United States Government Accountability Office

Report to Congressional Committees

May 2023

MISSILE DEFENSE

Annual Goals Unmet for Deliveries and Testing

Accessible Version

GAO-23-106011

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Annual Goals Unmet for Deliveries and Testing

GAO Highlights

Highlights of GAO-23-106011, a report to congressional committees

Why GAO Did This Study

Since MDA was established in 2002, the Department of Defense has spent over $194 billion, including $10.4 billion in fiscal year 2022. This spending was intended to equip operational commanders with a network of missile defense-related sensors, interceptors, and command and control capabilities. Over this time, missile threats from foreign adversaries have evolved, and MDA has faced persistent challenges as it attempts to keep pace. GAO has reported that MDA has not met the annual goals it sets for itself to deliver hardware and test its capabilities.

Congress included provisions in legislation for GAO to annually assess MDA's progress toward meeting its acquisition goals. This report—the 20th in this series—addresses the extent to which MDA (1) achieved its fiscal year 2022 baseline delivery goals and (2) completed its testing planned for fiscal year 2022. To conduct this work, GAO reviewed MDA's baseline reports, test plans, and the agency's responses to detailed question sets. In addition, GAO reviewed information provided by MDA contractors and DOD officials.

What GAO Recommends

As of June 2022, there were 23 previously issued recommendations that have not been implemented. GAO continues to believe that implementing these recommendations related to testing, transparency, and cost reporting would help address acquisition issues.

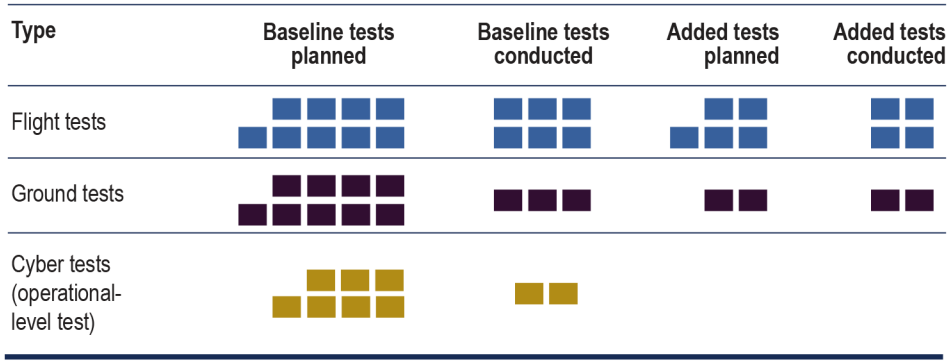
View GAO-23-106011. For more information, contact Jon Ludwigson at (202) 512-4841 or LudwigsonJ@gao.gov.

What GAO Found

The Missile Defense Agency (MDA) is charged with defending the United States, its deployed forces, and regional allies from missile attacks. MDA executes this mission through a layered system of capabilities, known as the Missile Defense System. Individual systems known as elements—for example, interceptors intended to destroy missiles in flight—provide these capabilities.

In 2022, MDA continued to deliver interceptors and radar upgrades to operational commanders, including those that were expected to be delivered in prior years, but it did not meet its annual goals. As a result, the warfighter has less fielded capability than planned. One element—the Terminal High Altitude Area Defense system—met its 2022 delivery goals. MDA did not complete its fiscal year 2022 flight, ground, and cyber baseline test program, consistent with prior years.

Missile Defense Agency Test Program Activities in Fiscal Year 2022



Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

Type	Baseline tests planned	Baseline tests conducted	Added tests planned	Added tests conducted
Flight tests	9	6	5	4
Ground tests	9	3	2	2
Cyber tests (operational-level test)	7	2		

Examples of MDA's fiscal year 2022 baselined test program results follow:

- **Flight testing:** Flight tests use actual hardware to demonstrate or assess system performance. MDA conducted six of nine planned tests, and met objectives in five of those six tests.
- **Ground testing:** Ground tests use simulations to model capabilities and limitations in a wider variety of potential situations than flight tests. MDA conducted a key ground test—originally planned for fiscal year 2020—intended to support decisions necessary to increase capability to defend the United States. However, MDA conducted three of nine planned ground tests, deleting or delaying the tests not conducted to future fiscal years.
- **Cyber testing:** Cybersecurity operational assessments evaluate cyber defense capabilities and vulnerabilities. MDA conducted two such tests in fiscal year 2022—about a year later than planned—but scaled back the scope of these tests and delayed five other tests to future years.

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Abbreviations

AA	adversarial assessment
AAF	Adaptive Acquisition Framework
AN/TPY-2	Army Navy/Transportable Radar Surveillance and Control Model 2
AWS	Aegis Weapon System
BMD	Ballistic Missile Defense
BMDS	Ballistic Missile Defense System
BOA	BMDS Overhead Persistent Infrared Architecture
C	Configuration
CBO	Congressional Budget Office
C2BMC	Command, Control, Battle Management, and Communications
CVI	cooperative vulnerability identification
CVPA	cooperative vulnerability and penetration assessment
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
DTM	Directive Type Memorandum
FEM	Flight Test Experiment Aegis Weapon System
FTM	Flight Test Aegis Weapon System
FTT	Flight Test Terminal High Altitude Area Defense Weapon System
FTX	Flight Test Other
GBI	Ground Based Interceptor
GMD	Ground-based Midcourse Defense
GPI	Glide Phase Intercept
GT	Ground Test
GTD	Ground Test Distributed
GTI	Ground Test Integrated
HBTSS	Hypersonic and Ballistic Tracking Space Sensor
ICBM	intercontinental ballistic missile
ICE	Independent Cost Estimate
IMTP	Integrated Master Test Plan
Inc	increment
IRBM	intermediate-range ballistic missile
ITRA	Independent Technical Risk Assessment
LRDR	Long Range Discrimination Radar
MDA	Missile Defense Agency
MDS	Missile Defense System
MRBM	medium-range ballistic missile
MSE	Missile Segment Enhancement

NASIC	National Air and Space Intelligence Center
NDAA	National Defense Authorization Act
NGI	Next Generation Interceptor
NORAD	North American Aerospace Defense Command
NORTHCOM	Northern Command
O&S	operations and sustainment
OTA	Operational Test Agency
OUSD	Office of the Under Secretary of Defense
PD	Pacific Dragon
QFY	Quarter of Fiscal Year
SBX	Sea-Based X-Band
SDA	Space Development Agency
SM	Standard Missile
SM CTV	Aegis Weapon System Controlled Test Vehicle
SRBM	short-range ballistic missile
TBG	Tactical Boost Glide
THAAD	Terminal High Altitude Area Defense
TH CTV	Terminal High Altitude Area Defense Weapon System Controlled Test Vehicle
TRL	Technology Readiness Level
UEWR	Upgraded Early Warning Radar
U.S.	United States

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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Congressional Committees

The Missile Defense Agency's (MDA) mission is to develop a Missile Defense System (MDS) to defend the U.S. homeland, allies, and deployed forces against missile attacks.[1] Since MDA was established in 2002, the Department of Defense (DOD) has spent over $194 billion, including $10.4 billion for fiscal year 2022, to equip operational commanders with this layered system of sensors, interceptors, and command and control capabilities to detect, track, and destroy incoming missiles. However, according to DOD, potential adversaries are investing substantially in their own offensive missile capabilities and continue to make significant advances. For example, according to DOD, North Korea continues to develop ballistic missiles capable of threatening the U.S. homeland; Iran has amassed the largest ballistic missile force in the Middle East; and Russia and China continue to develop advanced hypersonic missiles that can travel at exceptional speeds with unpredictable flight paths designed to evade current missile defense systems.

Our prior reporting on missile defense acquisitions has shown that MDA has faced persistent technical challenges and schedule pressures fielding missile defense capabilities necessary to keep pace with evolving missile threats and meet its annual acquisition goals.[2] Since 2002, the agency has had to cancel a number of critical efforts due to cost and technical challenges—a trend DOD indicated must not continue into the agency's third decade of operations given the importance of these systems.[3]

Since 2002, various National Defense Authorization Acts have included provisions for us to prepare annual assessments of MDA's progress

[1]From 2002 until 2019, the system was called the Ballistic Missile Defense System (BMDS). MDA renamed it to the Missile Defense System (MDS) to reflect the system's broadened focus on ballistic, cruise, and hypersonic missiles.

[2]See the Related GAO Products page at the end of this report.

[3]See Deputy Secretary of Defense Memorandum, Task to Review Missile Defense Agency Acquisition Approaches and Programs for Transfer (Washington, D.C.: Apr. 4, 2019).

toward meeting its acquisition goals. Specifically, the National Defense Authorization Act for Fiscal Year 2012, as amended, includes a provision for us to report annually on the extent to which MDA has achieved its acquisition goals and objectives, as reported in the annual Missile Defense System Accountability Report (MDAR) and to include such findings and recommendations as the Comptroller General considers appropriate.[4] This annual report, our 20th, addresses the extent to which MDA (1) achieved its fiscal year 2022 baseline delivery goals, and (2) completed its testing planned for fiscal year 2022.

To assess the extent to which MDA achieved its fiscal year 2022 baseline goals for deliveries, we identified and reviewed the agency's delivery baselines detailed in the MDAR that corresponds to MDA's fiscal year 2022 budget request, constituting the plans for which the agency requested funds in fiscal year 2022. Consistent with prior years, we focused our assessment on interceptor deliveries, sensor upgrades, and the delivery of a new Long Range Discrimination Radar (LRDR). To determine MDA's actual deliveries in fiscal year 2022, we reviewed agency documents, such as program execution briefings, briefings for congressional staff, and obtained responses to questionnaires we sent to MDA programs that are baselined in the MDAR, relevant contractors, and DOD components that have oversight on missile defense acquisitions.

To assess the extent to which MDA completed its testing planned for fiscal year 2022, we reviewed the agency's testing baselines detailed in the MDAR and MDA's Integrated Master Test Plan (hereafter called the Test Plan). Both of these documents correspond to MDA's fiscal year 2022 budget request, constituting the plans for which the agency requested funds in fiscal year 2022. We focused our assessment on flight, ground, and operational cyber tests. To identify the tests MDA conducted in fiscal year 2022, we reviewed agency documents, such as program execution briefings, briefings for congressional staff, and obtained responses to questionnaires we sent to MDA program offices, MDA's directorates for Engineering and Testing, and DOD components that participate in, or have oversight on MDA testing.

[4]The National Defense Authorization Act for Fiscal Year 2012, Pub. L. No. 112-81, § 232(a) (2011), as amended by the National Defense Authorization Act for Fiscal Year 2016, Pub. L. No. 114-92, § 1688 (2015), extended GAO's reviews through fiscal year 2020. Pub. L. No. 116-283, § 1644, further extended GAO's reviews through fiscal year 2025. See also National Defense Authorization Act for Fiscal Year 2002, Pub. L. No. 107-107, § 232(g) (2001).

Detailed assessments of the 11 MDS programs that are baselined in the MDAR are found in appendixes I-VI. In addition, appendixes VII-IX assess three emerging missile defense issues including MDA's counter-hypersonic efforts, cruise missile defense, and the defense of Guam.

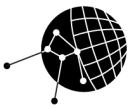
We conducted this performance audit from May 2022 to May 2023 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

MDA is responsible for developing an integrated missile defense system, also known as MDS, to protect the U.S. from missile attacks. The MDS is comprised of multiple elements necessary to identify a launch, track missile threats, and provides this information to individual interceptors designed to destroy incoming missiles. A key feature of MDA's mission is to integrate these elements into an increment of capability. As of March 2023, MDA has delivered and deployed five increments of capability that include an initial capability to defend the United States and our European allies. MDA is currently developing the next increment intended to provide additional capability to defend the United States, known as Increment 6B.1. Increment 6B.1—originally planned for June 2021—is scheduled to be mostly delivered in the third quarter of fiscal year 2023 with the remainder of the planned content to be delivered incrementally in fiscal year 2024.[5] Figure 1 provides a list and description of Missile Defense System programs included in our review.

[5]For additional details on Increment 6B.1, see GAO, *Missile Defense: Better Oversight and Coordination Needed for Counter-Hypersonic Development,* GAO-22-105075 (Washington, D.C.: June 16, 2022).

Figure 1: Description of Missile Defense System Programs Included in GAO's Review

	Name		Description
Aegis Ballistic Missile Defense		**Aegis Weapon System (AWS)**	A command and control system that manages all functions from threat missile detection to intercept.
		**Aegis Ashore**	A land-based system that uses a radar, command and control, and SM-3 interceptors. There are three locations: a test site in Hawaii, and two operational sites—one in Romania and one under construction in Poland.
		**Aegis Ballistic Missile Defense Standard Missile (SM)-3 interceptors**	SM-3 Block IA, IB, and IIA interceptors capable of identifying, tracking, and defending against short, medium, and intermediate-range threat missiles. The most recent interceptor variant—SM-3 IIA—has increased range, more sensitive seeker technology, and an advanced kill vehicle.
		**Command, Control, Battle Management, and Communications (C2BMC)**	A globally deployed system of software and hardware—workstations, servers, and network equipment—that facilitates the integration and management of diverse weapon systems and sensors to enable a coordinated response to defend against incoming threat missiles.
		**Ground-Based Midcourse Defense (GMD)**	A ground-based system with launch, communications, and fire control that uses interceptors with a booster and kill vehicle to defend against intermediate- and intercontinental-range missile threats.
Sensors		**Army Navy/Transportable Radar Surveillance and Control Model-2 (AN/TPY-2)**	A transportable X-band high-resolution radar capable of tracking missiles of all ranges. It operates in two modes: (1) forward-based mode—used for missions with Aegis Ballistic Missile Defense (BMD), GMD, and allied partners to detect threat missiles once launched, or (2) terminal mode—used for Terminal High Altitude Area Defense and Patriot missions to guide an interceptor to the descending threat missile.
		**Long Range Discrimination Radar (LRDR)**	A stationary, land-based, S-band radar that tracks incoming missiles for GMD and improves discrimination between the warhead-carrying vehicle and the decoys and other non-lethal objects.
		**Sea-Based X-Band Radar (SBX)**	A mobile, ocean-going X-band radar capable of being positioned across the globe to track missile threats. SBX primarily supports GMD missions and missile defense flight testing.
		**Upgraded Early Warning Radar (UEWR)**	A solid-state, phased-array, long-range radar that detects and provides critical early warning of sea-launched or intercontinental threat missiles. There are five locations: Alaska, California, Greenland, Massachusetts, and United Kingdom.
		**Targets and Countermeasures**	A variety of short-, medium-, intermediate-, and intercontinental-range targets to represent realistic threats during missile defense flight testing. The target ranges in kilometers are: short (less than 1,000), medium (1,000-3,000), intermediate (3,000-5,500), and intercontinental (greater than 5,500). Targets and Countermeasures provide assets to test the performance and capabilities of the MDS elements, but these testing assets are not operationally fielded.
		**Terminal High Altitude Area Defense (THAAD)**	A mobile, ground-based system organized as a battery that consists of interceptors, launchers, a radar, and fire control and communications to defend against short-, medium-, and limited intermediate-range threat missiles.

Source: GAO presentation of Missile Defense Agency data, GAO (icons). | GAO-23-106011

Notes: The Missile Defense Agency is developing and has already fielded additional Missile Defense System assets that are not included in this report because they fall outside the scope of the Missile Defense Accountability Report. In addition, programs that have transferred to a military service for production, operation, or sustainment, such as the Patriot Advanced Capability-3 program, are not covered in this assessment.

Aegis BMD interceptors also include SM-6 Dual I and SM-6 Dual II missiles. These interceptors allow a ship to defend itself and other nearby ships in a battle group. SM-6 Dual I and II baselines are not included in the Missile Defense Accountability Report and, thus, fall outside the scope of this review except insofar as they interact with Missile Defense Agency systems.

MDA's Acquisition Flexibilities and DOD's Steps to Improve Acquisition Outcomes and Oversight

When MDA was established in 2002, it was granted exceptional flexibilities to set requirements and manage the acquisition of the MDS. This allowed MDA to expedite the fielding of assets and integrated missile defense capabilities. MDA is not currently required to follow DOD's traditional requirements-setting process; instead, MDA and the warfighter determine missile defense requirements through a different process. While the warfighter is tasked with some requirements-setting responsibilities, MDA retains a role in determining operational-level requirements, which allows the agency to make its own requirements determinations during certain development activities.[6] In addition, MDA continues to have flexibility to diverge from the Defense Acquisition System—the management process through which DOD generally acquires its weapon systems.[7] MDA instead relies on an acquisition framework unique to the MDS.[8]

In 2020, DOD made significant changes to missile defense acquisition processes and responsibilities. DOD issued a memorandum in March 2020 that required, among other items, MDS programs to obtain external independent cost and technology risk assessments earlier in

[6]See Strategic Instruction (SI) 538-03, *Missile Defense (MD) Warfighter Involvement Process (WIP)* (July 26, 2020). For more information, see GAO, *Missile Defense: Recent Acquisition Policy Changes Balance Risk and Flexibility, but Actions Needed to Refine Requirements Process*, GAO-22-563 (Washington, D.C.: Nov. 10, 2021).

[7]To support the Defense Acquisition System, DOD established the Adaptive Acquisition Framework in January 2020, replacing the department's previous acquisition guidance. The Adaptive Acquisition Framework established new pathways for DOD acquisition programs to help deliver solutions to the end user in a timely manner, among other things. DOD Directive 5000.01, *The Defense Acquisition System* (Sept. 9, 2020) (incorporating change 1, July 28, 2022) and DOD Instruction 5000.02, *Operation of the Adaptive Acquisition Framework* (Jan. 23, 2020) (incorporating change 1, June 8, 2022).

[8]Deputy Secretary of Defense, *Missile Defense System Policies and Governance, Directive-Type Memorandum (DTM) 20-002* (Mar. 13, 2020) (incorporating change 3, Feb. 23, 2023); Missile Defense Agency (MDA) Instruction 5013.02-INS (Aug. 14, 2013); DOD Directive 5134.09, *Missile Defense Agency (MDA)* (Sept. 17, 2009).

development.[9] In addition, the memorandum assigned responsibility to the Under Secretary of Defense for Acquisition and Sustainment for deciding whether applicable MDS programs can proceed through certain iterative stages of acquisition—a responsibility previously assigned to the MDA Director. DOD issued the memorandum after completing studies of MDA's acquisition approaches in 2019 and determining that changes were needed to reduce acquisition risk and promote transfers of MDS elements to military services. In November 2021, we found that most of the changes in DOD's memorandum aligned with actions we have previously recommended and were consistent with acquisition best practices we had identified.[10]

DOD's efforts to codify the new polices from the March 2020 memorandum have taken the department longer than it expected. The memorandum requires that the policy changes be incorporated into the MDA charter, which must occur before the memorandum expires for the policy changes to become permanent. The memorandum was originally set to expire on August 21, 2021, but the Deputy Secretary of Defense has extended the deadline three times, with the memorandum currently set to expire on March 1, 2024. As of February 2023, DOD was going through the process of updating the MDA charter, which MDA indicated will also include notifying Congress in advance of the updated charter going into effect.[11]

Flight, Ground, and Cyber Testing within MDA

Testing, in general, is performed to collect critical data on individual elements or the integrated system to: (1) determine whether it is properly

[9]DTM 20-002. A directive-type memorandum (DTM) establishes DOD policy or implements policy established in existing DOD directives and instructions, also known as issuances, assigns responsibilities, and may provide procedures. According to DOD, a DTM will only be issued for time-sensitive actions and only when time constraints prevent publishing a new issuance or incorporating a change to an existing issuance. DTMs are not allowed by DOD to be used to permanently change or supplement existing issuances and cannot be effective for longer than 12 months from the date signed, unless extended in accordance with DOD policy.

[10]GAO-22-563.

[11]Section 1688(b) of the National Defense Authorization Act for Fiscal Year 2020 prohibited the Secretary of Defense from making any changes to missile defense non-standard acquisition processes and responsibilities until certain consultation, certification, reporting, and timeliness requirements were met. Pub. L. No. 116-92 (2019) (later codified at 10 U.S.C. § 205 by Section 1661 of the National Defense Authorization Act for Fiscal Year 2022, Pub. L. No. 117-81 (2021)).

designed, built, and integrated; (2) understand its performance, including its capabilities and limitations; and (3) support next steps and decisions. MDA conducts both developmental and operational testing. In addition, MDA uses multiple methods including flight, ground, and cyber tests to determine whether the element or system design will provide the desired capabilities.

MDA's testing baseline—the Integrated Master Test Plan—designates all of its system-level testing for the upcoming and future fiscal years and supports its annual funding requests. Specifically, it identifies each test by name, including the type of test, any targets (if applicable) required for use in testing, and the fiscal year and quarter in which it plans to conduct the test. The MDA Director and key external stakeholders approve the test plan semi-annually. Figure 2 provides additional information on the type and key purposes of MDA testing.

Figure 2: Missile Defense Agency Testing

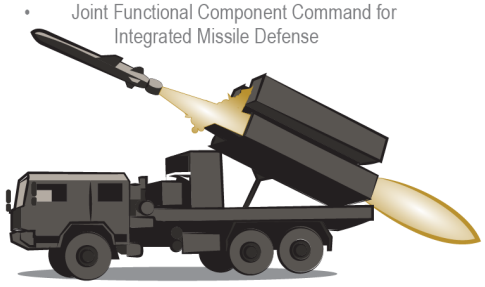
FLIGHT

DESCRIPTION AND PURPOSE

- Flight tests are an essential tool used to validate performance of the elements and Missile Defense System (MDS) by anchoring models and simulations to ensure they accurately reflect real performance.
- Intercept and non-intercept testing uses actual MDS elements and components to demonstrate and assess performance and potentially reduce risks for future tests.
- Flight tests demonstrate a single data point of element and system performance.

EVALUATORS

- MDS Operational Test Agency (OTA)
- Director, Operational Test and Evaluation (DOT&E)
- Combatant Commands
- Under Secretary of Defense for Research and Engineering, Director, Developmental Test, Evaluation, and Assessments
- Joint Functional Component Command for Integrated Missile Defense



GROUND

DESCRIPTION AND PURPOSE

- Simulations use a combination of actual element and system-level models, support infrastructure, and virtual targets that assess the capabilities and limitations of elements.
- Ground tests allow for testing under a wider variety of conditions than can be accomplished through flight testing.
- Each model and simulation receives certification that it operates as intended in representative, real-world conditions.

EVALUATORS

- MDS OTA
- DOT&E
- Under Secretary of Defense for Research and Engineering, Director, Developmental Test, Evaluation, and Assessments

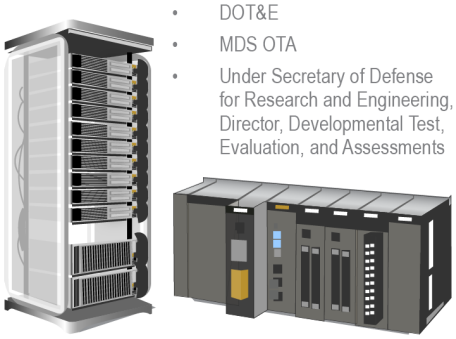
CYBER

DESCRIPTION AND PURPOSE

- Cyber tests are designed to identify cyber vulnerabilities, examine potential attack paths, evaluate operational cyber defense capabilities, and identify the potential operational mission effects.
- Cyber testing is comprised of two operational assessments, a Cooperative Vulnerability and Penetration Assessment (CVPA) and an Adversarial Assessment (AA).
- The CVPA provides initial information about the resilience of a system's cyber defense capabilities and helps develop the follow-up AA.
- The AA characterizes the operational effects caused by the threat representative cyberattack and the effectiveness of defensive capabilities.

EVALUATORS

- DOT&E
- MDS OTA
- Under Secretary of Defense for Research and Engineering, Director, Developmental Test, Evaluation, and Assessments



Source: GAO analysis of Missile Defense Agency Data. | GAO-23-106011

MDA Continued Delivering Assets to the Warfighter, but Did Not Achieve Annual Goals

MDA did not meet its annual delivery goals for fiscal year 2022, which is consistent with its performance in prior years. MDA partially met its delivery goals for its four types of interceptors in fiscal year 2022, and it delivered assets that were not delivered in prior years as it had planned. MDA also partially met its sensor delivery goals, although it delayed operational acceptance of two radars until at least fiscal year 2023.

MDA Partially Met Its Fiscal Year 2022 Interceptor Delivery Goals

MDA continued to deliver interceptors in fiscal year 2022, including interceptors that were previously planned to be delivered in prior years, but it did not achieve its stated baseline goals (see table 1). The reduced number of delivered assets leaves MDA with less fielded capability than planned.

Table 1: Missile Defense Interceptor Deliveries in Fiscal Year (FY) 2022

	FY 2022 delivery goals				
Interceptor	Planned	Actual	Backlogged deliveries	Total deliveries	Comments
Aegis Ballistic Missile Defense Standard Missile (SM)-3 Block IB	29	24	9	33	The Missile Defense Agency (MDA) delivered 33 interceptors in fiscal year 2022. This includes nine backlogged interceptors that were delayed following an SM-6 flight test failure. The Aegis program halted SM-3 Block IB deliveries to investigate the SM-6 failure since both interceptor types have common components. The five remaining interceptors planned for fiscal year 2022 were delivered in the first quarter of fiscal year 2023.
Aegis Ballistic Missile Defense SM-3 Block IIA	12	9	6	15	MDA plans to deliver the three remaining interceptors planned for fiscal year 2022 in fiscal year 2023. According to MDA officials, the six backlogged deliveries were initially delayed by assembly issues.
Ground Based Interceptors	2	1	1	2	MDA delivered the one remaining interceptor planned for fiscal year 2022 a few weeks into fiscal year 2023. MDA reported that the backlogged interceptor delivery was caused by a parts supplier issue.
Terminal High Altitude Area Defense (THAAD) interceptors	82	75	14	89	MDA successfully qualified a replacement part for a part that is no longer available. The THAAD program completed its delivery plans including the 14 interceptors backlogged from fiscal year 2021.

Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

According to MDA officials, the agency addressed issues over the past year that affected prior production efforts and led to late deliveries.

- Standard Missile (SM)-3: The Aegis program overcame a prior flight test failure and production problems to reduce the number of late SM-3 Block IB and Block IIA deliveries in fiscal year 2022. Specifically, according to MDA officials, while production did not stop, deliveries

were halted after a flight test failure involving an SM-6 interceptor that has common components with SM-3 Block IB interceptors. According to MDA officials, a review board identified manufacturing inconsistencies for some interceptor parts and MDA replaced these parts, as needed, to address potential issues. Consequently, MDA resumed SM-3 Block IB deliveries. According to MDA officials, delays to the Block IIA interceptors were due to various assembly issues. MDA has since identified the root causes of the issues and resumed deliveries. For further details on these interceptors, see appendix I.

- Ground Based Interceptor: The GMD program delivered two Ground-Based Interceptors, one of which was 3 years overdue, but missed delivering the remaining interceptor planned for fiscal year 2022 by a few weeks. According to MDA, the silo in which the interceptor was to be installed was not available at the time the interceptor completed production, resulting in a brief delay. The GMD program has one final Ground Based Interceptor in production, which is designated for use in GMD's next planned intercept flight test currently planned for the first quarter of fiscal year 2024. For further details on GMD, see appendix III.
- Terminal High Altitude Area Defense (THAAD): THAAD overcame a previous halt in production and cleared its backlog of late deliveries in fiscal year 2022. Production had been halted to qualify a replacement for a part that is no longer available. The new part was qualified in the first quarter of fiscal year 2021, allowing the delivery of the backlogged interceptors to be completed in December 2021. For further details on THAAD, see appendix VI.

MDA Upgraded Early Warning Radars, but Delayed the Delivery of a New Long-Range Radar

MDA made progress on upgrades to two Early Warning Radars and the construction of a new Long Range Discrimination Radar. However, according to program documentation, technical challenges and pandemic-related delays have continued to set the Sensors program behind schedule. For example, neither the Army Navy/Transportable Radar and Surveillance Control Model-2 (AN/TPY-2) or the Sea-Based X-Band Radar (SBX) radar received planned software upgrades originally delayed from fiscal year 2021.[12]

[12]For more information on Sensors program elements and their respective delivery goals, see appendix IV.

MDA achieved its fiscal year 2022 delivery goals for one of its two early warning radars. Specifically, MDA completed delivery of the upgraded early warning radar (UEWR) at Fylingdales Royal Air Force Station in the United Kingdom and achieved the initial operational acceptance milestone for another at Thule Air Base, Greenland. Operational acceptance for UEWR upgrades occurs in two steps—the upgraded components are installed for initial operational acceptance and subsequently monitored for compatibility. Final operational acceptance involves removing the legacy components after the upgrades have been proven effective. Despite delays, the Fylingdales UEWR site achieved its second operational acceptance milestone, thus completing the delivery process in March 2022. The Thule UEWR site achieved its initial operational acceptance milestone in November 2021. However, final operational acceptance for the Thule UEWR site—originally planned for fiscal year 2021—has been postponed to fiscal year 2023 due to personnel constraints caused by concurrent upgrades at other UEWR sites, among other factors.[13]

MDA completed initial fielding of the LRDR at Clear Space Force Station, Alaska, in December 2021 and expects the contractor to deliver the radar in the fourth quarter of fiscal year 2023. Initial fielding is an important milestone because it marks completion of military construction and the transition to testing and training for operational acceptance by the warfighter. As of February 2023, MDA expected the LRDR's operational acceptance to occur in the fourth quarter of fiscal year 2024. According to program documentation, delays to the LRDR have been primarily driven by technical challenges experienced by the prime contractor during construction, including integration of the radar's arrays, and COVID-19 pandemic-related inefficiencies. As we previously found, COVID-19 restrictions led to a cessation of construction activities at Clear Space Force Station, which MDA officials said slowed fiscal year 2022 radar integration and calibration progress by 4.5 months.[14]

[13]According to MDA officials, additional work at the Thule site to support its final operational acceptance milestone will be managed by the U.S. Space Force.

[14]For further details, see GAO-22-105075 and GAO, *Missile Defense: Fiscal Year 2020 Delivery and Testing Progressed, but Annual Goals Unmet*, GAO-21-314 (Washington, D.C.: Apr. 28, 2021).

MDA Conducted Less than Half of Its Planned Fiscal Year 2022 Testing

MDA did not complete all planned fiscal year 2022 flight, ground, and operational cyber tests. MDA's testing program for this past year included: (1) tests planned, based on their inclusion in the test baseline aligned to fiscal year 2022, and (2) tests added after the publication of the test baseline, which also includes added tests that involved MDA and external partners.[15] MDA conducted 10 of 14 flight tests, of which seven achieved their planned objectives. MDA also completed five of 11 ground tests, including a key ground test—planned originally for fiscal year 2020—designed to support operational capability decisions. Moreover, MDA conducted two operational cyber assessments, although with reduced scopes, and deferred five other planned operational cyber assessments to future years. Table 2 provides an overview of fiscal year 2022 flight, ground, and operational-level cyber tests.

Table 2: Missile Defense Agency Test Program Activities in Fiscal Year 2022

Type	Baseline tests planned	Baseline tests conducted	Added tests planned	Added tests conducted
Flight test	9	6	5	4
Ground test	9	3	2	2
Cyber test (operational-level test)	7	2	0	0

Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

MDA Met Its Objectives in Five of its Nine Planned Flight Tests

MDA conducted six of nine flight tests planned under its fiscal year 2022 baseline schedule. Of the six conducted tests, MDA successfully achieved objectives in one test where MDA was the primary participant and four where MDA participated with external partners, such as the Air Force or foreign allies. Table 3 shows details, descriptions, and outcomes for these nine tests.

[15]As MDA's mission evolves to counter emerging threats, the agency participates in flight tests planned and conducted by external and Allied partners such as the U.S. Navy, U.S. Air Force, Defense Advanced Research Projects Agency and Australian Defense Force.

Table 3: Summary of Baseline Flight Tests Planned for Fiscal Year 2022

Flight test name	Primary participants	Results
FTM-46	Aegis Ballistic Missile Defense (BMD)	**Not conducted** The Aegis Weapon System intercept test was intended to demonstrate the firing of a Standard Missile (SM)-3 Block IIA guided missile against an intermediate-range ballistic missile with countermeasures. According to the Missile Defense Agency (MDA) Director and program documentation, this test was not conducted due to analysis indicating that the mission would not meet the intended objectives as planned.
FEM-01	Aegis BMD and Command, Control, Battle Management, and Communications (C2BMC)	**Met objectives** MDA conducted an Aegis Weapon System non-intercept test in April 2022. The test successfully fired a SM-3 Block IIA guided missile against a modified medium-range ballistic missile (MRBM).
FTX-45	C2BMC and Long Range Discrimination Radar (LRDR)	**No-test**[b] MDA conducted a non-intercept test to demonstrate LRDR functionality against an MRBM target, among other things. A cabin pressure issue with the plane carrying the target resulted in a no-test. MDA is not planning a retest.
FTX-26[a]	Aegis BMD, C2BMC, LRDR, and Ground-Based Midcourse Defense (GMD)	**Delayed to fiscal year 2023** MDA was planning to conduct a non-intercept test to support the operational acceptance of LRDR. MDA delayed the test to the fourth quarter of fiscal year 2023 due to conflicts with LRDR site integration activities and acceptance testing.
Flight tests with external partners and MDA as a participant		
Flight test name	**External participants**	**Results**
FTX-42[a]	U.S. Air Force	**Met objectives** The Air Force successfully conducted a non-intercept test in May 2022 to assess upgrades made to the Reagan Test Site Sensor Suite in the Marshall Islands. The Air Force and MDA successfully collected radar, optics, and telemetry data.
PD-22 Event (E) 1	Foreign allies[c]	**Met objectives** PD-22 consisted of three test events, including a successful intercept test as well as tracking exercises and data sharing events between the United States and its allies. MDA used these events to test and evaluate new missile defense capabilities on Japanese and Korean ships and to support risk reduction and readiness for future international flight tests.
PD-22 E2	Foreign allies[c]	
PD-22 E3	Foreign allies[c]	
TBG-3	Defense Advanced Research Projects Agency (DARPA)	**Delayed to fiscal year 2023** This DARPA-led test was intended to demonstrate a hypersonic system. MDA intended to use the test to aid hypersonic defense efforts. DARPA delayed the test to meet the requirement that there be 6 months between TBG-2 and TBG-3.

Legend:

FTM - Flight Test Aegis Weapon System

TBG - Tactical Boost Glide

FEM - Flight Test Experiment Aegis Weapon System

FTX - Flight Test Other

PD - Pacific Dragon

Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-23-106011

[a]Designates a backlogged test: backlogged tests are tests that had already been delayed at least once from a previous fiscal year. Partner flight tests that are backlogged are not controlled by MDA and it is at the Partner Program's discretion to delay the test.

[b]A no-test is declared when external factors (e.g., weather) or anomalies with the target (e.g., intercept is not attempted) prevent the flight test from achieving its objectives.

[c]The foreign allies were the Japan Maritime Self-Defense Force, Republic of Korea Navy, the Royal Australian Navy, the Royal Canadian Navy, and the Belgian Navy.

MDA Met Objectives in Two of Five Added Flight Tests

In addition to the nine tests it planned to conduct in fiscal year 2022, MDA also added five flight tests that would enable it to test certain capabilities. MDA reported it successfully met its objectives in two tests, while two tests did not meet objectives due to external partner test asset issues, and another was delayed by the external partner until fiscal year 2023.

Table 4: Status of Flight Tests Added for Fiscal Year 2022

Flight test name	Primary participants	Results
FTT-21[a]	Terminal High Altitude Area Defense (THAAD) and Patriot[b]	**Met objectives** The Missile Defense Agency (MDA) successfully conducted an intercept test in March 2022 that demonstrated THAAD's capability to fire and control two Patriot Advanced Capability-3 (PAC-3) Missile Segment Enhancement (MSE) interceptors against one SRBM target.
TH CTV-01[a]	THAAD and Patriot[b]	**Met objectives** MDA successfully conducted a non-intercept flight test in February 2022 that demonstrated THAAD's capability to fire and control one PAC-3 MSE interceptor against a simulated short-range ballistic missile (SRBM) target. This test was added to address problems discovered during flight test TH-CTV-01 in fiscal year 2021.
Flight tests added with external partners		
Flight test name	**External participants**	**Results**
JFC-01	U.S. Navy	**Did not meet Objectives** The U.S. Navy intended this test to be the first demonstration of a hypersonic missile known as the Common Hypersonic Glide Body All-Up Round. MDA intended to use the test to demonstrate detection and tracking of a hypersonic vehicle in addition to gathering data for hypersonic defense development. The test asset experienced an anomaly shortly after ignition, which prevented complete data collection for the test.
TBG-2[a]	Defense Advanced Research Projects Agency (DARPA)	**Delayed to fiscal year 2023** This DARPA-led test was intended to demonstrate a hypersonic vehicle, as well as to gather data to inform hypersonic defense efforts. According to MDA, this test was added to the fiscal year 2022 test plan but conducted in fiscal year 2023. A problem with launch booster operations led to a no-test of the DARPA test asset.[c]

Flight test name	Primary participants	Results
FTX-43[a]	U.S. Army	**Did not meet objectives** The Army conducted a non-intercept flight test in October 2021 that was intended to demonstrate an overhead sensor's ability to track an advanced target. A motor issue caused the target to lose control during the test, resulting in only limited data being collected.

Legend:

JFC - Joint Flight Campaign

FTT - Flight Test Terminal High Altitude Area Defense Weapon System

TH CTV - Terminal High Altitude Area Defense Weapon System Controlled Test Vehicle

TBG - Tactical Boost Glide

Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-23-106011

[a]Designates a backlogged test: Backlogged tests are tests that had already been delayed at least once from a previous fiscal year. Partner flight tests that are backlogged are not controlled by MDA and it is at the Partner Program's discretion to delay the test.

[b]The Patriot tests included in this report are integration tests with Terminal High Altitude Area Defense; Patriot-only tests planned for fiscal year 2022 are not included.

[c]A no-test is declared when external factors (e.g., weather) or anomalies with the target (e.g., intercept is not attempted) prevent the flight test from achieving its objectives.

Not Completing Annual Testing Limits Effectiveness of Test Program

MDA's inability to conduct all of its planned flight tests has been a long-standing issue. Table 5 shows that between fiscal years 2017 and 2022, MDA has conducted roughly half of planned baseline flight tests.

Table 5: Planned Baseline Flight Tests (Fiscal Years (FY) 2017 – 2022)

Status	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	Total
Total	9	11	7	10	11	9	**57**
Conducted	6	7	2	3	7	6	**31**
Percent conducted	67%	64%	29%	30%	64%	67%	**54%**

Source: GAO analysis of Missile Defense Agency data. I GAO-23-106011

MDA's inability to conduct all its planned flight tests limits its ability to validate that the systems will provide the capabilities needed. For example, MDA intended to demonstrate certain LRDR capabilities in fiscal year 2022, but the associated flight tests FTX-45 and FTX-26 were either delayed or did not achieve their objectives. According to MDA officials, FTX-26 is now scheduled to occur at the end of fiscal year 2023, in the same quarter as the current planned date for the contractor's delivery of the LRDR to MDA. Any delays to MDA's testing schedule in fiscal year 2023 may delay FTX-26 until after the radar is delivered to the agency. Even if the test is conducted as planned, MDA will have limited

time to assess the test's results and take any necessary actions before delivery takes place. Due to these changes in LRDR testing, MDA will not fully verify that the LRDR can meet certain performance requirements before it intends to accept delivery of the LRDR from the contractor. Though FTX-26 is not required by the LRDR contract, the late timing of FTX-26 increases the risk that any issues found during testing will not be addressed prior to the contractor's delivery of the LRDR to MDA.

We recommended in July 2020 that an independent assessment be conducted on MDA's test scheduling due to the continued inability to complete its annual flight test plan.[16] MDA concurred with the recommendation and awarded a contract to the Institute for Defense Analyses (IDA) to conduct the assessment. IDA completed its review in February 2022 and made six recommendations to MDA designed to improve the feasibility of MDA's annual test plan. According to MDA officials, MDA has addressed three recommendations pertaining to (1) engaging operational testers earlier in the planning process, (2) developing a taxonomy for describing and monitoring flight tests changes, and (3) studying schedule change implications on investment priorities. MDA has ongoing efforts to address two other recommendations involving stakeholder coordination and mapping test assessment objectives. It is further assessing options to address the sixth recommendation to conduct a study to analyze the benefits of adjusting flight test schedule margins.

MDA Conducted Three of Nine Planned Ground Tests

MDA met objectives in three out of nine planned ground tests in fiscal year 2022. In addition, MDA was able to meet objectives in two added ground tests, including GTI-08a, a key ground test that had been delayed since fiscal year 2020. However, as a result of delays in conducting GTI-08a, MDA was not able to complete subsequent ground tests in its annual plan. The agency delayed four tests to future years and eliminated two others. An overview of the ground tests planned and executed can be found in table 6.

[16]GAO-20-432

Table 6: Summary of Missile Defense Agency's Fiscal Year 2022 Ground Test Results

Name of planned ground test	Status and description
GTI-09 Sprint 1	**Met objectives** Delayed from fiscal year 2021. Provided assessment of Missile Defense System capabilities for regional defense. Test assessed additional capabilities for Aegis, AN/TPY-2, C2BMC, and THAAD.
GTI-ISR (21)	**Met objectives** Delayed from fiscal year 2021. Demonstrated Missile Defense System interoperability with missile defense systems being co-developed by Israel.
SICO-08a-1	**Met objectives** Assessed C2BMC and AN/TPY-2 radar communications and interoperability. Originally named SICO-1.
GTD-08a[a]	**Delayed to fiscal year 2023** Delayed from fiscal year 2021. Intended to demonstrate strategic and regional capabilities. Test conducted October 2022.
GTI-09 Sprint 2	**Delayed to fiscal year 2023** Integrated test to assess regional capabilities. Delayed to fiscal year 2023.
GTD-09[a]	**Test deleted** Delayed from fiscal year 2021. Missile Defense system ground test intended to assess theater and regional capabilities.
GTI-08b[a]	**Delayed to fiscal year 2023 and 2024** MDS System level ground test intended to assess strategic, theater and regional capability and support an LRDR fielding decision.
SICO-08-2[a]	**Delayed to fiscal year 2023** Intended to assess interoperability between C2BMC and AN/TPY-2 upgrades. Originally named SICO-02.
SICO-08b	**Test deleted** Intended to assess Sensors communication.
Ground test added after publication of fiscal year 2022 baseline	
GTI-08a[a]	**Met objectives** Delayed from fiscal year 2020. Provided data to support Operational Capability and fielding decisions, and system effectiveness for MDS Increment 6B.1—a set of integrated capabilities designed to enhance defending the United States. This increment of capabilities consists of added capability for C2BMC, GMD, LRDR, SBX, and THAAD.
GCN 8B.7 SICO	**Met objectives** Test added in fiscal year 2022. Assessed the first phase of a GMD upgrade to address hardware and software obsolescence.

Legend:

AN/TPY-2 - Army/Navy Transportable Radar Surveillance and Control Model—2

C2BMC - Command, Control, Battle Management, and Communications

GCN – Ground-based Midcourse Defense Communications Network

GMD - Ground-based Midcourse Defense

GTD - Ground Test Distributed

GTI - Ground Test Integrated
ISR - Israeli
LRDR - Long Range Discrimination Radar
SBX - Sea-Based X-Band Radar
SICO - System Integration and Check Out
THAAD - Terminal High Altitude Area Defense.
Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

[a]Delays to GTI-08a caused the subsequent delays to the other planned ground tests.

MDA completed GTI-08a in April 2022—and was part of the largest and most complex incremental upgrade to MDA-provided capabilities to date.[17] The ground test was intended to demonstrate upgrades to Aegis, AN/TPY-2, C2BMC, GMD, SBX and the LRDR. However, officials from the Office of the Developmental Test, Evaluation, and Assessment and the Office of the Under Secretary of Defense for Research and Engineering, raised concerns that there were limitations with the test architecture. Results from GTI-08a will also support fielding decisions in fiscal year 2023.

Given the completion of GTI-08a, MDA's future ground test schedule is at risk as the agency works to resolve the ground tests delayed from fiscal year 2022 that are intended to demonstrate an increased capability and further assess strategic, theater, and regional capabilities. In addition, MDA's inability to execute its fiscal year 2022 ground test plan has delayed deliveries of capability. For example, MDA delayed deploying Increment 6B.1, which is intended to incorporate the LRDR and other capabilities, to the third quarter of fiscal year 2023 through fiscal year 2024 to align with the updated testing and assessment timelines. As a result of these actions, MDA has delayed the planned delivery of Increment 6B.2 from December 2022 to July 2024.

MDA Conducted Two Scaled-Down Operational Cyber Assessments but Did Not Complete Its Fiscal Year 2022 Plan

MDA conducted two operational cyber assessments in fiscal year 2022 designed to assess cyber vulnerabilities and the system's resiliency to

[17]As we previously reported, this test was originally named GTI-08 and planned for fiscal year 2020. The test was subsequently divided into GTI-08a and GTI-08b to better align with MDA's changes to its increment deliveries.

cyber-attacks and to support fielding decisions.[18] However, MDA did not complete the Cooperative Vulnerability and Penetration Assessment (CVPA) and Adversarial Assessment (AA) testing as originally planned, deferring part of the scope to fiscal year 2023. MDA also delayed five other assessments to future years. An overview of the operational cyber assessments planned and executed can be found in table 7.

Table 7: Missile Defense Agency Planned Operational Cyber Assessments in Fiscal Year 2022

Name of planned operational test	Increment and participating elements	Status and description
CVPA-08a	Increment 6.B.1: GMD, C2BMC, BOA, AN/TPY-2, SBX, THAAD, LRDR	**Conducted** Delayed from fiscal year 2021. Assessment conducted, in part, on operationally representative hardware to support fielding decisions for Increment 6.B1. The scope of the test was reduced, deferring GMD testing due to challenges developing ground system's software and was conducted the second quarter fiscal year 2023. In addition, according to MDA, LRDR was removed from the test and its schedule is under review.
AA-08a	Increment 6.B.1: GMD, C2BMC, BOA, AN/TPY-2, SBX, THAAD, LRDR	**Conducted** Delayed from fiscal year 2021. Assessment provided data needed for operational fielding decisions related to Increment 6.B1. The scope of the test was reduced, deferring BOA, C2BMC, and GMD testing to the second quarter of fiscal year 2023. In addition, according to MDA documentation, LRDR cyber testing is under review.
CVPA-D-08a	Increment 6.B.1: GMD, C2BMC, BOA, AN/TPY-2, THAAD, LRDR	**Delayed to fiscal year 2023** Test to assess the operational system of the participating systems to support fielding decision. Test was conducted the second quarter of fiscal year 2023.
CVPA-08b	Increment 6.B.2: GMD, C2BMC, LRDR	**Delayed to fiscal year 2024** Assessment of participating elements operational system's software to support fielding decisions. Test was delayed due to the ground test replan.
AA-08b	Increment 6.B.2: GMD, C2BMC, LRDR	**Delayed to fiscal year 2024** Assessment of participating elements operational system's software to support fielding decisions. Added in AN/TPY-2.
CVPA-09	Increment 6.B.1: C2BMC, AN/TPY-2	**Delayed to fiscal year 2024** Delayed from fiscal year 2021. Assessment of participating elements operational system's software to support fielding decisions. Removed AN/TPY-2 from test plan.
AA-09	Increment 6.B.1: C2BMC, AN/TPY-2	**Delayed to fiscal year 2024** Assessment of participating elements operational system's software to support fielding decisions. Removed AN/TPY-2 from test plan.

Legend:

AA - Adversarial Assessment

[18]Differing from flight tests where there is a single date of execution, CVPAs and AAs are campaigns that can run over several weeks.

AN/TPY-2 - Army/Navy Transportable Radar Surveillance and Control Model—2
BOA - BMDS, Overhead Persistent Infrared Architecture
C2BMC - Command, Control, Battle Management, and Communications
CVPA - Cooperative Vulnerability and Penetration Assessment
GMD - Ground-based Midcourse Defense
LRDR - Long Range Discrimination Radar
SBX – Sea-Based X-Band Radar
THAAD - Terminal High Altitude Area Defense
Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

As shown in the table, MDA conducted two operational cyber assessments—one CVPA and one AA. CVPA-08a, delayed from fiscal year 2021, utilized operationally representative hardware to demonstrate a defense against cyber vulnerabilities and supported fielding decisions for AN/TPY-2, C2BMC, and THAAD.[19] In addition, AA-08a demonstrated the ability of MDS to detect, respond to, survive, and recover from cyberattacks. However, MDA did not test all the systems it originally planned in both the CVPA and AA, and delayed the assessment of C2BMC the GMD ground system to the second quarter of fiscal year 2023. Moreover, according to MDA, LRDR was removed from the test and its schedule is under review.

MDA delayed the remaining fiscal year 2022 planned system-level operational assessments due to difficulties in conducting the planned testing and system availability. For example, according to program documentation, MDA was unable to complete the operational cyber assessment for the LRDR due to additional development being required prior to fielding. These delays increase the risk that MDA will have to delay the next increment of capability, known as Increment 6B.2, or deliver it with less knowledge of the risks to its cybersecurity necessary to support fielding decisions.

In addition, during fiscal year 2022, MDA conducted two developmental cybersecurity assessments.[20] MDA conducted a Cooperative Vulnerability Identification on the LRDR radar January 2022 and an Adversarial

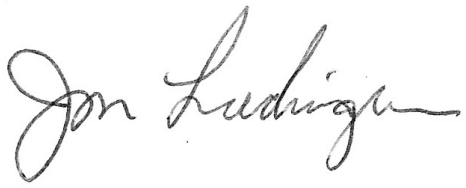
[19]Cyber test results and related test plans are classified and cannot be discussed in this report.

[20]MDA's Cybersecurity developmental testing consists of two assessments: a Cooperative Vulnerability Identification and an Adversarial Cybersecurity Developmental Test and Evaluation. The Cooperative Vulnerability Identification is used to collect data needed to identify vulnerabilities and plan mitigations. The Adversarial Cybersecurity Developmental Test and Evaluation uses realistic threat scenarios in a representative operating cyber environment to identify vulnerabilities.

Cybersecurity Developmental Test and Evaluation on GMD's ground system software in February and March 2022. Both assessments were conducted to assess the element's cyber posture.[21]

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, and to the Director of the Missile Defense Agency. In addition, the report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-4841 or LudwigsonJ@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix X.



Jon Ludwigson
Director, Contracting and National Security Acquisitions

[21]Specific objectives and the results to both assessments are classified and are not discussed in this report.

List of Committees

The Honorable Jack Reed
Chairman
The Honorable Roger Wicker
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Jon Tester
Chair
The Honorable Susan Collins
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Mike Rogers
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The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Ken Calvert
Chair
The Honorable Betty McCollum
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives


A


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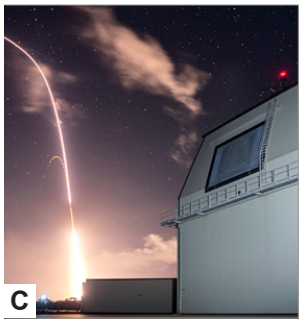
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Source: Missile Defense Agency. | GAO-23-106011

PROGRAM OVERVIEW

Aegis Ballistic Missile Defense (Aegis BMD)

Aegis BMD is the integrated naval element of the Missile Defense System (MDS) that provides regional and homeland missile defense capabilities. Below are some of the components of Aegis BMD.

A. Standard Missile (SM)-3 interceptors are designed to defend against short-, medium-, and intermediate-range enemy missiles.

B. Aegis Weapon System (AWS) is the command and control system that manages all functions from threat missile detection to intercept. AWS is jointly developed by the Missile Defense Agency (MDA) and the Navy as software spirals—incremental software upgrades—to improve capabilities over time.

C. Aegis Ashore is a land-based version of Aegis BMD. One site located in Hawaii serves as a test facility. Another site in Romania has been operational since May 2016 and provides regional defense. A third site in Poland is expected to be delivered in fiscal year 2023.

MDA and the Navy have a plan to transfer operational control for some portions of Aegis BMD. In general, MDA and the Navy both have development and support responsibilities for Aegis BMD according to a memorandum of agreement.

DELIVERIES

MDA did not meet its fiscal year 2022 goal for SM-3 Block IB interceptors as five planned interceptors were delivered after the fiscal year ended. MDA, however, delivered nine backlogged interceptors that were previously delayed due to a flight test failure. The Aegis program temporarily halted deliveries to investigate the failure, but missile production did not stop and deliveries subsequently resumed.

MDA also did not meet its goal for SM-3 Block IIA interceptors. Three interceptors planned for fiscal year 2022 were not delivered. MDA was able to deliver six backlogged interceptors that we previously reported were delayed due to missile assembly issues. The Aegis program addressed the issues, which allowed them to resume deliveries.

As reported by the agency, in August 2022, the Director, MDA approved an acquisition strategy to align SM-3 Block IB and Block IIA production under one contract. This production alignment is expected to maximize efficiencies in program management and obsolescence monitoring, among other synergies. According to MDA officials, they have not identified any disadvantages with this strategy. This acquisition strategy is currently under review by the Under Secretary of Defense for Acquisition and Sustainment to support a production decision for SM-3 Block IIA.

Aegis BMD Fiscal Year 2022 Deliveries

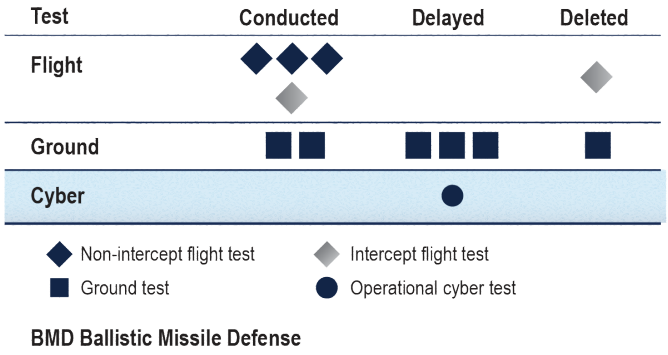
	Planned	Status
SM-3 Block IB	29 interceptors	**24 delivered.** 5 interceptors were late and delivered in the first quarter of fiscal year 2023. The total does not include 9 previously delayed interceptors that MDA delivered.
SM-3 Block IIA	12 interceptors	**9 delivered.** 3 interceptors are now planned to be delivered in fiscal year 2023. The total does not include 6 previously delayed interceptors that MDA delivered.

BMD Ballistic Missile Defense
SM Standard Missile

Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

TESTING

Aegis BMD Fiscal Year 2022 Planned Testing



Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

Aegis BMD conducted four flight tests in fiscal year 2022, including a successful intercept test event that demonstrated its interoperability with Japanese and Korean systems. The last test—Flight Test Experiment Aegis Weapon System-01—gathered data while an SM-3 Block IIA interceptor engaged a modified medium range ballistic missile target in a non-intercept test.

Aegis BMD conducted two planned ground tests. Ground Test Integrated (GTI)-09 Sprint 1 provided data to support decisions related to system capabilities affecting United States European Command and United States Central Command. GTI-ISR 21 assessed the system's interoperability with Israeli missile defense systems. Aegis BMD also participated in GTI-08a—a delayed test originally planned for fiscal year 2020—which provided data to support system capabilities decisions for Aegis and other missile defense system elements.

A planned Aegis BMD operational cyber test was delayed to fiscal year 2024 due to MDA's changes to its test plan that affected planned ground and cyber tests.

OTHER PROGRAM INFORMATION

Aegis Ashore

We reported in June 2022 that delivery of the Aegis Ashore system to Poland was originally planned for fiscal year 2018, but that construction challenges delayed delivery.[1] Total projected costs increased by 12 percent, including additional costs for retaining engineering and security services during the delays. The site remains under construction, but MDA officials stated there are no known technical risks. In addition, the Aegis Ashore program recently met key milestones. Specifically, Aegis Light Off occurred in June 2022, which signifies the initial powering up of the weapon system to observe if all integrated systems are operational. The program completed physical installation of the system and demonstrated it in October 2022. MDA expects to declare the site safe and technically capable in early 2023 and Navy acceptance is anticipated for later in the year.

Safe Service Life Extension

The Aegis program has been able to extend the safe service life of SM-3 Block IA and Block IB interceptors to ensure the interceptors can be used with no additional safety risk. Under this effort, the safe service life of Block IA interceptors increased from 12 to 18 years and Block IB interceptors increased from 8 to 12 years. The safe service life of Block IIA interceptors is currently 12 years and MDA is assessing the possibility to increase this to 16, or possibly up to 20, years. MDA officials described the process to extend an interceptor's safe service life, which includes testing and analysis of aged missile components to determine their suitability for extended service. The testing and analysis is conducted by industry and government stakeholders and subject matter experts at various locations and laboratories. MDA officials said safe service life extensions have helped address the challenge of meeting the Navy's interceptor inventory requirements, which typically entail high volume procurements and consistent repair and recertification throughput.

Software Development

MDA officials stated the Navy started implementing a multi-stage Development, Security, and Operations strategy to deliver software upgrades to Aegis platforms. The Navy started using a software factory—an automated process to develop software—in fiscal year 2021 and now plans to eliminate their legacy system for developing and delivering coded software capability in fiscal year 2024.[2] According to MDA officials, by fiscal year 2030 the Navy intends for this approach to be the sole means for developing and delivering coded software capability to all Aegis platforms. MDA officials explained this strategy provides the opportunity to significantly increase the speed of software deliveries to the fleet, as well as reduce costs and cybersecurity risk by integrating security functions in the development process. They stated, however, there is risk since it is a significant transition from current development strategies. They said the transition would require extensive retraining and hiring of government personnel to fully execute the strategy, as well as additional costs to develop the new required tools, such as software, models, and infrastructure.

[1]For additional details on Aegis Ashore, see GAO, *Missile Defense: Better Oversight and Coordination Needed for Counter-Hypersonic Development*, GAO-22-105075 (Washington, D.C.: June 16, 2022).

[2]For additional details on the use of software factories, see GAO, *Software Acquisition: Additional Actions Needed to Help DOD Implement Future Modernization Efforts*, GAO-23-105611 (Washington, D.C.: Apr. 5, 2023).

Source: Missile Defense Agency. | GAO-23-106011

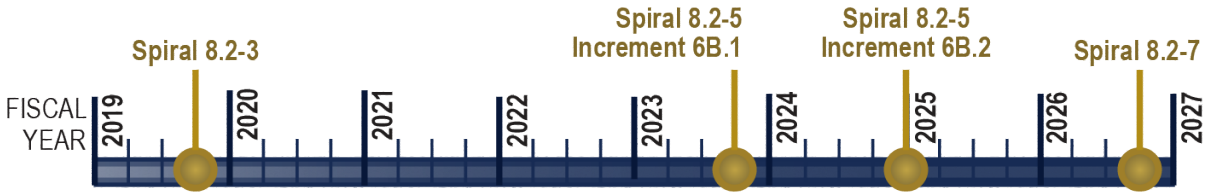
PROGRAM OVERVIEW

Command, Control, Battle Management, and Communications (C2BMC)

C2BMC is the integrating element of the Missile Defense System (MDS). A global system of hardware and software, C2BMC allows users to plan operations, see the battle develop, and manage across regional and global networks. Moreover, C2BMC enables defense of an area larger than those covered by the individual MDS elements and against more threat missiles simultaneously.

MDA is developing C2BMC in spirals—incremental hardware and software upgrades—that build upon prior capabilities. Spiral 8.2-3 is the current fielded spiral, while spirals 8.2-5 and 8.2-7 are in development. C2BMC is in continuous spiral development; thus, there are no plans to transfer to the military service(s).

Spiral Delivery Timeline for C2BMC



Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

DELIVERIES

In fiscal year 2022, MDA did not deliver as planned the first increment of spiral 8.2-5, known as Increment 6B.1, to allow for additional risk reduction testing and software fixes. MDA now plans to deliver the increment in fiscal year 2023. Increment 6B.1 is planned to integrate the Long Range Discrimination Radar, enable initial hypersonic tracking, and support space domain awareness conducted via Aegis-equipped Navy ships. MDA expects Increment 6B.2, the second increment of spiral 8.2-5, to be delivered in fiscal year 2024 and to integrate the Army's Integrated Air and Missile Defense Battle Command System into the MDS.

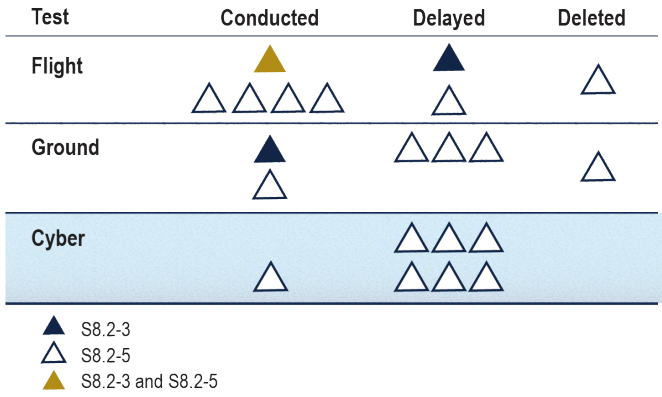
MDA plans to deliver spiral 8.2-7 in fiscal year 2026. The spiral is designed to provide improved system-level track and discrimination processing using input data from multiple radars and Ballistic Missile Defense System Overhead Persistent Infrared Architecture (BOA).[1] Other expected capabilities include enhancements to hypersonic tracking and space domain awareness, as well as support for the Defense of Guam mission. As of September 2022, MDA officials said the spiral 8.2-7 contractor had not achieved its software development milestones. However, they said changes in MDA's plan to implement capabilities are expected to provide more time to the contractor to work towards these milestones and align with the updated software development timeline. Officials also said a contractor-developed tool to identify cybersecurity vulnerabilities in real-time is behind schedule and the C2BMC program is working to ensure the contractor prioritizes this effort.

In September 2022, MDA completed early fielding of BOA 7.0. Compared to earlier versions, BOA 7.0 augments spaced-based sensor data processing, improves detection and track of threats, and enables initial hypersonic detection and track. MDA had planned to deliver BOA 7.0 together with spiral 8.2-5 in May 2023; however, the C2BMC program demonstrated BOA 7.0 could operate with the already fielded spiral 8.2-3. The C2BMC program also deployed BOA 7.0, while it was in operational testing, for a contingency operation during the Ukraine crisis. BOA 7.0 provided advanced threat tracking capability beyond the previously fielded BOA 6.1.

[1]BOA is a ground-based processing system that receives spaced-based sensor measurement data on threat missiles from which it generates track data. The track data are reported to C2BMC for use by missile defense sensors and weapon systems.

TESTING

C2BMC Fiscal Year 2022 Planned Testing



Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

Note: C2BMC supports multiple test types, but its capabilities are primarily assessed via ground tests.

In fiscal year 2022, C2BMC participated in seven planned flight and ground tests with six tests utilizing spiral 8.2-5. Previously, we reported spiral 8.2-5 participated in very little system-level testing to demonstrate software maturity and performance, so this represents an increase in utilization. Spiral 8.2-5 also participated in a ground test—Ground Test Integrated-08a. MDA officials stated this test, originally planned for fiscal year 2020, but not for fiscal year 2022, was part of the largest and most complex incremental upgrade to MDA-provided capabilities.

MDA planned seven operational cyber tests in fiscal year 2022, but only completed one test. MDA conducted the first of a two-part Cooperative Vulnerability and Penetration Assessment for the cyber test-08a campaign to augment information needed for Operational Capability Baseline decisions, which assess whether capabilities are ready to be added to the MDS. MDA did not conduct the second part nor the associated Adversarial Assessment as planned, delaying them until fiscal year 2023.

OTHER PROGRAM INFORMATION

Software Development

In October 2021, MDA activated the C2BMC software factory—an automated process to develop software. Software factory functions include automating coding, testing, and development up to software fielding. MDA officials noted the software factory can save time, resulting in certain tasks that took weeks to complete are now done within an hour. Additionally, some efforts that were done manually took over a year to complete, but now could be done in less than a week and with reduced human-induced errors. Officials stated the time saved frees resources to work on other priorities and to identify approaches to reduce technical and schedule risk. According to MDA, the C2BMC software factory is the first of its kind in MDA and the C2BMC program received a 1-year authority to operate the software factory from the Defense Counterintelligence and Security Agency (DCSA). MDA reported that as of December 2022, DCSA observed no new risks with the software factory and renewed the authority to operate for 3 years, the maximum amount permitted.

For the development of spiral 8.2-7, MDA continues to follow an Agile development approach. This approach includes establishing minimum viable products of capabilities, which add flexibility to the development process. For example, developed capabilities can proceed through milestones individually rather than in a suite of capabilities. MDA also expects Agile to improve their forecasting efforts by providing better management of resources across spirals, earlier recognition of constraints and mitigation efforts, and greater visibility to plan future iterations.

Cybersecurity

MDA is monitoring multiple cybersecurity challenges for C2BMC. According to MDA, the number of open issues and unresolved vulnerabilities are growing and have contributed to increasing risk for C2BMC. Although scanning for vulnerabilities has improved, it remains below MDA's agency standard. To address this situation, MDA officials provided a few strategies, such as increased program manager involvement, regular cybersecurity status meetings between system owners and cybersecurity staff, and a quicker process to patch vulnerabilities. MDA officials said C2BMC also has high cybersecurity risk due to a system infrastructure consisting of older products that are less supportable by the program's vendor. To improve C2BMC's risk posture, MDA has been upgrading hardware and software that is expected to enable a vendor supported infrastructure and correct cybersecurity issues. After these upgrades, system updates would still be needed to maintain vendor support.

Test Capacity

MDA plans to upgrade the C2BMC testbed configuration, a testing environment used for performance assessment and verification to ensure capabilities are valid for operational fielding. Examples of capabilities include missile defense system track and expanded hypersonic tracking. According to MDA officials, however, the testbed upgrade will likely be obsolete in a few years. To stay ahead of obsolescence risk, MDA is working with the contractor to develop a strategy for future C2BMC iterations.

MDA officials expressed concerns about the lack of available external system models and simulations of other MDA elements to enable early inter-element testing with C2BMC. The lack of models reduces confidence in system designs and impacts system-level test programs. Deficiencies in C2BMC software also may not be uncovered until late in ground test campaigns, which could cause development delays. To address the lack of models, MDA has identified alternative methods, including using internally developed emulators—interfaces that can represent elements during testing—as well as a variety of tests to assess C2BMC performance.

Source: U.S. Northern Command /Army Sgt. Jack W. Carlson III | GAO-23-106011

PROGRAM OVERVIEW

Ground-Based Midcourse Defense (GMD)

The Missile Defense Agency (MDA) is developing GMD to defend the United States against a limited ballistic missile attack from potential adversaries such as North Korea and Iran. To counter such threats, GMD, in conjunction with a network of ground-,sea-, and space-based sensors and command and controlsystems, launches Ground-Based Interceptors (GBI) from missile fields based in Fort Greely, Alaska and Vandenberg Space Force Base, California. GBIs boost toward the predicted location of an incoming missile and release kill vehicles equipped with thrusters and sensors to find and destroy the warhead through "hit-to-kill" collisions. Over the past two decades, MDA developed and fielded: a ground system consisting of fire-control consoles, interceptor launch and maintenance facilities, and a communications network; and an interceptor fleet, with 47 GBIs in the current inventory. MDA is developing a new GMD interceptor, called the Next Generation Interceptor (NGI), to defeat future missile threats.

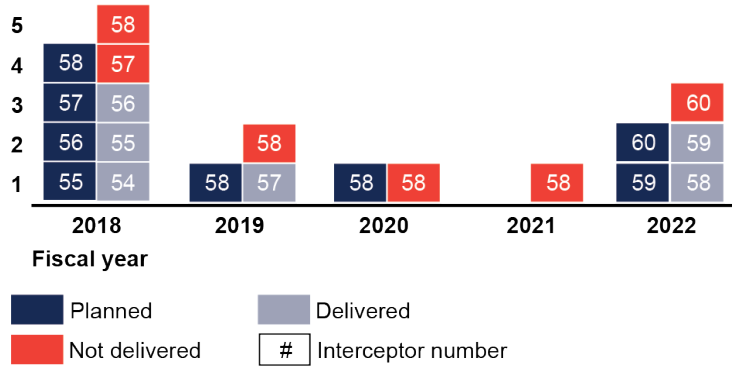
DELIVERIES

The GMD program overcame a three-year delay in delivering GBI 58 but fell short of its fiscal year 2022 delivery goals. As we previously reported, the GBI boost vehicle contractor mishandled a key avionics component in 2018, causing a cascade of production challenges and delays.[1] The contractor built a replacement avionics component but incurred multiple setbacks in the process, primarily with obtaining from a supplier a qualified electronic power conversion part necessary to build the new avionics component.

The program delivered GBI 59 as planned in the fourth quarter of fiscal year 2022 but delivered GBI 60 a few weeks later than planned in early fiscal year 2023. According to MDA, the program completed production of the GBI in late fiscal year 2022 as planned but the silo in which the GBI was to be installed was not available until early fiscal year 2023. Delivery occurs once the GBI is installed and silo integration and system checkouts have been completed. The program has one final new GBI—number 61—currently in production, which is designated for use in GMD's next planned intercept flight test, Flight Test GMD Weapon System-12, currently planned for the first quarter of fiscal year 2024. The delivery of GBI 61 will conclude an approximate two decade production run of the GBI.

The program also completed construction of Missile Field 4 at Fort Greely, Alaska in fiscal year 2022. The new 20-silo missile field will allow the GMD fleet to expand beyond its current total of 44 interceptors as well as accommodate the eventual initial production and delivery of Next Generation Interceptors. Although missile field construction is complete, some tasks remain, such as installing and testing launch support systems. MDA estimates a portion of the missile field will be ready for GBI emplacements by the end of fiscal year 2023.

GMD Interceptor Deliveries, Fiscal Years 2018–2022



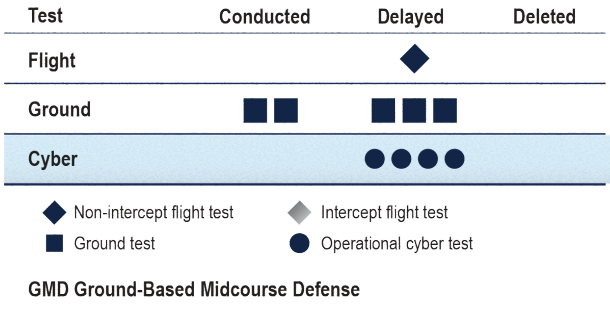
GMD = Ground-based Midcourse Defense

Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

[1]See GAO, Missile Defense: Better Oversight and Coordination Needed for Counter-Hypersonic Development, GAO-22-105075 (Washington, D.C.: June 16, 2022).

TESTING

GMD Fiscal Year 2022 Testing



Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

The GMD program planned to participate in a non-intercept test, called Flight Test Other (Sensor)-26, in fiscal year 2022 that was delayed to the fourth quarter of fiscal year 2023. The test is intended to demonstrate the Long Range Discrimination Radar and its ability to support GMD through a simulated engagement of an intermediate range ballistic missile.

MDA completed Ground Test Integrated (GTI)-08a in April 2022 after extended delays. The delayed execution of GTI-08a caused GMD to delay all baselined fiscal year 2022 ground and operational cyber testing into fiscal year 2023 and beyond. In January 2022, MDA approved a re-plan of the ground test program to address the bow wave of delayed testing events resulting from the extended delays to complete GTI-08a. In addition, the program added and completed a ground test, called GMD Communications Network 8B.7 System Integration Check Out, in fiscal year 2022. According to MDA, the test was a critical first phase of an upgrade to GMD's communications network to address hardware, software, and architecture obsolescence.

OTHER PROGRAM INFORMATION

Next Generation Interceptor

According to MDA, NGI is a competitive development effort with two different contractors pursuing unique interceptor designs to best meet the agency's homeland missile defense requirements. MDA reported that the designs proposed by the contractors include new booster solutions with multiple kill vehicles capable of defending against a greater volume of increasingly more complex missile threats as compared to the GBI, thereby increasing the defensive efficiency of the GMD fleet. Both contractors are currently focused on maturing technologies, testing parts for survivability, defining requirements at the subsystem level, and developing interceptor software in preparation for preliminary design reviews expected to occur before the end of 2023. According to MDA, both contractors were initially required to demonstrate their respective critical technologies at a Technology Readiness Level (TRL) 5 or higher prior to the preliminary design review.[1] At TRL 5, a technology has been tested in a laboratory or relevant environment but the hardware is not necessarily of the form and fit that would be integrated into the final product. In response to a review we conducted in 2022 and in an effort to reduce risk, MDA officials told us they are now requiring both contractors to demonstrate all critical technologies at a TRL 6 or higher by preliminary design review, which is a leading practice for space systems because it promotes design stability.[2]

Service Life Extension Program

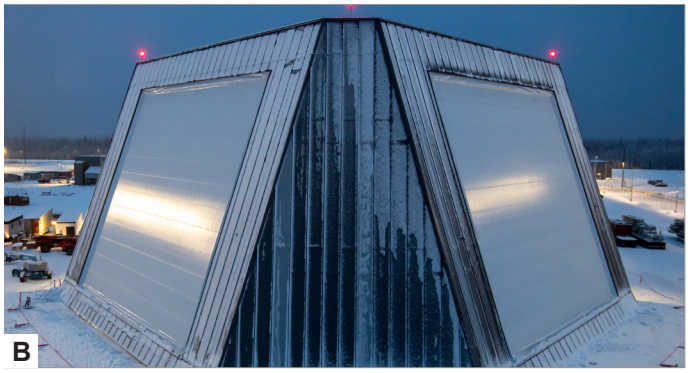
The GMD program is executing an effort to upgrade eleven of the fleet's older GBIs equipped with the heritage Capability Enhancement-I kill vehicle and Configuration (C)1 boost vehicle. According to MDA, the upgrades will improve reliability and enable the GBIs to retain significant capability and operational life beyond the initial delivery of NGI. The program plans to inspect, test, and replace kill vehicle and boost vehicle parts and components. In addition, the program plans to replace the existing C1 boost vehicle with the current C2 boost vehicle for some GBIs. As of August 2022, the program has: completed upgrades for and re-emplaced two GBIs on or ahead of schedule; and de-emplaced four additional GBIs for upgrades, one of which will receive a new C2 boost vehicle. The program planned to upgrade and return three of the four currently de-emplaced GBIs by the first and second quarters of fiscal year 2023 and the fourth GBI by the third quarter of fiscal year 2024. The program then plans to upgrade the remaining five GBIs—all of which will receive new C2 boost vehicles—by the first quarter of fiscal year 2025. Integrating Capability Enhancement-I kill vehicles with C2 boost vehicles will result in a new GBI configuration for the fielded fleet, requiring changes to GMD's ground system software.

Although the program has exceeded its schedule goals for the first two upgraded GBIs, the remaining nine GBIs planned for upgrades are expected to be delayed by several months. According to MDA, the upgrade plan has been in flux over the past year because of supply chain issues, delayed receipt of proposals from contractors, and fully realizing the effects of delays associated with the ground test re-plan. Specifically, the ground test re-plan delayed development of the ground system software that will be necessary to integrate the new GBI configuration by approximately 9 months. Moreover, the boost vehicle contractor experienced production challenges with Orion rocket motors, such as inadvertent silicone deposits found on multiple rubber components and splitting in the composite motor cases. MDA and the contractor conducted investigations and implemented corrective measures without disrupting production for new GBIs. However, production of the C2 boost vehicles that will be equipped on GBIs upgraded through the Service Life Extension Program have been delayed.

[1]TRLs are a scale of nine levels used to measure a technology's progress, starting with paper studies of a basic concept and ending with a technology that has proven itself in actual usage in the product's operational environment.

[2]Section 1668 of the National Defense Authorization Act for Fiscal Year 2022 required us to assess NGI's acquisition progress and brief the congressional defense committees on the results of our assessment. Pub. L. No. 117-81, § 1668(f)(6). We completed our assessment and briefed the committees in July 2022. For our leading practices on technology readiness assessments, see GAO, *Technology Readiness Assessment Guide: Best Practices for Evaluating the Readiness of Technology for Use in Acquisition Programs and Projects*, GAO-20-48G (Washington, D.C.: Jan. 7, 2020).


A


B


C


D

Source: Missile Defense Agency. | GAO-23-106011

PROGRAM OVERVIEW

Sensors

The Sensors program consists of various land- and sea-based radars to detect and track threat missiles through all phases of flight.

A. Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) are transportable X-band radars that operate in one of two modes: forward-based (tracks missile threats after launch) or terminal (helps guide interceptors to defeat incoming missile threats). There are 12 AN/TPY-2 radars located around the world.

B. Long Range Discrimination Radar (LRDR) is a fixed location S-band radar in Clear, Alaska. The LRDR will support Ground-based Midcourse Defense (GMD) against Pacific theater missile threats with persistent long-range midcourse discrimination, precision tracking, and hit assessment.

C. Sea Based X-Band (SBX) is a mobile X-band radar aboard an ocean-going, semi-submersible platform that can be positioned to cover any region on the globe.

D. Upgraded Early Warning Radar (UEWR) are fixed location ultra-high frequency band radars that can provide long-range early warning detection of ballistic missiles. Currently, there are five radars located across North America and Europe.

DELIVERIES

According to MDA documentation, the Sensors program did not complete all of its planned deliveries in fiscal year 2022 because of delays caused by the COVID-19 pandemic and other factors. For example, the Sensors program further delayed deliveries of software for AN/TPY-2 and SBX, as well as the operational acceptance of the LRDR site in Clear, Alaska.

However, the Sensors program did achieve initial fielding for the LRDR, which marks an important milestone toward delivery of the LRDR's operational capability to the warfighter. The agency postponed delivery by the contractor to the fourth quarter of fiscal year 2023 after delays to the element's test schedule and other technical challenges.

The Sensors program also delivered two digital and signal processor upgrades to UEWR sites in Fylingdales, United Kingdom and Thule, Greenland. According to MDA officials, additional work at the Thule site will be completed in fiscal year 2023 under the U.S. Space Force's Sustainment and Modification of Radar Sensors contract.

Sensors Fiscal Year 2022 Deliveries

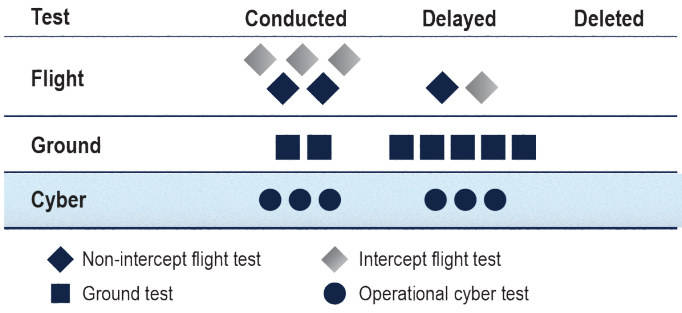
	Planned	Status
Army Navy/Transportable Radar Surveillance and Control Model-2 (AN/TPY-2)	Common Software build 4.0 that is expected to add discrimination and hypersonic tracking capabilities	**Delayed** to fiscal year 2023.
Long Range Discrimination Radar (LRDR)	1 LRDR site for final delivery to support homeland defense	**Delayed** to fiscal year 2023.
Sea Based X-band (SBX)	XBR software to improve missile threat discrimination	**Delayed** to fiscal year 2023.
Upgraded Early Warning Radar (UEWR)	Fylingdales Gen-2 upgrade final operational acceptance	**Completed** in fiscal year 2022.
	Thule Gen-2 upgrade initial operational acceptance	**Completed** in fiscal year 2022.

Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

Note: All deliveries listed in the table above were originally scheduled for a prior fiscal year.

TESTING

Sensors Fiscal Year 2022 Testing



Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

In fiscal year 2022, the Sensors program participated in two flight tests, one of which resulted in a no-test after technical issues with the aircraft carrying the target caused unsafe crew conditions (FTX-45). Another test (FTX-26) was delayed due to technical challenges at the LRDR site. As a result, both flight tests scheduled for fiscal year 2022 designed to demonstrate the LRDR's operational capability—FTX-45 and FTX-26—were not conducted as planned. MDA officials said the agency was not planning a retest of FTX-45 and, as of February 2023, had scheduled FTX-26 for the fourth quarter of fiscal year 2023.

In fiscal year 2022, the Sensors program participated in a significant ground test originally planned for fiscal year 2020—GTI-08a—which had pushed other planned ground tests behind schedule. GTI-08a provided data for multiple missile defense elements and was the first ground test to assess the LRDR's software and capabilities.

Sensors also participated in element-level operational cyber tests, including Cooperative Vulnerability and Penetration Assessments and an Adversarial Assessment.

OTHER PROGRAM INFORMATION

LRDR Completed Initial Fielding but Delays Increase Risk

MDA announced the completed construction and installation of radar arrays for the LRDR during an initial fielding ceremony in December 2021. However, the program continues to experience cost increases and schedule delays, which have postponed the contractor's delivery of the LRDR to MDA until the end of fiscal year 2023. For example, the prime contractor for the LRDR was affected by cessation of work at Clear Space Force Station because of the COVID-19 pandemic, and radar calibration proved more complex than expected. According to MDA documentation, the COVID-19 pandemic resulted in a 4.5 month delay to the delivery schedule at an increased cost of $43.7 million. Complexity of radar calibration also delayed delivery to MDA by an additional 4.5 months, and a radar component failure root-cause investigation and mitigation effort further delayed delivery by 9 months.

The LRDR is at risk of being delivered by the contractor to MDA before the program achieves critical knowledge points or participates in any successful flight tests. As a result, the LRDR's capability and limitations may not be fully known or verified prior to the government accepting the radar for operational use. According to MDA officials, the program further delayed five planned knowledge point events for the LRDR in fiscal year 2022 to either fiscal year 2023 or 2024. These knowledge points included assessing the LRDR's ability to acquire and track threat objects, among other capabilities. In addition, a delayed flight test designed to operationally assess the LRDR—FTX-26—is currently planned for the same quarter as the current date by which the contractor plans to deliver LRDR to MDA. Any delays to MDA's testing schedule in fiscal year 2023 may push FTX-26 to after this delivery is expected to take place. Even if the test is conducted as planned, MDA will have limited time to assess the test's results and take any necessary actions before LRDR is delivered to the agency. Although MDA officials said FTX-26 is not required to be conducted prior to the contractor's delivery, a flight test is required prior to operational acceptance of the radar by the U.S. Space Force.

Risks for Some Sensors

• AN/TPY-2 components are becoming obsolete and replacements are less available or more costly. Supply chain issues increase the risk that replacement parts will be delayed.

• UEWR currently has schedule risk due to concurrent upgrades and sustainment efforts at all five locations. In addition, the aging UEWR radars, deployed in the late 1980s and 1990s, are also facing sustainment risks resulting from parts obsolescence and a lack of available vendors. According to MDA officials, these risks are held by the U.S. Space Force.

• SBX needs to replace the radar dome—a protective shroud—to ensure continued performance after the end of the current radar dome's design life in 2025. In addition, MDA officials said an 8-year delay to 2030 for fielding key advanced discrimination capabilities poses a programmatic risk to maintaining continuity of software engineering expertise to continue development. According to MDA documentation, an experienced team is needed to refine discrimination performance, address newly allocated threats, and modify the SBX interface based on battle management design changes.

Source: Missile Defense Agency/Lisa Simunaci. | GAO-23-106011

PROGRAM OVERVIEW

Targets and Countermeasures

The Targets and Countermeasures program (hereafter referred to as the Targets program) supplies short-, medium-, intermediate-, intercontinental-range targets to represent threat missiles during developmental and operational testing of missile defense weapon systems. The target ranges in kilometers are: short (less than 1,000), medium (1,000-3,000), intermediate (3,000-5,500), and intercontinental (greater than 5,500). The quantity of targets each fiscal year is based on the requirements set forth in the Missile Defense Agency's (MDA) flight test schedule and the quality and availability of the targets is essential for the agency to successfully conduct planned flight testing.

Targets are solely test assets and are not operationally fielded.

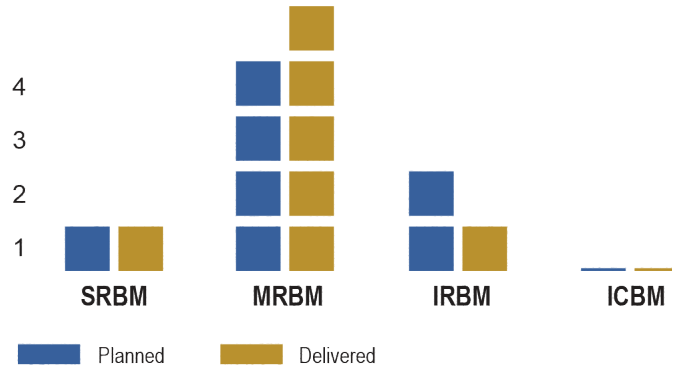
DELIVERIES

In fiscal year 2022, the Targets program planned to deliver two intermediate-range targets. One of those targets was delayed to fiscal year 2023 to align with changes to the schedule for FTX-26. The other target was delivered as planned to support an experimental sensor test funded by the U.S. Air Force to collect radar, optics, and telemetry data in support of upgrades to the Reagan Test Site sensor suite.

The Targets program also delivered five medium-range targets in fiscal year 2022, three of which were to support a series of joint tests with Japan (JFTM-07 E1-E3) executed in the first quarter of fiscal year 2023 to demonstrate Aegis weapon system capabilities. An additional medium-range target was delivered to support FEM-01, an Aegis Weapon System non-intercept test.

The Targets program adjusts the timing of a target's delivery to shortly before the flight test is planned to occur. As shown in the figure, this adjustment can result in deliveries differing from the annual goals.

Targets Fiscal Year 2022 Deliveries

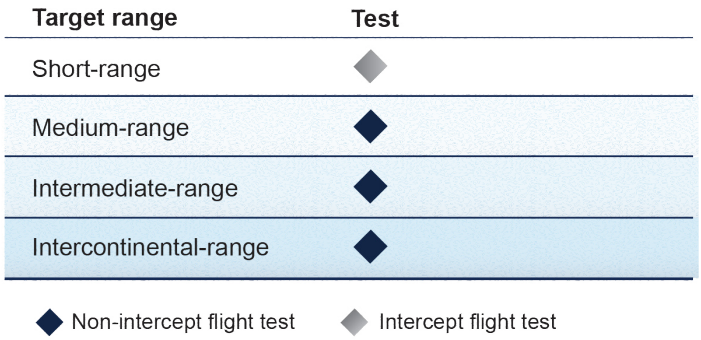


SRBM Short-range ballistic missile
MRBM Medium-range ballistic missile
IRBM Intermediate-range ballistic missile
ICBM Intercontinental ballistic missile

Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

TESTING

Targets Flown During Fiscal Year 2022 Flight Testing



Source: GAO analysis of Missile Defense Agency data. I GAO-23-106011

Note: Target ranges kilometers are: short (less than 1,000), medium (1,000-3,000), intermediate (3,000-5,500), and intercontinental (greater than 5,500).

In fiscal year 2022, the Targets program flew four targets. One intercontinental-range target was flown during a backlogged joint flight test—FTX-43—intended as a developmental tracking exercise for MDA involving an ICBM launch from Kodiak Island to the Reagan Test Site. However, an issue with the target's motor caused it to lose control during the test and limited data were collected as a result.

One intermediate-range target was flown during FTX-42. The target was successfully launched from sea near the Pacific Missile Range Facility toward the Reagan Test Site and was used to collect radar, optics, and telemetry data in support of upgrades planned for the facility.

The remaining targets—one short-range and one medium-range—were successfully flown during separate tests demonstrating Terminal High Altitude Area Defense (THAAD) and Aegis weapon system capabilities.

OTHER PROGRAM INFORMATION

Leveraging Risk-Reduction Opportunity for Inactive Target

According to MDA officials, the Targets program planned to leverage a non-intercept test (FTX-45) conducted in the fourth quarter of fiscal year 2022 as a risk reduction exercise for the Long Range Discrimination Radar (LRDR) and to ensure aircrew readiness prior to the next planned medium-range target mission (FTX-40). Due to depressurization issues with the aircraft carrying the target, FTX-45 resulted in a no- test and the target was not launched. According to MDA officials, the agency still met all personnel risk reduction goals by fully exercising the deployed team in all actions associated with a mission launch and is not planning a retest for FTX-45. Still, delays in a number of qualification efforts will postpone a readiness review for the FTX-40 mission by approximately a year to the second quarter of fiscal year 2024. FTX-40 will use a medium-range launch vehicle with a hypersonic re-entry vehicle—a significant first-time event.

Transitioning to New Motors for Some Targets

The Targets program is transitioning to a new motor for the intercontinental-range targets due to the age and availability of the current motors. The current motors are over 40 years old and are no longer being produced. For the limited supply that is available, the Targets program manages transportation and storage risks and ensures recurring inspections are completed to certify their flight-worthiness for testing. According to the Targets program, the first launch of the intercontinental-range targets with a new motor is planned for the fourth quarter of fiscal year 2025.

The Targets program is also transitioning to a new motor for a medium-range target due to the obsolescence of the current motors. According to the Targets program, the first launch of a medium-range target with a new motor is planned for the second quarter of fiscal year 2024.

The Targets program is also restarting a dormant production line for motors to use in some short- and medium-range targets. These motors have not been in production for at least 10 years, and, according to the Targets program, restarting the motor production line has cost $10.5 million as of December 2022. A static-fire motor test will complete the line's requalification process. The first launch of these targets with a new motor is planned for the third quarter of fiscal year 2024.

Source: Missile Defense Agency. | GAO-23-106011

PROGRAM OVERVIEW

Terminal High Altitude Area Defense (THAAD)

THAAD is a rapidly-deployable, globally-transportable, ground-based system to defend against short-, medium-, and limited intermediate-range threat missiles. A THAAD battery is comprised of launchers, a fire control unit, a communications system, a radar, and interceptors. The Undersecretary of Defense for Acquisition and Sustainment in October 2020 approved THAAD's entry into full-rate production. THAAD was authorized to increase the number of interceptors to 910. THAAD also received approval to procure an eighth battery and reported awarding the contract for this battery in April 2022. THAAD plans to continue production through fiscal year 2035 for remaining items, such as interceptors , and software upgrades.

Due to statutory changes, MDA no longer plans to transition THAAD to the Army.[1] However, MDA is seeking to continue the cost sharing agreement for operations, sustainment, and sustainment support of program elements with the Army.

DELIVERIES

According to MDA, THAAD delivered 89 interceptors in fiscal year 2022, all of which were delivered on time. THAAD planned to deliver 82 interceptors to complete Lots 10 and 11 (Lots are a specific quantity produced under identical conditions). THAAD qualified a part replacement which allowed Lot 10 (originally planned to be completed in fiscal year 2021) to be completed in December of 2021 and commenced delivery of Lot 11 the day after Lot 10 was complete.

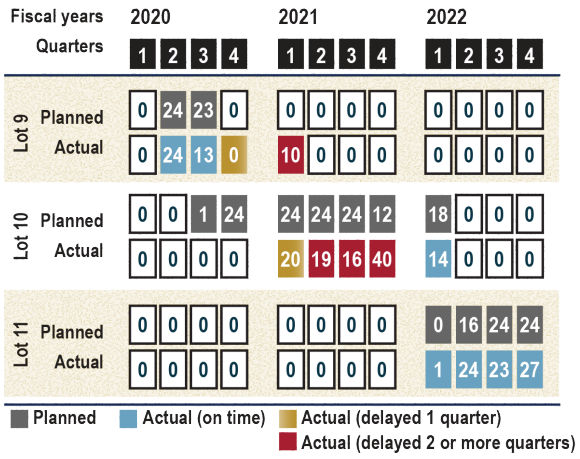
THAAD can currently deliver eight interceptors per month and surge up to 12 for temporary durations. The program has taken steps to more consistently deliver 12 interceptors per month if needed, and anticipates completing equipment planning and implementation in December 2022. However, the program will not move to a sustained 12 interceptor per month schedule unless needed.

THAAD also completed a production facility annex in fiscal year 2021 to provide additional space for stockpile reliability testing, recertification of interceptors that have exceeded their shelf life, and production surges. However, according to MDA, due to COVID-19 shortages and personnel staffing issues with a key contractor, the capability to process 20 stockpile reliability tests per year for December 2022 as initially projected, has been delayed to June 2023.

THAAD also delivered the final two pallets (MRP-Ts) designed to allow flexibility within deployed THAAD units to build, transport, and store preassembled missile packs.

[1]National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91, § 1676(b) (2017); James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 Pub. L. No. 117-263, § 1655 (2022).

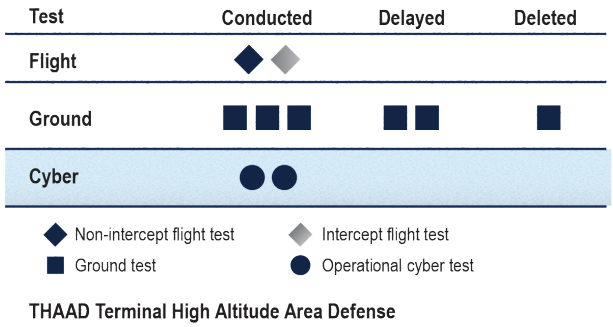
THAAD Interceptor Deliveries, Fiscal Years 2020-2022



Source: GAO analysis of Missile Defense Agency documentation. | GAO-23-106011

TESTING

THAAD Fiscal Year 2022 Testing



Source: GAO analysis of Missile Defense Agency documentation. | GAO-23-106011

Note: An operational cyber test consists of (1) a cooperative vulnerability and penetration assessment and (2) an adversarial assessment. The former provides data on a system's resilience when in operation and the latter identifies the system's effectiveness when defending against cyber attacks.

In fiscal year 2022, THAAD conducted two flight tests—FTT-21 and TH CTV-01a. FTT-21 was delayed from fiscal year 2021 and successfully demonstrated THAAD's capability to fire and control two Patriot Advanced Capability-3 Missile Segment Enhanced interceptors against one Short Range Ballistic Missile target. TH CTV-01a was a retest and successfully demonstrated THAAD's ability to also launch Patriot interceptors, thereby extending its defended area. The test further showed that the Patriot M903 Launcher LINK software issue observed in an earlier flight test was resolved.

In fiscal year 2022, THAAD participated in a significant ground test originally scheduled for fiscal year 2020—GTI-08a—which had pushed other ground tests behind schedule, and participated in GTI-09 Sprint 1 and GTI-ISR. Two other ground tests were delayed, while one was deleted. GTI-08a provided data to support operational capability decisions for THAAD, GTI-09 Sprint 1 provided erational decisions, and GTI-ISR demonstrated interoperability with missile defense systems being developed by Israel.

MDA conducted a successful operational cyber test, delayed from the last fiscal year. This test was intended to identify vulnerabilities and characterize the operational cyber resiliency for the THAAD 4.0 software build.

OTHER PROGRAM INFORMATION

Interceptor Backlog Cleared

The program began fiscal year 2021 with 35 interceptors backlogged due to a previous halt in production to qualify a replacement for a part that is no longer available. After qualifying the part replacement and resuming production, THAAD ended fiscal year 2021 with only 14 interceptors backlogged. The remaining 14 interceptors were delivered in the first quarter of fiscal year 2022, and THAAD immediately began delivery of the next lot (Lot 11). All planned deliveries for the next lot were delivered on time in fiscal year 2022.

Contracting Efficiencies

The program reported using actual contractor costs collected over the life of the program to negotiate the prices for Lot 13 and Lot 14 interceptors and for interceptors purchased by Saudi Arabia. This approach resulted in a 14 percent savings to the government and allowed the program to procure an additional 44 interceptors. Further, according to MDA, using this method reduced the technical evaluation period by 3 months, which allowed for earlier contract negotiations.

Production and Supply Concerns

The program has experienced difficulty due to COVID-19 related labor shortages and supply chain disruptions. The program expects these issues to continue for the next 1 to 2 years and anticipates costs and schedule issues as a result. Additionally, ground production has been affected by COVID-19 facility shutdowns, which have limited electronic piece part availability, and increased lead times. The program anticipates these issues will delay ground equipment delivery, which primarily effects Saudi Arabia.

Layered Homeland Defense

MDA was exploring the use of THAAD, the Ground-Based Midcourse Defense system, and Aegis ships, as well as various sensors to provide a layered homeland defense-protection of the U.S. primarily from intermediate- and intercontinental-range threat missiles. In 2022, MDA did not receive funding for layered homeland defense activities. THAAD capability upgrades tied to layered homeland defense, like development of enhanced two-color seeker software, will either be cancelled or delayed.

Software Update

THAAD system build 4.1, the follow-up to the THAAD 4.0 build, had its capabilities integrated into THAAD System Build 5.0. This integration was done to align THAAD system builds with MDA's December 2021 Phased Implementation Plan. THAAD 5.0 is anticipated to be released in fiscal year 2025 and will include capabilities such as expanded THAAD missile segment enhanced interceptor integration, improved cybersecurity, and the ability to launch THAAD remotely via radio frequency.

Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

ISSUE OVERVIEW

Counter-Hypersonics

Hypersonic weapons are an evolving threat that pose challenges for missile defense systems. These weapons are capable of flight at speeds of five times the speed of sound (Mach 5) or greater, which limits the time for defenses to react. Hypersonic weapons are also capable of maneuvering in flight, allowing them to obscure their intended target. In addition, hypersonic weapons are designed to spend the majority of their flight path inside the atmosphere, making them difficult to track for conventional ground sensors. All of these features complicate a successful intercept.

There are multiple types of hypersonic weapons, such as hypersonic boost-glide vehicles that use a rocket booster for initial propulsion and a detachable glide vehicle that flies to the intended target. MDA has two main efforts under development to defend against hypersonic weapons:

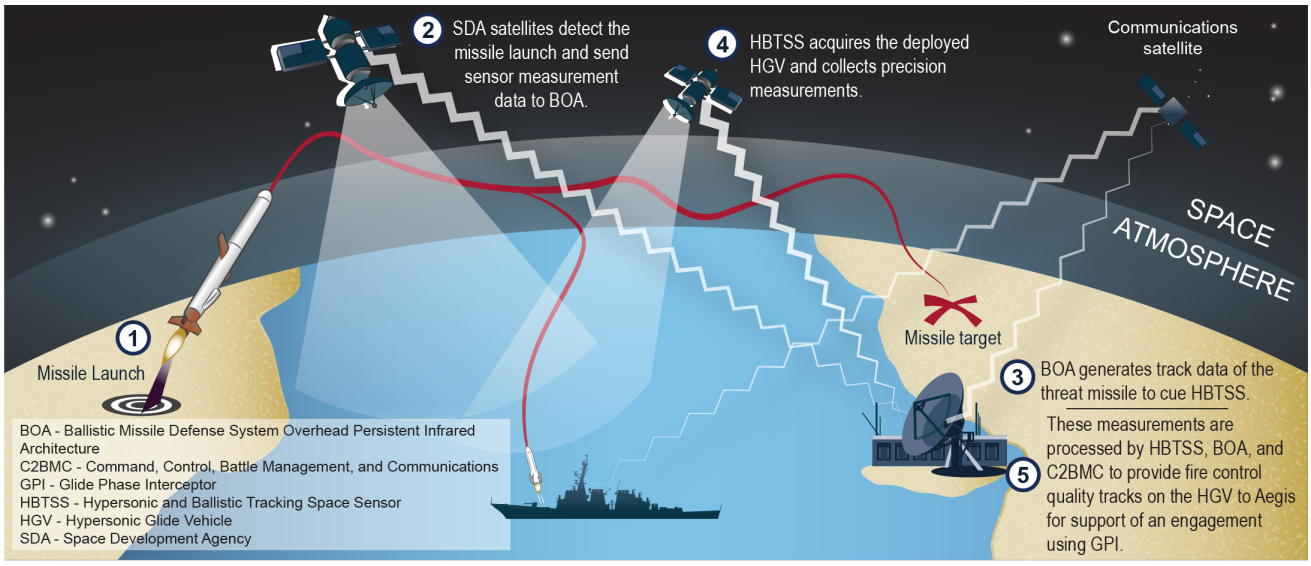
- Glide Phase Intercept (GPI) is a program that includes a missile being designed to be fired from Aegis-equipped ships to intercept a hypersonic weapon in the middle (or "glide") phase of its flight path.
- Hypersonic and Ballistic Tracking Space Sensor (HBTSS) is an effort to develop space-based sensors to track and support the intercept of a hypersonic weapon.

MDA'S COUNTER-HYPERSONICS ROLE

The National Defense Authorization Act (NDAA) for Fiscal Year 2017 designated the Director, Missile Defense Agency (MDA) as the executive agent for the defense against hypersonic missile threats, including responsibility for developing capabilities to counter hypersonic boost-glide vehicles. Subsequent NDAAs for fiscal year 2020 and fiscal year 2021 directed DOD to assign the Director, MDA, primary responsibility to develop a hypersonic and ballistic tracking space sensor payload and mandated the Director, MDA to coordinate this effort with the Director of the Space Development Agency (SDA), among others.

NOTIONAL DEPICTION OF MDA'S COUNTER-HYPERSONICS ARCHITECTURE

GPI is expected to work with existing and future systems to provide hypersonic defense. After a missile launch, SDA's wide field of view satellites, capable of viewing large portions of the globe, detect the threat launch and send sensor measurement data to BOA, which generates track data with accuracy sufficient to cue HBTSS. HBTSS then acquires the deployed Hypersonic Glide Vehicle (HGV) and collects precision angle measurements. These measurements are processed by HBTSS, BOA, and Command, Control, Battle Management, and Communications (C2BMC) to provide fire control quality tracks on the HGV to Aegis for support of an engagement using GPI. Below is a notional depiction of this hypersonic defense scenario.



Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

GPI STATUS AND CHALLENGES

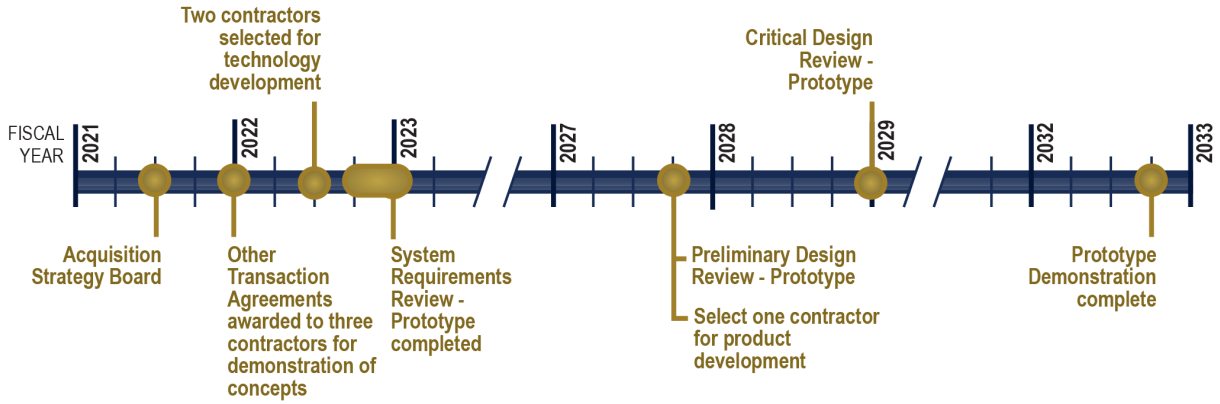
Events and Milestones

By the early 2030s, the GPI program plans to deliver a prototype capability for testing, demonstration data to inform further development, and 10 interceptors to be used for testing. The program established a plan to acquire the capability and identified key events and milestones for tracking development. The plan includes competitive development of the GPI missile leveraging multiple contractors to begin the effort, but only one contractor is anticipated to be selected to complete delivery of the prototype capability. In fiscal year 2022, MDA reported that three contractors were awarded Other Transaction Agreements to initiate work on the GPI program.[1] Later, in the fiscal year the program reported selecting two contractors to continue the development of GPI into the next phase of the acquisition process, technology development. In fiscal year 2023, the program expects to focus efforts on technology maturity and applying top level requirements to component level designs in preparation for the Preliminary Design Review.[2] Below are brief descriptions of these efforts.

- Determine the extent legacy components support missile designs. These determinations would help inform if additional testing and modifications of these components are necessary to ensure GPI requirements are met.
- Develop modeling and simulation tools to ensure robust missile modeling by Preliminary Design Review.
- Continue missile concept technical analysis, including refining algorithms to improve missile performance.
- Mature critical technology elements to ensure technologies reach a specific level of maturity by Preliminary Design Review.

The Preliminary Design Review is currently planned by the end of fiscal year 2027. The GPI program also anticipates down-selecting from two to one contractor near this date to continue until completing delivery of the prototype capability. See figure below for key events and milestones under the GPI program.

MDA Reported Key Milestones and Events for the Glide Phase Intercept Program



Source: GAO analysis of Missile Defense Agency data | GAO-23-106011

Note: As of March 2023, the Department of Defense reported in their Fiscal Year (FY) 2024 Budget Estimates updated planned dates for some Glide Phase Intercept program milestones and events. This includes Preliminary Design Review – Prototype in FY 2029, Critical Design Review – Prototype in FY 2032, and Prototype Demonstration complete in FY 2034.

Challenges

Previously we found in June 2022 that MDA had not planned to conduct an Independent Cost Estimate (ICE) or Independent Technical Risk Assessment (ITRA) for the GPI program before the product development phase, which is after the technology development phase.[3] These assessments are required for certain elements by DOD Directive-Type Memorandum 20-002 to mitigate risk. Since our reporting, MDA officials stated the Office of Cost Assessment and Program Evaluation (CAPE) completed a preliminary ICE for the GPI program in the August 2022 timeframe. As of February 2023, CAPE is working to finalize the ICE pending the final President's Budget program schedule. MDA officials also stated the Office of the Under Secretary of Defense for Research and Engineering completed an ITRA for the GPI program in the August 2022 timeframe as well. According to MDA, the ITRA found that the program should address technical risks earlier in the development schedule by building and testing hardware. The ITRA also recommended earlier testing. We plan to review the ICE and ITRA to assess whether MDA has acquired knowledge to manage risk for the GPI program.

[1]Other Transaction Agreements (OTA) are contracting mechanisms that are not subject to certain federal acquisition laws and requirements. See, e.g., 10 U.S.C. § 4022. OTAs are agreements other than procurement contracts, cooperative agreements, and grants. Cooperative agreements and grants are agreements with a principal purpose of transferring something of value (e.g., funding) to a recipient to carry out a public purpose rather than acquiring property or services for the DOD's direct benefit or use.

[2]Preliminary Design Review is a milestone in the acquisition process that ensures the preliminary design is complete and there is technical confidence it can meet the requirements.

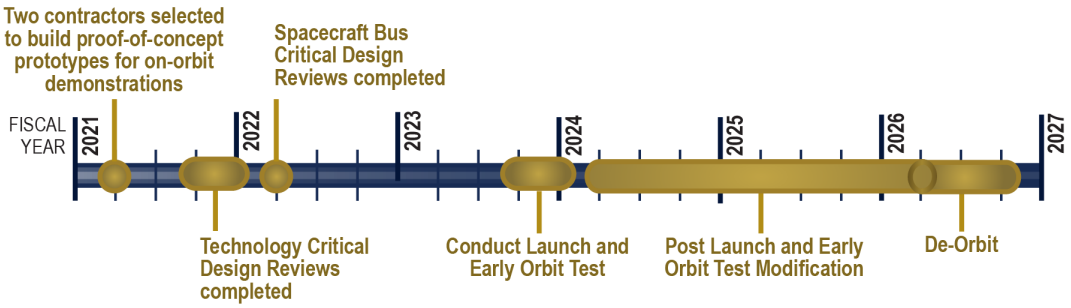
[3]See GAO, *Missile Defense: Better Oversight and Coordination Needed for Counter-Hypersonic Development,* GAO-22-105075 (Washington, D.C.: June 16, 2022).

HBTSS STATUS AND CHALLENGES

Events and Milestones

The HBTSS program plans to develop infrared sensors to provide missile tracking data on hypersonic and ballistic missile defense threats. To achieve this capability prototype HBTSS sensors will be mounted on satellites and integrated with satellite constellations developed by the SDA. Currently the HBTSS program is working on demonstrating proof-of-concept prototypes of the capability and two proof-of-concept prototype satellites are scheduled to launch and begin conducting early orbit test activities by the end of fiscal year 2023. While on orbit, the program plans to leverage MDA and partner flight test events and other targets of opportunity to characterize and validate HBTSS satellite performance. After on-orbit testing, MDA officials stated they would work with the SDA and Space Force to ensure warfighter requirements are met.[4] MDA efforts could include development of future missile defense sensor prototypes or additional on-orbit demonstrations to address evolving missile defense threats. See figure below for key events and milestones under the HBTSS program.

MDA Reported Key Milestones and Events for the Hypersonic and Ballistic Tracking Space Sensor Program



Source: GAO analysis of Missile Defense Agency data | GAO-23-106011

Challenges

We reported in June 2022 that MDA had not established a Memorandum of Understanding to delineate roles and responsibilities between the SDA, Space Force, and other relevant agencies for satellite development and operation in the missile defense and missile warning domains.[5] We indicated the lack of coordination could lead to the duplication of efforts with other DOD programs. In summer 2022, MDA, SDA, and the Space Force signed a Memorandum of Agreement to establish a combined program office that coordinates efforts for strategic missile warning, missile tracking, and missile defense. The agreement specifies responsibilities for each agency as well as initiatives in which all agencies will participate. MDA officials stated they have been working with the other agencies to ensure there is no overlap or duplication of efforts. For example, MDA officials provided examples where they were able to clarify roles and responsibilities with the other agencies that we previously found as lacking clarity:

- SDA is responsible for budgeting and delivering the HBTSS missile tracking capabilities into low earth orbit.
- SDA is responsible for operating the satellites that host the medium field of view sensors in future phases.
- SDA will procure launch services for both HBTSS and SDA wide field of view satellites for the operational constellation(s).

We plan to continue our review of the Memorandum of Agreement and conduct any follow-up work to determine if it sufficiently delineates roles and responsibilities for satellite development and operation in the missile defense and missile warning domains.

[4]The Space Development Agency coordinates the development and delivery of space-based capabilities. The Space Force is responsible for conducting global space operations. MDA is collaborating with both due to overlapping domains and missions.

[5]GAO-22-105075.

Source: Missile Defense Agency/Leah Garton. | GAO-23-106011

ISSUE OVERVIEW

Cruise Missile Defense

In 2019, the Missile Defense Agency (MDA) renamed its network of sensors, interceptors, and command and control capabilities from the Ballistic Missile Defense System to the Missile Defense System (MDS) to reflect a broadened focus on ballistic, cruise, and hypersonic missile threats. Cruise missiles are low-flying, maneuverable threats that can approach a target on a non-predictable path, while exploiting raised terrain and ground radar limitations to potentially avoid early detection (see figure). Hypersonic cruise missiles—those capable of flight at or above Mach 5—bring the additional challenge of high speed, which greatly compresses the timeline for detection and interception for the defender.

The cruise missile threat to the United States and its allies has grown over time. According to the Department of Defense (DOD), Russia and China continue to develop advanced cruise missiles that can be launched from aircraft, ground launchers, and ships or submarines. In addition, North Korea has also tested shorter range cruise missiles, and Iran has incorporated cruise missiles in attacks on its adversaries. Developing capability to counter this growing threat is necessary for an effective, layered missile defense. For modeling purposes, MDA uses data from North American Aerospace Defense Command (NORAD), U.S. Northern Command (USNORTHCOM), and National Air and Space Intelligence Center to define the characteristics of cruise missiles.

CURRENT CAPABILITY AND FUNDING

According to MDA officials, the MDS capability employed by the agency does not provide active defenses against cruise missile threats because it was not originally part of the agency's mission. In 2020, MDA was tasked to collaborate with NORAD and USNORTHCOM to develop notional cruise missile defense architecture options focused on the U.S. homeland.[1] After receiving USNORTHCOM requirements, MDA began developing an architecture and will lead a Joint Tactical Integrated Fire Control demonstration of limited cruise missile defense capabilities in the National Capital Region scheduled for fiscal year 2023. The effort includes developing systems engineering requirements, software modifications, models and simulations, and integration of joint sensors and launch vehicles into a fire control network.

MDA reported first receiving funds specifically to support cruise missile defense in fiscal year 2021. Although MDA did not request any funding for cruise missile defense, Congress appropriated $39.2 million to the agency, which MDA reports was in response to the fiscal year 2021 Unfunded Priorities List Report. According to MDA, in fiscal year 2022, MDA requested and received $13.9 million that was used for efforts related to the planned National Capital Region demonstration. MDA plans to use $10.9 million in fiscal year 2023 funding to continue those efforts.

[1]USNORTHCOM is DOD's leading geographic combatant command responsible for air defense of the continental United States. The United States and Canada established NORAD in 1957 to provide coordinated aerospace warning, air sovereignty, and protection for Canada and the continental United States. It was previously known as the North American Air Defense Command until 1981.

Cruise Missiles Can Evade Limited Radar Coverage

Source: GAO analysis of Missile Defense Agency documentation. | GAO-23-106011

MDA TO PLAY SUPPORTING ROLE ON U.S. HOMELAND DEFENSE

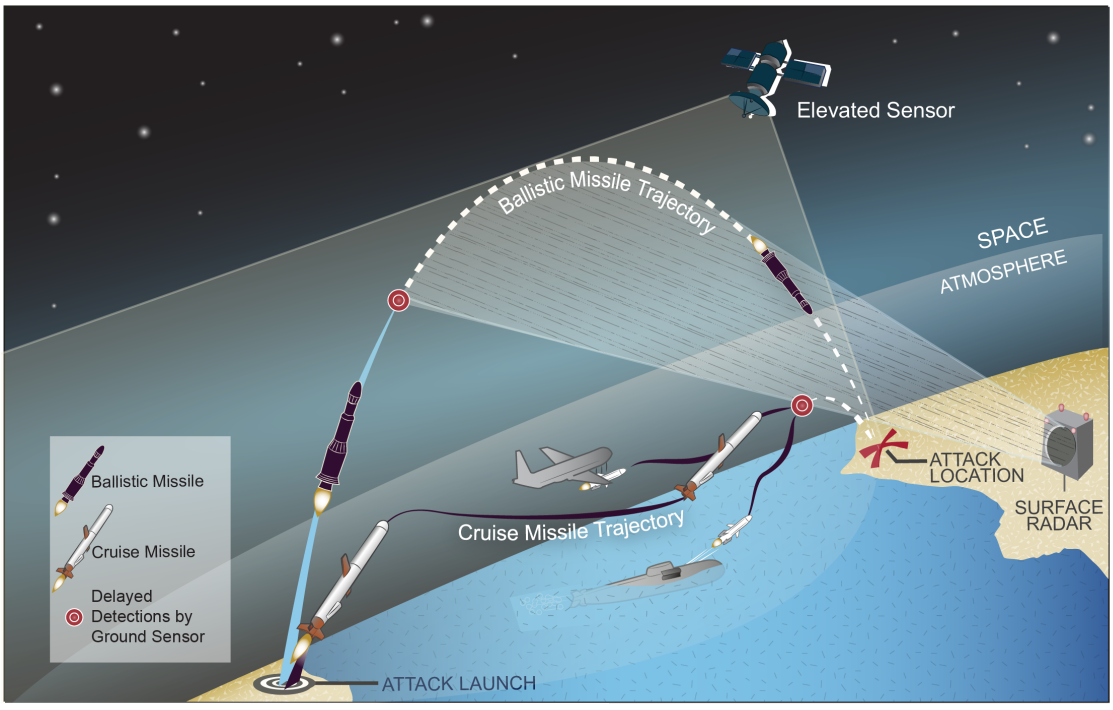
The National Defense Authorization Act for Fiscal Year 2017 included a statutory requirement for DOD to designate a lead acquisition organization for cruise missile defense of the U.S. homeland. The 2019 Missile Defense Review later highlighted the growing need for, among other things, improving defenses against evolving cruise missile threats. In August 2019, the Missile Defense Executive Board issued a recommendation to the Secretary of Defense that MDA be designated the lead acquisition organization. Although the secretary did not implement the board's recommendation, MDA began developing cruise missile defense architectures in 2020. MDA then performed an initial sensor and weapon coverage analysis based on USNORTHCOM's list of preferred proposed defended assets. In October 2022, the MDA's office responsible for cruise missile defense was absorbed by the MDA Chief Architect's Advanced Concepts Evaluations Group.

DOD designated the U.S. Air Force as the lead acquisition organization for cruise missile defense of the U.S. homeland in July 2022. According to a DOD document, the Department's designation reflected its priorities of domain awareness at range, early warning enhancements, and interagency air and space integration. While MDA and the Air Force had not yet formally agreed upon their roles and responsibilities, MDA has been working to ensure its plans for the National Capital Region demonstration align with the service's vision for cruise missile defense of the U.S. homeland. MDA officials said they were prepared to support the Air Force in its new role, including sharing prior analysis the agency developed in collaboration with NORAD and USNORTHCOM. MDA officials said they expect the Air Force to establish roles and responsibilities as a result of the service's mission analysis.

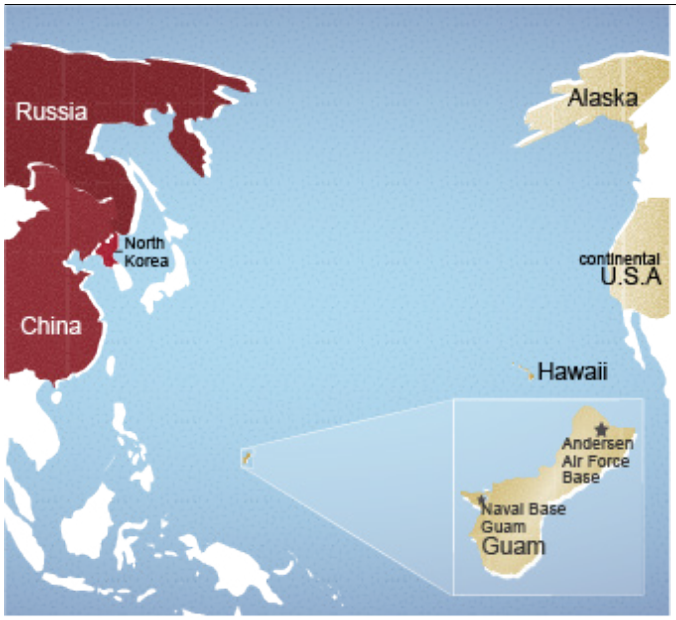
ARCHITECTURE REQUIREMENTS AND COST ESTIMATES

The 2022 Missile Defense Review states that the United States will examine active and passive defense measures to decrease the risk from any cruise missile strike against critical assets. Recent analyses of architecture requirements or acquisition and sustainment costs for cruise missile defense have focused on the U.S. homeland, with costs varying widely by the number of defended areas and type of fielded missile defense assets. In 2021, the Congressional Budget Office (CBO) published a report that investigated the threat that land-attack cruise missiles pose to the United States. The CBO report included four potential cruise missile defense architectures options with 20-year acquisition and sustainment costs ranging from $75 billion to $465 billion. According to the CBO report, the most significant factor in determining the effectiveness of a defensive architecture is the range of its radar sensors, which is determined primarily by their altitude. According to MDA officials, MDA's sensor and weapon analysis found that, although sites can be defended with current interceptors, elevated sensors are a critical component of any cruise missile defense architecture and must be developed to achieve required defensive capabilities. Elevated sensors, such as radars affixed to high towers or on satellites in low earth orbit, can expand the detection window for cruise missile threats relative to traditional ground sensors and provide decision-makers with more time to react and intercept the threat (see figure).

Elevated Sensors Expand the Detection Window for Cruise Missile Threats



Source: GAO analysis of Missile Defense Agency documentation. | GAO-23-106011



Source: GAO analysis of Department of Defense data; GAO (maps). | GAO-23-106011

ISSUE OVERVIEW

Defense of Guam

Guam is a United States island territory in the Indo-Pacific region. The island is approximately three times the size of Washington, D.C. with an estimated population of 170,000. Persons born on Guam are United States citizens.

Military officials have emphasized the importance of Guam for maintaining stability in the region. Guam serves as a hub for military operations, and multiple bases are on the island. Naval Base Guam is home to forward deployed naval vessels. Andersen Air Force Base provides millions of square feet to park aircraft. The Marine Corps activated Camp Blaz in 2020 and the base is under construction, with the intent of eventually accommodating approximately 5,000 Marines.

In recent years, according to DOD, North Korea and China have conducted missile tests that have heightened tensions in the region. Due to its proximity to these nations and its strategic importance, Guam is vulnerable to a potential attack. The 2022 Missile Defense Review states that the missile defense architecture for Guam will be commensurate with the island's unique status as both an unequivocal part of the United States as well as a vital regional location.

CURRENT CAPABILITIES AND NEW REQUIREMENTS

Guam's current missile defense requirements are for protection against simple ballistic threats from rogue states. As of October 2022, the on-island defense consisted of a single Terminal High Altitude Area Defense battery. A single ship equipped with the Aegis Ballistic Missile Defense system also provides support on an as-needed basis.

As adversary offensive missile capabilities evolve, DOD projects the current defense on Guam to be inadequate. In October 2022, MDA officials stated that United States Indo-Pacific Command, the combatant command overseeing the region, issued new requirements to upgrade Guam's defense. This includes 360 degree coverage, and layered defense against regional ballistic, maneuvering ballistic, hypersonic glide, and cruise missile threats emanating from any nation. The Guam defense systems would also employ open systems architecture—meaning adaptable systems—to enable the integration of future capabilities as sensors and weapons technologies evolve. See the table below for a comparison of the current and new requirements for missile defense on Guam.

Table 8: Defense of Guam Requirements Information Provided by the Missile Defense Agency

	Current Requirements	New Requirement
Nations	Rogue states [a]	Any nation, including rogue states[a] and near peer threats [b]
Coverage	No Requirement	360 degree coverage to defend against missile threats Layered defense with multiple elements capable of intercepting missile threats
Threats	Ballistic missiles [c]	Ballistic missiles[c] Maneuvering ballistic missiles[d] Hypersonic glide[e] Cruise missile[f]

Source: GAO analysis of Missile Defense Agency data | GAO-23-106011

[a]Limited offensive missile capability
[b]Significant and sophisticated offensive missile capability
[c]Parabolic and predictable flight path
[d]Capable of changing flight path
[e]Capable of flying in excess of Mach 5 and change flight path
[f]Capable of self-powered flight

ACQUISITION STRATEGY

According to MDA, the acquisition strategy for the Defense of Guam mission architecture consists of leveraging existing Army and Navy programs, Army rapid capability prototype efforts, and a new program that includes integration of the Aegis Guam Weapon System. The strategy aims to provide the capability to meet warfighter requirements to fulfill the Defense of Guam mission. MDA's primary mission, in coordination with the Navy, is ballistic and hypersonic defense on Guam, while the Army's primary mission is cruise missile defense. According to MDA, DOD is assessing whether an agency or service will serve as the lead for the Defense of Guam mission and coordinate the delivery of capabilities. MDA did not indicate when a decision could be made.

ARCHITECTURE

MDA, in coordination with the Army and the Office of Cost Assessment and Program Evaluation, considered multiple architectures for the Defense of Guam, including an Aegis Ashore-like approach. In 2022, however, the Deputy Secretary of Defense opted for an architecture consisting of transportable radars and launchers. MDA officials defined transportable components as having the ability to be deconstructed, relocated, and reconstructed in weeks to months within an area. Some components used from existing programs are expected to require adaptions to provide 360 degree missile defense coverage. For example, Aegis elements are expected to be adapted to be land based and transportable versus ship based or permanent structures.

MDA reported multiple components supporting the Defense of Guam. See table 9 below for these components.

Table 9: Missile Defense Components to Support the Defense of Guam

Type	Components	Owner	Description
Radars and sensors	Homeland Defense Radar – Guam (HDR-G)	MDA	Combined expected capabilities include 360 degree coverage for threat acquisition, track, and discrimination for ballistic, hypersonic, and cruise missile defense.
	Lower Tier Air and Missile Defense Sensor (LTAMDS)	Army	
	Sentinel A4	Army	
	Army Low Cost Surveillance (ALPS) Sensor	Army	
Command and control	Aegis Guam System	MDA/Navy	Combined expected capabilities include (1) weapons and radar command, control, and decision; (2) overhead and sensor data and situational awareness to warfighters and weapon systems; and (3) sensor, battle and communications management.
	Command and Control, Battle Management and Communications (C2BMC)	MDA	
	Integrated Air and Missile Defense Battle Command System (IBCS)	Army	
	Integrated Fires Communication Network (IFCN) Relays	Army	
	Remote Interceptor Guidance (RIG)-360	Army	
Launchers	Army Launchers	Army	Combined expected capabilities include utilization for ballistic, hypersonic, and cruise missile defense.
	M903 Launchers	Army	
	Indirect Fires Protection Capability (IFPC) Multi-Mission Launchers	Army	

Source: GAO presentation and analysis of Missile Defense Agency provided data. | GAO-23-106011

CURRENT ACTIVITIES AND TIMELINE

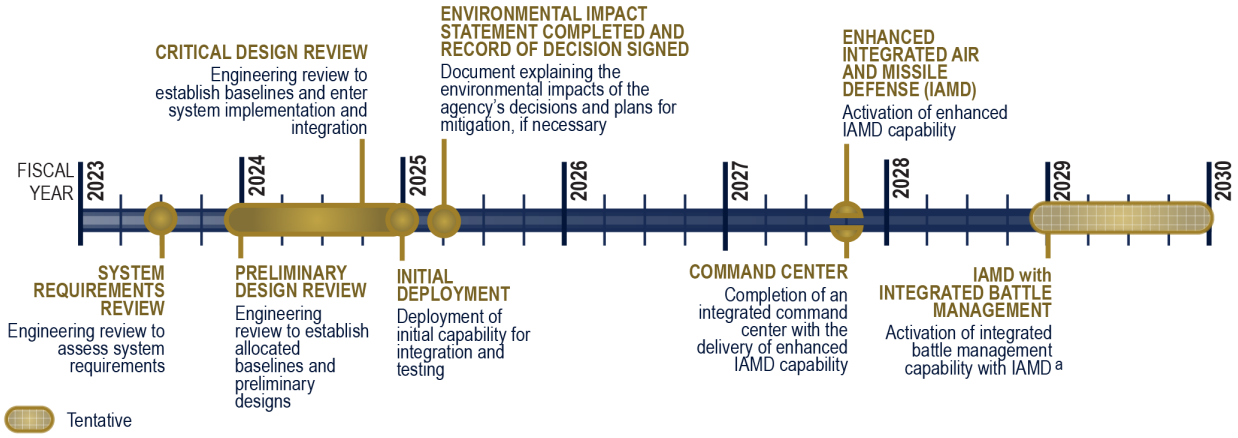
Site Selection

In fiscal year 2022, MDA reported receiving initial funding for the Defense of Guam mission and conducted site selection activities for missile defense components. MDA officials stated there are challenges in the site selection process. Available land is limited on the island and officials stated multiple entities compete for this land. They added Guam is also high risk for seismic activity and typhoons which will be factored into the military construction design considerations. Officials mentioned another factor to consider for possible sites is adjacent areas should not be affected by missile defense components and activities. For example, electromagnetic radiation from radars should not interfere with the surrounding air space and properties should be a sufficient distance away or barriers provided in the event of ordinance explosion. Officials noted environmental and cultural concerns are being considered, and the agency is involved in ongoing environmental impact studies. They stated initial sites are expected to be selected and approved in late fiscal year 2023.

Timeline

MDA has developed a plan to procure, acquire, develop, and integrate components and capabilities until the Defense of Guam architecture is operational. The figure below highlights key milestones and events over the next few years. In between milestones, MDA plans to conduct multiple developmental and operational tests. Initial deployment of limited equipment is expected to occur in early fiscal year 2025 and completion of the system is scheduled for fiscal year 2029.

Defense of Guam Key Milestones and Events



Source: GAO analysis of Missile Defense Agency data. | GAO-23-106011

[a]This event is not yet baselined and will not occur before the first quarter of fiscal year 2029.

Appendix X: GAO Contact and Staff Acknowledgments

GAO Contact

Jon Ludwigson at (202) 512-4841 or LudwigsonJ@gao.gov

Staff Acknowledgments

In addition to the contact named above, James Madar, Assistant Director; Pete Anderson; Dennis Antonio; Jennifer Franks; Tonya Humiston; Michelle Kim; John Ortiz; Ian Reed; Eric Smith; Steven B Stern; Brian Tittle; Hai V. Tran; and Alyssa Weir made key contributions to this report.

Appendix XI: Accessible Data

Data Tables

Data Table for Appendix I, Figure: Aegis BMD Fiscal Year 2022 Planned Testing

Test		Conducted	Delayed	Deleted
Flight	Non-intercept	3		
	Intercept	1		1
Ground		2	3	1
Cyber			1	

Data Table for Appendix II, Figure: C2BMC Fiscal Year 2022 Planned Testing

Test		Conducted	Delayed	Deleted
Flight	S8.2-3		1	
	S8.2-5	4	1	1
	S8.2-3 and S8.2-5	1		
Ground	S8.2-3	1		
	S8.2-5	1	3	1
	S8.2-3 and S8.2-5			
Cyber	S8.2-3			
	S8.2-5	1	6	
	S8.2-3 and S8.2-5			

Data Table for Appendix III, Figure: GMD Interceptor Deliveries, Fiscal Years 2018–2022

Fiscal Year	Planned Deliveries		Actual Deliveries		Non-deliveries	
	Total Quantity	Interceptor #	Total Quantity	Interceptor #	Total Quantity	Interceptor #
2018	4	#55-58	3	#54-56	2	#57-58
2019	1	#58	1	#57	1	#58
2020	1	#58	0	-	1	#58
2021	0	-	0	-	1	#58
2022	2	#59-60	2	#58-59	1	#60

Data Table for Appendix III, Figure: GMD Fiscal Year 2022 Testing

Test		Conducted	Delayed	Deleted
Flight	Non-intercept		1	
	Intercept			
Ground		2	3	
Cyber			4	

Data Table for Appendix IV, Figure: Sensors Fiscal Year 2022 Testing

Test		Conducted	Delayed	Deleted
Flight	Non-intercept	2	1	
	Intercept	3	1	
Ground		2	5	
Cyber		3	3	

Data Table for Appendix V, Figure: Targets Fiscal Year 2022 Deliveries

	Planned Deliveries	Completed Deliveries
Short-range ballistic missile (SRBM)	1	1
Medium-range ballistic missile (MRBM)	4	5
Intermediate-range ballistic missile (IRBM)	2	1
Intercontinental ballistic missile (ICBM)	0	0

Data Table for Appendix V, Figure: Targets Flown During Fiscal Year 2022 Flight Testing

Target range		Test
Short-range	Non-intercept	
	Intercept	1
Medium-range	Non-intercept	1
	Intercept	
Intermediate-range	Non-intercept	1
	Intercept	
Intercontinental-range	Non-intercept	1
	Intercept	

Data Table for Appendix VI, Figure: THAAD Fiscal Year 2022 Testing

Test		Conducted	Delayed	Deleted
Flight	Non-intercept	1		
	Intercept	1		
Ground		3	2	1
Cyber		2		

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