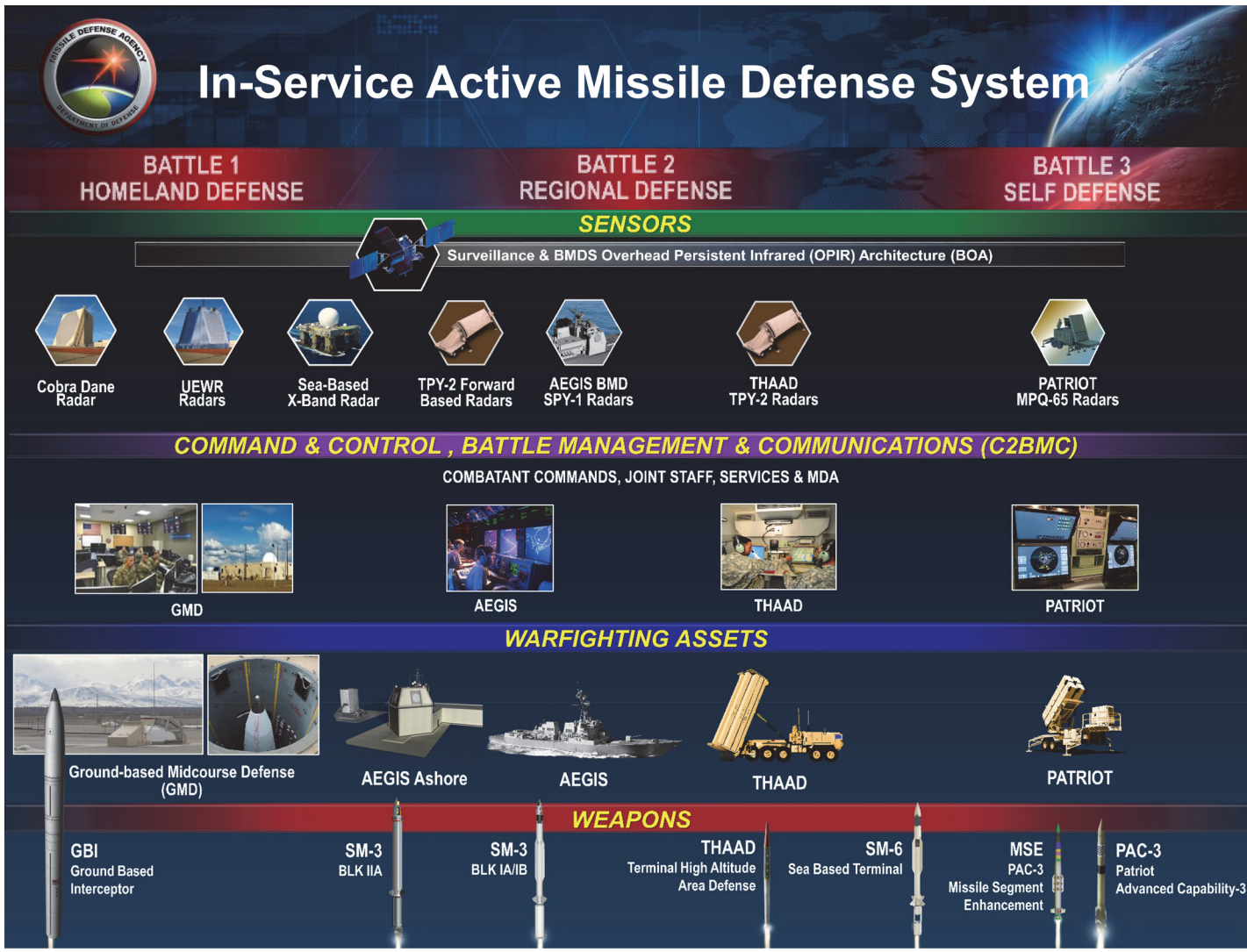
MISSILE DEFENSE SYSTEM



BMD - Ballistic Missile Defense
BLK - Block
MPQ - Mobile, Position Locating, Special Purpose
SM - Standard Missile
SPY - Surface Ship Radar Surveillance
TPY - Transportable Radar Surveillance
UEWR - Upgraded Early Warning Radar

Missile Defense System (MDS)

The Ground-based Midcourse Defense (GMD) weapon system has demonstrated the capability to defend the U.S. homeland from a small number of ballistic missile threats with ranges greater than 3,000 kilometers and employing simple countermeasures when supported by the full architecture of Missile Defense System (MDS) sensors. The Regional/Theater MDS has demonstrated the capability to defend the U.S. Indo-Pacific Command (USINDOPACOM), U.S. European Command (USEUCOM), and U.S. Central Command (USCENTCOM) areas of responsibility from a small number of medium- or intermediate-range ballistic missile threats with ranges less than 4,000 kilometers, and from representative raids against short-range ballistic missile (SRBM) threats. DOT&E assesses that the top five challenges, most of which were outlined in the FY22 Annual Report, for the MDS are: 1) the need for realistic and emerging threat representations in flight and ground testing; 2) the need for an adequate, accredited federation of modeling and simulation (M&S) with well understood and documented limitations to assess MDS effectiveness; 3) susceptibility of the MDS to cyberattack; 4) interoperability and maturation of engagement coordination; and 5) the need for test range infrastructure and instrumentation upgrades.

In FY23, the Missile Defense Agency (MDA) continued testing three significant new MDS capabilities:

- Aegis Ballistic Missile Defense (BMD) capability to detect, track, engage, and intercept a medium range ballistic missile (MRBM) target in the terminal phase of flight using a single salvo of two Standard Missile-6 (SM-6) Dual II Software Upgrade interceptors.
- Aegis Ashore Missile Defense System-Poland integration into the MDS.
- Initial Long Range Discrimination Radar (LRDR) performance through flight and ground testing in support of U.S. homeland defense and space domain awareness.

MDA started testing a significant new MDS capability of space domain awareness using the Army Navy/Transportable Radar Surveillance (Forward Based Mode) (AN/TPY-2 (FBM)) capability to detect, track, and report on resident space objects.

MDA delivered upgrades to the GMD Weapon System; Command and Control, Battle Management, and Communications; and the Sea-Based X-Band Radar (SBX) in FY23 that increase battlespace for the warfighter and improve network communication paths.

DOT&E will provide additional information and recommendations in the classified FY23 DOT&E Assessment Report of the MDS to be published in February 2024.

SYSTEM DESCRIPTION

The MDS is a geographically distributed system of systems that relies on element interoperability and warfighter integration for combat capability and efficient use of guided missile/interceptor inventory. As shown in Table 1, the MDS consists of six weapon systems, a sensor architecture (i.e., terrestrial, maritime, and global sensors), and a command and control element.

Table 1. Elements of MDA's Missile Defense System

Type	U.S. Homeland Defense	Global Regional/Theater Defense	Hypersonic Defense
Weapon Systems	**GMD[a]:** Defends the U.S. homeland against IRBM/ICBM attacks using GBIs to defeat threat missiles during the midcourse segment of flight. The MDA is developing a Next Generation Interceptor to supplement the current GBI fleet.	**Aegis BMD[a]:** Both sea- and land-based variants defend U.S. deployed forces and allies from SRBM, MRBM, and IRBM threats. Aegis BMD uses the SM-3 family of guided missiles against exo-atmospheric ballistic missile threats alongside SM-6 guided missiles that Aegis SBT (Inc 2 and Inc 3) uses for endo-atmospheric engagements. **THAAD[a]:** Defends U.S. deployed forces and allies from SRBM, MRBM, and IRBM threats using guided interceptors in both the exo- and endo-atmosphere. For extended engagements, THAAD can provide or accept target cues from Aegis BMD or other sensors via C2BMC. THAAD complements the upper-tier Aegis BMD and the lower-tier PAC-3 weapon systems. **PAC-3[b]:** Defends U.S. deployed forces and allies from SRBM and MRBM threats and aircraft attack and defeats enemy air assets. It is a mobile air and missile defense system employing a mix of PAC-3 hit-to-kill interceptors and PAC-2 blast fragmentation warhead interceptors.	**Aegis SBT (Inc 3)[a]:** Provides critical asset protection at sea and for joint forces ashore against ballistic, maneuverable, and hypersonic glide threats in the terminal phase. **GPI[a]:** Provides an additional layer of hypersonic defense augmenting Aegis SBT (Inc 3) to increase depth of fire against hypersonic threats. The program is currently competitively developing two prototype interceptors.
Terrestrial and Maritime Sensors	**Cobra Dane Radar[d]:** L-band fixed site phased array radar. **UEWRs[d]:** Ultrahigh frequency fixed site phased array radars. **SBX[a]:** X-band mobile phased array radar located aboard a self-propelled, ocean-going platform. **LRDR[a]:** S-band two-face fixed site phased array radar.	**AN/SPY-1 Radar[c]:** S-band four-face radar providing Aegis long-range surveillance and track functions in addition to guided missile engagement support. **AN/SPY-6(V)1 Radar[c]:** S-band four-face radar being installed on new construction Aegis DDG 51 Flight III destroyers. It will extend Aegis threat detection ranges and provide simultaneous ballistic missile and air defense support. **AN/TPY-2 (FBM) Radar[a]:** X-band single-face transportable phased array radar that also supports U.S. homeland defense. **LTAMDS[b]:** C-band three-face multi-function, multi-mission radar interfacing with IBCS and supporting interoperability with PAC-3.	Leverages U.S. homeland defense, global regional/theater defense, and global sensors.
Global Sensors	**SBIRS[d]:** Satellite constellation of infrared sensors. **BOA[a]:** Element that combines OPIR observations to provide missile event and track reports to C2BMC. **SKA[a]:** Network of space sensors providing interceptor hit assessments. **HBTSS[a]:** Network of space sensors to detect and track both ballistic and hypersonic threats and provide fire-control quality data to MDS sensors and weapon systems. MDA is planning to launch prototypes in 1QFY24.		
Command and Control	**C2BMC[a]:** Integrating element within the MDS providing deliberate and dynamic planning, situational awareness, sensor track management, engagement support and monitoring, data exchange between elements, and network management. C2BMC also directs sensor tasking for the LRDR, AN/TPY-2 (FBM) radars and provides cueing support to BOA.		

Notes:
[a] Under MDA development/sustainment. [b] Under Army development/sustainment. [c] Under Navy development/sustainment. [d] Under Space Force development/sustainment.

Acronyms: AN/SPY - Army Navy/Surface Ship Radar Surveillance; AN/TPY – Army Navy/Transportable Radar Surveillance; BMD – Ballistic Missile Defense; BMDS – Ballistic Missile Defense System; BOA – BMDS Overhead Persistent Infrared Architecture; C2BMC – Command and Control, Battle Management, and Communications; FBM – Forward-Based Mode; GMD – Ground-based Midcourse Defense; GBI – Ground-Based Interceptors; GPI – Glide Phase Interceptor; HBTSS – Hypersonic and Ballistic Tracking Space Sensor; IAMD – Integrated Air and Missile Defense; IBCS – IAMD Battle Command System; ICBM – Intercontinental Ballistic Missile; Inc – Increment; IRBM – Intermediate-Range Ballistic Missile; LRDR – Long Range Discrimination Radar; LTAMDS – Lower Tier Air and Missile Defense Sensor; MDA – Missile Defense Agency; MDS – Missile Defense System (formerly BMDS); MRBM – Medium-Range Ballistic Missile; OPIR – Overhead Persistent Infrared; PAC – Patriot Advanced Capability; SBIRS – Space-Based Infrared System; SBT – Sea-Based Terminal; SBX – Sea-Based X-band Radar; SKA – Space-Based Kill Assessment; SM – Standard Missile; SRBM – Short-Range Ballistic Missile; THAAD – Terminal High Altitude Area Defense; UEWR – Upgraded Early Warning Radar

MISSION

The Commanders of U.S. Northern Command (USNORTHCOM), USINDOPACOM, USEUCOM, and USCENTCOM employ the assets of the MDS to defend the United States, deployed forces, and allies against missile threats at all ranges and in all phases of flight.

PROGRAM

The MDS is a single Acquisition Category (ACAT) ID program that encompasses five of its six weapon systems (all but Patriot), most of its sensor architecture, and its command and control element. In 2002, the Secretary of Defense granted the MDA special acquisition authorities for the MDS, which allowed it to use tailored processes and milestones to deploy new capability, as soon as technologically possible, to defend the United States and its allies against limited ballistic missile attack. The mission of MDA is to develop and deploy a layered MDS to defend the United States, its deployed force, allies, and friends from missile attacks in all phases of flight.

The MDA manages the MDS through a series of six program baselines – Schedule, Test, Technical, Resource, Contract, and Operational Capability – and maintains responsibility for integrating all elements into the MDS whether or not the MDA developed the element. The MDA publishes the Test Baseline twice a year in an Integrated Master Test Plan (IMTP) that corresponds to the MDA Program Objective Memorandum submission to the Department and the President's Budget release to Congress. DOT&E approves each version of the IMTP, the latest of which was dated September 2023 (version 25.0).

The Army manages the Patriot and Lower Tier Air and Missile Defense Sensor (LTAMDS) programs. Patriot is an ACAT IC program. DOT&E approved the Patriot Post Deployment Build (PDB) 8.1 Test and Evaluation Master Plan (TEMP) in FY20. LTAMDS is a Middle Tier of Acquisition program for rapid prototyping; the Army expects to designate LTAMDS as an ACAT-1C at its Materiel Development Decision now planned for January 2025, delayed by approximately a year because of integration challenges and supply chain delays. DOT&E approved the LTAMDS initial TEMP in 2019. The program office continues to develop a Test and Evaluation Strategy, with DOT&E approval now expected in 1QFY24.

The Navy manages the AN/SPY-1 and AN/SPY-6(V)1 radar programs. The AN/SPY(6)1 is an ACAT IC program. DOT&E approved its TEMP in September 2022.

The Space Force operates and sustains four sensor systems integrated into the MDS: Cobra Dane Upgrade, five Upgraded Early Warning Radars (UEWRs), the Space-Based Infrared System (SBIRS) constellation, and the LRDR. The Air Force completed development and initial operational testing for the first three sensor systems prior to them becoming Space Force assets. The Space Force has not yet operationally accepted the LRDR. In FY23, DOT&E placed the UEWRs under oversight.

» MAJOR CONTRACTORS

- The Boeing Company
  - GMD Integration: Huntsville, Alabama
- Lockheed Martin Corporation
  - Aegis BMD, AAMDS, Aegis SBT, AN/SPY-1 radar, LRDR, and GPI: Moorestown, New Jersey
  - C2BMC: Huntsville, Alabama and Colorado Springs, Colorado
  - NGI "Black" AUR through Critical Design Review: Huntsville, Alabama (Note: Black and Gold denote the two NGI contractor teams)
  - SBIRS: Sunnyvale, California
  - THAAD Weapon System, PAC-3 Command and Launch System, and PAC-3 interceptor variants: Dallas, Texas
  - THAAD interceptors: Troy, Alabama
- Northrop Grumman Corporation
  - GMD Weapon Systems Development: Huntsville, Alabama
  - GBI Boost Vehicles: Chandler, Arizona
  - NGI "Gold" AUR through Critical Design Review and GPI: Huntsville, Alabama

  - BOA: Boulder, Colorado; Colorado Springs, Colorado; and Azusa, California
  - HBTSS through Prototype Demonstration Phase: Redondo Beach, California and Azusa, California
- RTX (formerly Raytheon Technologies)
  - GMD EKV, SM-3/6 Interceptors, LTAMDS, and GPI: Tucson, Arizona
  - Patriot Ground System and PAC-2 interceptor variants, AN/SPY-6(V)1 radar, AN/TPY-2 radar, SBX radar, and UEWRs: Tewksbury, Massachusetts
  - Cobra Dane Radar: Dulles, Virginia
- L3Harris Technologies
  - HBTSS through Prototype Demonstration Phase: Fort Wayne, Indiana
- Johns Hopkins University, Applied Physics Laboratory
  - SKA: Laurel, Maryland

TEST ADEQUACY

The MDA IMTP focuses on collecting the flight, ground (e.g., hardware-in-the-loop), and cybersecurity test data needed for contract compliance and operational capability declarations, as well as for the verification, validation, and accreditation of associated M&S. The MDA conducted testing in accordance with the DOT&E-approved IMTP although some events experienced technical and programmatic delays. Table 2 outlines the 31 flight, ground, high-fidelity M&S, and cyber survivability test events that the MDA performed or participated in during FY23. For each test event in Table 2, the footnotes indicate whether DOT&E approved the test plan and whether DOT&E observed the event.

Table 2. FY23 Testing

Date	Test	Mission Area	Description
June 2022 to October 2023	Patriot PDB-8.1 LUT[a,d]	Regional/Theater Defense	The Army conducted this OT to assess the effectiveness, suitability, and survivability of the Patriot PDB-8.1 system through flight test, accredited HWIL scenarios, and cyber survivability testing (CVPA and AA).
September 2022 to January 2023	SM-3 Block IIA M&S OT Runs for Record, Phase 2A[a,d]	Regional/Theater Defense	The MDA executed and delivered a set of high-fidelity M&S runs to assess Aegis BMD remote and organic engagement performance against select threats in scenarios relevant to the USINDOPACOM area of responsibility.
October 2022	Live Radiate-08a Part 1[c,e]	Space Domain Awareness	The MDA conducted this live-radiate test to collect data of the AN/TPY-2 (FBM) radar space domain awareness capabilities in an operational environment.
October 2022	Ground Test Distributed-08a (USNORTHCOM/USINDOPACOM) Part 1[c,e]	Homeland Defense and Regional/Theater Defense	The MDA and the MDS OTA conducted this DT/OT using distributed operational assets and HWIL laboratory test assets supporting MDS capability assessment in USNORTHCOM/USINDOPACOM geographic regions, examining new functions of LRDR, C2BMC, GMD, SBX, BOA, Aegis BMD, THAAD, and AN/TPY-2 (FBM).
October 2022	High Operational Tempo for Hypersonics Campaign-2[c,e]	Hypersonic Defense	The MDA participated in this joint Service flight test event, collecting data on new technologies in hypersonic environments.

Table 2. FY23 Testing, continued

Date	Test	Mission Area	Description
November 2022	Japan Flight Test Aegis Weapon System-07[c,d]	Regional/Theater Defense	The MDA and the Japan Maritime Self-Defense Force cooperatively demonstrated SM-3 engagement capabilities in four live fire events including two intercept events with Japanese destroyers. In the first intercept event, an SM-3 Block IIA engaged an MRBM target. The second intercept event was an integrated air and missile defense scenario whereby SM-3 Block IB Threat Upgrade and SM-2 Block IIIB missiles engaged an SRBM target and a cruise missile, respectively.
November 2022	Hypersonic Air Breathing Weapon Concept Flight Test-3[c,e]	Hypersonic Defense	The MDA participated in this DARPA event to collect hypersonic missile phenomenology and tracking data to inform future capability development.
November 2022	System Integration and Checkout-09-1 (USEUCOM/ USCENTCOM)[c,e]	Regional/Theater Defense	The MDA executed a limited architecture distributed event utilizing operational assets and focused on the verification of operational communication and message flows of theater/regional capabilities.
December 2022	Ground Test Integrated-08a (USNORTHCOM/ USINDOPACOM) Part 2[c,e]	Homeland Defense	The MDA and the MDS OTA conducted this follow-on DT/OT using HWIL laboratory test assets to support assessment of U.S. homeland defense MDS capabilities in the USNORTHCOM/USINDOPACOM geographic regions, focusing on GMD and C2BMC.
December 2022	Ground Test Distributed-07b (Aegis Ashore)[c,e]	Regional/Theater Defense	The MDA and the MDS OTA team conducted this DT/OT using distributed operational assets and HWIL laboratory test assets to support assessment of MDS capabilities in the USEUCOM geographic regions with a focus on Aegis Ashore integration and interoperability.
December 2022	Air-Launched Rapid Response Weapon AUR Test Flight-1[c,e]	Hypersonic Defense	The MDA participated in this Air Force event to collect hypersonic missile phenomenology and tracking data to inform future capability development.
January to December 2023	UEWR 22-1 Upgrade[a,e]	Homeland Defense	STARCOM conducted OT on each of the five UEWRs to evaluate the operational effectiveness, suitability, and survivability of those systems after the 22-1 upgrade.
January 2023	Ground Test Integrated-23 Sprint 1 (USNORTHCOM/ USINDOPACOM)[c,e]	Homeland Defense	The MDA executed an HWIL event collecting data supporting the assessment and fielding decisions of the upgraded IDT 8B.8, LMS 8C.1, GFC 8A.6.4 and GCN 8B.8 capability.
February 2023	SICO-09-2 (USEUCOM/ USCENTCOM)[c,e]	Regional/Theater Defense	The MDA executed a limited architecture distributed event utilizing operational assets and focused on the verification of operational communication and message flows of theater/regional capabilities.
February to March 2023	GMD/C2BMC/BOA Cyber Event[b,d]	Homeland Defense	The MDS OTA team, the MDA, and the U.S. Army's DEVCOM and TSMO performed cyber events at Fort Greely, Alaska; Schriever Space Force Base, Colorado; and Fort Drum, New York to assess outsider, insider, and nearsider threat postures. DOT&E did not approve the test plan because of critical limitations to test adequacy.

Table 2. FY23 Testing, continued

Date	Test	Mission Area	Description
March 2023	SICO-23 (N/I)[c,e]	Regional/Theater Defense	The MDA executed a limited architecture distributed event utilizing operational assets to support assessments and fielding of the upgraded IDT 8B.8, LMS 8C.1, GFC 8A.6.4 and GCN 8B.8 capability.
March 2023	Flight Test Aegis Weapon System-31 Event 1a[c,d]	Regional/Theater Defense	The MDA demonstrated an Aegis BMD capability to detect, track, engage, and intercept an MRBM target in the terminal phase of flight using the SM-6 Dual II with Software Upgrade in a single salvo of two interceptors fired at the target. Software Upgrade introduces select SBT Increment 3 capabilities into the Dual II missile.
March 2023	Patriot PDB 8.1 OT-3[a,e]	Regional/Theater Defense	The Army demonstrated the capability of the Patriot PDB-8.1 system to detect, track, engage, and intercept an MRBM with MSE interceptors.
March 2023	Ground Test Integrated-09 Sprint 2 (USEUCOM/ USCENTCOM)[c,e]	Regional/Theater Defense	The MDA conducted this developmental HWIL laboratory test to support assessment of MDS capabilities in the USEUCOM/ USCENTCOM geographic regions, examining new functions of C2BMC, Aegis BMD, THAAD, and Patriot.
March 2023	XBR 4.2 CVPA/ AA-08b (N/I)[a,d]	Homeland Defense	The MDS OTA, the MDA, and the U.S. Army DEVCOM and TSMO performed a CVPA and AA on the SBX XBR to assess insider and nearsider threat postures.
April 2023	Glory Trip-246[c,e]	Homeland Defense	The MDA participated in this Air Force Global Strike Command event to collect data, exercise MDS communication links, and perform future capability assessments.
May 2023	Formidable Shield-23[c,e]	Regional/Theater Defense	NATO forces executed this live fire exercise to build joint interoperability and demonstrate command and control in integrated air and missile defense scenarios. Two Aegis BMD destroyers detected and tracked SRBM targets during the exercise.
May 2023	Ground Test Integrated-103[c,e]	Regional/Theater Defense	The MDA conducted this limited architecture DT to characterize Aegis BMD cued acquisition with BOA and C2BMC using Common Interactive Broadcast and Link 16.
June 2023	Live Radiate-08a Part 2[c,e]	Space Domain Awareness	The MDA conducted this live-radiate test to collect data on the space domain awareness capabilities of the LRDR radar in an operational environment.
July 2023	SICO-08a-2 (USNORTHCOM/ USINDOPACOM)[c,e]	Homeland Defense	The MDA executed a limited architecture distributed event utilizing operational assets and focused on the verification of operational communication and message flows of theater/regional capabilities.
August 2023	Aegis Ashore MDS-Poland CVPA/AA[a,d]	Regional/Theater Defense	The MDA supported a cyber-survivability evaluation of the Aegis Baseline 9.B2.1 at the facility Poland. The assessment included outsider, insider, and nearsider threat postures.
August 2023	Patriot PDB 8.1 DT-1d[c,e]	Regional/Theater Defense	The Army demonstrated the capability of the Patriot PDB-8.1 system to detect, track, engage, and intercept a subscale aircraft target employing electronic attack with an MSE interceptor.

Table 2. FY23 Testing, continued

Date	Test	Mission Area	Description
August 2023	Flight Test Other-26[a,d]	Homeland Defense	The MDA conducted an OT of the LRDR to assess its ability to detect, track, and discriminate an operationally representative target. A target anomaly resulted in a no test.
September 2023	Flight Test Other-49[c,e]	Homeland Defense	The MDA conducted a tracking exercise for UEWR Clear, SBX, and LRDR in a non-OT.
September 2023	LTAMDS DT Missile Flight Test – Patriot-as-a-Target[c,e]	Regional/Theater Defense	The Army demonstrated the capability of a unit equipped with LTAMDS to detect, track, and engage a close range ballistic missile target with two PAC-3 CRI missiles. Sensor/Interceptor communication issues and range safety constraints prevented intercept of the target.
September 2023	Glory Trip-247[c,e]	Homeland Defense	The MDA participated in this Air Force Global Strike Command event to collect data, exercise MDS communication links, and perform future capability assessments.

Notes:
[a] Testing performed per DOT&E-approved test plan. [b] Test plan not approved by DOT&E. [c] Test plan not required by DOT&E. [d] Test observed by DOT&E. [e] Test not observed by DOT&E.

Acronyms: AA – Adversarial Assessment; AN/TPY - Army Navy/Transportable Radar Surveillance; AUR – All-Up Round; BMD – Ballistic Missile Defense; C2BMC – Command and Control, Battle Management, and Communications; CVPA – Cooperative Vulnerability and Penetration Assessment; DARPA – Defense Advanced Research Project Agency; DEVCOM – U.S. Army Combat Capabilities Development Command; DT – Developmental Test; FBM – Forward-Based Mode; FY – Fiscal Year; GCN – GMD Communications Network; GFC – GMD Fire Control; GMD – Ground-based Midcourse Defense; HWIL – Hardware-in-the-Loop; IDT - In-Flight Interceptor Communication System (IFICS) Data Terminal; LMS – Launch Management System; LRDR – Long Range Discrimination Radar; LTAMDS – Lower Tier Air and Missile Defense Sensor; LUT – Limited User Test; M&S – Modeling and Simulation; MDA – Missile Defense Agency; MDS – Missile Defense System; MRBM – Medium-Range Ballistic Missile; MSE – Missile Segment Enhancement; NATO – North Atlantic Treaty Organization; OT – Operational Test; OTA – Operational Test Agency; PAC – Patriot Advanced Capability; PDB – Post Deployment Build; SBT – Sea-Based Terminal; SBX – Sea-Based X-band Radar; SICO – System Integration and Checkout; SM – Standard Missile; SRBM – Short-Range Ballistic Missile; STARCOM – Space Training and Readiness Command; THAAD – Terminal High Altitude Area Defense; TSMO – Threat Systems Management Office; UEWR – Upgraded Early Warning Radar; USCENTCOM – U.S. Central Command; USEUCOM – U.S. European Command; USINDOPACOM – U.S. Indo-Pacific Command; USNORTHCOM – U.S. Northern Command; XBR – X-Band Radar

As previously reported, the need for additional threat representations, independently accredited M&S, and system survivability data in a cyber-contested environment presents significant challenges for DOT&E in completing a comprehensive assessment of the MDS. Specifically:

- Realistic and up-to-date representations of threat missile scenes are critical to the assessment of MDS performance. As DOT&E has noted since FY21, the rate of adversary threat development is currently faster than the pace of flight test target and ground test high-fidelity M&S threat model development. The MDA has made advancements to their threat modeling process, but models can still take several years to develop.
- Independent accreditation of M&S used in ground tests and high-fidelity analyses to ensure M&S can adequately represent current threat missile capabilities, electronic attack, countermeasures, post-intercept debris, and realistic raid sizes. DOT&E has emphasized this need in previous annual reports. The rate at which the MDA's models have been independently accredited has increased, but significant gaps remain. While over 90 percent of element sensor models are accredited, critical components

like newer threat models and post-intercept debris remain unaccredited. MDA and the MDS OTA are laying the foundation to accredit the End-to-end Digital Integrated System-level Simulation, which is a new MDS-level high-fidelity digital modeling architecture that presents a different set of challenges, once sufficient element assets are incorporated into it.

The MDS is a large system of systems with an extensive cyberattack surface. As noted in previous annual reports, the MDS OTA should focus on improving cyber test planning collaboration with DOT&E to ensure test adequacy, in particular by submitting test plans to DOT&E for approval at least 60 days prior to the test event and by ensuring these test plans include sufficient test lengths to assess system cyber survivability. Overall, more operationally realistic testing is needed both at the element- and the MDS-level to characterize MDS cyber survivability and identify potential areas for improvement. Periodic cyber Red Team events, emulating advanced adversaries, are needed to ensure MDS cyber defenses are and remain adequate to protect MDS missions. MDA is developing an action plan for persistent cyber operations (PCO) assessments of their internal and external networks. PCOs are the best way to emulate advanced cyber threats and find and fix mission-critical vulnerabilities.

Flight and ground test programs and high-fidelity M&S analyses at both the system- and element-level have been limited in the variety of realistic threat countermeasures, electronic attack, post-intercept debris scenes, raid sizes, and multi-element engagement scenarios. As reported in DOT&E's FY22 Annual Report, the MDA often designs flight tests to demonstrate a specific new capability, not for operational realism. Operationally realistic intercept flight tests are necessary to provide: 1) needed referent data to support verification, validation, and accreditation of models used in high-fidelity M&S and ground testing; 2) realistic data on multi-element interactions; and 3) data in multi-domain operations.

The Army as the lead Service, with MDA and the Navy, is currently developing a concept for a persistent, 360-degree, layered and integrated air and missile defense capability for the defense of Guam. This concept involves interoperability and coordination between multiple assets defending against cruise, ballistic, and hypersonic threats. The proposed architecture is made of both new and existing components in close proximity and with overlapping areas of regard. This presents a significant integration and test planning challenge. DOT&E assesses that the current test strategy needs significant further development to be adequate. An agile test program that fully explores interoperability and engagement planning through ground testing, tracking exercises, and intercept flight testing is warranted.

PERFORMANCE

» U.S. HOMELAND MISSILE DEFENSE

With the support of the full architecture of MDS sensors, the GMD weapon system has demonstrated the capability to defend the U.S. homeland from a small number of ballistic missile threats employing simple countermeasures and with ranges greater than 3,000 kilometers. In FY23, the MDA tested the ability of the newly constructed LRDR to track and discriminate a ballistic missile target. The Space Force plans to operationally accept LRDR no later than 2QFY25.

In FY23, the MDA continued development of an emerging-target lethality model for future lethality assessments based on ground-based interceptor hypervelocity impact testing conducted in FY22.

» REGIONAL/THEATER MISSILE DEFENSE

The regional/theater MDS has demonstrated a capability to defend the USINDOPACOM, USEUCOM, and USCENTCOM areas of responsibility from a small number of medium- or intermediate-range ballistic missile threats with ranges less than 4,000 kilometers, and from representative raids against SRBM threats.

Aegis BMD has demonstrated the capability to intercept non-separating, simple-separating, and complex-separating ballistic missiles in the

midcourse phase of flight with Standard Missile-3 (SM-3) guided missiles, although flight testing and M&S have not addressed all expected threat types, threat features, and raid sizes. Aegis BMD has also demonstrated a capability to intercept select ballistic missiles in the terminal phase of flight with SM-6 guided missiles. Flight testing in FY23 verified some of the corrective actions to address failure review board findings from the two Sea-Based Terminal Increment 2 flight tests in FY21. All fielded Aegis BMD variants have demonstrated sufficient reliability, with operational availabilities that exceed the specification. The SM-3 Block IIA missile is reliable as it meets its threshold reliability metric, but not with statistical confidence because of the relatively small number of live firings and ground test data collection events to date. The MDA has implemented a process to monitor the health and status of deployed SM-3 Block IIA missiles, which will provide additional reliability data for future assessments.

THAAD has demonstrated the capability to intercept and destroy ballistic missiles of varying types (short- to intermediate-range) inside or outside the earth's atmosphere during the terminal phase of flight, although the flight testing and M&S still need to address more complex engagement conditions and realistic raid scenarios. In FY23, the MDA indefinitely postponed a planned THAAD flight test due to the operational status of the AN/TPY-2 radar. The MDA is now planning for execution in FY24. The MDA and the Army continue to address THAAD training and component reliability shortfalls. In addition, the MDA continues to develop and deploy updates to the THAAD software for both the radar and THAAD Fire Control and Communications.

Patriot has demonstrated the capability to provide point defense against missile and aircraft attacks on deployed forces and critical assets and to defeat enemy surveillance air assets. Patriot continues to address shortfalls in reliability, training, and survivability. The Patriot PDB-8.1 Limited User Test (LUT) will assess how Patriot effectiveness, suitability, and survivability have changed since the last Patriot operational test that concluded in April 2019. DOT&E will publish the results of the PDB-8.1 LUT in a separate classified report in 1QFY24.

As reported in the FY22 DOT&E Annual Report, the Patriot M&S representations for ground tests used the new Battalion Simulation under development by the Army, but the Army has not yet provided sufficient verification and validation evidence to accredit the Battalion Simulation for performance assessments.

AN/SPY-1 and AN/TPY-2 Forward-Based Mode (FBM) radars contribute to regional/theater defense and monitoring. In the future, AN/SPY-6(V)1 will also contribute to those missions. In FY23, AN/SPY-1 demonstrated the capability to detect and track SRBMs and MRBMs during live intercept flight tests. The AN/SPY-6(V)1 radar prototype at the Pacific Missile Range Facility Barking Sands, Hawaii continues to track all classes of ballistic missiles, as available, during MDS flight tests. In FY23, AN/TPY-2 (FBM) demonstrated the capability to detect, track, and report on resident space objects based on space domain awareness tasking received by C2BMC during a live radiation event.

» HYPERSONIC MISSILE DEFENSE

The MDA collected hypersonic test data throughout FY23 to inform future sensors, sensor detection and tracking algorithms, and M&S validation. The MDA also conducted ground hypersonic impact, thermal, and aerodynamic testing to support the development of the M&S architecture specifically for hypersonic missile defense.

» COMMAND AND CONTROL AND SPACE SENSORS

Almost every FY23 test conducted by the MDA included space sensors acquiring, tracking, and reporting on observed objects. C2BMC globally and regionally integrates and synchronizes autonomous sensors, weapon systems, and operations. C2BMC is also a part of all system ground and flight tests, which verify and exercise current and future MDS capabilities. In FY23, C2BMC and BOA continued to support real-world situational awareness in USEUCOM. In two events in FY23, C2BMC communicated with Space Command and Control for space domain awareness, tasking LRDR and

AN/TPY-2 (FBM) and receiving reports back from the radars on resident space objects.

RECOMMENDATIONS

The MDA should:

1. Continue to increase the rate of regional/theater and U.S. homeland defense target and threat model development to keep pace with emerging real-world threats.
2. Continue to prioritize independent accreditation of M&S used in ground tests and high-fidelity analyses and ensure M&S can adequately represent current threat missile capabilities, electronic attack, countermeasures, post-intercept debris, and realistic raid sizes.
3. Ensure that relevant intercept flight testing is conducted prior to any planned high-fidelity M&S operational testing runs for record to provide referent data to support verification, validation, and accreditation of the models representing post intercept debris.
4. Ensure comprehensive cyber test and evaluation plans are created and developmental and operational cyber testing is completed prior to capability delivery to the warfighter.
5. Continue to work with DOT&E and combatant commands to conduct PCOs – Red Teams emulating advance adversaries – across MDS systems and networks.
6. Coordinate with the Army and Navy to ensure the test strategy for the defense of Guam incorporates multi-element interoperability and coordination into intercept flight testing.

The Army should:

1. Continue to develop the Patriot Battalion Simulation to address current shortfalls in supporting performance assessments, as well as fully fund the verification and validation efforts for the model.
2. Coordinate with MDA to ensure the test strategy for the defense of Guam incorporates multi-element interoperability and coordination into intercept flight testing.