, California, and Thule Air Base, Greenland. A third radar is operated by the Royal Air Force (RAF) with Air Force liaisons on site at RAF Fylingdales in the United Kingdom. The MDA and Air Force Space Command are also upgrading the Clear Air Force Station, Alaska, Early Warning Radar and the east coast Early Warning Radar at Cape Cod Air Force Station, Massachusetts.
  - The 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 Forward-Based Mode (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 Space-Based Infrared System (SBIRS) is a satellite constellation of infrared sensors operated by the Air Force with external interfaces to the BMDS located at Buckley AFB, Colorado, and Schriever AFB, Colorado.
  - The list of BMDS sensors also includes the Aegis AN/SPY 1 radar. See the Aegis Ballistic Missile Defense (BMD) article (page 215) for reporting on this sensor.
- The C2BMC system is a Combatant Command interface to the BMDS and the integrating element within the BMDS. C2BMC workstations are fielded at U.S. Strategic Command, U.S. Northern Command (USNORTHCOM), U.S. European Command (USEUCOM), U.S. Indo-Pacific Command (USINDOPACOM), and USCENTCOM; numerous Army Air and Missile Defense Commands; Air and Space Operations Centers; Maritime Operation 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.

- The C2BMC also provides a consolidated upper echelon BMD mission plan at the Combatant Command and component level.
- The C2BMC 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.
- BOA is a system within the C2BMC enterprise that receives raw infrared sensor information on boosting and midcourse ballistic objects and feeds that track data to C2BMC (S8.2-1 and beyond) for use in cueing BMDS sensors and weapon systems, and for situational awareness.
- Using the BMDS Communications Network, the C2BMC forwards AN/TPY-2 (FBM) and AN/SPY-1 tracks to Ground-based Midcourse Defense (GMD). C2BMC uses the Tactical Digital Information Link-Joint message formats to send C2BMC system track data to Aegis BMD, Terminal High-Altitude Area Defense (THAAD), Patriot, and coalition systems for sensor cueing and engagement support.

Mission

- Combatant Commands integrate the BMDS sensors and C2BMC with other BMDS elements to intercept ballistic missile threats that target the United States and U.S. allies.
  - Combatant Commands use the BMDS sensors to detect, track, and classify/discriminate ballistic missile threats.
  - 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
- SBIRS
  - Lockheed Martin Corporation, Space Systems – Sunnyvale, California
- C2BMC
  - Lockheed Martin Corporation, Rotary and Mission Systems – Huntsville, Alabama, and Colorado Springs, Colorado
- BOA
  - Northrop Grumman Corporation – Boulder, Colorado; Colorado Springs, Colorado; and Azusa, California

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Activity

- The MDA conducted all testing in accordance with the DOT&E-approved Integrated Master Test Plan.
- The MDA fielded BOA 5.1 in January 2018 and SBX X-band Radar (XBR) 3.3.4 in July 2018.
- The MDA completed the Final Design Review for the Long-Range Discrimination Radar in September 2018.
- During FY18, the MDA used the sensors and the command and control architecture in five intercept flight tests, five ground tests, five cybersecurity Cooperative Vulnerability and Penetration Assessments (CVPAs), three cybersecurity Adversarial Assessments (AAs), two Air Force intercontinental ballistic missile (ICBM) reliability and sustainment flight tests, and three individual element data collection flight tests.

Intercept Flight Tests

- The MDA and Navy conducted:
  - Navy fleet exercise Formidable Shield 17 (FS-17) in October 2017. FS-17 included an Aegis BMD intercept of a ballistic missile target as well as simulated intercepts.
  - Flight Test, Standard Missile-29 (FTM-29) in January 2018. The Aegis Ashore Missile Defense Test Facility attempted an engage-on-remote intercept using data from the AN/TPY-2 (FBM) CX3.0.0 Early Release (ER) radar. A Standard Missile-3 (SM-3) Block IIA guided missile failure precluded an intercept.
  - Navy fleet exercise Pacific Dragon 18 in August 2018.
  - Japanese Flight Test Mission-05 (JFTM-05) Event 1 and 2 in September 2018. A Japanese destroyer using a SM-3 Block IB guided missile intercepted a short-range ballistic missile target during Event 2; the destroyer conducted a simulated engagement of a short-range ballistic missile target during Event 1.
  - Software configurations for these tests were:

FLIGHT TEST	C2BMC	BOA	SBIRS	UEWR	AN/TPY-2 (FBM)
FS-17	S6.4-3		17-1	8.4.2	
FTM-29	S8.2-1	5.1	17-1		CX-3.0.0 ER
Pac Dragon 18	S8.2-1	5.1	17-1		
JFTM-5 Event 1	S8.2-1	5.1	17-1		
JFTM-05 Event 2	S8.2-1	5.1	17-1		

ER – Early Release

Ground Tests

- The MDA conducted:
  - Hardware-in-the-Loop GT in November 2017. The ground test assessed BMDS Capability Increment 4 functionality against ICBM threats and aided USNORTHCOM doctrine development.
  - Ground Test, Integrated-07b (GTI-07b) USEUCOM/USCENTCOM in April and May 2018. The ground test assessed European Phased, Adaptive Approach Phase 3 and BMDS Capability Increment 5 functionality in USEUCOM and USCENTCOM regional/theater scenarios.
  - GTI-18 Sprint 1 in April 2018. The ground test assessed the functionality of the U.S. Forces, Korea (USFK) Joint Emergent Operational Need (JEON) Phase 2 architecture.
  - GTI-18 Sprint 2 in July 2018. The ground test supported Aegis Baseline 9.C2 testing for modeling and simulation verification, validation, and accreditation prior to its Operational Capacity Baseline decision as well as system assessment for GMD Ground Systems 7A.0.1.1.
  - Ground Test, Distributed-07b (GTD-07b) USEUCOM/USCENTCOM in August and September 2018. The test used a distributed environment to assess BMDS performance in USEUCOM and USCENTCOM regional/theater defense, and to support deployment of the BMDS Capability Increment 5 functionality.
  - Software configurations for these tests were:

GROUND TEST	C2BMC	BOA	SBIRS	CD	UEWR	SBX XBR	AN/TPY-2 (FBM)
HWIL GT	S8.2-1		17-1	2.7.1.2	9.0.7/8.4.2	3.3.3	CX-2.1.1
GTI-07b (E/C)	S8.2-3 ER	6.1 ER	17-1				CX-3.0.0 ER
GTI-18 Sprint 1	S8.2-1	5.1/6.1 ER	17-1				CX-2.1.1
GTI-18 Sprint 2	S8.2-3 ER	6.1 ER	17-1	2.7.1.2	9.0.7	3.3.5 ER	CX-3.0.0
GTD-07b (E/C)	S8.2-3 ER	6.1 ER	17-1				CX-3.0.0

CD – Cobra Dane; E/C – U.S. European Command/U.S Central Command; ER –Early Release

CVPAs

- The Research Development and Engineering Command (RDECOM) Survivability/Lethality Analysis Directorate (SLAD), in support of the MDA, conducted:
  - XBR 3.3.x portion on the SBX in October 2017 (limited CVPA).
  - AN/TPY-2 (FBM) CX 2.1 radar in January 2018.
  - AN/TPY-2 (Terminal Mode (TM)) CX 2.1 radar in March 2018.
  - C2BMC S8.2-3 ER and BOA 6.1 ER in July 2018.
  - AN/TPY-2 (FBM) CX 3.0 ER in September 2018.

Adversarial Assessments (AAs)

- The Army Threat Systems Management Office, in support of the MDA, conducted:
  - C2BMC S6.4 (USEUCOM) in March 2018.
  - AN/TPY-2 (TM) CX 2.1 in April 2018.
  - C2BMC S8.2-3 ER, BOA 6.1 ER, and AN/TPY-2 (FBM) CX 3.0 ER in September 2018.

Air Force ICBM Reliability and Sustainment Flight Tests

- The Air Force conducted:
  - Glory Trip-226 (GT-226) in April 2018 and GT-224 in May 2018, using the SBX radar and overhead sensors. The Air Force was unable to complete GT-225 in July 2018 due to a missile failure.

Data Collection Flight Tests

- The MDA conducted:
  - A classified Cobra Dane/UEWR data collection event.
  - Flight Test, Other-33 (FTX-33) in March 2018. The test was an AN/SPY-6 developmental radar test, which included participation by SBIRS and overhead sensors.
  - Sensors-18 (SN-18) element test of the AN/TPY-2 (FBM) radar in May 2018 with a follow-on hardware-in-the-loop portion in August 2018. The test assessed electronic protection capabilities and supported further electronic protection development.
- In August 2018, the MDA tested the C2BMC S8.2-3 BMDS Planner in an USEUCOM planning exercise.
- The Army completed an urgent materiel release (conditional) in August 2018 for the AN/TPY-2 (FBM) CX 3.0 radar. The MDA and Army intend to close all remaining materiel release conditions for software version CX 2.1.0 and the electronic equipment unit x86 computer processor in 2019, and all conditions for software version CX 3.0 in 2020.

Assessment

- During FY18 testing, extensive sensor and command and control data were collected supporting development and fielding of new capabilities associated with European Phased, Adaptive Approach Phase 3, BMDS Capability Increment 5, and USFK JEON Phase 2 functionalities:
  - Sensor improvements on tactics, techniques, and procedures for engagement of new ICBM threats.
  - Aegis BMD engage-on remote capabilities interoperating with C2BMC, BOA, and the AN/TPY-2 (FBM) radar.
  - BOA data on threat acquisition and tracking.
  - AN/TPY-2 (FBM) search plan selection.
  - New SBX discrimination databases.
  - USFK JEON Phase 2 architecture.
- Further, FY18 cybersecurity assessments informed the network defense posture of parts of the BMDS in USEUCOM and provided data on how to reduce mission risk for these elements operating in a cyber-contested environment. Specific test data and resulting assessments are classified (see the classified DOT&E "FY18 Assessment of the BMDS," to be published in February 2019).
- The Army has completed transition of AN/TPY-2 (FBM) radar operations to organic soldier operations for all but one radar site. Transition to organic maintenance is still ongoing. Operator training and interactive electronic technical manuals continue to be deficient.

- The MDA demonstrated C2BMC S8.2-3 BMDS planner functionality in support of BMDS Capability Increment 5 functionality, and collaboration between the planner and the Aegis mission planner, the Air and Missile Defense workstation, and the THAAD tactical planner for defense design development.

Recommendations

1. The MDA should develop a comprehensive operational cybersecurity test and evaluation strategy for each BMDS sensor and C2BMC. This strategy should be included in the Integrated Master Test Plan and reflect:
   - Coordination with Deputy Assistant Secretary of Defense for Developmental Test and Evaluation to implement cybersecurity developmental test prior to operational test.
   - Coordination with the Navy to conduct integrated operational cybersecurity testing of the SBX concurrent with the XBR.
   - Coordination with the Air Force to conduct integrated operational cybersecurity testing of the UEWRs and COBRA DANE radar.
   - Plans to address test limitations and mitigate system deficiencies identified in previous cybersecurity assessments.
   - A process for using previous cybersecurity assessment results to inform cyber testing requirements and future engineering cycles.