United States Government Accountability Office

Report to Congressional Committees

June 2022

MISSILE DEFENSE

Better Oversight and Coordination Needed for Counter-Hypersonic Development

GAO-22-105075

GAO Highlights

Highlights of GAO-22-105075, a report to congressional committees

June 2022

MISSILE DEFENSE

Better Oversight and Coordination Needed for Counter-Hypersonic Development

Why GAO Did This Study

Since MDA was established in 2002, the Department of Defense has spent over $174 billion to equip operational commanders with a network of sensors, interceptors and command and control capabilities collectively called the Missile Defense System. Since 2017, MDA's mission has broadened to include hypersonic weapons, which are difficult to track and defeat because they are capable of maneuvering during flight.

Congress included provisions in legislation for GAO to annually assess MDA's progress toward meeting its acquisition goals. This report—the 19th to date—assesses (1) MDA's progress achieving its delivery and testing goals for fiscal year 2021, and (2) MDA's efforts to defend against hypersonic weapons. To conduct this work, GAO reviewed MDA's baseline reports, test plans, and the agency's responses to detailed question sets. GAO also interviewed officials within MDA and DOD.

What GAO Recommends

GAO recommends that the Undersecretary of Defense for Acquisition and Sustainment ensure that MDA obtains an independent technical risk assessment and cost estimate for the GPI effort.

GAO also recommends that, for the HBTSS effort, the Secretary of Defense ensures the responsibilities for satellite development and operation in the missile defense and missile warning domains are properly delineated.

DOD concurred with GAO's recommendations.

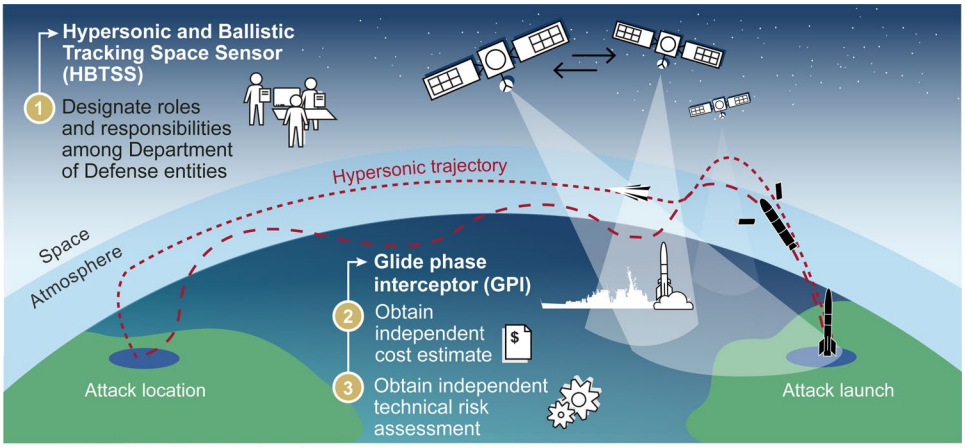
View GAO-22-105075. For more information, contact John D. Sawyer at (202) 512-4841 or SawyerJ@gao.gov.

What GAO Found

The Missile Defense Agency (MDA) continues to build components of the Missile Defense System (MDS), test its capabilities, and plan for countering evolving threats. In fiscal year 2021, MDA made progress, but continued to fall short of its goals for asset deliveries and testing. For example, MDA successfully delivered many of the planned interceptors and conducted developmental and operational cybersecurity testing for MDS elements; however, MDA did not conduct any planned system-level cybersecurity tests—leaving MDA without knowledge of its systems' vulnerabilities and contributing to programmatic delays. The shortfalls to planned system-level tests were partially attributable to the COVID-19 pandemic.

MDA's efforts to address hypersonic threats include the Glide Phase Interceptor (GPI) and Hypersonic and Ballistic Tracking Space Sensor (HBTSS). These efforts represent technologies that have considerable risks, but MDA has not taken necessary steps to reduce risks and ensure appropriate oversight from the Department of Defense (DOD) or stakeholder involvement.

Missile Defense Agency's Hypersonic Efforts in a Notional Scenario



Source: GAO analysis of Missile Defense Agency documentation. | GAO-22-105075

- GPI is a missile designed to shoot down a hypersonic weapon in the middle (or glide phase) of its flight. Contrary to a DOD directive with which MDA has aligned its effort, at the time of our review, MDA did not plan to obtain an independent technological risk assessment to determine the maturity of the technologies before proceeding with development. In addition, MDA did not plan to obtain an independent cost estimate.

- HBTSS is a concept of space-based sensors to track the unique flight path of a hypersonic weapon. However, MDA has not adequately coordinated the HBTSS effort with DOD's Space Development Agency and Space Force.

Increased DOD oversight and involvement would reduce risk. In addition, more clearly delineated roles and responsibilities would help avoid duplication, overlap, or fragmented capabilities among MDA and other DOD space agencies.

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Abbreviations

AA	adversarial assessment
AA	Aegis Ashore
A&S	Acquisition and Sustainment
ACD	Adversarial Cybersecurity Developmental Test and Evaluation
AN/TPY-2	Army Navy/Transportable Radar Surveillance and Control Model 2
ASD	At-Sea Demonstration
AWS	Aegis Weapon System
BAR	Ballistic Missile Defense System Accountability Report
BMD	Ballistic Missile Defense
BMDS	Ballistic Missile Defense System
BOA	BMDS Overhead Persistent Infrared Architecture
C2BMC	Command, Control, Battle Management, and Communications
CAPE	Cost Assessment and Program Evaluation
CE	Capability Enhancement
CVI	Cooperative Vulnerability Identification
CVPA	Cooperative Vulnerability and Penetration Assessment
DARPA	Defense Advanced Research Projects Agency
DFARS	Defense Federal Acquisition Regulation Supplement
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
DTM	Directive Type Memorandum
EPAA	European Phased Adaptive Approach
FS	Formidable Shield
FTI	Flight Test Integrated
FTM	Flight Test Aegis Weapon System
FTP	Flight Test Patriot Weapon System
FTT	Flight Test Terminal High Altitude Area Defense Weapon System
FTX	Flight Test Other

Abbreviations Continued

GBI	Ground-Based Interceptor
GM BVT	GMD Booster Vehicle Test
GMD	Ground-Based Midcourse Defense
GPI	Glide Phase Interceptor
GT	Ground Test
GTD	Ground Test Distributed
GTI	Ground Test Integrated
HAWC	Hypersonic Air-Breathing Weapon Concept
HBTSS	Hypersonic and Ballistic Tracking Space Sensor
HWIL	hardware in the loop
ICBM	intercontinental ballistic missile
ICE	independent cost estimate
IMTP	Integrated Master Test Plan
IRBM	intermediate-range ballistic missile
ITRA	independent technical risk assessment
JCE	joint cost estimate
JEON	Joint Emergent Operational Need
LBRR	lab based risk reduction
LRDR	Long Range Discrimination Radar
MDA	Missile Defense Agency
MDIOC	Missile Defense Integrated Operations Center
MDS	Missile Defense System
MFOV	Medium Field of View
MRBM	medium-range ballistic missile
MSE	Missile Segment Enhancement
NATO	North Atlantic Treaty Organization
NDAA	National Defense Authorization Act
NGI	Next Generation Interceptor
O&S	operations and sustainment
OTA	Operational Test Agency
OUSD	Office of the Under Secretary of Defense
pLEO	proliferated low earth orbit
radome	radar dome
R&E	Research & Engineering
RDT&E	research, development, test, and evaluation
RKV	Redesigned Kill Vehicle
SBX	Sea Based X-Band
SDA	Space Development Agency

Abbreviations Continued

SM	Standard Missile
SM CTV	Aegis Weapon System Controlled Test Vehicle
SRBM	short-range ballistic missile
TBG	Tactical Boost Glide
TCD	Technical Capability Declaration
THAAD	Terminal High Altitude Area Defense
TH CTV	Terminal High Altitude Area Defense Weapon System Controlled Test Vehicle
TLRD	Top Level Requirements Documents
UEWR	Upgraded Early Warning Radar
USNORTHCOM	United States Northern Command
WBS	work breakdown structure
WFOV	Wide Field of View

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Congressional Committees

Over the past 2 decades, the Missile Defense Agency (MDA) has made significant strides in developing, testing, and fielding missile defense capabilities to defend the U.S. homeland, allies, and deployed forces against missile threats. Since MDA was established in 2002, the Department of Defense (DOD) has spent over $174 billion to equip operational commanders with a network of sensors, interceptors, and command and control capabilities—collectively called the Missile Defense System (MDS)—to detect, track, and destroy incoming missiles.[1] However, according to DOD, potential adversaries are also investing substantially in their offensive missile capabilities and have made significant advancements. For example, North Korea has developed 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 missiles, known as hypersonic missiles, that can travel at exceptional speeds with unpredictable flight paths to evade missile defense systems.

As MDA enters into its third decade of operations, it will have to confront persistent challenges. Our prior reporting on missile defense acquisitions shows that MDA perennially struggles to fully achieve its annual acquisition goals and has had to cancel a number of critical efforts due to cost and technical challenges—a trend the department indicated must not continue given the importance of these systems. In 2020, DOD made changes to missile defense acquisition processes and responsibilities to better balance acquisition speed and programmatic risk. We found in November 2021 that the changes DOD made have the potential to improve MDA's acquisition outcomes, but more time is needed to measure the effects, as DOD is in the early stages of implementing the changes.[2] As MDA moves forward, it continues to face technical challenges and schedule pressures with fielding missile defense capabilities necessary to keep pace with evolving missile threats. MDA's

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

[2]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).

newest and most advanced efforts to defend against complex missile threats require high levels of research and development that entail significant technical risks.

Moreover, DOD and Congress will soon face difficult decisions over whether and how to fund the next generation of missile defense capabilities while also continuing to support MDA's existing portfolio of systems. In July 2020, we found that MDA is at a pivotal crossroad in terms of its ability to pursue new and advanced efforts while also maintaining its existing portfolio of systems that have not transferred to the military services.[3] According to DOD, concerns over cost and programmatic risks, among other items, have prevented the department from meeting a legislative directive to transfer missile defense programs from MDA to the military services once they reach the production phase of the acquisition process.[4] As a result, a growing portion of MDA's budget is occupied by production, operations, and sustainment expenses, with less funding available to dedicate to research and development. Budgeting for these programs, also known as elements, presents further challenges for decision makers because, as we found in February 2022, the full extent of missile defense operations and sustainment costs are not reported—expenses that can constitute a large portion of a program's overall cost.[5]

Since 2002, various National Defense Authorization Acts (NDAA) have included provisions for us to prepare annual assessments of MDA's progress toward meeting its acquisition goals. Specifically, the National

[3]GAO, *Missile Defense: Assessment of Testing Approach Needed as Delays and Changes Persist*, GAO-20-432 (Washington, D.C.: July 23, 2020).

[4]Congress described "missile defense program" (which we refer to simply as "programs" throughout this report) as "a missile defense program of the Missile Defense Agency that, as of the date specified in paragraph (1), has received Milestone C approval (as defined in section 2366 of title 10, United States Code)." National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91, § 1676(b) (2017). Congress mandated that MDA transfer the acquisition and total obligation authority of its missile defense programs to the military services by the time the President's fiscal year 2021 budget was submitted, later extended this deadline to the President's fiscal year 2023 budget submission, and again extended it to October 1, 2023. Pub. L. No. 115-91, § 1676(b), as amended by the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021, Pub. L. No. 116-283, § 1643 (2021), and National Defense Authorization Act for Fiscal Year 2022, Pub. L. No. 117-81, § 1663 (2021).

[5]GAO, *Missile Defense: Addressing Cost Estimating and Reporting Shortfalls Could Improve Insight into Full Costs of Programs and Flight Tests*, GAO-22-104344 (Washington, D.C.: Feb. 2, 2022).

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 Ballistic Missile Defense System Accountability Report (BAR) and include any other findings and recommendations on MDA's acquisition programs and accountability, as appropriate.[6] This report addresses the extent to which MDA (1) achieved its fiscal year 2021 baseline delivery and testing goals; and (2) reduced technological risks and coordinated with other DOD components on its counter-hypersonics efforts.

Detailed assessments of the 12 MDS elements we reviewed are found in appendixes I–VI. In addition, appendix VII includes our review of MDA's development of a Joint Emergent Operational Need.[7] Lastly, information regarding the status of our recommendations pertaining to missile defense can be found in appendix VIII. DOD continues to implement some of our prior recommendations. However, not all of our recommendations have been fully implemented.

To assess the extent to which MDA achieved its fiscal year 2021 baseline goals, we reviewed and identified the agency's delivery and testing plans as stated in the BAR and Integrated Master Test Plan (IMTP). Both of these documents correspond to MDA's fiscal year 2021 budget request, constituting the plans for which the agency requested funds to execute in fiscal year 2021. We focused our assessment on: (1) assets—primarily hardware but also software builds and other items; and (2) flight, ground, and cybersecurity tests. In addition, we reviewed agency documents, such as program execution briefings, and obtained responses to questionnaires we sent to DOD components and MDA programs. We also met with MDA program offices to obtain further insights.

[6]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).

[7]A report accompanying an introduced bill (S. 2987) included a provision for GAO to review the Missile Defense Agency's progress addressing a Joint Emergent Operational Need. S. Rep. No. 115-262, at 354 (2018). On October 10, 2019, we sent a draft report for the engagement to the Department of Defense for agency comment and a security review. DOD's response was significantly delayed and not provided until over 1 year later. However, the findings of the draft report had changed dramatically since October 2019. Consequently, we updated the findings from that draft report in appendix VII.

To assess MDA's efforts to develop counter-hypersonic capabilities, we reviewed plans and schedules identified in the BAR and reviewed MDA documents from its counter-hypersonic programs. We obtained responses to questionnaires from MDA and interviewed agency officials. We also interviewed officials and reviewed budget and acquisition planning documents from the Space Development Agency (SDA), Office of the Under Secretary of Defense (OUSD) for Acquisition and Sustainment (A&S), and OUSD for Research and Engineering (R&E). We compared our findings from these interviews and document reviews against criteria established in: (1) law, such as the National Defense Authorization Act for Fiscal Year 2020; (2) DOD policy; and (3) GAO-identified leading practices for knowledge-based acquisition and cost estimation.[8]

We conducted this performance audit from April 2021 to June 2022 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 a number of programs, also known as elements, with the purpose of defending against missile attacks. MDA's mission is to combine these elements into an integrated system-of-systems, known as the MDS. The goal of the MDS is to combine the abilities of two or more elements to achieve objectives that would not have been possible for any individual element. These emergent abilities are known as integrated capabilities or MDS-level capabilities, and are organized by increments, characterized by a set of individual elements

[8]For examples, see GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, GAO-20-195G (Washington, D.C.: Mar. 12, 2020); and *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).

combining to provide a certain capability.[9] Figure 1 provides a list and description of programs included in our review.

[9]As we previously reported, MDA has experienced difficulties in delivering the increments as planned. Specifically, some of the delivered increments include a more scaled-back capability than originally planned. In addition, in certain cases, the increments were delivered with insufficient testing to demonstrate the capability against the planned threats. For further details, see GAO, *Missile Defense: Some Progress Delivering Capabilities, but Challenges with Testing Transparency and Requirements Development Need to Be Addressed*, GAO-17-381 (Washington, D.C.: May 30, 2017); *Missile Defense: The Warfighter and Decision Makers Would Benefit from Better Communication about the System's Capabilities and Limitations,* GAO-18-324 (Washington, D.C.: May 30, 2018); and *Missile Defense: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability*, GAO-19-387 (Washington, DC.: June 6, 2019).

Figure 1: Description of Missile Defense System (MDS) Programs

	Name		Description
Aegis Weapon System		**Aegis BMD**	Ship- and land-based ballistic missile defense capabilities using a radar, command and control, and Standard Missile (SM)-3 interceptors.
		**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-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 to detect threat missiles once launched, or (2) terminal mode—used 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 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**	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]**	A variety of short-, medium-, intermediate-, and intercontinental-range targets to represent 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).
		**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-22-105075

Note: MDA is developing and has already fielded additional elements for the MDS that are not included in this report because they fall outside the scope of the BMDS Accountability Report.

[a]Targets and Countermeasures provide assets to test the performance and capabilities of the MDS elements, but these testing assets are not operationally fielded.

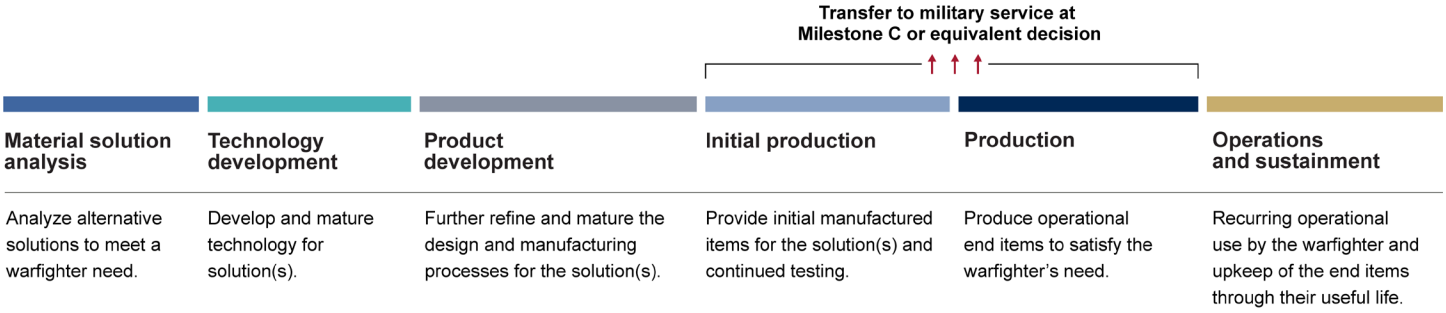
MDA's Acquisition Flexibilities and Steps to Improve Traceability and Oversight

When MDA was established in 2002, it was granted exceptional flexibilities to set requirements and manage the acquisition of the Ballistic Missile Defense System (BMDS)—developed as a consolidated system consisting of underlying elements or programs—that allowed MDA to expedite the fielding of assets and integrated missile defense capabilities. These flexibilities continue to allow MDA to diverge from DOD's traditional acquisition life cycle. They also allow MDA to defer the application of certain acquisition policies and laws designed to facilitate oversight and accountability until a mature capability is ready to be handed over to a military service for production and operation. Some such laws and policies include:

- obtaining the approval of a higher-level acquisition executive before making changes to an approved baseline;
- reporting certain increases in unit cost measured from the original or current baseline; and
- regularly providing detailed program status information to Congress, including specific costs, in Selected Acquisition Reports.

MDA also established an acquisition process that continues to guide the development of the MDS. Figure 2 describes the life-cycle phases of MDA's acquisition process.[10]

Figure 2: Missile Defense Agency (MDA) Acquisition Life-Cycle Phases



Source: GAO analysis of MDA data. | GAO-22-105075

DOD issued a memorandum in March 2020, called Directive-Type Memorandum (DTM-20-002), after completing studies in 2019 of MDA's acquisition approaches and determining that changes were needed in

[10]See appendixes I-VI for additional specifics on the status of each program regarding its acquisition life-cycle. In general, each program proceeds through all acquisition phases, although some phases are not applicable to certain programs.

order to reduce acquisition risk and promote MDS element transfers to military services. This memorandum required, among other items, external independent cost and technology risk assessments to occur earlier in MDS program development.[11] The memorandum also 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 Director, MDA.

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 our identified acquisition best practices but will likely take some time for DOD to implement.[12] However, we also found that DOD did not fully align missile defense programs undergoing early development to warfighter-validated requirements, increasing the risk of MDA delivering capabilities that do not fully meet the warfighter's needs. We recommended DOD establish processes and products to ensure MDA's programs are fully aligned with warfighter requirements, but the OUSD(R&E) did not agree, citing the need for MDA to retain the flexibility to develop capabilities based on existing technologies. Notably, OUSD(A&S) agreed with our recommendations, stating that they would involve the warfighter earlier in development to ensure operational requirements are met and potentially reduce the risk of having to make costly, time-consuming changes later in the process. Other DOD components, including U.S. Strategic Command and the Joint Staff, agreed with our recommendations, and we continue to believe that DOD should implement them. We will continue to monitor DOD's progress in aligning missile defense programs early in their development to warfighters' needs.

Flight, Ground, and Cybersecurity Testing within MDA

MDA's testing baseline—the IMTP—designates all of its system-level testing for the upcoming and future fiscal years and supports its funding requests. Specifically, it identifies each test by name, including the type of test, any targets (if applicable), and the fiscal year quarter of the test's planned execution. MDA finalizes the IMTP and it is signed by the Director, MDA and key external stakeholders semi-annually.

[11]Deputy Secretary of Defense, *Missile Defense System Policies and Governance, Directive-Type Memorandum (DTM) 20-002* (Mar. 13, 2020).

[12]GAO-22-563.

Testing, in general, is performed to collect critical data on individual elements or the integrated system to: (1) determine whether it is properly designed, built, and integrated; (2) understand its performance, including its capabilities and limitations; and (3) support next steps and decisions. MDA's testing, specifically, is both developmental and operational, the former verifying the design is built correctly and the latter demonstrating the system can successfully accomplish its mission in the hands of the warfighter under realistic conditions. In addition, MDA uses multiple methods including flight, ground, and cybersecurity to determine whether the element's or MDS's design will satisfy the desired capabilities. Table 1 provides additional information on the type and key purposes of MDA testing.

Table 1: Missile Defense Agency (MDA) Testing

Type	Key purposes	Evaluators
Flight	• Includes intercept and non-intercept testing • Uses actual Missile Defense System (MDS) elements and their components to assess and demonstrate performance	• MDS Operational Test Agency (OTA)[a] • 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	• Uses computer simulations of system performance • Uses combination of actual element and system-level models • Allows for testing under a wider variety of conditions than can be accomplished through flight testing	• MDS OTA • DOT&E • Under Secretary of Defense for Research and Engineering, Director, Developmental Test, Evaluation, and Assessments
Cybersecurity	• Designed to identify cyber vulnerabilities and examine potential attack paths • Evaluates operational cyber defense capabilities • Provides initial information about the resilience of a systems cyber capability	• 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-22-105075

[a]OTAs are independent operational testing agencies that conduct operational evaluations of operational effectiveness, operational suitability, and lethality. The MDS OTA conducts independent operational assessments of MDS capability and provides recommendations to the Commanding General, Army Test and Evaluation Command. MDA funds all the MDS OTA activities.

MDA's Counter-Hypersonic Threats Efforts

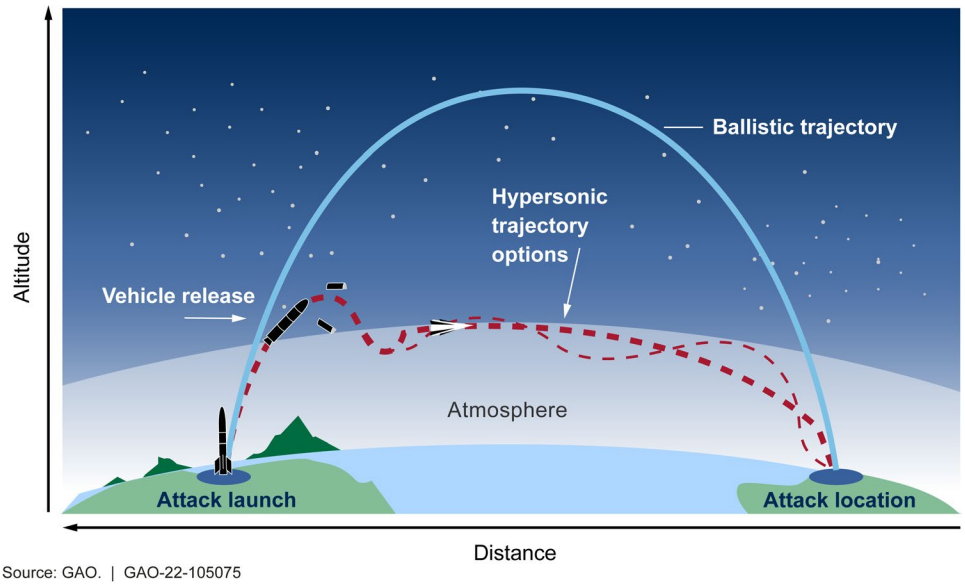
Starting in 2017, MDA has been directed to take on increasing responsibilities for the defense against hypersonic weapons. Specifically, the NDAA for Fiscal Year 2017 designated the Director, MDA as the executive agent for the defense against hypersonic missile threats.[13] The 2019 Missile Defense Review confirmed MDA's leading role in developing defenses against hypersonic weapons and emphasized the importance of developing a space-based sensor to support this capability.[14]

Hypersonic weapons are capable of flight at speeds five times the speed of sound (Mach 5) or greater, are capable of maneuvering in flight, and spend the majority of their flight path inside the atmosphere. Hypersonic weapons can provide several advantages over ballistic missiles. Their ability to maneuver in flight helps to obscure their intended target. In addition, their comparatively lower altitude and high speed make tracking them with conventional ground sensors difficult. Both of these features greatly complicate the objective of intercepting them (see figure 3).

[13]National Defense Authorization Act for Fiscal Year 2017, Pub. L. No. 114-328, § 1687 (2016). For DOD, an executive agent is the head of a DOD component to whom the Secretary of Defense or the Deputy Secretary of Defense has assigned specific responsibilities, functions, and authorities to provide defined levels of support for operational missions, or administrative or other designated activities that involve two or more of the DOD components.

[14]Department of Defense, Office of the Secretary of Defense, *Missile Defense Review* (Washington, D.C.: 2019).

Figure 3: Ballistic vs. Hypersonic Missile Trajectories



Source: GAO. | GAO-22-105075

MDA has two main efforts to develop defenses against hypersonic weapons: the Glide Phase Interceptor (GPI)—a missile designed to intercept a hypersonic weapon in the middle (or "glide") phase of its flight path. In addition, the Hypersonic and Ballistic Tracking Space Sensor (HBTSS) program—an effort to develop space-based sensors to track and potentially support the intercept of a hypersonic weapon.[15]

Glide Phase Interceptor

The GPI effort is still in the early stages of the acquisition process, but several important milestones are scheduled for fiscal year 2022, including a system requirements review and entry into the technology development phase. Over the course of fiscal year 2021, MDA developed a contract and acquisition strategy, seeking to award contracts in fiscal year 2022 and demonstrate a capability—if funding becomes available—by 2028.[16]

[15]According to MDA officials, these two programs are not the only counter-hypersonic efforts currently underway. MDA's Sea-Based Terminal effort uses the Navy's Standard Missile (SM)-6 against a hypersonic weapon in the final phases of its flight. MDA is also adapting or upgrading existing systems like C2BMC and AN/TPY-2 to support hypersonic defense.

[16]The fiscal year 2028 completion date for the Glide Phase Interceptor effort was contingent on funding availability. However, the President's budget request for fiscal year 2023, released March 28, 2022, reflects a funding profile that targets the 2030s for delivery.

Program documentation from this period states that the GPI effort was aligned with DTM-20-002, which among other things, prescribes procedures for missile defense system research, development, test, and evaluation, and procurement. GPI planning documents from fiscal year 2021 also indicate that the current phase of the effort would target a formal operational release of the capability to warfighters. MDA later backed away from this goal, at least for the current phase of the effort.[17]

MDA officials describe the current phase of the GPI effort as an "operational capability demonstration." MDA officials explained that this term describes an effort to rapidly develop and build a small number of demonstrator interceptors, with a portion intended for flight testing and any remaining available for future use. In this approach, acquisition plans and cost estimates do not extend past the research and development and initial production phases.

Hypersonic and Ballistic Tracking Space Sensor

The HBTSS program has existed in some form since 2018. In its current iteration, the program is developing an infrared sensor and algorithm that, when mounted to a satellite, will be able to detect a hypersonic weapon against the cluttered background of the surface of the earth and provide intercept-quality data to the GPI, among other systems. HBTSS's current phase is a prototype, not an operational capability, with two contractors demonstrating their design. The current phase of HBTSS seeks to place two demonstration sensors into orbit by the end of fiscal year 2023. Eventually, HBTSS will be integrated into a broader set of satellite constellations that are being developed by the Space Development Agency (SDA). DOD established SDA in 2019 to lead the development and deployment of new satellite architectures, emphasizing the use of large numbers of smaller, cheaper satellites in lower orbits. This concept is known as proliferated, low earth orbit (pLEO), and at present, SDA is developing multiple constellations (or "layers") to meet different requirements, including one for missile warning and missile defense. For this layer, SDA is developing satellites with a so-called Wide Field of View (WFOV) sensor. If deployed in sufficient numbers these WFOV sensors would provide "global persistence," meaning the ability to view the entire surface of the earth without gaps in coverage. According to MDA officials, the HBTSS sensor will employ a Medium Field of View (MFOV) sensor that lacks the ability to view the entire earth at once but would provide

[17]MDA said that, in lieu of an operational release, the agency will define completion of the current phase as demonstrating that the new GPI capability is "safe and technically effective in augmenting or enhancing a Combatant Commander's ability to conduct missile defense missions." We will continue to monitor the effect of this change.

greater sensitivity, and thus better accuracy, than a WFOV sensor. SDA is planning to launch eight WFOV satellites starting in fiscal year 2022. In an operational constellation, both MFOV satellites and WFOV satellites would work together with WFOV satellites initially detecting a hypersonic weapon and providing a cue to the MFOV satellites, that tells them where to look in order to provide missile tracking data. Currently, SDA reports to the OUSD(R&E), but as of the start of fiscal year 2023, the agency will become a branch of the Space Force.[18]

MDA Did Not Meet Acquisition Goals for Asset Deliveries or Testing in Fiscal Year 2021

MDA Did Not Deliver All Assets as Planned for Fiscal Year 2021

While MDA continued to deliver planned interceptors, it did not achieve all interceptor goals nor deliver the radar site as expected. Table 2 shows MDA fell short of the planned number of Aegis Standard Missile (SM)-3 Block IB and SM-3 Block IIA interceptors and did not complete delivery of the Long Range Discrimination Radar (LRDR) site. Although more Terminal High Altitude Area Defense (THAAD) interceptors were delivered than planned, MDA did not complete delivery of a specific lot of THAAD interceptors planned in fiscal year 2021.[19] The reduced number of delivered assets leaves MDA with less fielded capability than planned. For further details on individual programs, see appendixes I-VI.

[18]U.S. Space Force was established December 20, 2019, as a branch of the armed forces. Its missions include conducting space operations and protecting the interests of the United States in space.

[19]For further details on THAAD deliveries, see appendix VI.

Table 2: Missile Defense Asset Deliveries in Fiscal Year 2021

Asset	Planned delivery	Actual
Standard Missile-3 Block IB	32 interceptors	**23 delivered**. Goal not met as deliveries placed on hold until the resolution of a failure review investigation.[a]
Standard Missile-3 Block IIA	7 interceptors	**3 delivered**. Production temporarily halted during the year due to missile assembly issues.
Ground-Based Interceptors	0 interceptors	**0 delivered**. 1 planned delivery for fiscal year 2020 still not delivered in fiscal year 2021.[b]
Long Range Discrimination Radar	1 radar site	**0 delivered**. Radar delivery delayed due to cessation of work at Clear Space Force Station for COVID-19 safety and other integration challenges.
Terminal High Altitude Area Defense Interceptors	84 interceptors	**105 delivered**. Delivery includes 21 interceptors that were previously delayed and not planned for this year.

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

[a]For further details on Standard Missile-3 Block IB deliveries, see appendix I.

[b]According to Missile Defense Agency officials, the ground based interceptor was delivered in fiscal year 2022.

According to MDA, the primary causes for production issues that hindered fiscal year 2021 delivery goals include the following:

- **Standard Missile-3.** Entering into and during fiscal year 2021, MDA officials stated the SM-3 Block IIA program encountered multiple assembly issues that led to delays and a halt in production. First, in August 2020, MDA identified an electrical current problem due to errors in circuit card assembly. In October 2020, MDA discovered a second issue—loose wires in three separate missile assemblies—and decided to suspend production until the problem was fully resolved. According to officials, MDA has since made repairs to missiles in the fleet, as necessary, and updated instructions and wire testing procedures. MDA officials said SM-3 Block IIA deliveries are in progress. Officials also commented on the SM-3 Block IB program and they did not indicate any production concerns; however, planned deliveries were placed on hold to investigate possible issues with those interceptors.
- **Ground-Based Midcourse Defense.** The Ground-Based Midcourse Defense (GMD) program did not plan to deliver any interceptors in fiscal year 2021, even though one interceptor planned for fiscal year 2020 still had not been delivered. According to MDA officials, this

interceptor ultimately was delivered in fiscal year 2022. In previous reports, we found that parts issues contributed to delays.[20]

- **Long Range Discrimination Radar.** MDA planned to complete delivery of the LRDR site in fiscal year 2021, but, according to MDA, the COVID-19 pandemic affected the delivery schedule. First, Clear Space Force Station, Alaska, the location of LRDR, was shut down due to the pandemic, and all construction and radar integration work was temporarily halted. Officials noted other reasons contributing to the delay, including travel restrictions and general inefficiencies caused by COVID-19 limitations. Overall, MDA officials said COVID-19 delayed the delivery schedule by over 4 months. However, MDA did complete construction in the first quarter fiscal year 2022.[21]

MDA's failure to meet its planned deliveries in fiscal year 2021 is consistent with its performance from prior years. While delivery performance has varied by MDS element, our prior work identified overarching challenges across elements that affected planned deliveries.[22] Consistently falling short of delivery goals, for example, can create challenges for future acquisition plans. For example, we have previously found that the SM-3 Block IIA program has not delivered the planned number of interceptors in each of the past 4 fiscal years.[23] Based on MDA's delivery plan for SM-3 Block IIA, it expected to deliver 54 interceptors by fiscal year 2024. However, MDA is not on pace to achieve this goal, which will be more challenging due to the growing backlog of the undelivered interceptors and limitations in production capacity.

MDA Did Not Meet Testing Goals in Fiscal Year 2021

MDA's testing program conducted just over half of its fiscal year 2021 flight, ground, and cybersecurity tests, which are necessary to demonstrate asset capabilities. MDA's testing goals this past year—also called baseline tests—were established in the IMTP aligned to fiscal year

[20]MDA officials said GMD delivered this interceptor in December 2021. For further details on the delays, see GAO, *Missile Defense: Fiscal Year 2020 Delivery and Testing Progressed, but Annual Goals Unmet*, GAO-21-314 (Washington, D.C.: Apr. 28, 2021) and GAO-20-432.

[21]According to program officials, the LRDR completed construction in December 2021 allowing MDA to begin testing the radar. Formal delivery is planned for fiscal year 2022.

[22]For further details on individual program difficulties in achieving planned deliveries, see GAO-21-314, GAO-20-432, GAO-19-387, and GAO-18-324.

[23]For further details on Standard Missile-3 Block IIA past deliveries, see GAO-21-314, GAO-20-432, and GAO-19-387.

2021. The agency subsequently added tests not listed in the IMTP. Table 3 shows the total tests to be conducted in fiscal year 2021.

Table 3: Missile Defense Agency Test Program Activities in Fiscal Year 2021

Type	Total tests to be conducted	Total tests conducted	Baseline tests conducted
Flight test	**21**	**14**	7 of 11
Ground test	**10**	**4**	1 of 7
Cybersecurity test (system-level test)	**4**	**0**	—

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

Note: This table includes tests that were either part of the Missile Defense Agency's Integrated Master Test Plan baseline for fiscal year 2021 or added after publication of the test baseline and scheduled for fiscal year 2021.

MDA Conducted Most of Its Flight Tests

MDA conducted 14 out of the 21 total flight tests. MDA's flight testing program for this past year consisted of tests that were either: (1) planned, based on their inclusion on the IMTP test baseline aligned to fiscal year 2021, or (2) added after the publication of the test baseline, which also includes added tests that involved MDA and external partners.[24] Of these tests, MDA planned 11 tests in its test baseline and added 10 tests after the publication of the baseline. The 7 tests that were not conducted were postponed to a future date.

Planned Flight Tests

MDA conducted 7 of 11 planned flight tests from its fiscal year 2021 baseline schedule. Two flight tests were delayed by non-MDA partners. Table 4 shows details, descriptions, and outcomes for these 11 tests.

[24]MDA has participated or plans to participate in flight tests conducted by external partners such as the U.S. Army, U.S. Navy, U.S. Air Force, and Defense Advanced Research Projects Agency (DARPA).

Table 4: Status of Flight Tests Planned for Fiscal Year (FY) 2021

	Flight test name	Flight test type (intercept or non-intercept)	Conducted (yes or no)	Status and description	Backlogged test[a]
1.	FS-21 E1 (FS-21.1)[b]	Non-intercept	Yes	**Met objectives**. An Aegis Ballistic Missile Defense ship performed a simulated engagement of a short-range ballistic missile (SRBM) target with a Standard Missile (SM)-6 Dual II interceptor.	–
2.	FS-21 E2 (FS-21.3a)	Intercept	Yes	**Met objectives**. An Aegis Ballistic Missile Defense ship intercepted a medium-range ballistic missile (MRBM) target with an SM-3 Block IB Threat Upgrade interceptor.[c]	–
3.	FS-21 E3 (FS-21.6b)	Non-intercept	Yes	**Met objectives**. An Aegis Ballistic Missile Defense ship fired two SM-3 Block IA interceptors at simulated targets while engaging a raid of two anti-air warfare targets with two SM-2 Block IIIA interceptors.	–
4.	FS-21 E4 (FS-21.6a)	Intercept	Yes	**Met objectives**. An Aegis Ballistic Missile Defense ship engaged an MRBM target with an SM-3 Block IA interceptor using remote data.	–
5.	FTM-33	Intercept	Yes	**Partially met objectives**. An Aegis Ballistic Missile Defense ship attempted to intercept a raid of two SRBM targets with two salvos of two SM-6 Dual II interceptors (four total). The interceptors destroyed one of the SRBMs and MDA established a failure review board to determine the cause of the missed intercept.	✓
6.	GM BVT-03	Non-intercept	Yes	**Met objectives**. This was the first flight test to demonstrate Ground-Based Midcourse Defense (GMD) selectable 2-/3-stage interceptor capability. The interceptor successfully flew in 2-stage mode (i.e., operating without igniting the third stage booster) as designed to demonstrate a capability that increases the warfighter's battlespace.	✓
7.	TH CTV-01	Non-intercept	Yes	**Did not meet objectives**. The test intended to demonstrate Terminal High Altitude Area Defense (THAAD) capability to fire and control two Patriot Advanced Capability-3 Missile Segment Enhanced (MSE) interceptors against two simulated SRBM targets. The test did not meet its primary objective; however, it met some objectives such as track discrimination, sending launch commands, and firing interceptors.	–

	Flight test name	Flight test type (intercept or non-intercept)	Conducted (yes or no)	Status and description	Backlogged test[a]
8.	FTT-21	Intercept	No	**Delayed to FY2022**. Delayed due to issues discovered with THAAD's 4.0 software build during TH CTV-01. This test intends to demonstrate THAAD's ability to launch Patriot's MSE interceptors, thereby extending its defended area.	—
9.	FTX-26	Non-intercept	No	**Delayed to FY2022**. Delayed due to software and hardware availability and COVID-19 effects to the Long Range Discrimination Radar (LRDR) readiness. This will be a simulated GMD engagement and the first operational flight test with LRDR.	—
10.	FTX-42	Non-intercept	No	**Delayed to FY2022**. Delayed by the partner, the U.S. Air Force, due to developmental issues within its program	—
11.	TBG-2	Non-intercept	No	**Delayed to FY2022**. Delayed by the partner organization, the Defense Advanced Research Project Agency, due to COVID-19 restrictions and programmatic delays	—

Legend:
FS – Formidable Shield
FTM – Flight Test Aegis Weapon System
FTT – Flight Test Terminal High Altitude Area Defense Weapon System
FTX – Flight Test Other
GM BVT – Ground-Based Midcourse Defense Weapon System Booster Vehicle Test
TBG – Tactical Boost Glide
TH CTV – Terminal High Altitude Area Defense Weapon System Controlled Test Vehicle

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

Note: These flight tests were included in the Missile Defense Agency's Integrated Master Test Plan baseline aligned to fiscal year 2021.

[a]Backlogged tests have already been delayed at least once from a previous fiscal year.

[b]The FS-21 exercise, featuring multiple air and missile defense events led by the U.S. Navy and North Atlantic Treaty Organization (NATO) partners, originally included five Ballistic Missile Defense tests. However, FS-21 E5 was renamed and repurposed as a non-Ballistic Missile Defense event without Missile Defense Agency participation.

[c]The Aegis SM-3 Block IB Threat Upgrade is primarily software upgrades with some associated hardware upgrades to enhance discrimination capability—the ability to distinguish the incoming missile from other objects.

Added Flight Tests

MDA added 10 flight tests to its fiscal year 2021 testing schedule and conducted seven of these tests. However, two added flight tests were delayed by non-MDA partners. Table 5 shows details, descriptions, and outcomes for these 10 tests.

Table 5: Status of Flight Tests Added to Fiscal Year (FY) 2021

	Flight test name	Flight test type (intercept or non-intercept)	Conducted (yes or no)	Status and description	Backlogged test[a]
12.	FTM-31 E1	Intercept	Yes	**Test failure.** An Aegis Ballistic Missile Defense ship attempted to intercept a medium-range ballistic missile target with a salvo of two Standard Missile (SM)-6 Dual II interceptors. Intercept was not achieved, and the Missile Defense Agency (MDA) initiated a failure review board to determine the cause of the missed intercept.	✓
13.	FTM-44	Intercept	Yes	**Met objectives.** An Aegis Ballistic Missile Defense ship intercepted an intercontinental ballistic missile target with an SM-3 Block IIA interceptor using its Engage-on-Remote capability.[b]	✓
14.	FTP-27 E1	Intercept	Yes	**Met objectives.** The test demonstrated the Patriot Weapon System's capability to intercept a short-range ballistic missile target using Launch-on-Remote capability. This was the first successful demonstration of the Patriot Weapon System launching interceptors using Terminal High Altitude Area Defense data.[c]	✓
15.	SM CTV-04	Non-intercept	Yes	**Met objectives.** The test verified recent changes to the SM-3 Block IIA interceptor met flight performance requirements using a simulated target.	–
16.	FTX-43	Non-intercept	No	**Delayed to FY2022.** Test designed to capture data on an advanced target.[d]	–
				Flight tests added with MDA and external partners[e]	
17.	HAWC-4	Non-intercept	Yes	**Partially met objectives.** MDA leveraged this Defense Advanced Research Project Agency (DARPA) event to collect data to inform its development efforts for hypersonic defense.	✓
18.	HAWC-5	Non-intercept	Yes	**Met objectives.** MDA leveraged this DARPA event to collect and provide overhead sensor data to the Command, Control, Battle Management and Communications Enterprise Sensors Laboratory.	✓
19.	TBG-1	Non-intercept	Yes	**Partially met objectives.** MDA leveraged this DARPA event—the first flight test of the DARPA Tactical Boost Glide vehicle—to collect data.	✓

	Flight test name	Flight test type (intercept or non-intercept)	Conducted (yes or no)	Status and description	Backlogged test[a]
20.	HAWC-7	Non-intercept	No	**Delayed to FY2022**. This test was removed from MDA's test baseline. DARPA conducted the test in March 2022.	✓
21.	HAWC-9	Non-intercept	No	**Delayed to FY2022**. This test was removed from MDA's test baseline, but DARPA is planning to conduct the test in FY2022.	✓

Legend:
DARPA – Defense Advanced Research Projects Agency
FTM – Flight Test Aegis Weapon System
FTP – Flight Test Patriot Weapon System
FTX – Flight Test Other
HAWC – Hypersonic Air-Breathing Weapon Concept
SM CTV – Aegis Weapon System Controlled Test Vehicle
TBG – Tactical Boost Glide

Source: GAO analysis of MDA data. | GAO-22-105075

Note: These flight tests were added after publication of MDA's Integrated Master Test Plan baseline aligned to fiscal year 2021.

[a]Backlogged tests have already been delayed at least once from a previous fiscal year.

[b]Engage-on-Remote is the use of data from other sensors to engage a threat and expand the range available for intercept.

[c]Launch-on-Remote is the use of data from other sensors to launch interceptors at a threat even before the weapon system can acquire the threat on its own sensors.

[d]MDA conducted FTX-43 in October 2021, and preliminary reports indicate the test did not meet objectives.

[e]External partners are considered to be other entities, such as the U.S. Army, U.S. Navy, U.S. Air Force, and DARPA.

Incomplete Flight Testing, Consistent with Prior Performance, Limits Knowledge

MDA's failure to conduct a large portion of its flight tests is consistent with what we have found in prior years. Table 6 shows that, since at least fiscal year 2017, MDA has not conducted all planned baseline flight tests for any year.[25] As we have previously found, this pattern demonstrates a fundamental disconnect between MDA's planning and execution.[26] Overall during this period, MDA has conducted 52 percent of planned

[25]While our analysis focuses on the past five years, GAO has reported on MDA's difficulties in conducting planned testing since fiscal year 2004. For examples of our prior reporting, see GAO, *Missile Defense: Actions are Needed to Enhance Testing and Accountability*, GAO-04-409, (Washington, D.C.: April 23, 2004); *Defense Acquisitions: Production and Fielding of Missile Defense Components Continue with Less Testing and Validation than Planned*, GAO-09-338, (Washington, D.C.: March 13, 2009); and *Missile Defense: Mixed Progress in Achieving Acquisition Goals and Improving Accountability*, GAO-14-351, (Washington, D.C.: April 1, 2014); and GAO-20-432.

[26]For further details on our previous work assessing MDA's test planning and execution, see GAO-20-432.

baseline flight tests—tests that were planned through the annual IMTP process that aligns with the fiscal year budget request.

Table 6: Planned Baseline Flight Tests (fiscal years [FY] 2017–2021)

Status	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	Total
Total	9	11	7	10	11	48
Conducted	6	7	2	3	7	25
Percent conducted	67%	64%	29%	30%	64%	52%

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

Further, MDA's history of falling short of its annual flight test plan has resulted in fewer demonstrations of its elements' capabilities than planned. Although MDA continues to plan and add tests to its flight test schedule to demonstrate various capabilities, test cancellations and changes to test objectives have precluded demonstrating capabilities as planned. MDA has made efforts in a prior year to adjust its test plan to shift the objectives of a canceled test to another test to ensure data are collected and capabilities demonstrated. For example, FTX-24 was planned to occur in fiscal year 2017, testing an SM-6 interceptor against a short-range ballistic missile target.[27] This test was removed from the test baseline, but according to MDA officials, the test objectives were later demonstrated in fiscal year 2021 in FTM-33.

However, in at least one instance MDA did not adjust its test plans and did not collect all data it intended to during testing. For example, FTM-24 was planned for fiscal year 2017 to test an SM-3 Block IB threat upgrade against a medium-range ballistic missile (MRBM) target. The test was initially delayed then subsequently canceled after the agency experienced difficulties developing a target to test the interceptor's upgrades. MDA has not made any plans to conduct this test.[28]

Additionally, even for tests that MDA conducts, it has in some cases changed the test objectives from what was originally planned. For example:

- FTM-29 was conducted in fiscal year 2018 and was intended to demonstrate an intercept with an intermediate-range ballistic missile (IRBM) target. MDA did not achieve an intercept during this test.

[27]For further details on the FTX-24 test, see GAO-18-324.

[28]For further details on the FTM-24 test, see GAO-18-324.

Previously we found that another test, FTM-45, served as an opportunity to validate corrective actions after the FTM-29 test failure. However, instead of using an IRBM as a target, this test used an MRBM as a target, which does not pose the same challenge. While FTM-45 successfully intercepted the target and MDA considered the test met requirements to proceed, it did not demonstrate the intended capability that was not proven in FTM-29.[29]

- Flight Test Integrated (FTI)-03 was conducted in fiscal year 2019 and intended to intercept two IRBM targets using Aegis Weapon System's Engage-on-Remote capability, which uses data from other sensors to engage a target. However, four weeks before the flight test, one IRBM target was removed from the test due to range safety concerns. MDA proceeded with the scaled-down test and successfully demonstrated the Engage-on-Remote capability and intercepted the single target. Consequently, since only one target was utilized, MDA did not fully demonstrate the capability to intercept two IRBM targets as it originally intended.[30]

In July 2020, we noted MDA consistently fell short of executing its test plan it deemed executable. Therefore, to reduce risk of less testing than originally planned and less data to demonstrate and validate capabilities, we recommended that MDA ensure an independent assessment is conducted of its process for developing and executing its annual flight test plan. DOD concurred with the recommendation and the Institute for Defense Analyses is conducting the assessment that is expected to be completed in the spring of 2022.[31]

MDA Conducted Less Than Half of Its Fiscal Year 2021 Ground Tests

MDA scheduled seven ground tests in fiscal year 2021 and conducted one test. However, MDA later added three ground tests that were conducted during the fiscal year. Table 7 shows the details, descriptions, and outcomes for the 10 tests.

[29]For further details on the FTM-29 and FTM-45 tests, see GAO-20-432 and GAO-19-387.

[30]For further details on the changes to FTI-03, see GAO-20-432.

[31]For further details, see GAO-20-432.

Table 7: Fiscal Year (FY) 2021 Ground Tests

	Ground tests planned in the Missile Defense Agency's FY 2021 baseline		
	Ground test name	**Conducted (yes or no)**	**Status and description**
1.	GTI-21 Sprint 1	Yes	**Met objectives.** Provided data to support Operational Capability Decision for the Terminal High Altitude Area Defense weapon system
2.	GTI-08a	No	**Delayed to FY2022**. The test intended to provide data for multiple Operational Capability Decisions including introducing the Long Range Discrimination Radar to the Missile Defense System. Delayed by software readiness and subsequently due to COVID-19 restrictions
3.	GTI-09 Sprint 1	No	**Delayed to FY2022.** Delayed due to ground test GTI-08a schedule delays
4.	GTD-08a	No	**Delayed to FY2022.** Delayed due to ground test GTI-08a schedule delays
5.	GTI-09 Sprint 2	No	**Delayed to FY2022.** Delayed due to ground test GTI-08a schedule delays
6.	GTI-ISR (21)	No	**Delayed to FY2022.** Delayed due to ground test GTI-08a schedule delays
7.	GTD-09	No	**Delayed to FY2022.** Delayed partly due to ground test GTI-08a schedule delays
	Ground tests added after publication of FY 2021 baseline		
8.	GTI-21 Sprint 2	Yes	**Partially met objectives**. Assessed the performance of the Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) in an expected intermediate configuration. The test did not assess all objectives, such as AN/TPY-2 acquisition and discrimination performance.
9.	ASD-1	Yes	**Met objectives.** Demonstrated the capability of an Aegis Ballistic Missile Defense ship to detect, track, and report space objects based on orders from the Command, Control, Battle Management, and Communications system
10.	ASD-2	Yes	**Met objectives.** Demonstrated the capability of an Aegis Ballistic Missile Defense ship to detect, track, and report space objects based on orders from the Command, Control, Battle Management, and Communications system

Legend:
GTI – Ground Test Integrated
GTD – Ground Test Distributed
ASD – At-Sea Demonstration

Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-22-105075

Note: According to officials, MDA continues to implement a new approach to its ground testing planning, although implementation has stalled due to delays in the ground test schedule. After full implementation, this approach is expected to allow for more flexibility in test design including the ability to reconfigure tests in the face of developmental delays.

Five of the tests were delayed due to delays conducting the ground test GTI-08a. According to MDA officials, GTI-08a was delayed due to software readiness. There were also problems integrating the system-level framework, and later COVID-19 restrictions caused additional

delays.[32] Among the restrictions was a 2-month pause on the test schedule. GTI-08a's delay has prevented MDA from providing data for multiple Operational Capability Baseline decisions, including introducing the LRDR to the Missile Defense System.[33] Further, along with the five tests not conducted this year, MDA officials said the delay has affected the schedule of ground tests in future fiscal years. MDA plans to conduct GTI-08a in fiscal year 2022.

MDA Did Not Conduct Any System-Level Operational Cybersecurity Assessments, Delaying Programmatic Decisions

MDA planned to conduct four system-level operational cybersecurity tests in fiscal year 2021. For a second year in a row, however, MDA did not conduct any such tests. This situation occurred despite MDA entering fiscal year 2021 with incomplete knowledge of cybersecurity vulnerabilities of its system due to a substantial testing deficit from prior years. As we previously found, MDA failed to meet its annual operational cybersecurity testing goals in 2019 and did not conduct any of the 17 operational cyber assessments planned in fiscal year 2020.[34] All system-level operational cyber testing for fiscal year 2021 has been pushed to fiscal year 2022 due to delays to ground and subsequently cyber test campaigns, and the cyber test program schedule continues to undergo MDA review. Results from the fiscal year 2021 tests were necessary to inform fielding decisions for seven MDS elements. These decisions are now delayed until at least fiscal year 2022.

Delayed System-Level Tests

For fiscal year 2021, MDA followed its new cybersecurity test plan and planned the system-level operational cybersecurity tests through its integrated master test baseline via the same process used for flight and ground test planning.[35] This resulted in two planned cyber campaigns for the fiscal year. The campaigns were to be comprised of lab-based risk

[32]GTI-08a was formerly part of one ground test, GTI-08, that was split into two ground tests, GTI-08a and GTI-08b. After the split, MDA revised the ground testing schedule, to support element software deliveries and risk reduction testing prior to conducting GTI-08a. For further details of the test planning history of GTI-08a, see GAO-21-314.

[33]The Operational Capability Baseline is an engineering management database containing the operational configuration of Missile Defense System hardware and software versions fielded for warfighter use. The operational capability baselines present information on the fielding plans, capabilities and limitations, and supporting activities for operational capability deliveries.

[34]GAO-21-314 and GAO-20-432.

[35]Missile Defense Agency, *Ballistic Missile Defense System Cybersecurity Test Concept of Operations (MDA Policies and Procedures for Execution)*, DT-102 (Fort Belvoir, Va: Mar. 19, 2019).

reduction (LBRR), cooperative vulnerability penetration assessment (CVPA) and adversarial assessment (AA) events that corresponded to two planned ground test events, GTI-08a and GTI-09.[36] GTI-08a, the primary ground test for Increment 6B.1, whose performance data is needed to support operational capability decisions for seven elements, is now delayed until at least February 2022.

Due to GTI-08a delays and flight test software availability issues, the CVPA and AA events planned for second and third quarters of fiscal year 2021 were also delayed. Future cybersecurity testing—CVPAs and AAs associated with GTI-09 and beyond—is currently under review by MDA with several tests undergoing a replanning process. MDA did not provide any information on future testing time frames. MDA officials told us that they have set up a cyber testing plan that will support element specific operational fielding decisions rescheduled for fiscal year 2022. But, according to MDS OTA officials, they are unaware whether MDA has considered how to plan, execute, and assess test events if new COVID-19 restrictions are directed. As a result, the MDS OTA team told us it thinks that MDA should conduct a review of fiscal year 2022 test plans in order to minimize the effect of COVID-19 restrictions on planned system-level operational cyber tests.

Conducted Element-Level Operational and Developmental Tests

Although no system-level operational cyber tests were conducted during fiscal year 2021, MDA conducted two element-level operational tests in December 2020, a CVPA and AA on the SBX Radar. According to DOT&E officials, these tests faced limitations, but put MDA on the path of addressing its operational cybersecurity testing deficit. Moreover, despite limitations, MDS OTA officials told us they believe that results from both of these tests will add value to the upcoming fielding decision for the radar software currently in development.[37]

In addition, MDA conducted a hardware in the loop (HWIL) CVPA for the AN/TPY-2 in forward-based mode that utilized the actual element

[36]LBRR, previously known as Element Cybersecurity Events, are element-level risk reduction test events supported with formal test qualification software. IMTP v22.1 dated May 27, 2021, removed LBRRs from the test baseline. Agency officials explained that LBRRs, used in preparation for operational cyber testing, were no longer needed since the agency now follows the developmental testing guidelines outlined in *DOD's Cybersecurity Test and Evaluation Guidebook*.

[37]Cybersecurity test results and related test plans are classified and, thus, cannot be discussed in detail in this report.

hardware and software to conduct a cyber test in a simulated operational environment.[38] This is the first time MDA has used the HWIL environment to support cyber testing. According to MDS OTA officials, results from the HWIL cyber events helped build a body of evidence for upcoming operational tests and allowed for improved planning of cyber test objectives. Additionally, the MDS OTA team continues to explore the viability of the HWIL cyber test solution to augment future element and system-level operational cyber testing. Both DOT&E and MDS OTA expect MDA to conduct additional HWIL testing in fiscal year 2022 in order to address some of the existing limitations based on the most recent cybersecurity test results.

In addition, during fiscal year 2021, MDA focused on the developmental cyber test program and conducted ten tests—four cooperative vulnerability identification and six adversarial cybersecurity developmental test and evaluation—on four MDS elements.[39]

Delayed Fielding Decisions

Results from the delayed ground and cyber tests were necessary to inform fielding decisions for seven elements, and these decisions are now delayed until fiscal year 2022. Moreover, the decisions are at risk for additional delays due to challenges conducting necessary cyber tests. Specifically, CVPA-08a and CVPA-09, scheduled to begin during the second and fourth quarters of fiscal year 2021, were intended to identify cyber vulnerabilities and characterize the operational cyber resilience of recent software builds of GMD, C2BMC, SBX radar, THAAD, AN/TPY-2 radar, LRDR, and BMDS Overhead Persistent Infrared Architecture (BOA).[40] Additionally, AA-08a, planned for the third quarter of 2021, would have assessed the ability of the MDS and these elements to

[38]According to *DOD's Cybersecurity Test and Evaluation Guidebook*, high-fidelity operational environments often impose restrictions on cybersecurity testing; thus, earlier testing in simulated operational or developmental environments allows for more rigorous testing before operational testing and should be performed during the developmental test and evaluation phase. Cyber ranges and HWIL facilities provide more realistic environments while minimizing risk to operational networks. DOD, *Department of Defense, Cybersecurity Test and Evaluation Guidebook*, Version 2.0, Change 1 (February 10, 2020).

[39]Cybersecurity developmental testing consists of two assessments: Cooperative Vulnerability Identification (CVI) and an Adversarial Cybersecurity Developmental Test and Evaluation (ACD). CVI is used to collect data needed to identify vulnerabilities and plan mitigations. ACD event uses realistic threat scenarios in a representative operating cyber environment to identify vulnerabilities.

[40]BOA is a stand-alone system associated with C2BMC.

detect, respond to, survive, and recover from cyber-attacks. Test delays triggered by COVID-19 restrictions and the resulting lack of data required to demonstrate element software readiness led to changes to the agency's test and technical baselines. As a result of these redesigned baselines, operational fielding decisions of Increment 6B.1 capabilities, which include the above noted elements, were moved from December 2021 to September 2022, a delay of 9 months.[41]

Cybersecurity Resilience Strategy

During fiscal year 2021, MDA worked on several foundational guidance documents that address cyber developmental test and evaluation, cyber engineering analysis, and cyber technical risk assessment and threat reporting as part of its agency-wide MDS Cybersecurity Resiliency Strategy designed to incorporate cyber considerations during the entire life cycle of the MDS.[42] This new strategy has four goals—identify cyber threats, reduce attack opportunities, improve defensive operations, and strengthen cyber capabilities—comprising of 34 initiatives that will facilitate the delivery of operationally resilient and survivable systems to the warfighter. The fiscal year 2021 focus was on developing guidance tailored for the MDS and identifying a prioritized list of foundational initiatives, with cyber threat intelligence identified as the highest priority. All initiatives are in the early planning stages and all foundational guidance documents are currently in various stages of drafting and coordination within MDA.

MDA also highlighted its creation of new cyber roles, working groups, and cyber organizations within the agency. Specifically, the Cybersecurity Systems Engineering Working Group, comprised of internal and external stakeholders, is intended to foster coordination and execution of strategy initiatives, while the Cybersecurity Executive Steering Group is to provide a collaborative leadership forum for implementing a holistic approach to MDA cyber decision making. Also created are the Cyberspace Mission Support Division and the Defensive Cyberspace Operations Division. The first is tasked with continuous improvement of MDA cyber capabilities in support of a secure and uncompromised MDS. The second supports defensive cyber operations, conducts security controls and validation

[41]MDS-level integrated capabilities are organized by increments. MDA has delivered Increments 1-5. Increment 6B, currently in development, was replanned and split into Increment 6B.1 and Increment 6B.2 in 2019. As of May 2022, delivery of Increment 6B.1 has been further delayed to April 2023, likely delaying the operational fielding decisions of the listed capabilities.

[42]Missile Defense Agency Memorandum, *Missile Defense System Cybersecurity Resilience Strategy,* (Fort Belvoir, Va: June 26, 2020).

testing, and ensures a capable and trained MDA cybersecurity workforce. The MDA Chief Information Officer is the overall agency lead for cybersecurity during this reorganization period, and the MDA Chief Engineer has been tasked with leading the development of a detailed strategy implementation plan for the MDS and is coordinating its execution. According to the MDA Chief Engineer, implementation of the initiatives is ongoing.

MDA's Counter-Hypersonic Efforts Face Technological Challenges and Lack Coordination with External Stakeholders

MDA currently has two main efforts to develop glide-phase defenses against hypersonic weapons: GPI and HBTSS. Both efforts face unique challenges to delivering operational capabilities in an effective and economical manner. GPI, for instance, faces technology risks and is employing a tailored acquisition approach, and current plans lack important external reviews that would help to mitigate the program's technology and cost risks. The HBTSS program, on the other hand, is more technologically mature, but MDA has not adequately coordinated its efforts with other DOD stakeholders. The agency is now advocating for an independent, MDA-managed satellite system with risks of duplication or overlap with other DOD efforts.[43]

The GPI Effort Poses Technology, Schedule, and Cost Risks, and Its Program Schedule Lacks Plans for Risk Mitigation Reviews

DOD officials briefed on the GPI effort describe it as a significant undertaking that will be technically very challenging to accomplish. Several OUSD(R&E) officials stated that the GPI effort would be at least as technically complex as the Next Generation Interceptor, currently MDA's most challenging program. As we have found, building an interceptor capable of defeating a hypersonic glide vehicle is uniquely challenging, particularly because a hypersonic vehicle itself is difficult to build.[44] In general, intercept systems must be able to outperform their target in order to complete an intercept, often by a significant margin. Consequently, in order to achieve an intercept of a hypersonic target, a new GPI missile would have to operate in hypersonic flight conditions while also exceeding adversary hypersonic systems in key areas, such as speed or maneuverability.

The technology risks facing the GPI effort amplify its schedule and cost risks. MDA's initial plans called for delivery in fiscal year 2032, but the

[43]GAO defines these terms as follows: *duplication* occurs when two or more agencies or programs are engaged in the same activities or provide the same services to the same beneficiaries; *overlap* occurs when multiple agencies or programs have similar goals, engage in similar activities or strategies to achieve them, or target similar beneficiaries.

[44]GAO-20-432.

agency has since begun to advocate for an acceleration to fiscal year 2028. According to MDA's internal cost estimate, this acceleration would reduce the total cost of the program from $4.2 billion to $3.7 billion.[45] MDA officials stated that these savings largely come from reduced program overhead due to the shortened timeline. This acceleration front-loads the effort's costs in the first several years to a degree that would require MDA to exceed preplanned budget caps, which has not yet been approved. According to MDA officials, exceeding these caps is subject to DOD approval and will be determined through the process of formulating the President's budget request for fiscal year 2023.[46] Further, OUSD(R&E) officials expressed skepticism that this accelerated GPI schedule would be possible, stating that MDA would need to mature a number of technologies to be successful. They told us they did not believe that front-loading money at the start of the program would accelerate the pace of technology development. If the program proceeds according to an accelerated schedule, only to later discover it to be unrealistic, then the proposed cost savings from the acceleration could be lost due to delays.

OUSD(R&E) officials also expressed concerns that the structure of the program as an operational capability demonstration limited their insight into the program, even for this early stage. These officials stated that what they had seen of the GPI effort's acquisition strategy strongly resembled the first stages of a formal program of record. However, because MDA has classified GPI as an operational capability demonstration, the effect has been a reduced level of OUSD(R&E) oversight as compared to a typical program at this stage, especially as planned for phases beyond research and development.

At the time of our review, GPI program documents were missing plans for several required analyses that would serve to mitigate some of these risks. MDA documentation states that the GPI effort is aligned with Directive Type Memorandum (DTM) 20-002, which generally governs oversight authorities of MDA. DTM-20-002 states that programs that exceed the research, development, test, and evaluation (RDT&E) dollar thresholds for Acquisition Category I programs (more than $525 million in

[45]This amount includes only research and development costs, and makes no provision for additional production, operations or sustainment.

[46]The President's budget request for fiscal year 2023 was released March 28, 2022. In it, the GPI program's funding profile no longer reflects a fiscal year 2028 delivery, but instead targets a date in the 2030s.

fiscal year 2020 constant dollars) require an independent cost estimate (ICE) and independent technical risk assessment (ITRA) before a program advances to the product development phase. However, GPI planning documents showed no plans for soliciting an ICE or an ITRA. Per DTM 20-002, these analyses are supposed to be independent; the ICE is conducted by the Director, Cost Analysis and Program Evaluation, and the ITRAs are overseen by the OUSD(R&E). These products are intended to provide objective analysis designed to increase decision-makers' knowledge of a program's risks before key decision points.

We have also reported on the importance of ICEs and ITRAs to understanding programmatic risks.[47] For example, our Cost Estimating Guide notes that optimistic program managers often believe in the original estimates for their plans without adequately allowing for changes in scope, schedule delays, or other elements of risk.[48] As such, independent perspectives are important to defend against overly optimistic assumptions by program managers. Similarly, our Technology Readiness Assessment guide identifies these assessments as a fundamental means for evaluating an important component of program risk—the maturity of critical technologies.[49] Our previous work found that the readiness of critical technologies at the start of a program affects the cost and schedule of developing a product, and that technology risk assessments provide important information for developers, managers, and governance and oversight bodies. Therefore, programs not obtaining these independent analyses are in danger of proceeding without a full understanding of programmatic risk.

There is a provision within DTM 20-002 by which MDA programs can have the requirement for an ICE or ITRA waived. Specifically, the DTM states the OUSD(A&S), at their discretion, can delegate their milestone decision authority to the Director, MDA, and in so doing, remove most of the requirements for independent reviews, including ICEs and ITRAs. While there are no explicit criteria for delegation in the DTM, OUSD(A&S)

[47]GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, GAO-20-195G (Washington, D.C.: Mar. 12, 2020); *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); and *F-35 Joint Strike Fighter: Action Needed to Improve Reliability and Prepare for Modernization Efforts*, GAO-19-341 (Washington, D.C.: Apr. 29, 2019); and GAO-22-104344.

[48]GAO-20-195G.

[49]GAO-20-48G.

officials stated that the Under Secretary historically has granted requests for delegation based on the technical maturity of a program and its overall level of risk. Examples of acquisitions which OUSD(A&S) delegated its authority include additional procurements of stable designs, such as GMD boosters. By contrast, OUSD(A&S) has not delegated authority on more technically risky programs that were still in the design and development phase, such as the Next Generation Interceptor. Some GPI program documents explicitly stated that the program planned to request delegation, though more recent documents have been silent on the issue. During our review, we asked MDA officials, first, if program plans lacking any ICE or ITRA were accurate and, second, if they still planned to request delegation. MDA officials said that schedules lacking ICEs or ITRAs were accurate. As for delegation, officials said that a decision on whether to request a delegation had not been made, but MDA would not rule out the possibility of requesting it in the future. Delegating milestone decision authority does not change the level of programmatic risk within GPI, which is comparatively high. As a result, the value of ICEs and ITRAs before key milestones remains the same. Moreover, absent the delegation of milestone decision authority as stated above, DTM 20-002 currently requires them, as acquisition documentation we have received from MDA states the agency aligned GPI's acquisition strategy with this policy.[50]

HBTSS Lacks Coordination with Other DOD Stakeholders, Posing Risks of Duplication and Overlap

SDA and OUSD(A&S) officials told us that, for several years, the division of labor between MDA and SDA was widely understood as follows: MDA was responsible for developing the HBTSS sensor, and SDA would be responsible for integrating the sensor onto its satellites for operational use.[51] However, this division of labor was never explicitly documented, and subsequent DOD reports have complicated this understanding without confirming or refuting this assignment of responsibilities.

[50]As a draft of this report was being finalized, MDA informed us that the Deputy Secretary of Defense requested that a completed ICE be submitted no later than June 2022 for the GPI effort in advance of a Technology Development Decision. We will work with DOD and Cost Analysis and Program Evaluation to obtain more information related to this request, but at present this ICE has not been completed and we have no documentation that MDA is planning on an ICE for the Product Development phase as required by the DTM.

[51]A congressional report also noted concerns that MDA, rather than the appropriate agency (Space Force), could be developing and fielding satellite constellations beyond a prototype stage. S. Rep. No. 117-39, at 277-78 (2021). The bill this report accompanied was not passed.

The NDAA for Fiscal Year 2020 sought to address some of this uncertainty. This NDAA charged the Director, MDA with developing a sensor payload for tracking of hypersonic and ballistic missiles.[52] At the same time, the law also instructed the Director, MDA to pursue the development of this payload in coordination with SDA, as appropriate.[53] The act also requested a report from the Secretary of Defense, who tasked OUSD(R&E) with its completion, on the overall coordination strategy for this capability, the assignment of responsibilities, and how the agencies would avoid duplication.[54]

Efforts to Coordinate HBTSS Fall Short of DOD Plans

OUSD(R&E) responded to the congressional request with two reports released several months apart (May 2020 and January 2021). While these reports stated that the MFOV sensors developed as part of HBTSS would indeed be integrated into SDA's architecture, neither report stated which agency would operate the satellites hosting the MFOV sensors in future phases. Thus, it was not specified whether MDA could in the future develop (1) sensors for inclusion on SDA satellites, (2) satellites of its own for inclusion in SDA's broader tracking layer, or (3) operate an entirely separate constellation.

The reports did lay out areas in which MDA and SDA would coordinate their efforts. The May 2020 report stated that OUSD(R&E) would oversee the development of a memorandum of understanding between MDA and SDA to formalize the agencies' roles and responsibilities in the broader SDA architecture. MDA later stated that Space Force was eventually included in the draft memorandum as well. The January 2021 report, which described itself as a "roadmap" for the future architecture, further stated that the eight SDA WFOV satellites and the two HBTSS MFOV satellites (slated for launch starting in 2022 and 2023, respectively) would be equipped with optical cross-links. These cross-links enable the ability of the satellites to communicate with each other directly in space. Equipping these satellites with the cross-links would allow them to practice and demonstrate the WFOV-MFOV detection and cueing process described in the January 2021 roadmap. This roadmap further stated that SDA would procure and provide launch services for both HBTSS and SDA.

[52]Pub. L. No. 116-92, § 1683.

[53]*Id.*

[54]*Id.*

However, since the 2021 roadmap was presented to Congress, MDA has made decisions about HBTSS that run contrary to several aspects of the roadmap's plan. For example:

- MDA has declined to equip the HBTSS demonstrators with the optical cross-links needed to communicate with SDA's satellites. MDA officials told us that they made this decision to avoid becoming unnecessarily involved in SDA's plans. MDA stated that a technical risk assessment determined it would create an unnecessary risk. However, when we asked for documentation of this assessment, MDA stated that there was no documentation available. MDA also stated that they would consider including cross-links on future iterations of HBTSS, even though HBTSS has not been budgeted funding past the current two-satellite phase.
- MDA also declined to procure launch services through SDA, stating that the orbital requirements of the HBTSS demonstrators precluded using the same launch vehicle. MDA officials said that these orbital requirements were not new and predated the roadmap report by several years. Affirming a plan to procure launch services through SDA, when doing so is not technically possible, indicates the need for better coordination.

SDA and MDA officials also said that progress on the memorandum of understanding stalled at some point in 2021. According to SDA officials, the main reason for the lack of progress was that, at present, there were few, if any, areas to coordinate with MDA. Based on MDA's decisions, their satellites could not communicate in space, they would be launched separately, and MDA had invested considerable sums into its satellite ground control facility, such that the HBTSS satellites would operate independently. Though SDA and MDA would continue to work together in some areas (and indeed, they had worked together in several areas prior to 2020), these areas did not require a memorandum of understanding to execute.

Risks of Duplication and Overlap Increase in the Absence of Coordination

In October 2021, MDA proposed a plan that would continue the HBTSS program past the current phase, expanding it until it provided an operational satellite constellation. DOD has not requested or received funding for this expanded effort, but under this proposed plan, an additional phase of HBTSS would launch six satellites in the fiscal year 2025 time frame. The satellites would be operational demonstrators, meaning they could eventually be used by warfighters for operational purposes, including providing data for GPI. Following this phase would come the production phase, which would involve a production decision

and declaration of a formal initial operational capability. MDA's plan did not assign a target date to the production phase.

These plans pose a significant risk of duplication or overlap with SDA's tracking layer. If completed, MDA's MFOV constellation would still depend on the SDA tracking layer for a cue in order to track a hypersonic weapon.[55] While the HBTSS sensor is more sensitive than SDA's, both SDA and MDA officials acknowledged that the SDA's satellites can meet the requirements for intercept-quality data that MDA determined were necessary for the GPI. Both MDA and SDA officials said that the GPI interceptor's current requirements for sensor accuracy are equivalent to what is necessary to provide a Launch-on-Remote capability and that the WFOV sensor planned for SDA's satellites meets or exceeds this threshold. MDA officials did note, that the MFOV HBTSS sensor, if deployed properly, will be able to provide the more difficult Engage-on-Remote capability; however, this was not the original GPI requirement.[56] This set of advantages and disadvantages is not static. Because of the short operational life of satellites in pLEO architectures, SDA plans also provide for improvements over time, adding new capabilities every 2 to 4 years. SDA's near-term plans include the deployment of MFOV sensors capable of supporting engage on remote in future iterations of the tracking layer. Further, even if an HBTSS constellation could provide this added capability sooner than SDA, it may not be useful. As noted above, GPI will most likely not be completed until sometime in the 2030s and even then will not be available for operational use. If MDA pursues its plans to expand HBTSS, it risks constructing a separate and independent satellite constellation, for which the current requirements are already

[55]MDA officials later said that HBTSS Phase IIB satellites can accept a cue from any capable sensor through the Missile Defense System command and control network. The limitations of these sensors are well known and thus any operational capability would be heavily reliant on the SDA layer in order to function.

[56]Launch on Remote (LoR) capabilities allow an interceptor to be launched using data from a remote sensor. Engage on Remote (EoR) capabilities allow an in-flight interceptor to engage the threat using data from a remote sensor.

being met by SDA's constellations, and whose additional capabilities may exist without a system ready to take advantage of them.[57]

Conclusions

MDA is currently at a crossroads, needing to balance its ability to maintain and develop ongoing MDS elements while also pursuing new and advanced efforts that are research and development-intensive and carry significant technical risks and financial commitments. In developing new efforts, our prior work on leading practices in defense acquisition emphasizes the importance of developing knowledge early in the acquisition process. Performance shortfalls or design flaws that are discovered later in the acquisition process are more likely to contribute to cost and schedule overruns and other adverse program outcomes. Having independent insights into program technical risks and costs are key components of the knowledge-based acquisition process. MDA's GPI effort is already a highly ambitious and technically challenging effort with cost and schedule risks. Should MDA continue with the GPI effort without an independent cost estimate and independent technical risk assessment, then decision makers—including MDA—will lack knowledge essential for managing program risks and thus increase the risk of the program not achieving its goals.

In addition, MDA's efforts to coordinate the HBTSS program with other DOD stakeholders have fallen short of the goals DOD has established and communicated to Congress. Not coordinating and clearly defining roles and responsibilities at early stages of this program has put MDA in a position of making decisions that could limit future abilities to coordinate with SDA, and proposing development of an independent satellite capability that would largely duplicate the functions of an SDA constellation that already meets MDA's requirements. Without clear lines of delineation in the authorities among MDA and SDA and better coordination of efforts, MDA risks expending significant resources on a system that is largely duplicative.

[57]In response to a draft of this report, MDA officials stated that the full, operational HBTSS constellation the agency envisioned would not be "independent" as it would eventually transition to the services for operations. However, during the course of our audit, we asked MDA officials whether they had taken steps to facilitate transition planning, such as establishing a hybrid program office or developing a written transition plan in coordination with the Space Force. They said that while they had worked with Space Force on some issues, they had yet to decide to take any of these specific steps, and that they had no timeline for doing so.

Recommendations for Executive Action

We are making the following three recommendations to DOD.

The Secretary of Defense should direct the Under Secretary of Defense for Acquisition and Sustainment to ensure that the GPI effort obtains:

1. An Independent Cost Estimate developed by the Director of Cost Assessment and Program Evaluation prior to entering the Product Development Phase as defined by DTM 20-002. (Recommendation 1)
2. An Independent Technical Risk Assessment conducted by the Under Secretary of Defense for Research and Engineering prior to entering the Product Development Phase as defined by DTM 20-002. (Recommendation 2)

The Secretary of Defense should ensure the Missile Defense Agency, Space Development Agency, Space Force, and any other relevant agencies establish a memorandum of understanding that delineates roles and responsibilities for satellite development and operation in the missile defense and missile warning domains. This memorandum should establish which agencies will develop operational satellites (including prototypes) and articulate a process by which duplication and overlap will be avoided. (Recommendation 3)

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for review and comment. DOD provided written comments on our report, which are reprinted in appendix VIII. DOD concurred with our recommendations to ensure an independent cost estimate and technical risk assessment are conducted. In addition, DOD concurred with our recommendation to establish a memorandum of understanding that delineates the roles and responsibilities for satellite development and operation in the missile defense and missile warning domains. DOD also provided technical comments, which were incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, and to the Director, MDA. 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 SawyerJ@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.

John D. Sawyer
Acting Director, Contracting and National Security Acquisitions

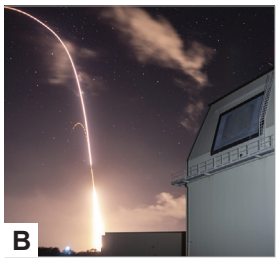
List of Committees

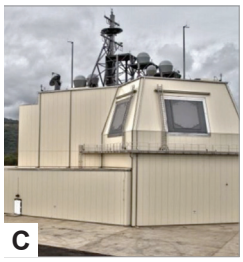
The Honorable Jack Reed
Chairman
The Honorable James M. Inhofe
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Jon Tester
Chairman
The Honorable Richard Shelby
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

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

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





Source: Missile Defense Agency. | GAO-22-105075

[1]We did not assess the Aegis BMD SM-3 Block IA because it has been in production since 2005 and it is currently operational for regional defense of Europe, as well as other regions. ►

PROGRAM OVERVIEW

Aegis Ballistic Missile Defense (Aegis BMD)

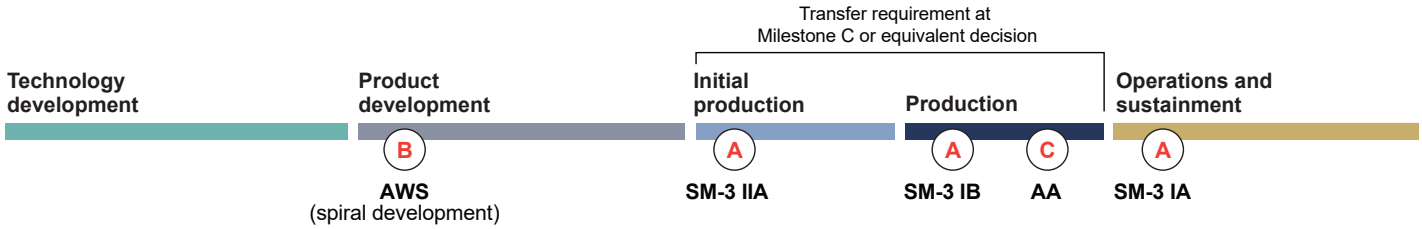
Aegis BMD includes ship- and land-based missile defense capabilities as follows:

A. Standard Missile (SM)-3 interceptors—IA , IB, and IIA—are designed to defend against short-, medium-, and intermediate-range enemy missiles.[1]

B. Aegis Weapon System (AWS) consists of software spirals jointly developed by MDA and the Navy to provide integrated and improved capabilities over time.

C. Aegis Ashore (AA) is a land-based version with three sites: Hawaii, Poland, and Romania.

MDA and the Navy have a transfer plan for some portions of Aegis BMD. Most portions of Aegis BMD are in production or beyond, but have not completely transferred to the Navy. In general, MDA and the Navy both have development and support responsibilities according to a memorandum of agreement.



Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

DELIVERIES

The Aegis Ashore site in Poland was originally planned to be delivered in fiscal year 2018, but has experienced significant construction delays due to contractor under-performance, according to Missile Defense Agency (MDA) officials. The program currently estimates that this site will be delivered no earlier than fiscal year 2022.

An AWS software spiral—Aegis Baseline 9.C2.1—was delivered as planned in fiscal year 2021. The program noted, however, that these capabilities will not be available until Command, Control, Battle Management, and Communications (C2BMC) spiral 8.2-5 and the Navy's upgraded SM-6 Dual II missiles are fielded (see appendix II).[1]

SM-3 interceptors experienced production issues that led to delays in deliveries for fiscal year 2021. SM-3 Block IIA production was halted to investigate multiple test and component anomalies, some of which required re-work of delivered interceptors. An incremental production decision planned for fiscal year 2021 was delayed pending a revised cost estimate.

[1]SM-6 missiles generally fall outside the scope of this review except insofar as they interact with MDA systems.

Aegis BMD Fiscal Year 2021 Deliveries

	Planned	Status
Aegis Ashore	0 sites	The Poland site delays continued and the delivery date is not earlier than fiscal year 2022.
Aegis Weapon System	1 software spiral	**Delivered.** Aegis Baseline 9.C2-1.
SM-3 Block IB	32 interceptors	**23 delivered.** Remaining deliveries were halted due to a recent flight test failure of the SM-6 missile, which shares major components with the SM-3 Block IB.
SM-3 Block IIA	7 interceptors	**3 delivered.** Production temporarily halted due to missile assembly issues.

BMD Ballistic Missile Defense
SM Standard Missile

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

COVID-19

- Aegis Ashore experienced increased travel and labor costs for all three sites due to travel restrictions, but the program does not anticipate these issues for fiscal year 2022.
- According to program officials, AWS software installations were disrupted by ship yard availability and deployment dates and quarantine requirements for contractors performing the installations led to a $554,000 cost increase.
- SM-3 Block IIA interceptors experienced delays at test facilities due to pandemic quarantine requirements.

TESTING

Aegis BMD Fiscal Year 2021 Testing

Test	Conducted	Delayed	Deleted
Flight	◆ ◆ ◆ ◈ ◈ ◈ ◈ ◈		
Ground	■ ■ ■	■ ■	
Cybersecurity			

◆ Non-intercept flight test ◈ Intercept flight test

■ Ground test ● Operational cybersecurity test

BMD Ballistic Missile Defense

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

Aegis BMD conducted eight flight tests in fiscal year 2021. One test—FTM-44—demonstrated the SM-3 Block IIA's ability to intercept an intercontinental range target for a potential homeland defense scenario. Another test demonstrated the SM-3 Block IIA's new guidance electronics unit, which has previously experienced performance issues. Aegis BMD conducted two tests using SM-6 missiles, but both have ongoing failure review boards. FTM-31 E1—a salvo (two missiles) against a medium-range target—failed as neither missile intercepted the target. FTM-33—a salvo (4 missiles in total) against a raid of two short-range targets—had one success and one failure. Aegis BMD also participated in a series of international tests to demonstrate interoperability with North Atlantic Treaty Organization partners; all of which were successful.

Aegis BMD participated in three ground tests in fiscal year 2021. Two assessed AWS's ability to track certain space objects and the other provided data on its search, track, and remote engagement capabilities. Remaining tests were delayed due to COVID-19.

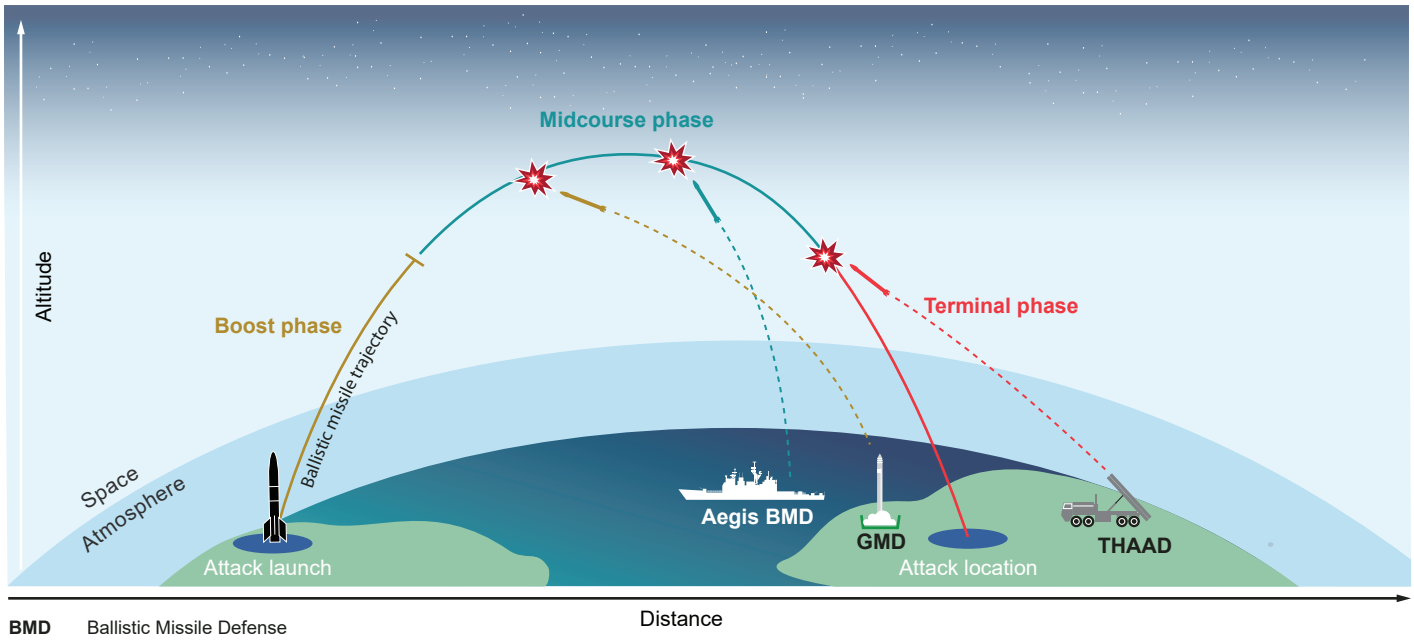
Aegis BMD did not plan to conduct operational cybersecurity tests in fiscal year 2021, though the program did conduct several developmental cybersecurity tests.

OTHER PROGRAM INFORMATION

Layered Homeland Defense

A flight test in fiscal year 2021—FTM-44—was part of an effort to evaluate if the SM-3 Block IIA interceptor, either in its current form or upgraded, could contribute to a layered homeland defense capability against intercontinental threat missiles (see figure). This flight test was successful and MDA was able to use the results to support the planning and analysis for this capability. However, further planning for this capability is largely on hold pending DOD approval of a report on the possible concepts of operations for this capability, additional funding, and direction from Congress according to MDA officials. For more information, see appendix VI.

Notional Depiction of Layered Homeland Defense



BMD Ballistic Missile Defense
GMD Ground-Based Midcourse Defense
THAAD Terminal High Altitude Area Defense

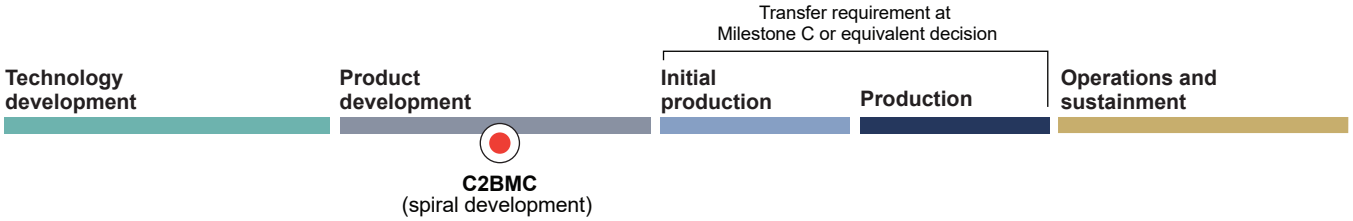
Source: GAO depiction of Missile Defense Agency data. | GAO-22-105075

Source: Missile Defense Agency. | GAO-22-105075

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—workstations, servers, and network equipment—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, thereby conserving interceptor inventory. MDA is developing C2BMC in spirals—software and hardware upgrades—that build upon prior capabilities. Spiral 8.2-3, fielded in fiscal year 2019, is currently in use while spirals 8.2-5 and 8.2-7 are in development. C2BMC is in continuous spiral development; thus, it will not transfer to the military service(s).



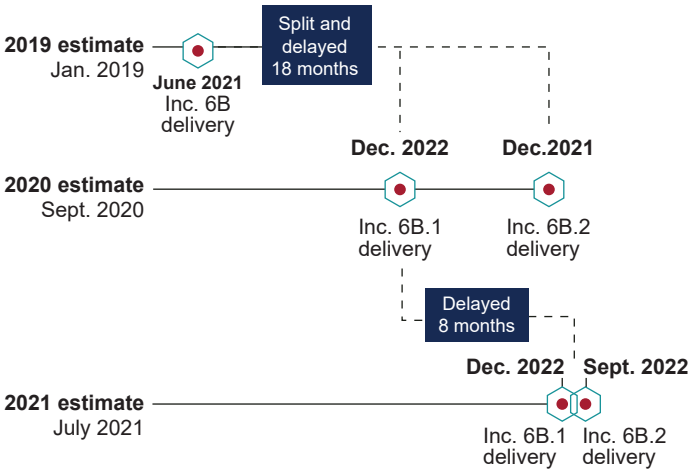
Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075
Note: Transfer is not applicable to the C2BMC program.

DELIVERIES

Spiral 8.2-5 plans to provide capabilities to support homeland defense, including control of the Long Range Discrimination Radar (LRDR), hypersonic threat missile tracking and reporting, and space domain awareness capabilities. This spiral was split into two increments—Inc. 6B.1 and 6B.2—to synchronize with the 2019 replan of related MDS capability and to offset COVID-19 effects. Delivery of Inc. 6B.1's five functionalities, originally planned for fiscal year 2021, was initially delayed to September 2022 due to agency-wide testing delays and pandemic restrictions (see graphic), but has since been further delayed to April 2023.

Spiral 8.2-7 plans to refine the LRDR's space awareness capabilities in support of homeland defense. The program held a developmental baseline review for this spiral in April 2021, which established its technical program of record and ushered it into the product development phase. C2BMC plans to deliver this spiral in March 2024.

C2BMC Spiral 8.2–5 Extended Delivery Delays



C2BMC Command, Control, Battle Management, and Communications

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

Note: As of May 2022, Increment 6B.1 delivery is scheduled for April 2023 and Increment 6B.2 for July 2024.

COVID-19

- Spiral 8.2-5's development progress was slowed by facility access restrictions and quarantine requirements, but program officials said that C2BMC's prime contractor has used numerous mitigations, including added staffing, to try and offset productivity losses.
- COVID-19 personnel access restrictions impacted MDA's ability to test, resulting in agency-wide test delays. Ground Test Integrated (GTI)-08a, a pivotal test that will demonstrate C2BMC integration of LRDR and space domain awareness capabilities, has been further delayed until at least February 2022.

TESTING

C2BMC Fiscal Year 2021 Testing

Test	Conducted	Delayed	Deleted
Flight	▲▲▲ ▲▲▲▲▲	▲△	
Ground	▲▲△△	▲△△△△△	
Cybersecurity		△△△	

▲ S8.2-3 △ S8.2-5

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

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

In fiscal year 2021, C2BMC participated in 12 tests, with only two ground tests— At-Sea Demonstration (ASD)-1 and ASD-2—utilizing spiral 8.2-5 software and the remaining 10 using the currently fielded spiral 8.2-3. To date, spiral 8.2-5 has participated in very little system-level testing and additional testing is needed to demonstrate software maturity and performance prior to its current planned delivery dates in September and December 2022.[1]

While ASD-1 was critical in demonstrating one aspect of MDS space domain awareness capability, future tests will provide data needed to refine this new capability. One of test—GTI-08a—was was further delayed from the third quarter of fiscal year 2020 to at least February 2022. This test intends to (1) demonstrate spiral 8.2-5's ability to correlate and report data to and from multiple sensors and systems, (2) refine space domain capabilities, and (3) support the decision to use Inc. 6B.1 operationally. Extended delay of this pivotal test caused a ripple effect to subsequent ground, cyber, and flight tests and has the potential to delay development, operational capability decisions, and fielding activities for the spiral.

[1]As of May 2022, Increment 6B.1 delivery is scheduled for April 2023 and Increment 6B.2 for July 2024.

OTHER PROGRAM INFORMATION

Cybersecurity

C2BMC did not participate in any operational cybersecurity tests during fiscal year 2021 due to agency-wide delays resulting from COVD-19 restrictions and software readiness according to program officials. The program's cooperative vulnerability and penetration assessment, initially scheduled to begin in May 2021, is now planned for the third quarter of fiscal year 2022.[2] For the second consecutive year, lack of operational cyber testing has delayed the cyber certification of spiral 8.2-5's software development architecture—originally planned for fiscal year 2019—which added schedule risk to the program and may delay the operational fielding of the spiral. Completion of the developmental architecture is crucial to the demonstration of this spiral's software maturity. Based on incremental engineering reviews, Director Operational Test and Evaluation officials note that implementation of 8.2-5's developmental architecture is going well in some areas and requires more work in others. The program did complete two developmental cyber tests on spiral 8.2-5, a cooperative vulnerability identification in October 2020 and adversarial cybersecurity developmental test and evaluation in May 2021.[3]

Additionally, C2BMC is continuing its implementation of DevSecOps, an iterative software developmental practice whose goal is a more rapid delivery of safer software. DevSecOps uses automation to increase collaboration between development, security and operations and focuses on frequent delivery of secure software to the warfighter. The program recently completed the first phase of the effort focused on building a continuous integration and deployment of a C2BMC prototype and has initiated phase two that among other things, will include automation of security access controls for the developmental and operational systems.

[2]Operational cybersecurity testing consists of two assessments: Cooperative Vulnerability and Penetration Assessment (CVPA) and an Adversarial Assessment (AA). CVPA provides initial information about the resilience of a system in an operational context, which is used to develop the subsequent AA. The AA characterizes the operational effects caused by a threat representative cyberattack and the effectiveness of defensive capabilities.

[3]Developmental cybersecurity testing consists of two assessments: Cooperative Vulnerability Identification (CVI) and an Adversarial Cybersecurity Developmental Test and Evaluation (ACD). CVI is used to collect data needed to identify vulnerabilities and plan mitigations. An ACD event uses realistic threat scenarios in a operationally representative cyber environment to identify vulnerabilities.

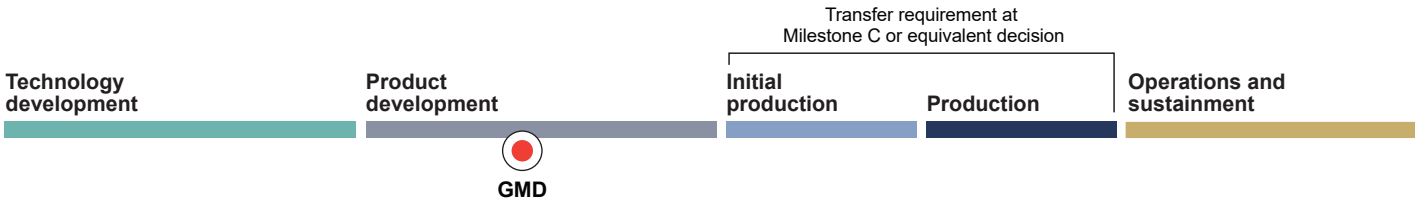
Source: U.S. Northern Command /Army Sgt. Jack W. Carlson III | GAO-22-105075

PROGRAM OVERVIEW

Ground-Based Midcourse Defense (GMD)

The Missile Defense Agency (MDA) is developing the GMD system 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 control systems, 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 fleet of 44 GBIs and a ground system consisting of fire-control consoles, interceptor launch and maintenance facilities, and a communications network. MDA is developing a new GMD interceptor, called the Next Generation Interceptor (NGI), to defeat future missile threats.

MDA currently has no plans to transfer GMD to the Army.

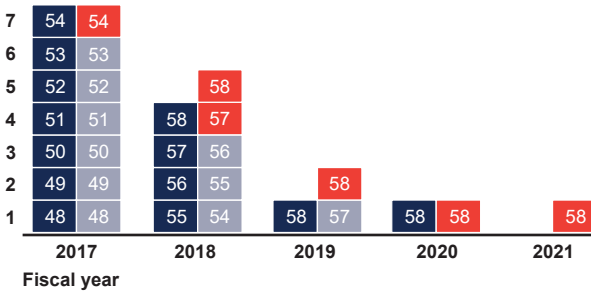


Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075
Note: GMD has ongoing activities in all phases of the acquisition life cycle.

DELIVERIES

GMD delivered a GBI in December 2021 that was originally planned for delivery over three years ago. MDA rebaselined the delivery date for the outstanding GBI (#58) to fiscal year 2020 but production challenges delayed delivery to fiscal year 2022. The production delays originate from an issue in 2018 where the boost vehicle contractor mishandled a key avionics component and had to build a new one. The contractor subsequently experienced quality issues with a vendor who supplied an electronic power conversion part needed to build the avionics component. The contractor worked with a new vendor to supply the part, but the first several production lots were rejected due to quality issues. The supplier eventually resolved the issues but boost vehicle production was delayed from 2019 to 2021 as a result. GMD delivered and emplaced the GBI in December 2021.

GMD Interceptor Deliveries, Fiscal Years 2017–2021



GMD Ground-Based Midcourse Defense

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

COVID-19

- GMD overcame COVID-19-related delays constructing a new missile field at Fort Greely, Alaska.
- GMD met an urgent warfighter request to install additional fire control workstations at Cheyenne Mountain Space Force Station to enable crew separation in line with pandemic protocols.
- MDA delayed ground tests, in part, due to COVID-19 restrictions and pandemic protocols.
- GMD is projecting longer production lead times for GBI components and launch support system items due to the limited availability of microelectronic components from COVID-19-related supply issues.

TESTING

GMD Fiscal Year 2021 Testing

Test	Conducted	Delayed	Deleted
Flight	◆	◆	
Ground		■■	
Cybersecurity		●●	

◆ Non-intercept flight test ◈ Intercept flight test

■ Ground test ● Operational cybersecurity test

GMD Ground-Based Midcourse Defense

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

In September 2021, MDA successfully flight tested a GBI using only two of its three booster stages while in flight which can expand GMD's battlespace to engage missiles. GMD also performed two developmental cybersecurity tests. However, officials noted that MDA delayed a key ground test—GTI-08a—because of challenges associated with COVID-19 and software readiness across several MDA elements, including GMD. GMD's other planned tests for fiscal year 2021 were all dependent on successful completion of the ground test and were thus delayed. These tests are important because they demonstrate new GMD capabilities, notably GMD's ability to use the recently delivered Long Range Discrimination Radar.

OTHER PROGRAM INFORMATION

Next Generation Interceptor

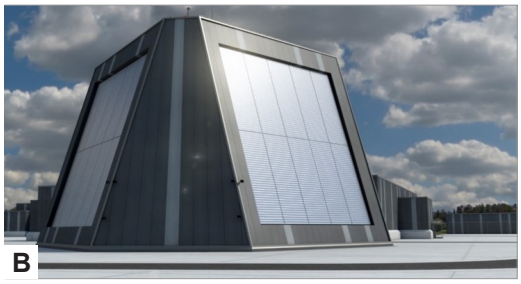
GMD began development of the NGI in fiscal year 2021 and has completed some initial program planning activities and requirements reviews. GMD is pursuing NGI concepts with multiple kill vehicles capable of defending against a greater volume of increasingly more complex missile threats as compared to the GBI, thereby increasing the defensive efficiency of the GMD fleet. In January 2021, the Under Secretary of Defense for Acquisition and Sustainment approved transitioning NGI to the Technology Development Phase and awarding a minimum of two development contracts to maintain competition through the program's critical design review when designs are expected to be mature and stable. MDA awarded contracts to Lockheed Martin and Northrop Grumman in March 2021. Both contractors conducted a series of technical reviews in fiscal year 2021 through early fiscal year 2022 and the program is planning to mature technologies, test parts, and continue developing NGI concepts in fiscal year 2022.

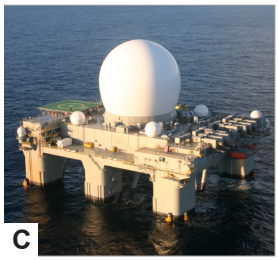
GMD Service Life Extension Program

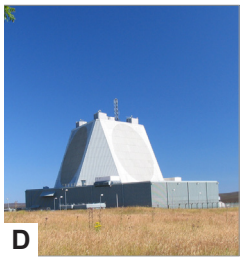
GMD is planning to upgrade nine GBIs that were originally emplaced starting in 2004 to improve reliability and performance, but the program is unable to formally extend the fleet's service life. GMD plans to inspect, test, and replace kill vehicle and boost vehicle parts and components and, for some interceptors, replace the entire 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. However, the program lacks the spare parts necessary for parts testing to officially extend the GBI fleet's planned 20-year service life in accordance with industry and military standards. GMD continually assesses the reliability of fielded GBIs because, according to MDA, interceptor reliability and performance are expected to degrade over time due to various effects of aging, such as corrosion and fatigue. According to MDA, it has confidence that the service life of GBI parts can extend beyond their official expiration date based on parts testing the program has performed on multiple production lots.

GMD Contract Strategy

GMD is moving forward with plans to award multiple contracts to execute the various aspects of developing, producing, integrating, testing, maintaining, and sustaining the GMD system. According to MDA, most of the GMD program (except NGI) is currently executed through the Development and Sustainment Contract, which was originally awarded in 2011 to Boeing. The period of performance of the contract was previously extended to the end of 2023 for the bulk of the contract's scope, according to program documentation. The program anticipates extending the contract to fiscal year 2025 to complete the currently planned increment of capability. In fiscal year 2021, MDA awarded two NGI development contracts and released draft requests for proposals for a GMD Weapons System contract and a System Integration, Test, and Readiness contract.







Source: Missile Defense Agency. | GAO-22-105075

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.

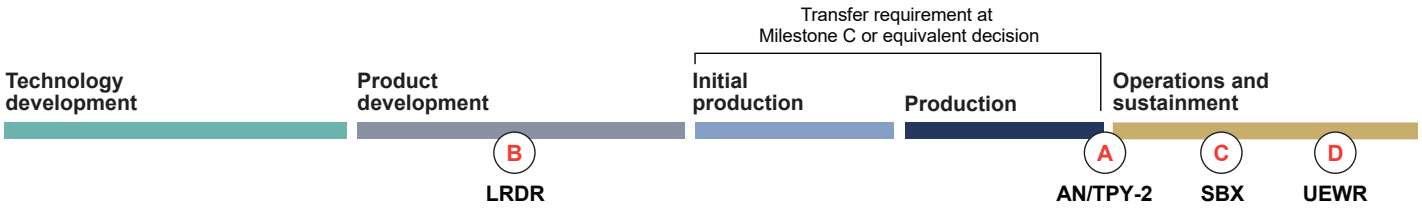
A. Army Navy/Transportable Radar Surveillance and Control Model-2 (AN/TPY-2) are transportable X-band radars that operate in one of two modes: forward-based (tracks threat missiles after launch) or terminal (helps guide interceptors to defeat incoming threat missiles). There are 12 radars located around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

B. Long Range Discrimination Radar (LRDR) is a fixed location S-band radar in Clear, Alaska, for long-range discrimination capability.

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 threat missiles. Locations include Beale, California; Fylingdales, United Kingdom; Thule, Greenland; Clear, Alaska; and Cape Cod, Massachusetts.

Transfer of AN/TPY-2 to the Army is pending congressional direction. LRDR is expected to transfer to the Space Force by fiscal year 2023. MDA and the Navy share responsibility for the SBX. And UEWR transferred to the Air Force in 2013.



Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

Note: Sensors have ongoing activities in multiple phases of the acquisition life cycle.

DELIVERIES

According to officials, the Sensors program did not complete its planned deliveries in fiscal year 2021 due to COVID-19 restrictions and delays. Specifically, the Sensors program delayed deliveries of software for AN/TPY-2 and SBX, the LRDR site, and the operational acceptance of the UEWR location in Thule (see table). Despite COVID-19 restrictions, the Sensors program made progress delivering capabilities. For example, the program installed all ten LRDR primary array panels. Also, the program completed operational acceptance of the the UEWR Cape Cod and Clear locations in November 2020 and April 2021, respectively.

Sensors Fiscal Year 2021 Deliveries

	Planned	Status
Army Navy/Transportable Radar Surveillance and Control Model-2 (AN/TPY-2)	2 x86 processor upgrades	**Canceled.** Program officials said they plan to include upgrades in future modernization efforts.
	Common Software build 4.0 that is expected to add discrimination and hypersonic tracking capabilities	**Delayed.** Will be delivered in three installments over fiscal years 2022 and 2023.
Long Range Discrimination Radar (LRDR)	1 LRDR site to support homeland defense	**Delayed** to fiscal year 2022.
Sea Based X-band (SBX)	XBR software to improve threat missile discrimination	**Delayed** to fiscal year 2022.
Upgraded Early Warning Radar (UEWR)	Thule operational acceptance	**Delayed** to fiscal year 2022. A delayed assessment at the Beale location contributed to the delay at Thule.

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

COVID-19

- Pandemic restrictions have hindered the completion of planned work across the Sensors program.
- The Sensors program experienced cost increases to maintain the LRDR while on-site construction was paused and to test and quarantine SBX personnel in line with COVID-19 protocols.
- Ground and cybersecurity testing were delayed, which resulted in developmental delays and affected software readiness.

TESTING

Sensors Fiscal Year 2021 Testing

Test	Conducted	Delayed	Deleted
Flight	◈ ◈ ◈ ◆ ◆	◆ ◈	
Ground	■ ■	■ ■ ■ ■ ■	
Cybersecurity	● ● ●	● ● ●	

◆ Non-intercept flight test ◈ Intercept flight test

■ Ground test ● Operational cybersecurity test

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

In fiscal year 2021, Sensors participated in five flight tests.

- AN/TPY-2 participated in two flight tests—FTP-27 Event 1 and TH CTV-01. The first test demonstrated the Patriot Weapon System's ability to launch interceptors using data from Terminal High Altitude Area Defense's (THAAD) radar (AN/TPY-2). The second test experienced issues with THAAD's 4.0 software build necessitating a retest in fiscal year 2022.
- UEWR participated in two international flight tests—FS-21 Events 2 and 4—and another flight test—SM CTV-04.

In fiscal year 2021, AN/TPY-2 participated in two ground tests—GTI-21 Sprint 1 and Sprint 2—to provide data to support a decision to field certain THAAD capabilities. Other ground tests were shifted to fiscal year 2022 while awaiting the completion of GTI-08a, which has been delayed due to software readiness and COVID-19 restrictions. GTI-08a will provide data for multiple missile defense systems and is the first ground test to assess the LRDR 's software and capabilities.

SBX and AN/TPY-2 participated in element-level operational cybersecurity tests, including Cooperative Vulnerability and Penetration Assessments and an Adversarial Assessment.

OTHER PROGRAM INFORMATION

Risks for Some Sensors

Sensors officials noted the following risks:

- AN/TPY-2 components are becoming obsolete and replacements are less available or more costly.
- UEWR currently has schedule risk due to concurrent upgrades and sustainment efforts at all five locations. Sensors officials emphasized the need to deconflict the schedule to maintain system availability.
- SBX needs to replace the radar dome (radome)—a protective shroud—to ensure continued performance after the end of the current radome's design life in 2025. Sensors officials noted replacement challenges include determining optimum adhesives and sealants to prevent the recurrence of premature materiel failure.

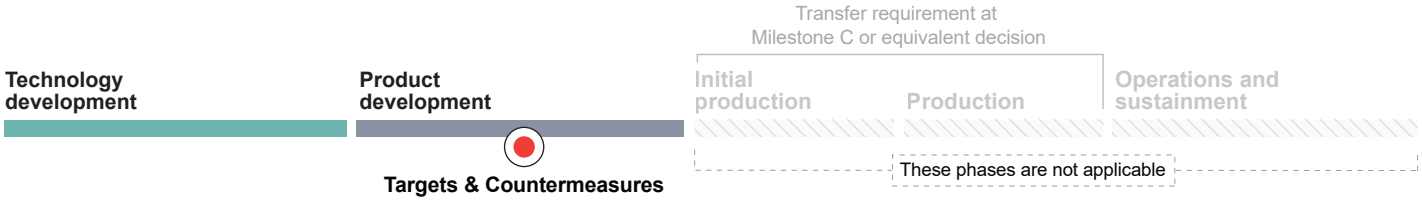
Source: FTM-31 E1 target launch from PMRF. | GAO-22-105075

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. As such, this program will remain in product development and transfer to a military service is not applicable.



Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

DELIVERIES

In fiscal year 2021, the Targets program delivered a total of seven targets—four shifted from the prior fiscal year due to testing delays and three as planned. All seven targets were used in flight testing for the Aegis weapon system, as outlined in the testing section below.

Five targets planned for delivery in fiscal year 2021 were either delayed to fiscal year 2022 or are no longer needed. For example, one short-range target for a THAAD flight test—FTT-21—to support an operational need in Korea was delayed (see appendixes VI and VII). Two of three intermediate-range targets were delayed and the third is no longer needed. An intercontinental-range target for a technology demonstration flight test—FTX-43—wherein sensors will track and collect data on an advanced vehicle was also delayed.

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 can result in deliveries either exceeding or not meeting annual goals.

Targets Fiscal Year 2021 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-22-105075

COVID-19

- The Targets program experienced a cost increase of approximately $2 million from extended deployments of contractor personnel—due to pandemic quarantine requirements—to support flight testing.
- The Targets program offset some cost increases by maximizing the use of virtual technologies and reducing travel to sites that support the production and assembly of the targets.
- The Targets program encountered supplier delays and longer lead times, which contractors have advised may result in some targets being delivered late and at a higher cost.

TESTING

Targets Flown During Fiscal Year 2021 Flight Testing

Target range	Test
Short-range	◈ ◈ ◆
Medium-range	◈ ◈ ◈
Intermediate-range	
Intercontinental-range	◈

◆ Non-intercept flight test ◈ Intercept flight test

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

Note: 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).

In fiscal year 2021, the Targets program flew seven targets, some of which were new or for a first-time event, to support testing for the Aegis weapon system.

Two new targets—a short-range (two of these) and a medium-range—were flown during FTM-33 and FTM-31 Event 1, respectively, for testing the Aegis's Standard Missile (SM)-6 Dual II interceptors. The Targets program said both new targets generally performed as needed, but there is an ongoing review to determine the cause of a failure during FTM-31 Event 1.

One intercontinental-range target was flown during a congressionally mandated flight test—FTM-44—to assess the Aegis SM-3 IIA interceptor's capability against a broader threat range than its design intended.

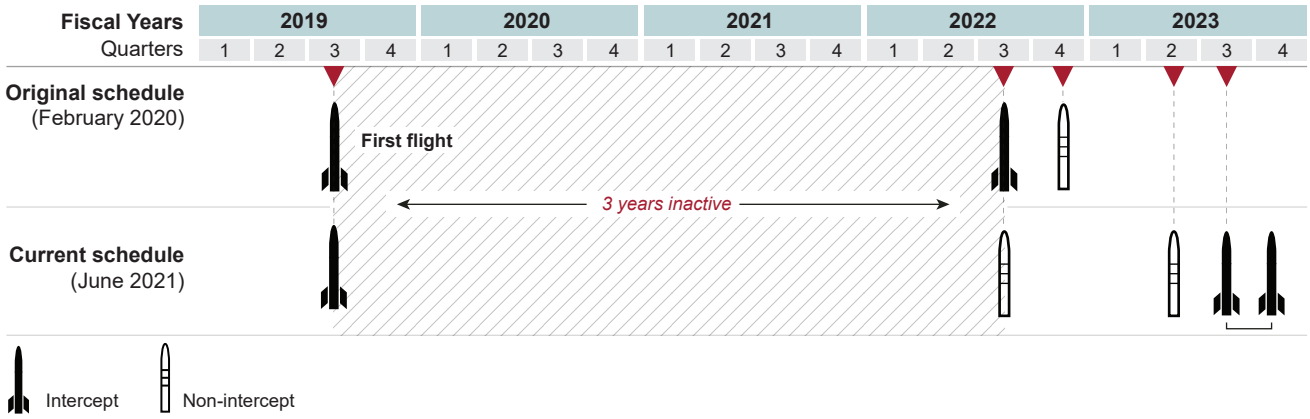
The remaining targets—a short-range and two medium-range —were flown during a multi-part international test—FS-21—to demonstrate the Aegis ships' ability to inter-operate with allied systems and sensors, among other things.

OTHER PROGRAM INFORMATION

Leveraging Risk-Reduction Opportunity for Inactive Target

According to the Targets program, it is leveraging an upcoming non-intercept test to reduce risks for a medium-range target (MRBM T1/T2). This target flew for the first time in August 2019 but has not flown since. The program plans to fly this target as a hypersonic threat during a flight test—a significant first time event—in the second quarter of fiscal year 2023. Thus, the Targets program said it plans to reverify the contractor's procedures and resolve any issues during a non-intercept flight test in the third quarter of fiscal year 2022, as shown in the figure.

Reverifying Medium-Range Target's Performance through Non-intercept Test



Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

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, so there is a limited supply available. 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 is planned for the third quarter of fiscal year 2028.

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 is planned for the second quarter of fiscal year 2023.

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. According to the Targets program, the first launch is planned for the second quarter of fiscal year 2024.

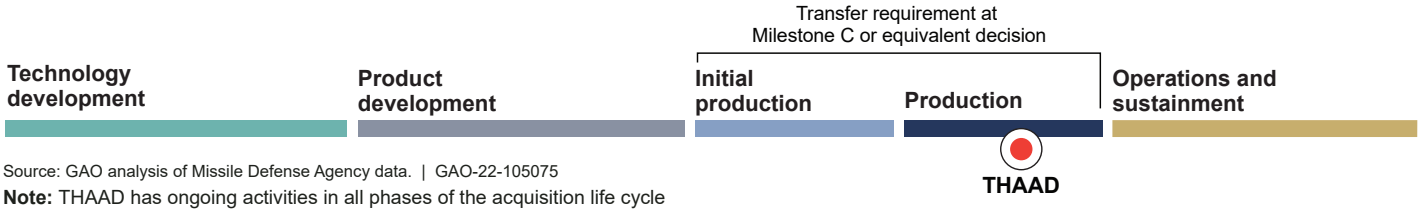
Source: Missile Defense Agency. | GAO-22-105075

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. In October 2020, the Undersecretary of Defense for Acquisition and Sustainment approved THAAD's entry into full-rate production. THAAD was authorized an increase in the number of interceptors up to 910 and received approval for an eighth battery. THAAD plans to continue production through fiscal year 2035 for remaining items, such as interceptors, software upgrades, and hardware for the eighth battery.

Current legislation requires the Missile Defense Agency (MDA) to transfer ownership (acquisition and total obligation authority) of programs like THAAD to the respective military service (the Army) when approved for full-rate production. Congress's current deadline for transfer is October 1, 2023. However, MDA is seeking to retain this program in perpetuity.



Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075
Note: THAAD has ongoing activities in all phases of the acquisition life cycle

DELIVERIES

THAAD delivered 105 interceptors in fiscal year 2021. THAAD planned to deliver 84 interceptors to complete Lot 10 (Lots are a specific quantity produced under identical conditions). However, THAAD was unable to complete Lot 10 due to a previous halt in production to qualify a replacement for a part that is no longer available. As shown in the figure, this halt in production shifted some Lot 9 interceptors into fiscal year 2021, and THAAD plans to deliver the remaining Lot 10 interceptors into fiscal year 2022.

THAAD can currently deliver eight interceptors per month and surge up to 12 for temporary durations. However, the program is taking steps to more consistently deliver 12 interceptors per month if needed by procuring additional tooling and test equipment. 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.

THAAD also delivered 13 pallets designed to transport more THAAD interceptors at one time to needed locations.

THAAD Interceptor Deliveries, Fiscal Years 2020-2022

		2020				2021				2022			
Fiscal years / Quarters		1	2	3	4	1	2	3	4	1	2	3	4
Lot 9	Plannned	0	24	23	0	0	0	0	0	0	0	0	0
	Actual	0	24	13	0	10	0	0	0	0	0	0	0
Lot 10	Plannned	0	0	1	24	24	24	24	12	0	0	0	0
	Actual	0	0	0	0	20	19	16	40	14	0	0	0

Planned; Actual (on time); Actual (delayed 1 quarter); Actual (delayed 2 or more quarters)

THAAD Terminal High Altitude Area Defense
Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

COVID-19

- THAAD officials highlighted delays with development and production activities due to pandemic-driven restrictions on travel and facility access.
- THAAD experienced issues ordering and receiving parts from some suppliers, according to officials, but worked to minimize disruptions to production.
- THAAD had to use interim workarounds, such as virtual technologies, to conduct some on-site visits, provide training to the warfighter, perform property inventories, and support the transit of equipment and munitions.

TESTING

THAAD Fiscal Year 2021 Testing

Test	Conducted	Delayed	Deleted
Flight	◆ ◈	◈	
Ground	■	■■■■■■	
Cybersecurity		●	

◆ Non-intercept flight test ◈ Intercept flight test
■ Ground test ● Operational cybersecurity test

THAAD Terminal High Altitude Area Defense

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

Note: An operational cybersecurity 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 2021, THAAD conducted two flight tests—FTP-27 E1 and TH CTV—and delayed one—FTT-21—to fiscal year 2022. All of these flight tests support an operational need. The first test proved Patriot's ability to use THAAD's tracking and discrimination data to intercept short-range threat missiles sooner. The second test planned to show THAAD's ability to launch Patriot interceptors, thereby extending its defended area. However, issues discovered during TH CTV-01 with THAAD's 4.0 software build necessitated a retest in fiscal year 2022.

THAAD participated in one ground test—GTI-21 Sprint 1—and delayed six others. This test assessed integration between THAAD and Patriot, THAAD's ability to launch interceptors locally and remotely, and interoperability among various systems using THAAD's 4.0 software build.

However, MDA delayed an operational cybersecurity test for the THAAD 4.0 software build to fiscal year 2022 due to the testing delays and failures outlined above. Program officials noted that this software build is a significant stride to improve cybersecurity for THAAD, but they are awaiting further testing to verify its performance.

OTHER PROGRAM INFORMATION

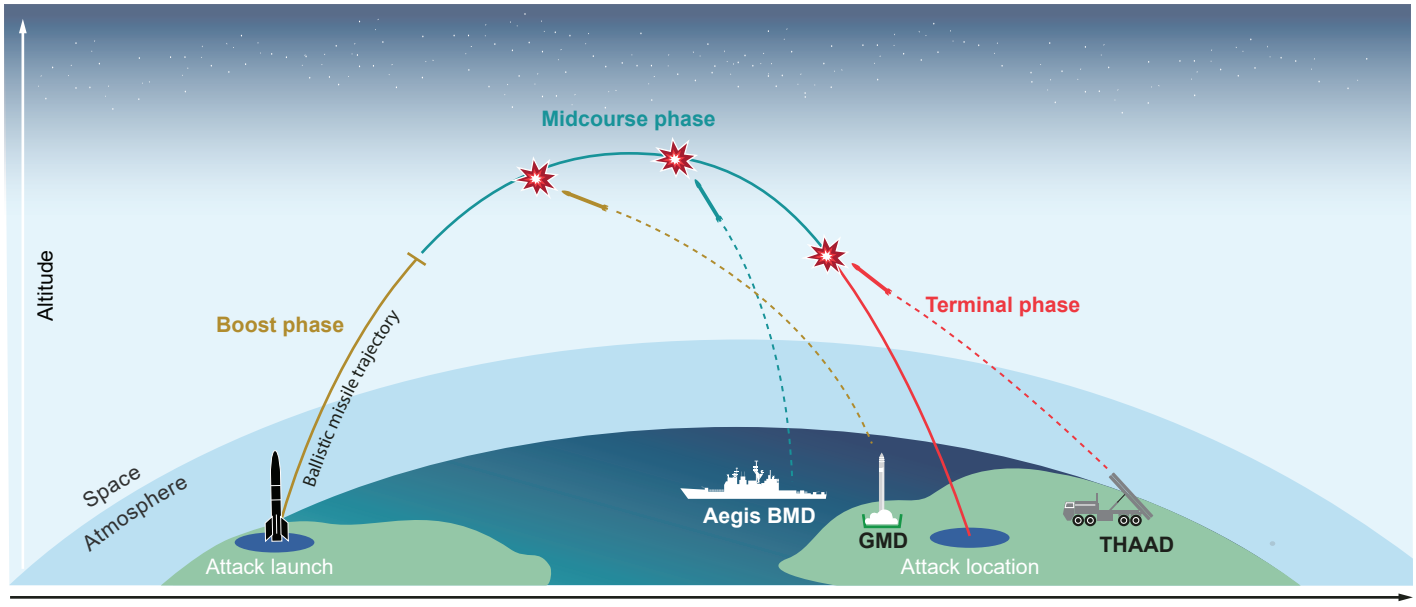
Innovations

THAAD held a demonstration in March 2021 using a high-voltage, on-board vehicle power system architecture that has possibilities to provide less expensive and more reliable mobile power solutions. According to program officials, it was the first demonstration of its kind in the world.

Layered Homeland Defense

MDA is 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. THAAD would need a number of software and hardware upgrades to provide such a capability.

Notional Depiction of Layered Homeland Defense



BMD Ballistic Missile Defense
GMD Ground-Based Midcourse Defense
THAAD Terminal High Altitude Area Defense

Source: GAO depiction of Missile Defense Agency data. | GAO-22-105075

Source: Missile Defense Agency. | GAO-22-105075

PROGRAM OVERVIEW

Joint Emergent Operational Need (JEON)

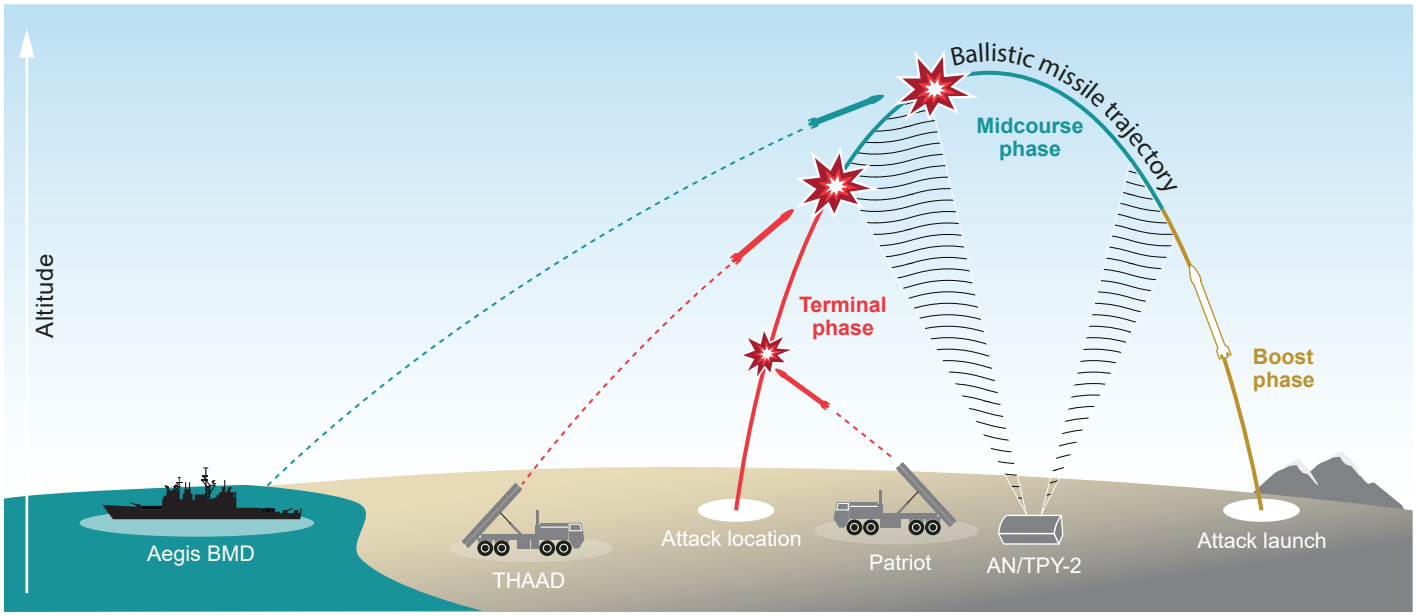
North Korea has accelerated efforts to field missiles capable of threatening deployed U.S. forces, allies, and partners in the region. It has fielded an increased number of regional missiles and diversified its launching platforms to include road-mobile and submarines. Since 2015, North Korea has test-launched over two dozen regional missiles, including a salvo launch of five ballistic missiles in 2017 that the country announced simulated the mission of targeting U.S. bases in Japan.

Amid this testing, upgraded capabilities were requested in 2017 to defend against the North Korean threat. This request came in the form of a JEON—a high-priority, warfighter-identified need that requires a rapid solution. Specifically, the warfighter sought increased integration between existing missile defense systems (outlined below) in order to cover and defend wider areas against a broader array of threats. The Missile Defense Agency (MDA) and Department of Defense (DOD) stakeholders developed a plan with capability deliveries planned into 2021.

THE PLAN

DOD's original plan to address the JEON, approved in August 2017, included capabilities that integrate three missile defense systems—Terminal High Altitude Area Defense (THAAD), Patriot, and Aegis Ballistic Missile Defense (BMD). These systems have complementary capabilities, and, when integrated enable a layered defense to intercept threats at different altitudes (see figure). DOD's original plan to address the JEON involved phased capability deliveries into 2021, designed to defend larger areas and allow for increased defensive flexibility against the various ways North Korea could launch its short- and medium-range ballistic missiles in a coordinated attack.

Notional Depiction of Integrated Capabilities for the Joint Emergent Operational Need (JEON)



AN/TPY-2 Army Navy/Transportable Radar Surveillance and Control Model-2
BMD Ballistic Missile Defense
THAAD Terminal High Altitude Area Defense

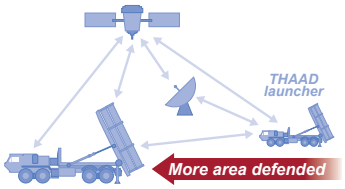
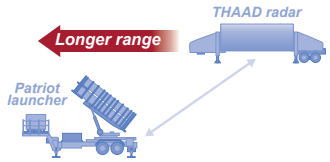
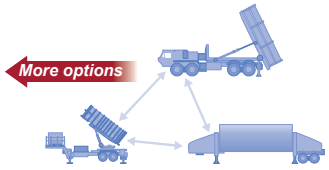
Source: GAO depiction of Missile Defense Agency data. | GAO-22-105075

MDA and DOD made progress achieving some of the initial aspects of the plan. This included emplacing additional THAAD launchers and support equipment to increase the ability to target multiple threats, and upgrading THAAD and Patriot software to expand performance against additional threats. However, DOD decided not to budget for the final phase and stakeholders revised the plan in early 2018. Specifically, DOD did not request funding for $1.3 billion in JEON requirements and refocused the effort on specific warfighter priorities related to THAAD and Patriot integration.

DELIVERIES

MDA has delivered the first two capabilities of the revised JEON plan—THAAD Remote Launcher Part 1 and Patriot Launch-on-Remote (THAAD).[1] According to MDA's fiscal year 2021 baseline, the final JEON capability delivery—Initial THAAD/Missile Segment Enhancement (MSE) Integration— was planned for the third quarter of fiscal year 2021. However, according to MDA officials, it was subsequently delayed to the first quarter of fiscal year 2022 and then to the third quarter of fiscal year 2022 amid the testing issues discussed below. The remaining capabilities from the original JEON plan are no longer officially a part of the effort, though two of three are still included in MDA's future delivery plans (see figure).

Overview of the Joint Emergent Operational Need Capability Deliveries

Capability	Description	Current Status
THAAD Remote Launcher, Part 1 	Adds flexible communication paths to THAAD launchers, extending launcher emplacements far beyond the current limit, which will increase the number of defended assets.	Delivered, December 2019
Patriot Launch-on-Remote (THAAD) 	Allows Patriot to launch its interceptor using THAAD track data. This increases coverage of Patriot batteries by taking advantage of THAAD's longer range radar, allowing Patriot to launch its interceptor sooner, and intercept the threat earlier.	Delivered, March 2021
Initial THAAD/MSE Integration 	Allows THAAD to plan for and engage with Patriot Advanced Capability-3 Missile Segment Enhancement (MSE) interceptors or THAAD interceptors. This is accomplished by adding MSE launchers (fiber optic connection) and MSE missiles as a component of a THAAD battery.	Delayed to the third quarter of fiscal year 2022
Expanded THAAD Remote Launcher	Allows THAAD to deploy more launchers per battery to fire at threat missiles.	Delayed to the third quarter of fiscal year 2022, pending completion of testing
Full THAAD/MSE Integration	Adds THAAD integration of the MSE remote launcher capability.	2030
Upper Tier Engagement Coordination (THAAD-Patriot-Aegis BMD)	Allows weapon systems with shared defensive responsibilities within an area of operations to coordinate in order to conduct more efficient engagements. This increases the likelihood that each shooter engages the threat it is best positioned to engage and avoids wastage by multiple engagements of the same threat.	Removed

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

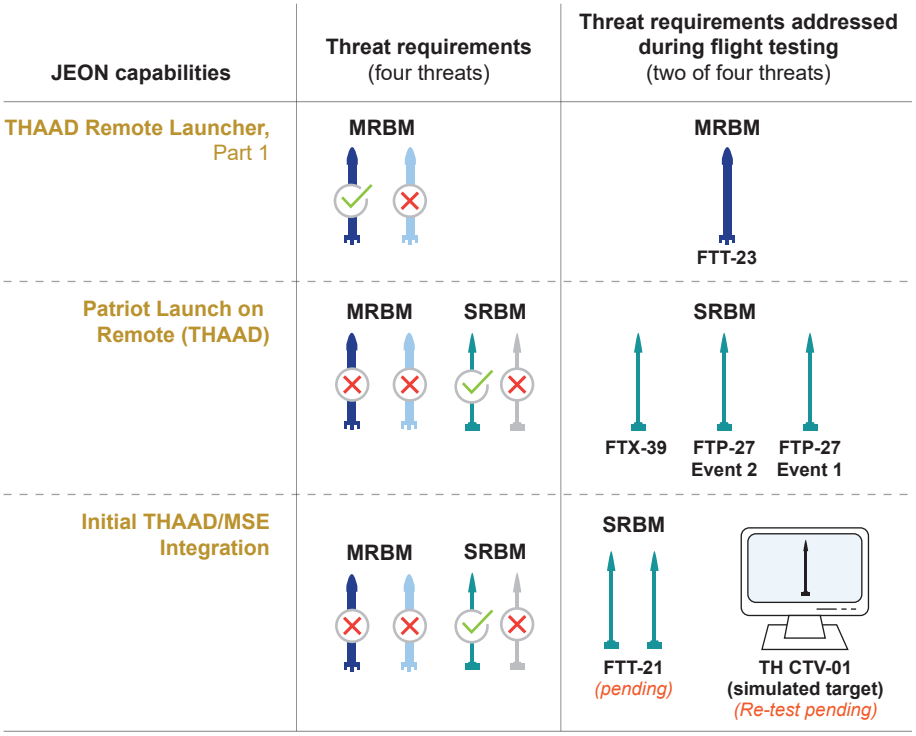
[1]GAO, *Missile Defense: Fiscal Year 2020 Delivery and Testing Progressed, but Annual Goals Unmet*, GAO-21-314, (Washington, D.C.: April 28, 2021); and *Missile Defense: Assessment of Testing Approach Needed as Delays and Changes Persist*, GAO-20-432, (Washington, D.C.: July 23, 2020).

TESTING

MDA has conducted most of its planned flight tests for the revised JEON plan, but not all tests have been successful. For example:

- In FTX-39, the short-range ballistic missile target failed shortly after launch and was terminated for safety concerns before THAAD and Patriot could collect any data.
- In FTP-27 Event 2, THAAD showed it could track and discriminate the missile target and send track data to support Patriot launching its interceptors. But, the interceptors failed due to a software error, preventing an end-to-end demonstration of the capability.
- In TH CTV-01, THAAD tracked and discriminated two simulated targets, calculated firing solutions, and provided commands to Patriot to launch MSE interceptors; however, both MSE interceptors self-destructed shortly after launch due to a software anomaly, according to MDA officials. MDA is planning to conduct a retest of TH CTV-01 in the second quarter of fiscal year 2022, followed by FTT-21, both of which are in support of the THAAD/MSE Integration capability.

Joint Emergent Operational Need (JEON) Capability Threat Requirements and Flight Tests



FTP	Flight Test Patriot	**MSE**	Missile Segment Enhancement
FTT	Flight Test THAAD	**SRBM**	Short-Range Ballistic Missile
FTX	Flight Test Other	**THAAD**	Terminal High Altitude Area Defense
JEON	Joint Emergent Operational Need	**TH CTV**	THAAD Control Test Vehicle
MRBM	Medium-Range Ballistic Missile		

✓ Tested ✗ Not tested

Source: GAO analysis of Missile Defense Agency data. | GAO-22-105075

In addition, the capabilities for the revised JEON plan will not be fully assessed against all of the threats originally identified—two short-range and two medium-range—prior to being delivered to the warfighter for operational use. Most notably, as shown in the figure, only one of the two medium-range threats will be represented during the JEON flight tests. According to the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)), resource constraints prevent MDA from flight testing capabilities against every possible threat prior to delivery to the warfighter. However, MDA has additional flight tests scheduled in fiscal years 2023 and 2024 to assess THAAD and Patriot interoperability, including two with medium-range targets. An operational flight test is also planned in fiscal year 2028 with Aegis, THAAD, and Patriot. While not officially a part of the revised JEON plan, these flight tests will provide additional data as MDA continues its incremental approach to delivering capabilities.

MDA also conducts ground testing against a wider variety of threat representations, according to OUSD(R&E). However, MDA continues to use unaccredited models—an issue we have previously reported—which increases the risk of distorted results on the system performance.[2] According to DOD's Director for Operational Test and Evaluation (DOT&E), MDA has yet to conduct ground testing with accredited models for Patriot Launch on Remote (THAAD)—a capability already delivered. A new Patriot model released during fiscal year 2020 is still under development and accreditation efforts are ongoing.

[2]Since MDA cannot conduct enough system-level flight testing of the entire Missile Defense System (MDS) to completely assess performance, decision makers use information from model-based ground tests to evaluate the operational effectiveness of the system. However, according to DOD and MDA policy, models used to operationally assess weapon systems must be accredited to ensure they reflect the real-world system. For more details, see GAO, *Missile Defense: Fiscal Year 2020 Delivery and Testing Progressed, but Annual Goals Unmet*, GAO-21-314 (Washington, D.C.: Apr. 28, 2021); and *Missile Defense: The Warfighter and Decision Makers Would Benefit from Better Communication about the System's Capabilities and Limitations*, GAO-18-324 (Washington, D.C.: May 30, 2018).

Appendix VIII: Prior Missile Defense Recommendations

Since 2010, we have made 61 recommendations to improve various areas of missile defense, 52 (85 percent) of which the Department of Defense (DOD) either fully or partially concurred.[1] In the paragraphs that follow, we outline the current status for these 61 recommendations—23 have been implemented, 23 remain open, and 15 have not been implemented. Also, in order to identify any trends for implementation status, we used the content of the recommendations to identify five thematic categories:

1. accuracy and completeness of costs,
2. acquisition decisions and progress,
3. coordination with stakeholders,
4. documentation and reporting, and
5. executability of testing.

We then sorted each of the 61 recommendations into a single category.

The Missile Defense Agency (MDA) has implemented 23 of the 61 recommendations, almost all of which DOD concurred with. Specifically, MDA has taken some notable steps to address recommendations in three of our five categories:

- To ensure the accuracy and completeness of its cost estimates, in 2012 MDA issued a *Cost Estimating and Analysis Handbook* that is generally aligned with GAO's *Cost Estimating and Assessment Guide.* MDA also incorporated sunk costs into its cost estimates and improved internal reviews of cost estimates, to include establishing an independent group for reviews.[2]
- To improve its acquisition decisions and progress, MDA analyzed potential alternatives before embarking on a certain effort and conducted additional testing to verify the performance of some

[1]For this analysis, we included 17 GAO reports since 2010—when MDA established baselines—that exclusively focus on MDA. There are other GAO reports wherein MDA was a part of a sample group or that include some aspect of missile defense; however, we did not include these in our analysis. See the Related GAO Reports at the end of this report for a complete list of the reports we included in our analysis.

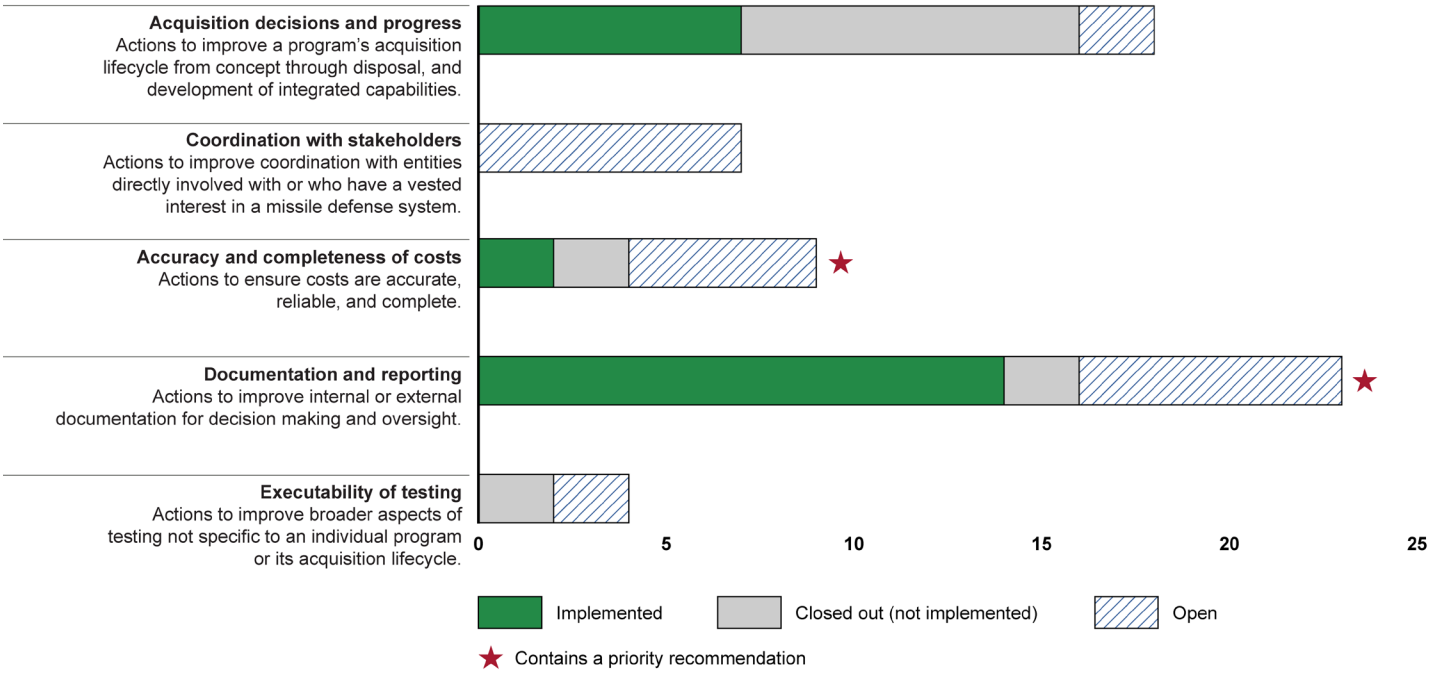
[2]MDA, *Cost Estimating and Analysis Handbook* (Jun. 19, 2012) and GAO, *Missile Defense: Cost Estimating Practices Have Improved, and Continued Evaluation Will Determine Effectiveness*, GAO-15-210R (Washington, D.C.: Dec. 12, 2014). MDA updated its *Cost Estimating and Analysis Handbook* in July 2021.

interceptors following design changes before proceeding further with production.

- To improve its documentation and reporting, MDA established baselines and set schedules for delivering assets and executing testing. MDA has also improved the transparency of its documentation and reporting by cross-walking changes to its program baselines and test plans.

As shown in figure 4, MDA has not yet implemented any of the recommendations related to coordinating with stakeholders and ensuring the executability of testing, and each open recommendation is explained in more detail in table 8 below.

Figure 4: Implementation Status of Selected GAO Recommendations on Missile Defense, Fiscal Years 2010-2022, by Category



Source: GAO. | GAO-22-105075

Note: Priority recommendations are the most important to save the federal government money, aid in decision making, and improve government programs. The Comptroller General of the United States sends the Department of Defense an annual report on open priority recommendations to encourage actions. See the most recent report: GAO-21-522PR. We analyzed 61 GAO recommendations from 17 reports between 2010 and 2022 that exclusively focus on the Missile Defense Agency. We sorted each recommendation into five broad categories. We used the most prominent aspect of each recommendation as the basis for categorization and limited each recommendation to a single category. Since the categories and sorting are based on our interpretation of each recommendation, they are subject to variation; however, we have determined that they are suitable for our purposes.

There are 23 recommendations that remain open, of which DOD did not concur with six. Most of these open recommendations are newer, originating in 2017 or later, and we understand that it can take time to complete the necessary action. However, there are two open recommendations from 2013, as shown in figure 5, which we have designated as priority because, in general, they help save the federal government money, aid in congressional decision-making, and improve government programs, among other things.[3] Specifically, these open priority recommendations address the completeness of MDA's life-cycle cost estimates to ensure all costs are accounted for and the traceability of MDA's program baselines to maintain insight into their performance over time.[4] DOD has requested that we close these recommendations as implemented, noting actions that MDA has taken; however, we recently assessed MDA's actions and found them insufficient because the cost estimate and baseline issues persist.[5] We subsequently identified additional practical actions that MDA can take to close these recommendations as implemented, but neither DOD nor MDA has acknowledged our proposed actions. Therefore, these priority recommendations remain open.[6]

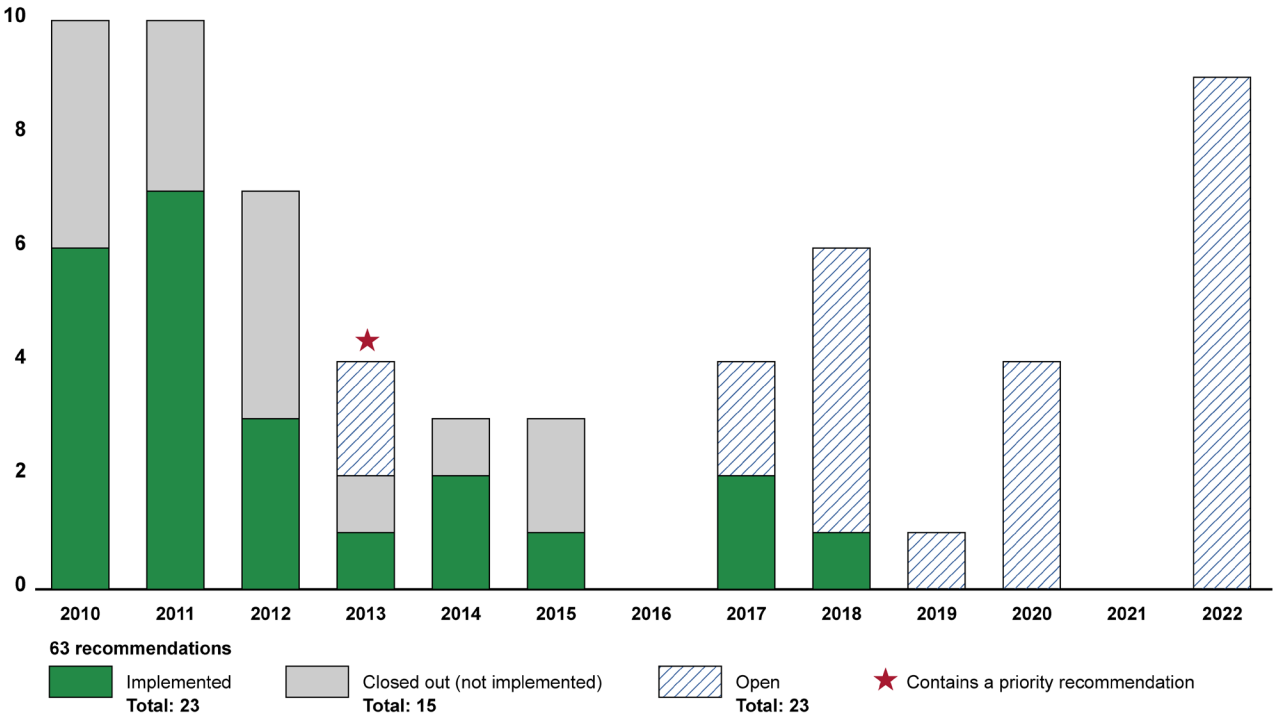
[3]The Comptroller General of the United States issues an annual report on open priority recommendations to encourage action. The most recent annual report was released in August 2021. See GAO, *Priority Open Recommendations: Department of Defense,* GAO-21-522PR (Washington, D.C.: Aug. 2, 2021).

[4]GAO, *Missile Defense: Opportunity to Refocus on Strengthening Acquisition Management*, GAO-13-432 (Washington, D.C.: Apr. 26, 2013).

[5]GAO*, Missile Defense: Addressing Cost Estimating and Reporting Shortfalls Could Improve Insight into Full Costs of Programs and Flight Tests*, GAO-22-104344 (Washington, D.C.: Feb. 2, 2022).

[6]GAO will close a priority recommendation under certain conditions, including if: (1) it is fully implemented, (2) it is no longer relevant, or (3) GAO would not make the same recommendation today given circumstances. However, none of these conditions are pertinent to the priority recommendations in GAO-13-432.

Figure 5: Implementation Status of Selected GAO Recommendations on Missile Defense, Fiscal Years 2010-2022, by Fiscal Year



Source: GAO. | GAO-22-105075

Note: Priority recommendations are the most important to save the federal government money, aid in decision making, and improve government programs. The Comptroller General of the United States sends the Department of Defense an annual report on open priority recommendations to encourage actions. See the most recent report: Priority Open Recommendations: Department of Defense, GAO-21-522PR (Washington, D.C.: Aug. 2, 2021).

All 23 open recommendations are listed in table 8 below.

Table 8: Open Recommendations on Missile Defense, 2013-2022

Report number	Recommendation	DOD position	GAO position
GAO-13-432	Include all costs, including the military service's operations and sustainment (O&S), in the agency's life cycle cost estimates. (A priority recommendation)	Partially concurred. The Department of Defense (DOD) noted the preparation of a number of joint cost estimates (JCE) with the military services to capture the O&S costs for specific programs. DOD considers this recommendation closed and no further action is planned.	MDA continues to not account for all costs—specifically, the O&S costs which can represent up to 70 percent of a program's cost. Decision makers need to understand the full cost of a program for investment and funding determinations. Most applicable programs do not have a JCE as required by policy, and there are multiple and disparate sources that capture the O&S costs for other programs. In 2022, we advised MDA that in order for it to meet the intent of our recommendation it should include a citation to the JCE or other source(s) that capture the O&S costs in its life-cycle cost estimates and baseline reporting (GAO-22-104344).
	Ensure traceability of the agency's acquisition baselines so that meaningful comparisons can be made over time. (A priority recommendation)	DOD concurred. DOD highlighted MDA's addition of a list of significant changes to its baseline reporting. MDA told us that a program's performance over time can be discerned by collating the list of significant changes. DOD considers this recommendation closed and no further action is planned.	MDA continues to have traceability issues with its baselines despite the addition of the list of significant changes. Decision makers need traceable baselines to understand each program's progress and to consider the prudence of its continuation. In 2022, we advised MDA to explore and rectify the underlying causes for the traceability issues in order to meet the intent of this recommendation (GAO-22-104344).
GAO-17-381[a]	Increase traceability and insight into MDA's test program by: (a) including a detailed crosswalk of test changes in each test plan; (b) addressing test scheduling policy deficiencies in line with GAO's leading practices; (c) issuing guidance and rectify test cost estimate deficiencies in line with GAO's leading practices; and (d) identifying requested funding amounts by test in the annual budget submission.	DOD concurred with part a, but did not concur with parts b, c, and d. DOD highlighted actions MDA has taken for parts a, b, c, and d. Specifically, MDA includes a crosswalk of changes in each test plan for part a, revised its scheduling policy for part b, revised the process for preparing test cost estimates and issued guidance for part c, and started sending Congress funding breakouts by test for part d. DOD has requested closure of this recommendation.	We are in the process of closing this recommendation as implemented.

Report number	Recommendation	DOD position	GAO position
	Develop a plan to transition the responsibility for determining the operational capability requirements for the missile defense systems from MDA to the U.S. Combatant Commanders (i.e. the warfighter) and in the interim, require the MDA to obtain concurrence of the Achievable Capabilities List prior to its release.	DOD did not concur. DOD and MDA have taken actions to better involve the warfighter in the requirements-setting process. DOD considers this recommendation closed.	MDA still determines the operational capability requirements for missile defense systems in the early stages of development. As a result, these systems may not fully meet the warfighter's needs. In 2021, we recommended that the U.S. Strategic Command establish a process for documenting and validating initial operational capability requirements (GAO-22-563).
GAO-18-324	Revise the agency's policies to require all integrated capabilities—broader capability achieved by combining the individual capabilities of two or more systems—be included in a Technical Capability Declaration (TCD).	DOD partially concurred. DOD noted revisions to MDA's TCD policies to clarify the process. DOD considers this recommendation closed.	Though updated, MDA's TCD policies still do not establish clear requirements and identify which integrated capabilities are to be included in a TCD. A TCD provides the warfighter information on the integrated capabilities' performance and limitations; without which, the warfighter may be ill-prepared for its operational use.
	Clarify the agency's policy on a TCD's requirements, process, and key milestones, and require a timely Assessment Requirements Review for meaningful input to the agency's test plans.	DOD concurred. DOD noted revisions to MDA's TCD policies to clarify the process. DOD considers this recommendation closed.	Though updated, MDA's TCD policies still do not set forth criteria for which capabilities are to be included in a TCD and the timing of certain reviews to ensure the test plan is constructed properly. Without this information, integrated capabilities could continue to be omitted and inadequately tested.
	Ensure validation and accreditation of the models used in the agency's operational ground tests.	DOD concurred. DOD noted that MDA has taken some action and more models are now accredited. DOD considers this recommendation closed.	All models used in operational ground tests are not accredited due to continued access issues to needed data, according to the accrediting entity—the Ballistic Missile Defense System Operational Test Agency. Lack of accreditation means the warfighter may be relying on inaccurate data about a system's performance during real-world operations.
	Include the validation and accreditation status of models used in operational ground tests, and any limitations on results, in TCD and other capability delivery packages.	DOD concurred. DOD noted that MDA revised its policies accordingly. DOD considers this recommendation closed.	We are working to confirm that the revisions have been put into effect in a recent TCD or capability delivery package; however, we have had limited access to this classified information due to the ongoing COVID-19 pandemic.

Report number	Recommendation	DOD position	GAO position
	Develop written agreements, as appropriate, between the agency and the military services on modeling and simulations technical and funding requirements.	DOD concurred. DOD said that MDA is in the process of updating written agreements with the military services to include this information.	These agreements are not yet finalized. We will continue to monitor MDA's efforts to finalize and execute written agreements.
GAO-19-387	Use available schedule margin to conduct flight testing against an intermediate-range threat and a raid prior to delivering European Phased Adaptive Approach (EPAA) Phase 3.	DOD partially concurred. DOD highlighted MDA's addition of two ground tests for EPAA Phase 3—one completed in fiscal year 2020 and the other delayed to an undetermined date pending the construction of the Aegis Ashore site in Poland, currently scheduled for no earlier than fiscal year 2022. MDA does not plan to add the recommended flight tests.	While both ground tests—a simulation—and flight tests—actual performance—are needed to assess system performance. Without flight tests to confirm system performance in these scenarios, the warfighter faces risks and uncertainty during real-world operations.
GAO-20-177[b]	Coordinate with the defense intelligence community on the agency's collective priorities for threat assessments and any needed resources.	DOD concurred. DOD said that MDA follows departmental processes for threat assessments and holds both formal and informal discussions with the defense intelligence community. DOD considers this recommendation closed.	MDA now meets quarterly with the defense intelligence community to discuss its prioritized threat assessment needs; however, MDA officials recently told us that they have not coordinated with the defense intelligence community on the associated resource needs. If the defense intelligence community lacks the necessary resources to produce timely threat assessments, MDA may risk using irrelevant or outdated threat information for its acquisition decisions.
	Provide insight into and obtain input from the defense intelligence community on the agency's threat space, threat parameters, and threat models.	DOD concurred. DOD noted that MDA fully engages the defense intelligence community. DOD considers this recommendation closed.	MDA is improving coordination by jointly working on the threat space for some new programs and jointly developing threat models for use in ground tests. DOD has an opportunity formalize these processes in MDA's charter—DOD Directive 5134.09—which is currently undergoing revision. If these updates are included in this directive, then we plan to close this recommendation as implemented.
	Coordinate with the defense intelligence community to establish a validation process for the agency's threat models.	DOD concurred. DOD said that a working group with MDA, the defense intelligence community, the operational test agency for missile defense was established, and a memorandum is nearly complete to formalize a process.	We will continue to monitor progress while awaiting the defense intelligence community's concurrence with the memorandum on the process.

Report number	Recommendation	DOD position	GAO position
GAO-20-432[c]	Conduct an independent assessment of the agency's process for developing and executing its annual test plan.	DOD concurred. MDA expects the Institute for Defense Analyses' assessment to be complete in March 2022 and will thereafter determine any necessary corrective actions to implement.	We will review the results of the Institute for Defense Analyses' assessment and MDA's implementation of any necessary corrective actions.
GAO-22-563	Establish a process for documenting and validating operational-level warfighter requirements in an initial requirements document.	DOD did not concur. DOD said establishing a process is counter to codified direction on MDA's unique acquisition authorities and processes. DOD considers this recommendation closed and no action is required.	We will continue to monitor ongoing changes led by the Joint Chiefs of Staff on a requirements validation process. In the meantime, without warfighter validation of requirements, MDA risks delivering systems that fall short of the warfighter's operational needs.
	Perform analyses of alternatives for all major Missile Defense System programs using warfighter-validated initial requirements documents.	DOD did not concur. DOD stated that MDA would recommend an edit to its charter during ongoing revisions to perform such analyses in collaboration with DOD Cost Assessment and Program Evaluation (CAPE) and the warfighter.	We will continue to monitor ongoing revisions to MDA's charter, and if and to what extent this information is included.
	Coordinate with the combatant commands and military services on the Top Level Requirements Documents (TLRD) prior to starting technology and product development.	DOD did not concur. DOD noted the feasibility and prudence of preparing a TLRD prior to technology development but also said it would premature to do so. DOD considers this recommendation closed and no action is required.	The Office of the Secretary of Defense directed MDA to prepare a TLRD for a new missile defense system prior to receiving approval to start technology development; however, such direction has not been applied to other systems. Preparing TLRDs ensures systems maintain a linkage to warfighter-approved operational requirements; without which, some systems may not meet warfighter's operational needs.
GAO-22-104344[d]	Ensure all applicable programs have an up-to-date JCE to capture the military services' O&S costs.	DOD concurred. DOD said that MDA intends to revise pertinent policies to ensure applicable programs have a JCE.	We are awaiting the revised policies and will continue to monitor progress.
	Require JCEs to be independently verified DOD CAPE.	DOD concurred. DOD said that MDA intends to revise pertinent policies to require JCEs to be independently verified by DOD CAPE.	We are awaiting the revised policies and will continue to monitor progress.
	Explore and rectify work breakdown structure (WBS) inconsistencies to ensure each program has a WBS that is aligned with the contractor WBS, and includes a WBS dictionary.	DOD concurred. DOD noted MDA's recent revisions to its Cost Estimating and Analysis Handbook to ensure close alignment between the program and contractor WBS and that each WBS has a WBS dictionary.	We are working to confirm that these revisions rectify the WBS inconsistencies.

Report number	Recommendation	DOD position	GAO position
	Update the agency's Cost Estimating and Analysis Handbook to specify that actual costs be regularly incorporated into flight test cost estimates.	DOD concurred. DOD noted MDA's recent revisions to its Cost Estimating and Analysis Handbook that require cost estimates to be regularly updated with actual costs.	We are working to confirm that the agency's cost estimates are being regularly updated with actual costs, as newly required by policy.
	Require a comparison to the original program cost baseline in each iteration of the agency's baseline reporting.	DOD did not concur. DOD said that MDA's current baseline reporting meets statutory requirements and that comparisons to the original baseline are of little value due to the constantly changing scope to address warfighter needs. DOD considers this recommendation closed.	Decision makers have limited insight into the cost performance of MDA's programs without recurring comparisons to the original baseline, as set forth in law and GAO's leading practices. Such comparisons show how the expected investment in a program has evolved, which decision makers can use to adjust priorities and funding, or to cancel a program in the event costs become untenable.
	Begin tracking each system's costs—the combined total of all programs that comprise the system—in its annual baseline reporting.	DOD did not concur. DOD said that MDA's current baseline reporting meets statutory requirements and that each system's costs can be discerned by compiling the relevant baselines. DOD considers this recommendation closed.	Decision makers lack insight into the full cost of MDA's systems needed for investment and funding determinations, among other things. MDA shifts costs across and outside of program baselines and also makes untraced adjustments to some baselines; thus, compiling relevant baselines is insufficient to capture the full costs of each system.

Source: GAO. | GAO-22-105075

[a]When we make a recommendation that has multiple parts, each part of that recommendation must be addressed to close it as implemented. When sufficient action has been taken to address specific parts, we update our public database accordingly. However, the entire recommendation (i.e., all parts) remain open until all parts have been addressed.

[b]This report is the unclassified version of a report by the same name.

[c]In February 2022, the Institute for Defense Analyses completed its independent assessment of MDA's processes for flight test planning and execution.

[d]In May 2021, GAO changed its numbering style for report names to reflect the fiscal year the report is issued and the job code under which work was completed.

Appendix IX: Comments from the Department of Defense

UNDER SECRETARY OF DEFENSE
3030 DEFENSE PENTAGON
WASHINGTON, DC 20301-3030

RESEARCH
AND ENGINEERING

13 May 2022

Mr. John Sawyer
Acting Director, Contracting and National Security Acquisitions
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Sawyer:

This is the Department of Defense response to the Government Accountability Office (GAO) Draft Report GAO-22-105075, "MISSILE DEFENSE: Better Oversight and Coordination Needed for Counter-Hypersonic Development," dated May 2022 (GAO Code 105075). The Department is providing the enclosed official response to the draft report recommendations and the enclosed technical comments for GAO's consideration to correct technical and factual inaccuracies in the draft report. Washington Headquarters Support will provide the final security classification review memo via separate correspondence.

Sincerely,

SHYU.HEIDI.1247033714 Digitally signed by SHYU.HEIDI.1247033714 Date: 2022.05.13 14:19:13 -04'00'

Heidi Shyu

Enclosure:
1. Department Response to Recommendations
2. Department Technical Comments

RESPONSE TO DRAFT REPORT GAO-22-105075 RECOMMENDATIONS

RECOMMENDATION 1: The Secretary of Defense should direct the Under Secretary of Defense for Acquisition and Sustainment to ensure that the Glide Phase Interceptor (GPI) effort obtain a Director, Cost Assessment and Program Evaluation Independent Cost Estimate prior to entering the Product Development Phase as defined by DTM 20-002.

RESPONSE 1: Concur.

RECOMMENDATION 2: The Secretary of Defense should direct the Under Secretary of Defense for Acquisition and Sustainment to ensure that the GPI effort obtain an Under Secretary of Defense for Research and Engineering-approved Independent Technical Risk Assessment prior to entering the Product Development phase as defined by DTM 20-002.

RESPONSE 2: Concur.

RECOMMENDATION 3: The Secretary of Defense should ensure the Missile Defense Agency, Space Development Agency, Space Force, and any other relevant agencies establish a Memorandum of Understanding that delineates roles and responsibilities for satellite development and operation in the missile defense and missile warning domains. This memorandum should require which agencies will develop operational satellites (including prototypes), and articulate a process by which duplication and overlap will be avoided.

RESPONSE 3: Concur.

ENCLOSURE 1

Appendix X: GAO Contact and Staff Acknowledgments

GAO Contact

John D. Sawyer at (202) 512-4841 or SawyerJ@gao.gov

Staff Acknowledgments

In addition to the contact named above, LaTonya Miller, Assistant Director; Christopher (James) Madar, Assistant Director; Steven B. Stern (Analyst-in-Charge); Matthew Ambrose; Pete Anderson; Dennis Antonio; Jasmina Clyburn; Jim Cora; Lori Fields; Jennifer Franks; Helena Johnson; Joe Kirschbaum; Jennifer Leotta; Patty Lentini; Michael Moran; Miranda Riemer; Brian Tittle; Hai V. Tran; and Alyssa Weir made key contributions to this report.

Related GAO Products

Report number	Report date	Report title
GAO-22-104344	Feb. 2, 2022	Missile Defense: Addressing Cost Estimating and Reporting Shortfalls Could Improve Insight into Full Costs of Programs and Flight Tests
GAO-22-563	Nov. 10, 2021	Missile Defense: Recent Acquisition Policy Changes Balance Risk and Flexibility, but Actions Needed to Refine Requirements Process
GAO-21-314	Apr. 28, 2021	Missile Defense: Fiscal Year 2020 Delivery and Testing Progressed, but Annual Goals Unmet
GAO-20-432	Jul. 23, 2020	Missile Defense: Assessment of Testing Approach Needed as Delays and Changes Persist
GAO-20-177	Dec. 11, 2019	Missile Defense: Further Collaboration with the Intelligence Community Would Help MDA Keep Pace with Emerging Threats
GAO-19-92C	May 1, 2019	Missile Defense: Further Collaboration with the Intelligence Community Would Help MDA Keep Pace with Emerging Threats
GAO-19-387	Jun. 6, 2019	Missile Defense: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability
GAO-18-324	May 30, 2018	Missile Defense: The Warfighter and Decision Makers Would Benefit from Better Communication about the System's Capabilities and Limitations
GAO-17-381	May 30, 2017	Missile Defense: Some Progress Delivering Capabilities, but Challenges with Testing Transparency and Requirements Development Need to Be Addressed
GAO-16-339R	Apr. 28, 2016	Missile Defense: Ballistic Missile Defense System Testing Delays Affect Delivery of Capabilities
GAO-15-345	May 6, 2015	Missile Defense: Opportunities Exist to Reduce Acquisition Risk and Improve Reporting on System Capabilities
GAO-15-210R	Dec. 12, 2014	Missile Defense: Cost Estimating Practices Have Improved, and Continued Evaluation Will Determine Effectiveness
GAO-14-351	Apr. 1, 2014	Missile Defense: Mixed Progress in Achieving Acquisition Goals and Improving Accountability
GAO-13-432	Apr. 26, 2013	Missile Defense: Opportunity to Refocus on Strengthening Acquisition Management
GAO-12-486	Apr. 20, 2012	Missile Defense: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency
GAO-11-372	Mar. 24, 2011	Missile Defense: Actions Needed to Improve Transparency and Accountability
GAO-10-311	Feb. 25, 2010	Defense Acquisitions: Missile Defense Transition Provides Opportunity to Strengthen Acquisition Approach

Source: GAO. | GAO-22-105075