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MISSILE DEFENSE

Fiscal Year 2020 Delivery and Testing Progressed, but Annual Goals Unmet

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GAO-21-314

GAO@100 Highlights

Highlights of GAO-21-314, a report to congressional committees

April 2021

MISSILE DEFENSE

Fiscal Year 2020 Delivery and Testing Progressed, but Annual Goals Unmet

Why GAO Did This Study

For over half a century, the Department of Defense has funded efforts to defend the U.S. from ballistic missile attacks. This effort consists of diverse and highly complex land-, sea-, and space-based systems and assets located across the globe. From 2002 through 2019, MDA—the agency charged with developing, testing, integrating, and fielding this system of systems—received about $162.5 billion. The agency also requested about $45 billion from fiscal year 2020 through fiscal year 2024.

In fiscal year 2020, MDA's mission broadened to include evolving threats beyond ballistic missiles such as defending against hypersonic missile attacks. With the inclusion of non-ballistic missile threats, the Ballistic Missile Defense System is in the process of transitioning to the Missile Defense System.

Congress included a provision in statute that GAO annually assess and report on MDA's progress. This, our 18th annual review, addresses the progress MDA made in achieving fiscal year 2020 delivery and testing goals.

GAO reviewed planned fiscal year 2020 baselines, along with program changes due to COVID-19 restrictions, and other program documentation and assessed them against responses to GAO detailed question sets and program and baseline reviews. GAO also interviewed officials from MDA and various Department of Defense Combatant Commands.

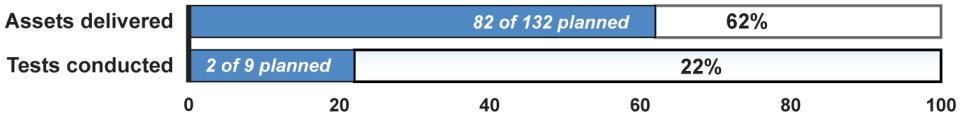
We do not make any new recommendations in this report but continue to track the status of prior recommendations.

View GAO-21-314. For more information, contact John D. Sawyer at 202-512-4841 or SawyerJ@gao.gov.

What GAO Found

In fiscal year 2020, the Missile Defense Agency (MDA) made progress toward achieving its delivery and testing goals for some of the individual systems—known as elements—that combine and integrate to create the Missile Defense System (also known as the Ballistic Missile Defense System). However, MDA did not complete its overall planned deliveries or annual testing. The figure below shows MDA's progress delivering assets and conducting flight tests against its fiscal year 2020 plans.

Percentage of Missile Defense Agency Planned Deliveries and Flight Tests Completed for Fiscal Year 2020



Source: GAO analysis of Missile Defense Agency data. I GAO-21-314

- **Deliveries—**In fiscal year 2020, MDA delivered many assets it had planned. Specifically, MDA was able to deliver 82 missile interceptors for 3 elements. However, MDA was not able to deliver all planned interceptors, including one originally planned for 2018 for the Ground-based Midcourse Defense program, as the program experienced delays related to qualifying parts from a new supplier.
- **Flight testing—**MDA conducted two planned flight tests, but neither was successful. The issues were due to problems with non-MDA assets, but the agency was able to collect important data. In addition, COVID-19 restrictions also affected the planned schedule. However, the delays continue a trend of MDA's inability to conduct planned annual flight testing, resulting in assets and capabilities that are subsequently delayed or delivered with less data than planned.
- **Ground testing—**In fiscal year 2020, MDA continued to implement a new ground testing approach that the agency began in fiscal year 2019. In addition, MDA successfully completed three planned ground tests demonstrating defense capabilities for the U.S., U.S. forces and regional allies. However, MDA delayed two other ground tests to future fiscal years and expects disruptions in fiscal year 2021, in part due to ongoing COVID-19 disruptions.
- **Cyber—**Despite failing to meet annual operational cybersecurity assessments since 2017, MDA canceled its planned fiscal year 2020 operational assessments, instead taking steps to implement a new approach designed to improve cyber system requirements while streamlining cyber test planning. It is premature to assess whether this new approach will achieve its intended goals.

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Abbreviations

AA	Adversarial Assessment
AN/TPY-2	Army Navy/Transportable Radar Surveillance and Control Model- 2
AWS	Aegis Weapon System
BAR	BMDS 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
CDR	Critical Design Review
CENTCOM	United States Central Command
COVID-19	Coronavirus Disease 2019
CVPA	Cooperative Vulnerability and Penetration Assessment
DARPA	Defense Advanced Research Projects Agency
DFARS	Defense Federal Acquisition Supplement
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation

EPAA	European Phased Adaptive Approach
EUCOM	United States European Command
GBI	Ground-based Interceptor
GMD	Ground-based Midcourse Defense
GM BVT	GMD Booster Vehicle Test
GT	Ground Test
GTD	Ground Test Distributed
GTI	Ground Test Integrated
HAWC	Hypersonic Air-Breathing Weapon Concept
HGV	Hypersonic Glide Vehicle
ICBM	Intercontinental Ballistic Missile
IMTP	Integrated Master Test Plan
INDOPACOM	United States Indo-Pacific Command
IRBM	Intermediate-Range Ballistic Missile
LRDR	Long Range Discrimination Radar
MDA	Missile Defense Agency
MDS	Missile Defense System
MSE	Missile Segment Enhancement
MRBM	Medium-Range Ballistic Missile
NATO	North Atlantic Treaty Organization
NGI	Next Generation Interceptor
OTA	Operational Test Agency
PAC-3	Patriot Advanced Capability-3
RKV	Redesigned Kill Vehicle
SBX	Sea Based X-Band
SM-3	Standard Missile-3
SRBM	Short-Range Ballistic Missile
TBG	Tactical Boost Glide
THAAD	Terminal High Altitude Area Defense
UEWR	Upgraded Early Warning Radar
USNORTHCOM	United States Northern Command

441 G St. N.W.
Washington, DC 20548

April 28, 2021

Congressional Committees

For over half a century, the Department of Defense (DOD) has been funding efforts to develop and field a system—known as the Ballistic Missile Defense System (BMDS)—to detect, track, and defeat enemy ballistic missiles. In response to evolving threats that currently include hypersonic and cruise missiles, the focus of the system has broadened in recent years beyond ballistic missiles. To better communicate this revised mission, the Missile Defense Agency (MDA)—the agency charged with developing and integrating this system of systems—now refers to this system as the Missile Defense System (MDS).[1] The MDS includes a diverse and highly complex collection of land-, sea-, and space-based systems and assets located across the globe. From 2002 through 2019, MDA received approximately $162.5 billion and plans to spend an additional $45 billion from fiscal year 2020 through fiscal year 2024 to continue its efforts.

Since 2002, various National Defense Authorization Acts have included provisions for GAO to prepare annual assessments of MDA's progress toward meeting its acquisition goals. Specifically, the National Defense Authorization Act for Fiscal Year 2012, as amended, includes a provision for us to report annually on the extent to which MDA has achieved its acquisition goals and objectives, as reported in its acquisition baselines in the BMDS Accountability Report (BAR); and include any other findings and recommendations on MDA's acquisition programs and accountability, as appropriate.[2]

For 17 years, we have reported on MDA's progress and challenges in developing and fielding BMDS capabilities as well as other transparency, accountability, and oversight issues. This, our 18th annual report, addresses the extent to which MDA progressed in achieving fiscal year

[1]With the inclusion of non-ballistic missile threats (including hypersonic threats and cruise missile threats), the Ballistic Missile Defense System (BMDS) is transitioning to the Missile Defense System (MDS). Until the change is consistent in the Department of Defense and the Missile Defense Agency, the terms will be used interchangeably.

[2]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), which extended GAO's reviews through fiscal year 2020.

2020 delivery and testing goals for MDS elements, as planned in its annual baseline.[3] In addition, appendixes I-VI contain more detailed information on the 12 MDS elements we assessed in this report, and their fiscal year 2020 activities.

To assess the extent to which MDA and its programs progressed in achieving fiscal year 2020 goals, we reviewed MDA's planned delivery and testing baselines. We assessed their plans as expressed in the April 16, 2019 BAR which aligns with the fiscal year 2020 budget request, its Integrated Master Test Plan, and midyear update.[4] We also evaluated the extent to which Coronavirus Disease 2019 (COVID-19) affected fiscal year plans and MDA's plan to offset any delays in future fiscal years.[5] We assessed the agency's plans and performance against our work on best practices for knowledge-based defense acquisition, Department of Defense Acquisition policy, and the Defense Federal Acquisition Regulation Supplement (DFARS).[6]

For the missile defense elements covered in this report, we provided detailed questionnaires to the MDA programs, element contractors, and DOD entities that focused on fiscal year 2020 plans, changes to their plans due to COVID-19 restrictions, and their achievements prior to and after the COVID-19 restrictions took place. To verify MDA's answers and to determine perturbations to MDA's schedule and testing for future years, we assessed MDA officials' responses, and corroborated their

[3]GAO has initiated a review on MDA's cost estimates and expects to release its findings summer 2021.

[4]We acknowledge MDA completed software builds and related capability deliveries in fiscal year 2020. However, for our review, we focused our assessment on MDA's hardware deliveries, including interceptors.

[5]The outbreak of COVID-19, a strain of coronavirus, was first reported in December 2019, in Wuhan, China. In the weeks that followed, the virus quickly spread around the globe. On January 31, 2020, the Secretary of Health and Human Services declared a public health emergency for the United States, retroactive to January 27, 2020. While a pandemic will not directly damage physical infrastructure, such as power lines or computer systems, it threatens the operation of critical systems by potentially removing the essential personnel needed to operate them from the workplace for weeks or months.

[6]For our prior work on knowledge based defense acquisitions and acquisition best practices, see GAO, *Federal Acquisitions: Congress and the Executive Branch Have Taken Steps to Address Key Issues, but Challenges Endure,* GAO-18-627, (Washington, DC: Sept. 12, 2018); and *Defense Acquisitions: DOD's Revised Policy Emphasizes Best Practices, but More Controls Are Needed*, GAO-04-53 (Washington D.C.: Nov. 10, 2003). For an example of DOD's acquisition policy, see Department of Defense Instruction (DODI) 5000.2T, Operation of the Defense Acquisition System, (Jan. 7, 2015) (incorp. change 6, eff. Jan. 23, 2020).

answers with external DOD entities such as the Office of the Director of Operational Test and Evaluation (DOT&E) and BMDS Operational Test Agency (OTA). In addition, we held phone interviews at an unclassified level with officials from MDS elements, as necessary, to discuss provided answers and with DOD officials to discuss fiscal year acquisition progress. Specifically, we discussed the agency's plans and performance in interviews with agency officials, contractors, and relevant officials in various DOD combatant commands.

We modified our methodology due to COVID-19 restrictions that limited our access to, analysis, and discussion of classified information. For example, one key document used to brief MDA's Director on each system's progress and risks—known as the Director's Program Review—is a classified document. While we were not able to assess the entire document, MDA provided unclassified portions for the fourth quarter of fiscal year 2020.

We conducted this performance audit from April 2020 to April 2021 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 systems, 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.[7]

Table 1 provides a list and description of elements included in our review.

Table 1: Description of Missile Defense System (MDS) Elements

MDS element[a]	Description
Aegis Ballistic Missile Defense (BMD) Weapon System	Aegis BMD includes ship- and land-based ballistic missile defense capabilities using a radar, command and control, and Standard Missile-3 (SM-3) interceptors.
Aegis BMD SM-3 Block IB	Aegis BMD SM-3 Block IB features capabilities to identify and track objects during flight to defend against short-, medium-, and intermediate-range ballistic missiles threats.
Aegis BMD SM-3 Block IIA	Aegis BMD SM-3 Block IIA has increased range, more sensitive seeker technology, and an advanced kill vehicle to defend against medium- and intermediate-range ballistic missiles.
Aegis Ashore	Aegis Ashore, a land-based version of Aegis BMD, uses SM-3 interceptors and Aegis BMD capabilities as they become available and will have three locations: one test site in Hawaii and two operational sites—one in Romania and one under construction in Poland.
Command, Control, Battle Management, and Communications (C2BMC)	C2BMC is a globally deployed system of hardware—workstations, servers, and network equipment—and software that links and integrates individual elements, allowing users to plan ballistic missile defense operations, see the battle develop, and manage networked sensors. C2BMC integrates Ballistic Missile Defense System Overhead Persistent Infrared Architecture, which is made up of space-based sensors that support the MDS missions by providing cues and tasking to downstream sensors and weapon systems.
Ground-based Midcourse Defense (GMD)	GMD is a ground-based system with launch, communications, and fire control components that uses interceptors with a booster and a kill vehicle to defend against intermediate- and intercontinental-range ballistic missiles. The fielded inventory of GMD interceptors currently consists of: 20 interceptors equipped with the Configuration (C)1 boost vehicle and Capability Enhancement (CE)-I kill vehicle; 16 interceptors equipped with the C1 boost vehicle and CE-II kill vehicle; and 8 interceptors equipped with the C2 boost vehicle and CE-II Block I kill vehicle.
Sensors	
Army Navy/ Transportable Radar Surveillance and Control Model 2 (AN/TPY-2)	AN/TPY-2 is a transportable X-band high-resolution radar capable of tracking ballistic missiles of all ranges that can be used in two modes: (1) forward-based mode—to support Aegis BMD, Terminal High Altitude Area Defense (THAAD), GMD, and allied missile defense engagements, or (2) terminal mode—to support THAAD and Patriot engagements.

[7]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).

MDS element[a]	Description
Long Range Discrimination Radar (LRDR)	LRDR will be an S-band radar providing capabilities to track incoming missiles and improve discrimination of the warhead-carrying vehicle from decoys and other non-lethal objects for GMD. Initial fielding is expected in fiscal year 2021.
Sea Based X-Band (SBX)	SBX is a radar capable of tracking, discriminating, and assessing the flight of ballistic missiles. It is mounted on a mobile, ocean-going, semi-submersible platform capable of being positioned to cover any region of the globe. SBX primarily supports the GMD system for defense of the U.S. and is considered a critical sensor for GMD, in part because it is able to provide tracking information to GMD as it targets an incoming threat missile.
Upgraded Early Warning Radars (UEWR)	UEWR is a solid-state, phased-array, long-range radar that detects sea-launched or intercontinental ballistic missiles. Five UEWRs have been upgraded and integrated into the MDS to improve sensor coverage by providing critical early warning, tracking, object classification, and cueing data. UEWRs are located in Beale, California; Fylingdales, United Kingdom; and Thule, Greenland. Clear, Alaska, and Cape Cod, Massachusetts, radars were added to the Operational Capacity Baseline in February 2019 and December 2019, respectively.
Targets and Countermeasures[b]	Targets and Countermeasures provide a variety of highly complex short-, medium-, intermediate-, and intercontinental-range targets to represent realistic threats during MDS flight testing.
Terminal High Altitude Area Defense (THAAD)	THAAD is a mobile, ground-based system to defend against short-, medium-, and limited intermediate-range threats using a battery that consists of interceptors, launchers, a radar, and fire control and communication systems.

Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

[a]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.

[b]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 BMDS—developed as a single program—that allow MDA to expedite the fielding of assets and integrated missile defense capabilities. These flexibilities allow MDA to diverge from DOD's traditional acquisition life cycle and 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 of the laws and policies include such things as:

- obtaining the approval of a higher-level acquisition executive before making changes to an approved baseline,[8]

[8]Department of Defense Instruction 5000.85, Major Capability Acquisition (August 6, 2020).

- reporting certain increases in unit cost measured from the original or current baseline,[9]
- obtaining an independent life-cycle cost estimate prior to beginning system development or production and deployment, and[10]
- regularly providing detailed program status information to Congress, including specific costs, in Selected Acquisition Reports.[11]

In response to concerns related to oversight, Congress and DOD have taken a number of actions. For example, Congress enacted legislation in 2008 requiring MDA to establish cost, schedule, and performance baselines—starting points against which to measure progress—for each element that has entered the equivalent of system development or is being produced or acquired for operational fielding.[12] MDA reported its newly established baselines to Congress for the first time in its June 2010 BAR. Since that time, Congress has required more details for the content of these baselines.[13]

In addition, in 2010, MDA also established an acquisition process that continues to guide the development of the MDS. However, as we reported in July 2020, Congress and the Secretary of Defense are considering whether existing elements that are in production or beyond, known as fielding operations and sustainment, should transfer to the military services, as originally intended by the Secretary of Defense and per legislative direction.[14] At this point, most elements are in production or beyond. Table 2 describes the life-cycle phases of MDA's acquisition process.

[9]10 U.S.C. § 2433.

[10]10 U.S.C. § 2334.

[11]10 U.S.C. § 2432.

[12]Pub. L. No. 110-181, § 223(g) (2008), repealed by Pub. L. No. 112-81, § 231(b)(2) (2011).

[13]See, e.g., Pub. L. No. 112-81, § 231, as amended, codified at 10 U.S.C. § 225, requiring the MDA Director to establish and maintain an acquisition baseline for each program element of the BMDS and each designated major subprogram of such program elements before the date on which the program element or major subprogram enters the equivalent of engineering and manufacturing development and before production and deployment. This law details specific requirements for the contents of the acquisition baseline.

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

Table 2: Missile Defense Agency Acquisition Life-Cycle Phases

Material solution analysis	Technology development	Product development	Initial production	Production
An analysis period to develop potential alternative solutions.	For developing and maturing technology solutions for a capability shortfall.	To further develop the potential Ballistic Missile Defense System component to refine and mature the design and manufacturing issues.	Used primarily to provide an initial base for production and provide articles for continued testing.	For producing final operational end items to satisfy warfighter-capability requirements.

Source: Missile Defense Agency Directive 5010.18, GAO (presentation). | GAO-21-314

The agency has documented the key knowledge that is needed prior to the technology development, product development, initial production, and production phases. For example, as part of the process, MDA requires a program to identify alternatives to meet the mission's needs before it can proceed to MDA's technology development phase. MDA officials have stated in the past that they expect that aligning the development efforts with the phases will help to ensure that they obtain the appropriate level of knowledge before allowing acquisitions to move from one phase to the next.

In early March 2020, the Deputy Secretary of Defense issued a memorandum that "establishes policy, assigns responsibilities, and prescribes procedures for MDS research, development, test and evaluation; procurement; and operations and sustainment in order to reduce risk and promote MDS element transfers to the military departments while maintaining agility." The memorandum—which updates the roles, responsibilities, and authorities of MDA, the military departments, and the Office of Secretary of Defense—became effective August 20, 2020. The Secretary of Defense directed MDA to incorporate these changes into its management instruction and manual. According to MDA, some aspects of the memorandum were already a part of the agency's best practices for acquisition and program management; and, since the memorandum has taken effect, MDA has begun incorporating implementation steps into existing MDA acquisition processes.[15]

Furthermore, to enhance oversight of the information provided in the BAR, MDA continues to incorporate suggestions and recommendations from GAO. However, not all of our recommendations have been fully implemented. For example, in April 2013, we recommended that MDA

[15]According to agency officials, MDA is currently updating its policies and manuals and expects to issue interim guidance memorandum to address process and oversight changes by February 2021. As such, we did not review these changes in this year's audit.

stabilize its acquisition baselines so that meaningful comparisons can be made over time to support oversight. MDA stated that the information presented in the BAR is sufficient; however, we continue to find that the lack of stable baselines makes comparison difficult and, in some instances, impossible.[16]

Flight, Ground, and Cybersecurity Testing within MDA

MDA's testing baseline—the Integrated Master Test Plan (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 it is planned for execution. The IMTP is finalized and signed annually.[17]

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 ground, cybersecurity, and flight testing to determine whether the element's or MDS's design will satisfy the desired capabilities:

- **Flight Testing**—includes intercept and non-intercept testing. Flight tests use actual elements and their components to assess and demonstrate performance. Flight tests alone are insufficient because they only demonstrate a single collection data point of element and system performance. Flight tests are, however, an essential tool used to both validate performance of the elements and MDS. Flight tests

[16]In May 2020, we sent a letter to the Secretary of Defense, in part, to call attention to areas in which two open recommendations on missile defense should be given high priority by DOD. One of those recommendations included stabilizing baselines and clearly tracking any revisions for missile defense programs. For additional information, see GAO, *Missile Defense: Opportunity to Refocus on Strengthening Acquisition Management*, GAO-13-342, (Washington, D.C.: April 26, 2013).

[17]The annual IMTP is signed by the Director, MDA along with external stakeholders that include the Director, Operational Test and Evaluation; Director, Developmental Test and Evaluation; Commander, Army Test & Evaluation Command; Commander, Navy Operational Test & Evaluation Force; Commander, Air Force Operational Test & Evaluation Center; Commander, Joint Interoperability Command; and Commander, Joint Functional Component Command Integrated Missile Defense representing the Combatant Commands.

are also necessary to anchor models and simulations and to ensure they accurately reflect real performance. Non-intercept and target only tests enable evaluation of specific performance aspects or scenarios and potentially reduce risks for future tests. The BMDS OTA, DOT&E, and the Combatant Commands—DOD organizations comprised of forces from multiple military services and structured by geographical area or functional responsibilities—assess MDA element- or system-level, performance during developmental and operational testing.

- **Ground Testing**—uses modeling and simulations, which are computer representations that simulate the system's performance to assess the capabilities and limitations of how elements or the MDS perform under a wider variety of conditions than can be accomplished through the limited number of flight tests conducted. Ground tests use a combination of actual element and system-level models, support infrastructure, and virtual targets in order to repeatedly conduct scenarios that may be too costly or subject to constraints as a flight test. To ensure that the models and simulations accurately represent the element- or system level, each undergoes verification, validation, and accreditation—an official certification that it operates as intended in representative, real-world conditions. The BMDS OTA serves as the accreditation agent in support of accreditation efforts for operational test and evaluation purposes. MDA performs the verification, validation, and accreditation for developmental test and evaluation purposes. In 2019, MDA began transitioning to a new ground testing approach, eschewing large scale ground test campaigns for smaller but more focused ground test sprints, meant to allow MDA more flexibility in test design.[18]
- **Cybersecurity Testing**—includes a Cooperative Vulnerability and Penetration Assessment (CVPA) and an Adversarial Assessment (AA). These operational assessments are intended to identify cyber vulnerabilities, examine potential attack paths, evaluate operational cyber defense capabilities, and identify the potential operational mission effects (e.g., loss of critical operational capability) in a cyber-threat environment while conducting operational missions. Specifically, a CVPA provides initial information about the resilience of a system in an operational context, which is used to identify initial vulnerabilities and to develop the subsequent AA. The AA

[18]As we reported in July 2020, while the transition to sprints may provide benefits, testing officials raised concerns about the increased pace of testing that was outpacing the availability of software and data needed to validate and accredit models and simulations used in these tests. See GAO-20-432.

characterizes the operational effects caused by threat representative cyberattack and the effectiveness of defensive capabilities.

MDA Achieved Some of Its Asset Delivery and Testing Goals for Fiscal Year 2020 as Initial Effects of COVID-19 Restrictions Came into Focus

In fiscal year 2020, MDA achieved a portion of its asset delivery plans as outlined in the BAR. Specifically, MDA delivered all planned Aegis Standard Missile (SM)-3 Block IB interceptors. However, MDA was unable to complete its planned deliveries as quality problems with supplier-provided parts contributed to delays. Specifically, deliveries of Aegis SM-3 Block IIA and Terminal High Altitude Area Defense (THAAD) interceptors were only partially completed, and delays continued for an additional homeland defense Ground-Based Interceptor originally expected in fiscal year 2018. MDA conducted two of nine planned flight tests—neither of which were successful, as both encountered technical issues with Army assets—and participated in two additional flight tests with external partners. MDA also completed three ground tests as planned, demonstrating capabilities for the defense of the United States and regional allies. However, MDA delayed two other ground tests planned for fiscal year 2020 and continues to manage ongoing issues related to preparations for one of them. Further, according to MDA officials, MDA did not conduct any of the 17 planned operational cybersecurity tests, but instead implemented a new cyber-test planning approach, approved by the Director, MDA in March 2019.

MDA Met One Asset Delivery Goal for Fiscal Year 2020 as It Worked to Overcome Prior Delays

MDA met asset delivery goals for one of four MDS elements during fiscal year 2020. As table 3 shows, MDA delivered all 35 Aegis BMD SM-3 Block IB interceptors as planned, but fell short of its goals for Aegis BMD SM-3 Block IIA and THAAD interceptors. Delays also continued for a Ground-Based Interceptor initially planned for fiscal year 2018. For additional details on these elements, see appendixes I, III, and VI.

Table 3: Missile Defense Asset Deliveries in Fiscal Year 2020

Asset	Planned delivery	Status
Standard Missile-3 Block IB	35 interceptors	**35 delivered**.
Standard Missile-3 Block IIA	11 interceptors	**Five delivered**. Delivery delays due to a flight test failure and associated corrective actions.
Ground-Based Interceptors	1 interceptor	**0 delivered**. Program continues to experience delays related to qualifying electronic parts from a new supplier for this interceptor, which the Missile Defense Agency originally planned for fiscal year 2018.

Asset	Planned delivery	Status
Terminal High Altitude Area Defense Interceptors	85 interceptors	**42 delivered.** Deliveries were halted from June through September 2020 while awaiting a qualified replacement for an electronics part that was no longer available. Qualification was subsequently achieved and interceptor deliveries resumed in October 2020.

Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

MDA Did Not Complete Its Annual Flight Test Plan, a Consistent Trend That Limits Insight into the System's Capabilities and Limitations

MDA did not successfully complete its fiscal year 2020 flight test plan. We reported in July 2020 that MDA has struggled over the past decade to execute its annual flight test plan, with MDA frequently revising the schedule by adding new tests and delaying or deleting others.[19] This trend continued in fiscal year 2020. MDA and the U.S. Army jointly conducted two planned flight tests during fiscal year 2020, but neither was successful as software issues with Army assets led to a no-test declaration in one and a failure in the other.[20] Of the remaining seven tests planned, MDA canceled one and delayed six to future fiscal years. These delays included FTM-44, a developmental test mandated by Congress to evaluate and demonstrate whether an Aegis BMD SM-3 Block IIA is capable of intercepting an intercontinental ballistic missile (ICBM) target.[21] The reasons for these testing disruptions during fiscal year 2020 varied but include the aftereffects of the flight test failure, asset availability, programmatic delays, and COVID-19 travel restrictions. As we have previously reported, testing disruptions—such as the delays and removals of planned tests from the schedule that MDA has experienced since 2010—result in assets and capabilities that are subsequently delayed, or delivered with less data than planned due to reduced testing.[22] Table 4 provides an overview of the nine flight tests planned in MDA's baseline test schedule for fiscal year 2020, as well as an additional test subsequently added to the schedule but delayed due to COVID-19.

[19]GAO-20-432.

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

[21]National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91, § 1680 (2017). MDA conducted FTM-44 in November 2020, prior to the December 31, 2020, legislative deadline. Preliminary reports indicate that the test was a success.

[22]In July 2020, we recommended MDA ensure an independent assessment is conducted of its process for developing and executing the annual flight test plan. DOD concurred with this recommendation and is currently taking steps to implement this recommendation, with its completion planned for September 2021. For further details, see GAO-20-432.

Table 4: Fiscal Year (FY) 2020 Flight Tests

Flight Tests Planned in the Missile Defense Agency's Fiscal Year 2020 Baseline					
Name of planned flight test		**Flight test type**	**Conducted (yes or no)**	**Status and description**	**Backlogged test[a]**
1	FTX-39	Non-intercept	Yes	**No test.** The test intended to simulate a Patriot Weapon System Patriot Advanced Capability (PAC)-3 Missile Segment Enhancement (MSE) engagement of a threat representative short-range ballistic missile (SRBM) target, utilizing the Patriot Launch-on-Remote (THAAD) capability.[b] However, the target failed after launch and was terminated by the range safety team prior to radar acquisition.	—
2	FTP-27 E2	Intercept	Yes	**Failed.** The test intended to demonstrate a Patriot Weapon System PAC-3 MSE engagement of a threat representative SRBM target, utilizing the Patriot Launch-on-Remote (THAAD) capability. The PAC-3 MSEs failed to intercept the target. However, according to MDA, the test still successfully demonstrated the Launch on Remote (THAAD) capability.	—
3	FTP-27 E1	Intercept	No	**Delayed until FY2021** due to FTP-27 E2 failure review board and return to flight certification.[c]	—
4	FTO-03 (FTO-03 E2)	Intercept	No	**Deleted** due to the loss of Army support for both a Patriot unit and an Army-Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) radar. Objectives reallocated to future events.	✓
5	GM BVT-03	Non-intercept	No	**Delayed until FY2021** due to the availability of ground-based interceptor hardware and software.	—
6	FTM-44	Intercept	No	**Delayed until FY2021** due to Coronavirus Disease 2019 (COVID-19), associated travel restrictions, and subsequent flight test deconfliction. FTM-44 had already been delayed earlier in the fiscal year for flight test deconfliction following the addition of FEX-01 and programmatic delays to other flight test events.[d]	—
7	FTM-30	Intercept	No	**Delayed until FY2024** to ensure 18-month separation from FTX-23 to support model validation and analysis. Objectives reallocated to ground tests.	✓
8	FTM-32	Intercept	No	**Delayed until FY2023** due to programmatic delays, addition of FEX-01, and deconfliction of test resources and assets.	✓
9	FTM-33	Intercept	No	**Delayed until FY2021** due to programmatic delays, addition of FEX-01, and deconfliction of test resources and assets.	✓

Flight Tests Added after Publication of Fiscal Year 2020 Baseline					
1	FTM-31 E1	Intercept	No	**Delayed until FY2021** due to COVID-19 and associated travel restrictions.	✓

Legend:

E – Event
FEX – Flight Test Experiment Other
FTM – Flight Test Aegis Weapon System
FTO – Flight Test Operational
FTP – Flight Test Patriot Weapon System
FTX – Flight Test Other
GM BVT – Ground-based Midcourse Defense Weapon System Booster Vehicle Test
✓ – Backlogged test

Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-21-314

Note: As in previous years, tests where MDA participated but did not possess the primary system under test (e.g., Army's Patriot program or Israel's Iron Dome) were omitted. The Patriot tests included in this report are integration tests with Terminal High Altitude Area Defense (THAAD); Patriot-only tests planned for fiscal year 2020 are not included.

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

[b]A no-test is declared when external factors (e.g., weather) or anomalies with the target (e.g., intercept is not attempted) prevent the flight test from achieving its objectives. Patriot Launch-on-Remote (THAAD) allows Patriot to launch its MSE interceptor using THAAD AN/TPY-2 track data before Patriot acquires the threat and executes the intercept with its own radar. This increases the coverage area of the Patriot batteries.

[c]MDA and the U.S. Army jointly conducted FTP-27 E1 in October 2020, and preliminary reports indicate that the test was a success.

[d]MDA conducted FTM-44 in November 2020, and preliminary reports indicate that the test was a success.

Both of the planned flight tests conducted by MDA and the U.S. Army in fiscal year 2020 were in support of an urgent regional capability called Patriot Launch-on-Remote (THAAD). This capability allows the Army's Patriot Weapon System to launch its Patriot Advanced Capability (PAC)-3 Missile Segment Enhancement (MSE) interceptor using THAAD Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) radar track data before Patriot acquires the threat and executes the intercept with its own radar. This increases the coverage area of the Patriot batteries.

- In the first test, named FTX-39, the primary objective was a simulated PAC-3 MSE intercept of a threat representative short-range ballistic missile (SRBM) target utilizing Patriot Launch-on-Remote (THAAD). However, the range safety team terminated the Army-supplied Black Dagger target after a software error caused it to drift outside of acceptable flight safety boundaries. The termination occurred prior to the THAAD AN/TPY-2 radar acquiring the target. Consequently, THAAD and Patriot did not collect data on the target. MDA declared this a no-test.

- In the second test, named FTP-27 E2, the primary objective was a live intercept of a threat representative SRBM target with two PAC-3 interceptors utilizing Patriot Launch-on-Remote (THAAD). The interceptors failed and a subsequent Army failure review board found the root cause was that the compact disk used to update the two interceptors was missing a portion of the necessary software.[23] According to MDA, the test still successfully demonstrated the Patriot Launch-on-Remote (THAAD) capability despite the failed intercept. Specifically, MDA officials noted that Patriot received the remote track data from THAAD's AN/TPY-2 radar, developed a firing solution, launched its interceptors, detected and correlated with the remote track, and provided guidance uplinks. DOT&E concurred that the test demonstrated this capability, while BMDS OTA officials stated the significance of the test failure was low with regard to the operational force and future of Patriot Launch-on-Remote (THAAD).[24]

As MDA broadens its mission in response to evolving threats, the agency 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). In fiscal year 2020, MDA participated in one such flight test to support the development of hypersonic defense capabilities.[25] MDA also participated in an international test to collect data for future Aegis engagements. An overview of the flight tests planned and executed with external partners is included in table 5.

[23]According to MDA, this anomaly does not impact any current PAC-3 or PAC-3 MSE fielded software.

[24]The follow-up to this test—FTP-27 E1, which had been delayed from fiscal year 2020 pending the outcome of the failure review board—was conducted in October 2020. Early reports indicate that the PAC-3 MSEs successfully intercepted the target. We will discuss this test further in a subsequent report.

[25]In contrast to ballistic missile payload trajectories, hypersonic glide vehicle (HGV) payloads are capable of maneuvering or changing direction on the way to a target, which makes tracking difficult. The 2019 Missile Defense Review confirmed MDA's lead role in developing defenses against HGVs. According to MDA officials, fully achieving this capability will require the development of wholly new intercept systems, supporting technologies, and a new sensor architecture. For additional information about MDA's new responsibility for addressing hypersonic threats, see GAO-20-432.

Table 5: Additional Flight Tests Planned for Fiscal Year 2020 with Missile Defense Agency (MDA) and External Partners

Name of added flight test		Flight test type	Conducted (yes or no)	Status and description
1	FEX-01	Non-intercept	Yes	**Met MDA test objectives.** The U.S. Navy and U.S. Army executed a launch of a hypersonic glide body to inform hypersonic technology development. MDA monitored and gathered tracking data to support the development of a hypersonic defense capability.
2	Pacific Dragon 2020	Non-intercept	Yes	**Met MDA test objectives.** Trilateral ballistic missile tracking and Tactical Data Link information-sharing event with the Japanese Maritime Self-Defense Force, Republic of Korea Navy, and U.S. Navy. MDA used the test for risk reduction to collect data for future Aegis Ballistic Missile Defense flight tests.
3	HAWC-4	Non-intercept	No	**Delayed.** The Hypersonic Air-Breathing Weapon Concept (HAWC) program is a joint Defense Advanced Research Projects Agency (DARPA) and U.S. Air Force effort that seeks to develop and demonstrate critical technologies to enable an effective and affordable air-launched hypersonic cruise missile. MDA added four HAWC tests to its schedule for fiscal year 2020 and planned to collect data and characterize sensor performance for Modeling & Simulation and algorithm development for hypersonic defense capabilities. According to MDA, DARPA is working to reschedule these tests.
4	HAWC-5	Non-intercept	No	
5	HAWC-7	Non-intercept	No	
6	HAWC-9	Non-intercept	No	
7	TBG-1	Non-intercept	No	**Delayed.** Missile Defense System tracking exercise to support the development of a hypersonic defense capability.[a]

Legend:

FEX – Flight Test Experiment Other
HAWC – Hypersonic Air-Breathing Weapon Concept
TBG – Tactical Boost Glide

Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-21-314

[a]According to MDA, TBG-1 was conducted during the first quarter of fiscal year 2021.

MDA Completed Some Fiscal Year 2020 Ground Testing as It Implements Its New Approach

MDA successfully conducted three planned ground tests in fiscal year 2020, demonstrating defense capabilities for the U.S., U.S. forces, and regional allies. In addition, MDA conducted another test in support of U.S. Central Command verifying operational communications of a new AN/TPY-2 radar site. However, MDA delayed two other ground tests to future fiscal years.[26] The delayed ground tests were intended to demonstrate capability for the European Phased Adaptive Approach and further homeland, regional ally, and U.S. forces' defense. Ground testing disruptions will continue in fiscal year 2021, according to the BMDS OTA, as MDA addresses pre-testing element-level integration issues that have been exacerbated by ongoing COVID-19 disruptions. MDA also continues to face challenges with the accreditation of models and simulations used

[26]One of the delayed ground tests split into two tests. See table 6.

during ground testing, an issue we previously reported.[27] Table 6 provides an overview and status of fiscal year 2020 ground tests.

Table 6: Fiscal Year 2020 Ground Tests

	Name of planned ground test	Combatant Commands	Conducted (yes or no)	Status and description
1	GTI-07c	U.S. Northern Command (USNORTHCOM) and U.S. Indo-Pacific Command (INDOPACOM)	Yes	**Met objectives.** Evaluated homeland and regional defense capabilities.
2	GTI-20 Sprint 1	U.S. European Command (USEUCOM) and U.S. Central Command (CENTCOM)	Yes	**Met objectives.** Evaluated software updates in support of the European Phased Adaptive Approach (EPAA) Phase 3 Technical Capability Declaration.
3	GTI-20 Sprint 2	USNORTHCOM and INDOPACOM	Yes	**Met objectives.** Evaluated Terminal High Altitude Area Defense (THAAD) and Patriot performance for regional defense.
4	GTD-07b (Aegis Ashore)	USEUCOM and CENTCOM	No	**Delayed** due to military construction delays at the Aegis Ashore Missile Defense System Poland site. Test was expected to collect data for the EPAA Phase 3 Technical Capability Declaration.
5	GTI-08	USNORTHCOM and INDOPACOM	No	**Divided and delayed.** GTI-08 was divided into GTI-08a and GTI-08b to coincide with Increment 6, which was divided into 6B.1 and 6B.2.[a]

Legend:

GTD – Ground Test Distributed
GTI – Ground Test Integrated

Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-21-314

[a]MDA capability deliveries are organized around Increments, or sets of capabilities, which are realized by upgrading and integrating MDS elements. For additional information on our reporting on MDA's incremental approach, see GAO-17-381.

Among the delayed ground tests from fiscal year 2020 was GTI-08—expected to assess performance in defense of the United States and the Asia-Pacific region from varying range attacks—which MDA split into GTI-08a and GTI-08b. This adjustment came after MDA conducted a replan of Increment 6B and split those planned capability deliveries into Increment 6B.1 and Increment 6B.2. According to MDA, Increment 6B.1 provides

[27]In May 2018, we recommended that models used for operational tests be validated and accredited for such assessments. While DOD concurred with this recommendation and is actively working with the BMDS OTA to resolve any issues, according to BMDS OTA officials, some models remain unaccredited. Therefore, it is premature to close out this recommendation, but we will continue to track MDA's progress on taking the necessary steps to implement this recommendation. For further details on the risks of using unaccredited models, see GAO-18-324.

complex, integrated upgrades across the MDS and requires interdependent software upgrades across multiple systems. In April 2020, MDA revised the Increment 6B.1 ground testing schedule to support element software deliveries and incorporate risk reduction testing, which is designed to reduce risk to interoperability and integration prior to the formal ground test—in this case, GTI-08a. This revision also delayed the expected Operational Capacity Baseline date of Increment 6B.1 from the third quarter of fiscal year 2021 to the first quarter of fiscal year 2022.[28]

According to the BMDS OTA, GTI-08a is delayed until the third quarter of fiscal year 2021. Element-level testing discovered problems with integrating the system-level framework, and COVID-19 restrictions worsened this issue by delaying the necessary software development and system-level testing. The GTI-08a issues are also delaying other planned ground tests until fiscal year 2022.

MDA continues to make progress addressing modeling and simulations limitations, though some challenges remain. According to the BMDS OTA, cooperation from MDA on providing data necessary for model accreditation continued in fiscal year 2020. The BMDS OTA and MDA also collaborated with the intelligence community to develop a threat accreditation plan and threat implementation processes for the framework and element models and simulations, which the BMDS OTA said has been the top accreditation issue.

Conversely, MDA has not been able to fully implement and resolve all issues related to its new ground test sprint approach, which we reported on in July 2020.[29] The BMDS OTA raised a concern that the rapid tempo of these sprints does not currently allow modeling and simulations accreditation to keep pace. According to DOT&E, the first series of sprints in fiscal year 2019 went relatively smoothly because many of the models were the same versions used during testing in fiscal year 2018. In fiscal year 2020, MDA used multiple models that remain unaccredited for the three ground tests conducted. As we reported in May 2018, the use of unaccredited models increases the risk that test results are distorted, and leaves decision makers without key information on how the system will

[28]MDA makes capability deliveries through approved changes to its Operational Capacity Baseline. Proposed changes to the baseline are coordinated with the warfighter, including the affected combatant commands. The combatant commands then assess these element capabilities to determine whether to accept them.

[29]For further details on MDA's new ground test sprint approach, see GAO-20-432.

perform.[30] According to MDA, the latest revision to the Ground Test Concept of Operations included processes that the agency expects will address this concern moving forward.

MDA Did Not Conduct Any Planned Fiscal Year 2020 Operational Cybersecurity Assessments, as the Agency Restructures Its Approach

MDA improved its cybersecurity planning and testing efforts in recent years; however, it did not conduct any of its planned operational cybersecurity assessments needed to assess vulnerabilities in fiscal year 2020.[31] Specifically, in fiscal year 2020, MDA planned 17 operational cybersecurity assessments—13 element-level cooperative assessments and four adversarial assessments—but completed none (see table 7).[32]

Table 7: Fiscal Year 2020 Operational Cybersecurity Assessments

	Cooperative Vulnerability and Penetration Assessment		Adversarial Assessment	
Element	**Planned**	**Completed**	**Planned**	**Completed**
Aegis Ballistic Missile Defense	5	0	2	0
Army Navy/Transportable Radar Surveillance and Control Model 2	2	0	1	0
Command, Control Battle Management, and Communications	2	0	1	0
Ground-based Midcourse Defense	0	0	0	0
Long Range Discrimination Radar	1	0	0	0
Sea-Based X-Band Radar	2	0	0	0
Terminal High Altitude Area Defense	1	0	0	0
Total	**13**	**0**	**4**	**0**

Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

[30]GAO-18-324.

[31]Operational cybersecurity testing consists of two types of assessments: a Cooperative Vulnerability and Penetration Assessment (CVPA) and an Adversarial Assessment (AA). A 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 threat representative cyberattack and the effectiveness of defensive capabilities.

[32]Fiscal Year 2020 operational cyber tests were designed to assess Increments 5 (11 assessments) and 6 (six assessments). Increment 5 is the deployed MDS increment, while Increment 6 is a future capability currently in development.

According to MDA officials, the agency did not execute the cooperative vulnerability and adversarial assessments because MDA officials felt the information that would have been obtained from these tests was not needed, as all fiscal year 2020 Operational Capability Baseline decisions that relied on this information had already been completed. In addition, during fiscal year 2020, the agency began re-structuring its cybersecurity test planning efforts to align with its March 2019 four-phase cybersecurity test concept of operations.[33] Moving forward, cyber tests will be planned and documented in the test baseline using the same process as flight and ground tests. For example, under the new approach, internal and external stakeholder input will inform cyber test requirements, which in turn will drive cyber test design and execution of testing for each capability increment. MDA officials stated that this new approach will improve cyber system requirements while streamlining cyber test planning, resource allocation, and results analysis. However, it is too soon to know how effective the new approach will be until it is fully implemented.[34]

The lack of testing during fiscal year 2020 coupled with persistent testing shortcomings over the last 3 years are representative of a broader MDA cybersecurity development issue. For instance, we reported in July 2020 that MDA conducted its largest combined cooperative cyber assessment in fiscal year 2019, as well as the first operational adversarial assessment, but failed to meet its fiscal year 2019 testing goals. We also reported that MDA failed to complete the cybersecurity testing for capabilities delivered in 2017 and 2018 and did not address deficiencies from prior year's shortfalls.[35]

Moreover, in 2020, DOT&E assessed that completed cybersecurity testing contained limitations, and its results were insufficient for

[33]Phases one and two involve requirements setting and cyber test planning, while phases three and four consist of test execution and analysis and reporting of results. For further details, see Missile Defense Agency DT-102, *Ballistic Missile Defense System Cybersecurity Test Concept of Operations (MDA Policies and Procedures for Execution*) (March 19, 2019).

[34]Due to COVID-19 restrictions, GAO and MDA were unable to hold classified meetings to discuss specifics about MDA's new approach. We plan on assessing the new approach and its effectiveness in future reviews.

[35]GAO-20-432.

Increments 4, 5, and 5A operational assessments.[36] In addition, according to the BMDS OTA, although cyber operational testing began in June 2017, some MDS elements have not received any cyber operational testing to date, while others have only received partial testing of cyber defensive postures. DOT&E and BMDS OTA have made recommendations to address shortfalls in MDA's cyber testing, noting that further element-level testing is needed to identify and address system cybersecurity vulnerabilities, not just for planned capability but also for currently deployed MDS capability increments. However, program documentation does not indicate any planned cybersecurity testing for already delivered increments.[37] Consequently, continued testing, as DOT&E and the BMDS OTA recommends, is critical to identify and address vulnerabilities that could result in disruption of operations by an adversary for MDA and its missile defense system.

Agency Comments

We are not making any recommendations in this report. We provided DOD with a draft of this report. MDA provided technical comments, which we 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.

[36]Increment deliveries signify delivery of integrated MDS-level capabilities, which are designed to improve effectiveness and efficiency of the MDS over its constituent elements working independently. Increments 4, 5, and 5A are intended to increase defenses in the United States and those of our allies in the European and Asian regions. For additional information, see GAO-17-381.

[37]Fiscal year 2020 cyber testing was intended to assess current Increment 5 and the future Increment 6. No cyber tests were conducted during fiscal year 2020 and tests planned for fiscal year 2021 will only assess future Increment 6.

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 VII.

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

List of Committees

The Honorable Jack Reed
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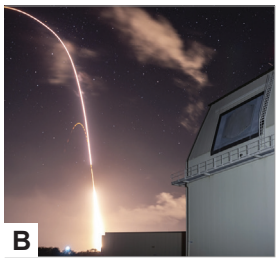
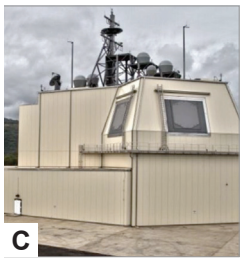




Source: Missile Defense Agency. | GAO-21-314

[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)

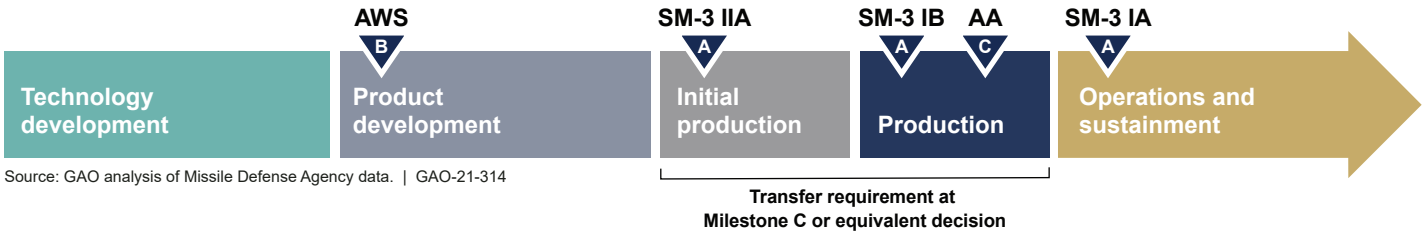
Aegis BMD includes ship- and land-based missile defense capabilities as follows:

A. Standard Missile-3 interceptors (SM-3)—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 transferred to the Navy in line with an existing legislative requirement. Rather, MDA is seeking relief from this requirement to retain Aegis BMD.



Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

DELIVERIES

The Aegis BMD program delivered all 35 planned SM-3 Block IB interceptors for fiscal year 2020. However, the program only delivered 5 of 11 planned SM-3 Block IIA interceptors due to the need to investigate and remediate an anomaly with the interceptor's thruster detected during flight test FTI-03. The first two SM-3 Block IIA interceptors that the program delivered for the year—a primary and spare—were necessary to complete the flight test FTM-44. MDA also successfully delivered the Aegis BMD 4.1.2 software spiral to the Navy in fiscal year 2020, consistent with its planned baseline.

Aegis BMD Fiscal Year 2020 Deliveries

	Planned	Status
SM-3 IB	35 interceptors	35 interceptors delivered
SM-3 IIA	11 interceptors	5 interceptors delivered
AWS	1 software delivery	1 software delivery
AA	Poland site construction complete	Delayed to fiscal year 2022 at the earliest

Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

COVID-19 IMPACTS

- Among the Aegis BMD programs, COVID-19 impacts have largely been limited to test delays. SM-3 Block IB and IIA program officials reported no direct impact to their production schedules, although in the case of the SM-3 Block IIA there have been impacts on certain suppliers. AWS program officials reported that some ship-board software upgrades would be delayed due to travel restrictions and isolation requirements.
- MDA officials stated that neither the U.S. nor Polish governments imposed any COVID-19 restrictions that would have limited construction activities at the Aegis Ashore site in Poland.

FISCAL YEAR 2020 TESTING OVERVIEW

Aegis BMD Fiscal Year 2020 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-21-314

In fiscal year 2020, the Aegis BMD program did not conduct any of the six planned flight tests, deleting one and delaying the remaining five. Most notably, a major operational flight test—FTO-03—was deleted, leaving the SM-3 Block IIA interceptor to enter initial production with a single operational flight test. Some flight tests were initially delayed due to range availability and higher priority flights tests (such as FEX-01) and delays were then exacerbated by pandemic-driven travel restrictions. A congressionally mandated flight test—FTM-44—pitting an SM-3 Block IIA interceptor against a simple ICBM, was delayed, but executed in November 2020.

The Aegis BMD program participated in three of five planned ground tests in fiscal year 2020. The two ground tests were delayed due to the pandemic and the unavailability of the Poland Aegis Ashore site, respectively.

All seven cybersecurity tests scheduled for fiscal year 2020 were consolidated into a single test, which was subsequently delayed.

OTHER PROGRAM INFORMATION

Efforts to Include the SM-3 Block IIA in a Homeland Defense Role Introduce New Risk

MDA's effort to include the SM-3 Block IIA interceptor in a new "layered" homeland defense against intercontinental ballistic missile (ICBM) threats targeting the U.S. could introduce considerable cost, schedule, and performance uncertainty to a program that has just entered initial production. The GMD weapon system currently provides defense against ICBMs, but this new effort would add the SM-3 Block IIA and THAAD weapon system as layers underneath that provided by GMD. For further details on the GMD and THAAD weapon systems see their respective appendixes.

ICBM intercepts are more challenging than the IRBM intercepts for which the SM-3 IIA was originally designed. MDA's most recent attempt to create a system for intercepting ICBMs, known as the Redesigned Kill Vehicle (RKV), re-used some parts from the SM-3 Block IIA. DOD cancelled the RKV before it could complete development after significant cost and schedule overruns and questions about the ability of the design to overcome specific performance risks. Parts re-used from the SM-3 Block IIA were implicated in some of the RKV's performance shortfalls. Even so, planning for an anti-ICBM capability for the SM-3 Block IIA continued during and even after the RKV's termination.

Achieving such a capability will require surmounting several challenges. According to MDA, during the November 2020 flight test named FTM-44, the SM-3 Block IIA struck a simple ICBM target. This was not an operational test, however, and it was executed under highly favorable conditions. More development work is needed for the SM-3 Block IIA to support a layered homeland defense capability. MDA documents show that the agency now plans to develop and procure an upgraded version of the SM-3 Block IIA for the specific purpose of fulfilling the homeland defense mission.

Delays at the Aegis Ashore Site in Poland Continue

According to MDA officials, the Aegis Ashore site in Poland continues to experience delays owing to poor performance by the main construction contractor. Based on MDA's latest estimate of completion no earlier than fiscal year 2022, the site will be between three and four years late. According to MDA, in February 2020, the Army Corps of Engineers (which manages construction at the site) notified the main contractor that earnings from all future invoices would be retained, and released only upon the completion of certain key activities. MDA stated that the contractor did not meet these benchmarks and as a result had not been paid since February 2020.

MDA currently attributes $79 million in cost increases to these delays.

MDA Awarded a Multiyear Procurement Contract for the SM-3 Block IB

The SM-3 Block IB received full production authorization in fiscal year 2018. MDA planned to award both a sustainment contract to provide ongoing support as well as a multi-year procurement contract shortly afterward (previous contracts had been largely annual), in fiscal year 2019. MDA awarded neither contract in fiscal year 2019. While MDA requested and Congress provided multi-year procurement authority, officials said the program did not receive the funding to award a contract in fiscal year 2019.

MDA expected to be able to award the contract in the third quarter of fiscal year 2019, but did not do so until March 2020. MDA stated that production was not affected by this delay.

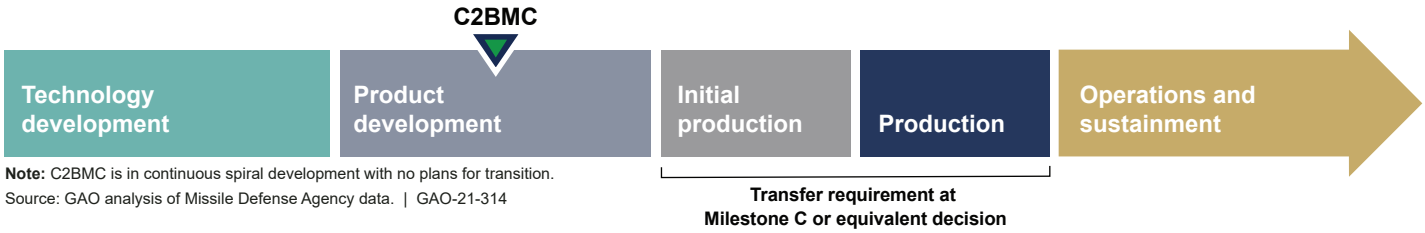
Source: Missile Defense Agency. | GAO-21-314

PROGRAM OVERVIEW

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

C2BMC, a global system of hardware—workstations, servers, and network equipment—and software, is the integrating element of the Missile Defense System (MDS). As the integrator, C2BMC allows users to plan operations, see the battle develop, and manage certain MDS sensors across regional and global networks. Moreover, C2BMC enables defense of an area larger than those covered by the individual MDS elements and against more missiles simultaneously, thereby conserving interceptor inventory. MDA is developing C2BMC in spirals, or software and hardware upgrades, that build upon prior capabilities. Spiral 8.2-3, fielded in fiscal year 2019, is currently in use while spiral 8.2-5 is in development.[1] Spiral 8.2-7 is in early development and has yet to be baselined.

[1]C2BMC spiral deliveries are associated with BMDS Overhead Persistent Infrared Architecture (BOA) upgrades—a system within the C2BMC enterprise. Spiral 8.2-3 is utilizing BOA 6.1 while Spirals 8.2-5 with BOA 7.0 and 8.2-7 with BOA 7.1 are currently in development. ▶



Note: C2BMC is in continuous spiral development with no plans for transition.
Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

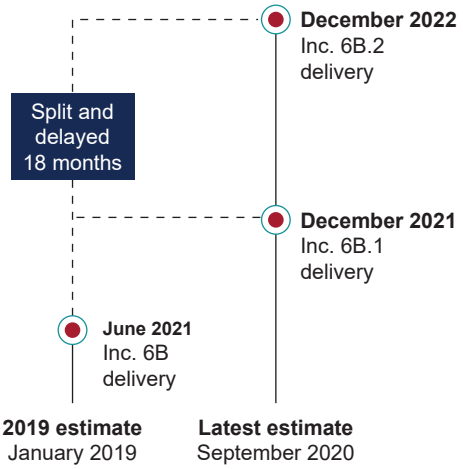
DELIVERIES

While no C2BMC spiral deliveries were planned or delivered in fiscal year 2020, the program delivered post-fielding updates for Spiral 8.2-3. In addition, in October 2019, C2BMC demonstrated initial hardware interoperability with THAAD and NATO command and control systems during NATO Ensemble Test 19, a simulated multinational test.

Spiral 8.2-5 is being developed to provide various capabilities in support of Homeland Defense, including control of the Long Range Discrimination Radar (LRDR) and hypersonic threat tracking reporting. This spiral will be delivered in two sets to synchronize with the replan of related MDS capability and to offset COVID-19 impacts.[2] Fielding of C2BMC functionality in support of Increment 6B.1 is planned for December 2021 while fielding of functionality corresponding to Increment 6B.2 is set for December 2022, a delay of approximately 18 months from the original delivery estimate. Among this spiral's fiscal year 2020 accomplishments are installation of Spiral 8.2-5 hardware and software at Cheyenne Mountain and Clear Air Force stations completed between March and August 2020.

[2]MDS level integrated capabilities are organized by increments. MDA has delivered Increment 1-5. Increment 6B, currently in development, was replanned and split into Increment 6B.1 and Increment 6B.2 in 2019. Both Increment 6B.1 and 6B.2 capabilities center on the use of long range discrimination radar in support of Homeland Defense.

Delayed Delivery of C2BMC Spiral 8.2-5



Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

COVID-19 IMPACTS

- Spiral 8.2-5's development is behind schedule due to COVID-19 workforce restrictions in Colorado and Alabama that affected MDA testing.
- Spiral 8.2-7's development has been delayed due to government staffing and classified environment restrictions. As a result, the content presented during the August 2020 Spiral 8.2-7 systems requirements review was less than planned and a supplemental review was required.
- Operational cyber updates and a number of sustainment projects on deployed Spiral 8.2-3 assets were delayed due to personnel availability and travel restrictions and are replanned for 2021.
- Severity and duration of C2BMC's COVID-19 cost and schedule related impacts are yet to be assessed.

FISCAL YEAR 2020 TESTING OVERVIEW

C2BMC Fiscal Year 2020 Testing

Test	Conducted	Delayed	Deleted
Flight	△	▲ ○	▲
Ground[a]	▲ ▲ ▲	▲ △	
Cybersecurity		▲ ▲ △	

▲ S8.2-3 △ S8.2-5 ○ 8.2-7

[a]C2BMC supports multiple test types, but its capabilities are primarily assessed via ground tests.

Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

In fiscal year 2020, C2BMC participated in four MDS test events, one of which utilized an experimental version of Spiral 8.2-5 and gathered critical data for development against advanced threats. However, C2BMC officials delayed the planned ground test campaign, GTI-08, the first integrated MDS level test of Spiral 8.2-5. The test delay was caused by the inability to perform element software testing as well as delayed hardware in the loop testing due to COVID impacts.[3] In order to mitigate the delay and address this spiral's technical risk—lack of select element models--MDA inserted an integration phase prior to the start of GTI-08 campaign. This risk reduction event, initiated in September 2020, will provide the necessary environment to verify software updates, address interoperability issues and observe more complex element level test cases. Its results will inform the final GTI-08 schedule along with all subsequent ground tests.

[3]Hardware in the loop testing is a type of interactive simulation that includes one or more actual system components operating in conjunction with simulated components.

OTHER PROGRAM INFORMATION

Cybersecurity

In fiscal year 2020, none of the three planned C2BMC's operational cybersecurity assessments were conducted, as MDA is restructuring its cyber test planning approach. Moving forward, cyber tests will be planned and documented via the same agency process used for flight and ground tests in order to streamline test planning and resource allocation. Lack of fiscal year 2020 operational cyber testing of Spiral 8.2-5 has delayed the cyber certification of its 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.

During fiscal year 2020, C2BMC continued software development updates to meet Spiral 8.2-5 cybersecurity baseline requirements. In September 2020, BMDS OTA proposed that MDS elements conduct developmental cyber tests since no operational testing events were performed during the fiscal year. In late September 2020, C2BMC conducted the initial cooperative vulnerability identification test, a developmental event utilizing Spiral 8.2-5 in support of the GTI-08 risk reduction event discussed above.[4] The follow-on adversarial developmental test is scheduled for January 2021.

According to MDA, C2BMC's cyber challenges are rooted in the rapid pace of technological innovation and development of new capabilities. The program implemented an Agile software development process, discussed below, and is working toward a development capability named DevSecOps in order to mitigate these challenges. DevSecOps, an extension of Agile principles, is an iterative software development 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. According to MDA, the continued pursuit of DevSecOps, estimated for implementation in fiscal year 2022, will allow for faster secure cyber changes without impacts to warfighter capability deliveries.

Software Development

Spiral 8.2-5 is the first C2BMC spiral to utilize the Agile development approach, designed to deliver more frequent and responsive capability drops and updates. According to MDA, this iterative development approach is designed to provide a shorter find-to-fix cycle and decrease the risk of defects by emphasizing continuous assessment of performance and real time feedback from the Warfighter on the adequacy of upgrades and fixes. Although designed to reduce risk, the transition to this approach has presented MDA with challenges. For example, the lack of synchronization between C2BMC and other elements' developmental versions along with agency wide operational schedules has contributed to delays in testing and capability verification events. According to the office of Director, Operational Test and Evaluation, MDA is mitigating these challenges by building schedules that account for these restrictions, and we will continue to assess whether the adjustments will be enough to offset the delays.

Program Risk

As noted above, Spiral 8.2-5's fiscal year 2020 technical risk centers around the lack of select MDA element models. As of September 2020, C2BMC is missing model representations of the latest developmental versions of GMD, AN/TPY-2, and BOA. A representation of BOA 7.0 model is undergoing integration for use in developmental testing, but the AN/TPY-2 model will not be available until 2021 and there are no plans for the receipt of the GMD model. According to the prime contractor, lack of adequate GMD capability testing during development may trigger 8.2-5 code rework late in the process resulting in negative cost and schedule impacts. The C2BMC program is employing mitigations, such as early integration events, inter-element testing, and the use of element model representations and recorded re-plays from prior test events in lieu of system models.

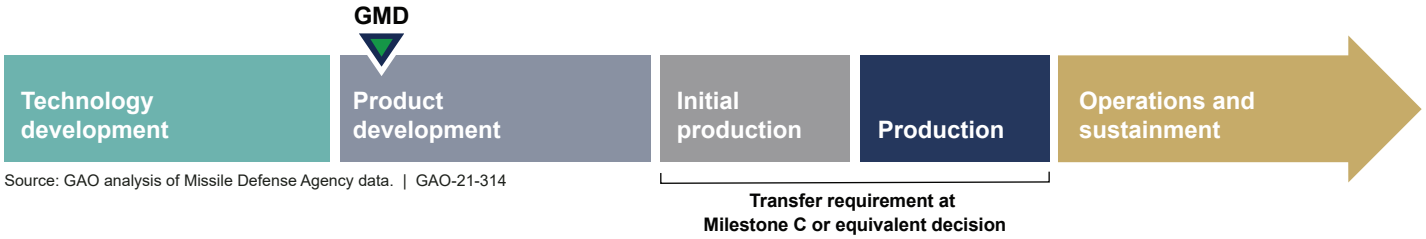
[4]Cybersecurity developmental testing consists of two assessments: Cooperative Vulnerability Identification (CVI) and an Adversarial Cybersecurity Developmental Test and Evaluation (ACD). CVI is used to collect data needed to identify vulnerabilities and plan mitigations. ACD event uses realistic threat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

Source: Army Sgt. Jack W. Carlson III | GAO-21-314

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 rogue states 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 Air Force Base, California. GBIs boost toward the predicted location of an incoming enemy missile and release kill vehicles to find and destroy the threat. 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 facilities, and a communications network. MDA is developing a new GMD interceptor, called the Next Generation Interceptor (NGI) to defeat future missile threats. GMD is in the product development phase, although it has ongoing activities in all phases of the acquisition life cycle. MDA currently has no plans to transfer GMD to the U.S. Army.



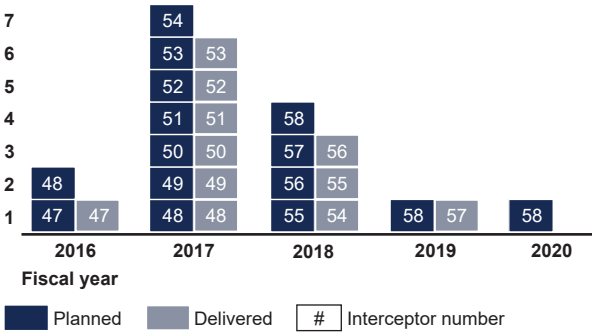
Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

DELIVERIES

MDA did not deliver the one GBI planned for fiscal year 2020. Production delays originate from an issue in 2018 where the boost vehicle contractor mishandled a key avionics component of the boost vehicle.[1] The contractor made progress in 2020 resolving production issues but also experienced further setbacks qualifying electronic parts from a new vendor. These electronic parts are necessary to build a new booster avionics module to replace the one that was mishandled. Once completed, the boost vehicle can be assembled and integrated with the kill vehicle. MDA has re-baselined its plans to deliver the GBI as part of a future increment of capability delivery. MDA now plans for the GBI to be delivered in the fourth quarter of fiscal year 2021, three years later than originally planned.

[1]For more information on the delays, see GAO, *Missile Defense: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability*, GAO-19-387 (Washington, D.C.: June 6, 2019), 12; and *Missile Defense: Assessment of Testing Approach Needed as Delays and Changes Persist*, GAO-20-432 (Washington, D.C.: July 23, 2020), 13.

GMD Interceptor Deliveries, Fiscal Years 2016-2020



Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

COVID-19 IMPACTS

- The GMD system maintained 24/7 operational availability throughout the COVID-19 pandemic in fiscal year 2020.
- MDA implemented a plan to reduce the impacts of COVID-19 on mission objectives, including allowing access to facilities and travel for essential work with guidelines to ensure safety of the workforce.
- The GMD program experienced delays on a number of development, sustainment, and construction activities as a direct result of the COVID-19 pandemic. Some activities were delayed by a month or less while others were delayed five to eight months.

FISCAL YEAR 2020 TESTING OVERVIEW

GMD Fiscal Year 2020 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-21-314

Note: GM BVT-03 and GTI-08 (N/I) were not planned activities in the April 2019 Ballistic Missile Defense System (BMDS) Accountability Report (BAR) for GMD. The tests are associated with Increment 6b, which MDA had not yet baselined at the time the report was released. However, the tests were included in the February 2019 Integrated Master Test Plan version 20.1, which is the formal test plan for the BMDS. Moreover, according to MDA, the April 2019 BAR was aligned with IMTP version 20.1. As such, we included these tests in our review of GMD's planned fiscal year 2020 activities.

In fiscal year 2020, GMD did not conduct its one planned flight test, GMD Booster Vehicle Test (GM BVT)-03, because of challenges developing a 2-/3-stage selectable GBI functionality (see section below on GMD performance improvements for further details). The program intends to use a mock kill vehicle for GM BVT-03, which MDA has assessed will have minimal-to-no impact on the test and will allow a tactical kill vehicle to remain in the fielded fleet. According to MDA, the GMD program's technical direction agent agreed with this approach but noted that it was a missed opportunity to discover any unknown kill vehicle issues in the flight test environment.

Also in fiscal year 2020, GMD conducted Ground Test Integrated (GTI)-07c but did not conduct GTI-08 as planned. GTI-07c supported the fielding of a software upgrade for an older configuration of the GMD kill vehicle that remains in the fielded interceptor fleet. GTI-08 was split into two separate tests and delayed, in part, by complications of the COVID-19 pandemic.

OTHER PROGRAM INFORMATION

Next Generation Interceptor

MDA plans to award contracts to two contractors in the second quarter of fiscal year 2021 to develop separate NGI solutions. According to MDA, the agency recommends carrying the two contractors through the critical design review phase of the program when the system's design is expected to be mature and stable. The GMD program then intends to continue with one contractor into flight testing and production. The program generally expects the NGI development competition will be completed in early fiscal year 2026. The program would then conduct qualification testing and two intercept flight tests in fiscal year 2027, which, if successful, would allow NGI production to start. The program plans for 21 tactical NGIs (1 of which is planned to be used for testing) to be delivered starting in the fourth quarter of fiscal year 2028 and completed by the end of fiscal year 2030. According to MDA, the actual development schedule will be established by the selected contractors following source selection. MDA's initial cost estimate for NGI is $11.3 billion. The estimate includes 8 development NGIs and 21 production NGIs intended to, in part, expand GMD's inventory.

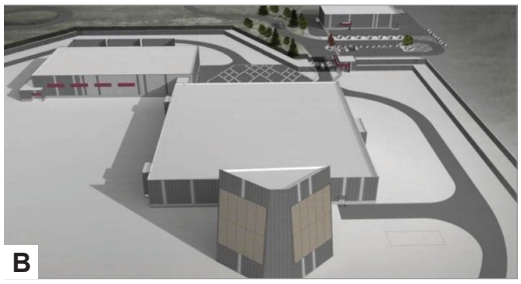
GMD Performance Improvements

The GMD program is developing a capability to expand GMD's battlespace by enabling the GBI to fly out using two of the interceptor's three booster stages. The program refers to this as the 2-/3-stage selectable GBI functionality. According to the MDA Director, this functionality would provide the warfighter with more flexibility because it allows the option of burning all three of the booster stages to shoot further out or burning only two of the booster stages to shoot at incoming missiles as they continue to approach and fly overhead. The program plans to achieve the functionality through an update to the system's software. In 2019, the program realized that a known design limitation on the kill vehicle would create significant performance risk if the 2-stage flyout functionality were employed as initially envisioned. The program considered redesigning hardware on the kill vehicle and then retrofitting the fielded fleet with the redesign in order to achieve the 2-stage flyout functionality. However, MDA officials told us in January 2021 that the prime contractor's initial estimate for the effort was nearly $1 billion. MDA subsequently revisited the 2-stage performance requirements and instead decided to pursue a software-only solution that program officials stated would achieve roughly half of the battlespace expansion previously expected. According to MDA, this approach was a much simpler path that allows the program to achieve performance gains that effectively balances overall mission trades.

Homeland Defense Underlay

MDA is considering plans to augment GMD's defense of the U.S. homeland, in part, by utilizing the Aegis Weapon System and its Standard Missile (SM)-3 Block IIA interceptors and Terminal High Altitude Area Defense (see respective appendixes for additional information). According to MDA, these systems could be positioned and operated as a series of independent shooters to achieve an initial layered defense capability and updated later to become integrated. Currently, GMD's fire control and engagement planning does not take into account any other interceptor systems. Consequently, according to the GMD prime contractor, GMD's fire control software would have to be optimized to work with other interceptor systems. Moreover, managing an engagement between multiple interceptor systems would require more cohesive integration with overall battle planning by the command and control element of the Missile Defense System than currently exists today. Updating GMD's software to fight with other interceptor systems would likely be a complex endeavor for the program and require a robust development and testing program at a time when the program is focused on developing the NGI. Coordination with other interceptor systems would also be challenging because the GBI has hardware constraints that limit communication opportunities with ground systems while in flight. Although MDA's initial approach is based on GMD acting independent of other interceptor systems, the agency has not yet demonstrated whether and how the GMD system would perform in such a scenario and the implications on warfighter concepts of operation.


A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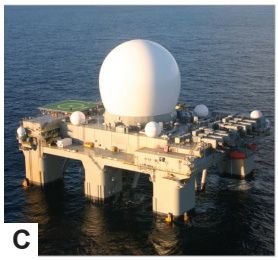
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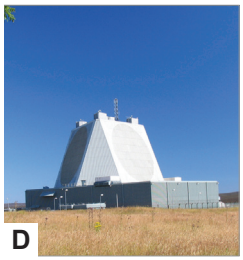
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Source: Missile Defense Agency. | GAO-21-314

PROGRAM OVERVIEW

Sensors

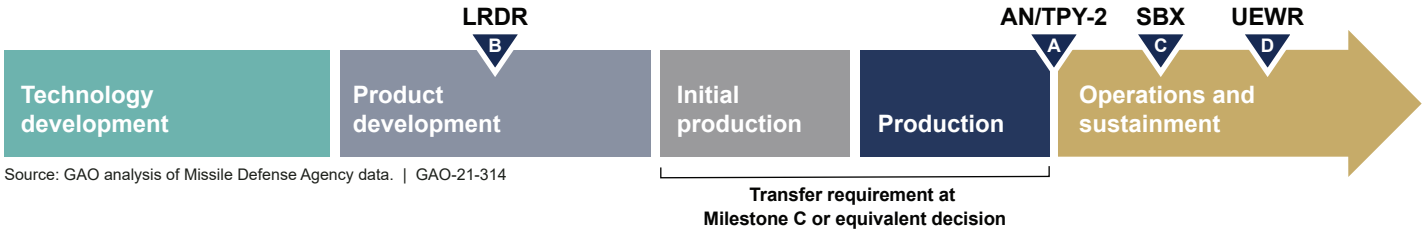
A. Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) is a transportable X-band, high-resolution radar capable of tracking ballistic missiles of all ranges.

B. Long Range Discrimination Radar (LRDR) will be an S-band radar in a fixed location to track incoming missiles and improve discrimination of the warhead-carrying vehicle from decoys and other non-lethal objects.

C. Sea Based X-Band (SBX) is a mobile radar aboard an ocean-going, semi-submersible platform that can be positioned to cover any region of the globe and is capable of tracking, discriminating, and assessing the flight of ballistic missiles.

D. Upgraded Early Warning Radar (UEWR) is a phased-array radar in five fixed locations to detect and track land- or sea-launched long-and intercontinental-range ballistic missiles. Locations include Beale, California; Fylingdales, United Kingdom; Thule, Greenland; Clear, Alaska; and Cape Cod, Massachusetts.

There are transfer plans with the Army and Navy, respectively, for AN/TPY-2 and SBX. There is currently no transfer plan with the Air Force for LRDR. UEWR transferred to the Air Force in 2013.



Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

DELIVERIES

The Sensors program accomplished some of its planned goals in fiscal year 2020, including the delivery of two upgraded x86 electronic equipment units and the acceptance of SBX software XBR 4.0.1 to support improved discrimination. LRDR completed installation of four of ten primary array panels and all ten secondary array panels. UEWR upgrades at the Clear and Cape Cod sites completed operational acceptance-1 (OA-1), which, according to MDA, verifies that the temporarily installed system hardware and software work on site.

However, the remaining UEWR events planned for fiscal year 2020 were delayed until future fiscal years. According to MDA, OA-1 for Fylingdales and BMDS certification of Cape Cod are delayed until fiscal year 2021 due to COVID-19. Further, OA-1 for Thule is delayed until fiscal year 2021 due to COVID-19 and operational scheduling delays, and BMDS certification of Clear is delayed until fiscal year 2022 due to on-site construction delays, COVID-19, and operational scheduling delays.

Sensors Fiscal Year 2020 Delivery Plans

	Planned	Status
AN/TPY-2	2 upgraded x86 electronic equipment units	Completed
LRDR	Installation of primary and secondary array panels	Partially completed
SBX	XBR 4.0.1 software fielding	Completed
UEWR	Clear Operational Acceptance-1 (OA-1) and Cape Cod OA-1	Completed
	Fylingdales OA-1 and Thule OA-1	Delayed
	Clear and Cape Cod BMDS Certifications	Delayed

Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

COVID-19 IMPACTS

- Evacuation of personnel from Clear Air Force Station affected the planned work for LRDR.
- Operational acceptance of upgrades at Fylingdales and Thule UEWR sites were delayed.
- BMDS certification of Clear and Cape Cod UEWR sites were delayed.

FISCAL YEAR 2020 TESTING OVERVIEW

Sensors Fiscal Year 2020 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-21-314

In fiscal year 2020, AN/TPY-2 participated in two flight tests—FTX-39 and FTP-27 E2. The objectives for both tests were to demonstrate interoperability between Terminal High Altitude Area Defense (THAAD) and Patriot in support of an urgent warfighter capability. In FTX-39, the range safety team terminated the Army-supplied short-range target after it drifted off course, preventing AN/TPY-2 in terminal mode from collecting data. In FTP-27 E2, AN/TPY-2 in terminal mode demonstrated the ability to detect, track, discriminate threat missiles and transmit the data to Patriot. For additional details on THAAD, see Appendix VI.

The Sensors program participated in three ground tests—GTI-20 Sprint 1, GTI-20 Sprint 2, and GTI-07c—demonstrating capabilities for the defense of the homeland, deployed U.S. forces, and regional allies. Additionally, MDA conducted a System Integration and Checkout (SICO) of a new AN/TPY-2 forward-based mode radar site in support of U.S. Central Command (CENTCOM) verifying operational communications.

MDA delayed all operational cybersecurity assessments planned for fiscal year 2020, which included three for AN/TPY-2, one for LRDR, and two for SBX. According to MDA, a new approach for cyber testing is being implemented, which they believe will improve cyber system requirements while streamlining cyber test planning, resource allocation, and results analysis.

OTHER PROGRAM INFORMATION

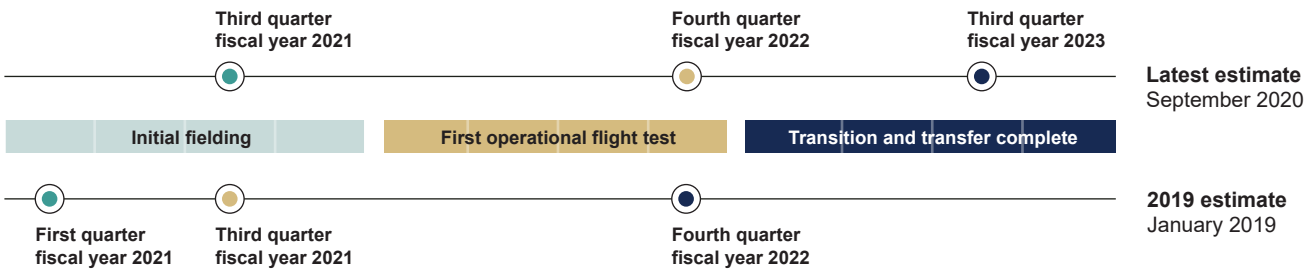
Early LRDR Progress Derailed by COVID-19 Shutdown, Delaying Key Upcoming Dates

LRDR made progress during fiscal year 2020, as the prime contractor completed installation of four of ten primary array panels and all ten secondary array panels. Integration of radar electronics, cooling, communications, and power equipment also began, but was not finished as planned. As we reported in July 2020, LRDR program officials were monitoring risks during fiscal year 2019 that could threaten the transfer of LRDR to the government. These risks included manufacturing of the array panels, subarray assembly suite modules, and auxiliary power group cabinets. During fiscal year 2020, production of the subarray assembly suites and auxiliary power group cabinets were completed; however, the contractor experienced positive COVID-19 cases on its array panel production line, delaying completion from August 2020 to October 2020 due to shift quarantines. According to the contractor, installation of the remaining primary array panels were subsequently completed during the first quarter of fiscal year 2021.

The onset of COVID-19 paused work in March 2020 and LRDR personnel were evacuated from Clear Air Force Station. According to MDA, revisions to State of Alaska travel restrictions in June 2020 led to remobilization of personnel, which completed in August 2020. This pause derailed progress during the second half of the fiscal year for LRDR and, according to agency officials, negotiations with the contractor are ongoing to address additional costs. According to the contractor, the increase included the costs to maintain critical staff on site to monitor the radar and equipment during the evacuation period, as well as production impacts, redeployment, and the performance impacts to the overall contract.

Initial fielding, the first operational flight test, and completion of the transition and transfer process to the U.S. Air Force have all been delayed, in part due to the COVID-19 disruptions. See figure below.

Long Range Discrimination Radar Delays



Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

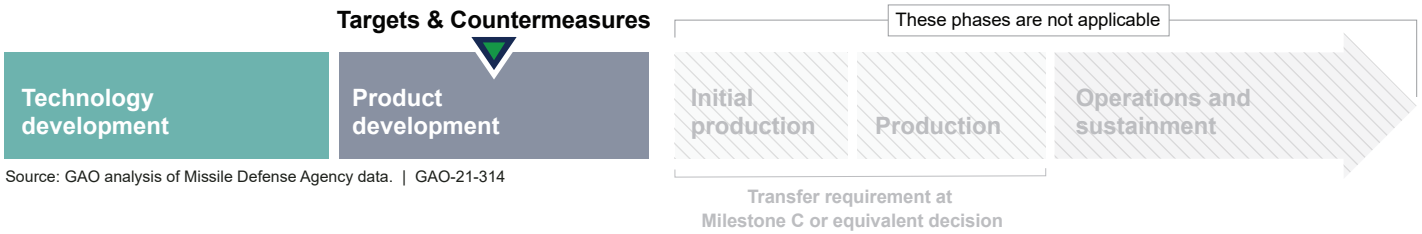
Source: Missile Defense Agency. | GAO-21-314

PROGRAM OVERVIEW

Targets and Countermeasures

The Targets and Countermeasures program (hereafter referred to as the Targets program) supplies short-, medium-, intermediate-, intercontinental-range missiles to represent enemy threat missiles during the 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 MDA's 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-21-314

DELIVERIES

The Targets program delivered 3 of 8 planned targets for flight testing in fiscal year 2020, but none of these targets flew as planned due to travel and other restrictions driven by the pandemic, according to program officials. However, Targets program officials cited notable steps to ensure that an ICBM target was on-site and ready for FTM-44—a congressionally directed flight test to assess an Aegis BMD SM-3 IIA interceptor's capabilities against an ICBM. For example, the Targets program ensured personnel remained on-site to safeguard the target until the test was conducted in November 2020. Three targets planned for delivery in fiscal year 2020 were for an operational test—FTO-03—that was canceled and Targets program officials said they will work to repurpose these unused targets for future flight tests. The remaining targets planned for delivery in fiscal year 2020 were delayed (see table, Targets Fiscal Year 2020 Deliveries, to the right).

Targets Fiscal Year 2020 Deliveries

Planned	Delivery Status
2 SRBM	**Delayed.** Two SRBM T4-G targets were postponed due to development challenges and the pandemic, per program officials.
3 MRBM	**Partially delivered.** One MRBM T3c2 was delivered for a test program officials said was delayed due to the pandemic. One MRBM T4-B was no longer required. One MRBM T1 was delayed because the test it was planned for—FTO-03—was canceled.
2 IRBM	**Partially delivered.** Both IRBM targets were planned for use in FTO-03—a major operational test that was cancelled. One was delivered, but not used. Program officials said both targets will be repurposed for a future flight test.
1 ICBM	**Delivered.** An ICBM was delivered and later flown in FTM-44, a congressionally directed test to demonstrate capabilities of the Aegis BMD SM-3 IIA interceptor—a broader capability than the intended design of this interceptor (see appendix I).
Planned: 8	**Delivered. 3**

SRBM = Short-range ballistic missile, **MRBM** = Medium-range ballistic missile, **IRBM** = Intermediate-range ballistic missile, and **ICBM** = Intercontinental ballistic missile

Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

COVID-19 IMPACTS

- Targets program officials are still assessing the schedule impacts from the pandemic. So far, they have made adjustments to the program's target delivery schedules for several delayed flight tests. Specifically, some assets will now remain with the contractor in storage until personnel are available to safely and properly process and use the assets. In addition, travel restrictions and mandatory quarantines have prevented key personnel from participating in testing.
- The Targets program reported an up to at least $34 million cost impact from the pandemic. For example, there were additional costs to redeploy personnel to support and safeguard the ICBM target for FTM-44 while awaiting the execution of the flight test and reconfiguration of production and integration facilities to accommodate social distancing and other safety protocols.

FISCAL YEAR 2020 TESTING OVERVIEW

The Targets program did not fly any targets in fiscal year 2020 to support weapon system testing.

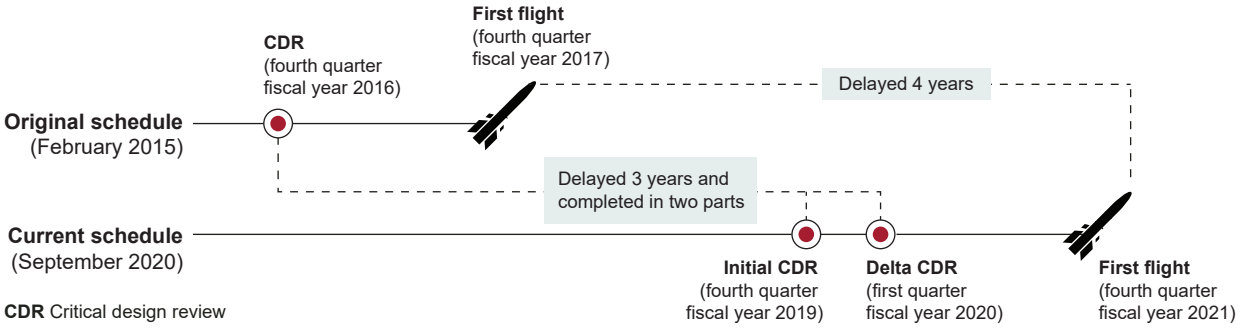
However, the Army supplied two SRBM targets—Black Daggers—for flight tests executed in fiscal year 2020—FTX-39 and FTP-27 E2. The Army supplied these targets because Patriot was the primary weapon system under test. For FTX-39, the target drifted outside of acceptable flight safety boundaries and was terminated by the range safety team. As such, MDA declared this event a no-test. For FTP-27 E2, the target was successful, but the Patriot interceptors failed due to incomplete flight test software on a compact disk being loaded on the interceptors.

OTHER PROGRAM INFORMATION

Critical Design Review Finalized for SRBM T4-G Target

Targets program officials finalized the critical design review (CDR) for the SRBM T4-G target in fiscal year 2020, three years later than originally planned. A CDR assesses the final design of a target to ensure it can proceed into production and testing and meet its performance requirements within cost and schedule. Program officials said they conducted this CDR in two parts—an initial and delta review—August and October 2019, respectively. According to program officials, the delays were primarily due to technical challenges with this unique and complex target. Thus, the delays in finalizing the CDR postponed the first flight test with this target for an Aegis program (not assessed in this report) by four years, as shown in figure below.

Targets Program Finalizes Critical Design Review for the SRBM T4-G Target After Multiple Delays

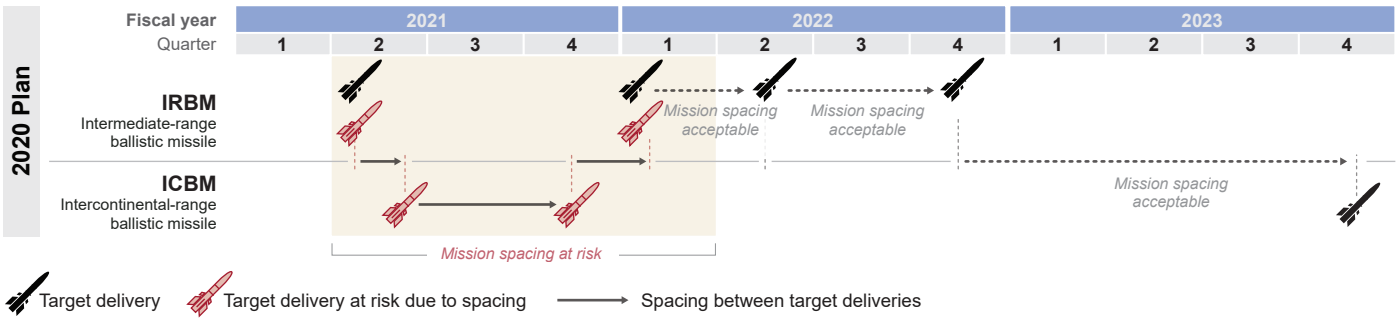


Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

Availability Risks for Intermediate- and Intercontinental-Range Targets

Some IRBMs and ICBMs through fiscal year 2022 are at risk of not being available as planned because, in some instances, the Targets program has not adhered to the contractor's target delivery spacing. While not contractual, the delivery spacing is necessary due to processing, storage, and transport limitations. For example, these limitations dictate at least 9 months between ICBM deliveries, which is currently not the case between the second and fourth quarter of fiscal year 2021, per a delivery schedule the Targets program provided to us in October 2020. Officials from the contractor are working with the Targets program and will likely mitigate this issue and they are also considering solutions, such as procuring additional equipment to transport or process the targets and expanding storage, to avoid such occurrences in the future.

Planned Intermediate- and Intercontinental-Range Targets Deliveries through Fiscal Year 2023



Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

Source: Missile Defense Agency. | GAO-21-314

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 ballistic missile attacks. A THAAD battery is comprised of: launchers, a fire control unit, a communications system, a radar, and interceptors. The current program of record includes seven batteries and interceptor quantities that can extend up to 910 based on the full-rate production decision in October 2020. THAAD has delivered all seven batteries to the Army for operational use and plans to continue production through fiscal year 2029 for remaining items, such as interceptors and software upgrades.

MDA and the Army have a transfer agreement and are taking steps to prepare for the transfer of THAAD to the Army per the National Defense Authorization Act for Fiscal Year 2018. However, DOD is requesting relief from the requirement to transfer as MDA is seeking to retain this program.

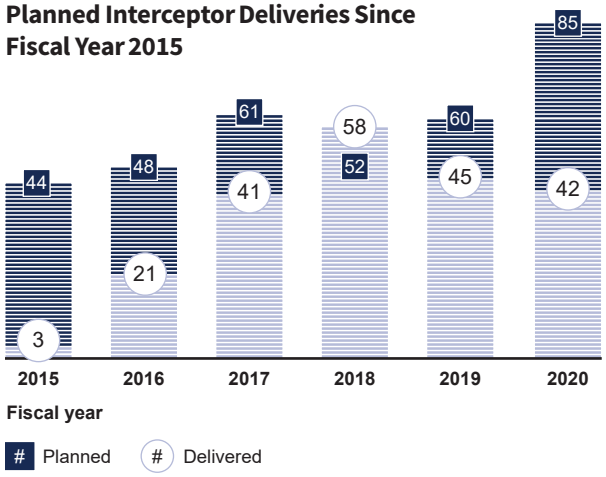
Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

DELIVERIES

THAAD delivered 42 of 85, or 49 percent, of planned interceptors for fiscal year 2020 and halted further deliveries June through September while awaiting a qualified replacement for a part that is no longer available. THAAD's contractor proceeded with production while working to qualify the replacement part, which was a risk to the program if the qualification was not successful. Yet, the qualification was successful and interceptor deliveries resumed in October 2020.

Production setbacks have previously hindered the program's ability to meet its goals each fiscal year. However, THAAD officials are working to improve production and increase throughput. For example, program officials are planning to build a production facility annex which will provide a separate space for stockpile reliability testing, recertification of interceptors, and production surges. In addition, THAAD received full-rate production approval from the Under Secretary of Defense for Acquisition and Sustainment in October 2020.

THAAD Has Generally Fallen Short of Planned Interceptor Deliveries Since Fiscal Year 2015



Source: GAO analysis of Missile Defense Agency data. | GAO-21-314

COVID-19 IMPACTS

- The THAAD program faced challenges executing standard program mission requirements due to workspace limitations and quarantine requirements, but the full impacts to cost and schedule are currently unknown.
- The THAAD program experienced issues ordering and receiving parts from some suppliers, but was able to work with the contractor to identify mitigations and minimize disruptions to production.
- THAAD program officials developed workarounds to continue conducting audits of the program's suppliers since travel restrictions have prevented on-site audits. However, these workarounds have been less than optimal and prolonged delays will increase risks to the program.
- THAAD supported contributions to the pandemic by working with one of its suppliers to leverage an existing technology that could be used in masks and filtration devices.

FISCAL YEAR 2020 TESTING OVERVIEW

THAAD Fiscal Year 2020 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-21-314

In fiscal year 2020, THAAD participated in two flight tests—FTX-39 and FTP-27 E2—that both demonstrated interoperable capabilities between THAAD and Patriot in support of an urgent warfighter need, despite some technical challenges.

Three ground tests were completed for the program to support the operational availability of capabilities for an urgent regional warfighter need, currently projected for February 2021. THAAD delayed the remaining ground test which was divided into two separate ground tests—GTI-08a and GTI-08b—to coincide with another capability delivery.

THAAD delayed its planned operational cybersecurity test—a cooperative vulnerability and penetration assessment (CVPA)—for fiscal year 2020 because MDA is restructuring how it plans cybersecurity testing. The CVPA is the first of two necessary tests for an operational cybersecurity assessment to support the fielding decision for a capability or asset. The information from this test provides data on the resilience of the system in an operational context, which is used for the subsequent Adversarial Assessment—the second of the two tests. This assessment characterizes the operational effects from a threat representative cyber-attack and the effectiveness of the defensive capabilities.

OTHER PROGRAM INFORMATION

Homeland Defense Underlay

MDA is considering the use of THAAD as an underlay in support of homeland defense—protection of the U.S. primarily from intermediate- and intercontinental-range threats. The Ground-based Midcourse Defense program is the principal provider of homeland defense, but in fiscal year 2019 the House Armed Services Committee requested detailed analysis and a report on how THAAD can contribute since it is a rapidly-deployable and globally-transportable system that can be sent where it is needed at the time. The committee noted that THAAD has previously been deployed to perform homeland defense in Hawaii when the threat dictated the need. THAAD officials said they had generated some initial analysis that shows THAAD's capability for homeland defense exists and could be improved with additional development. Thus, THAAD program officials are taking steps in preparation for an effort now known as THAAD Layered Homeland Defense (LHLD), to include developing the requisite plans and contracts. For example, THAAD program officials released a request for information in June 2020 and secured $350 million in funding for fiscal years 2021 through 2023. However, there are a number of significant upgrades and steps to address obsolescence that would be needed to enhance THAAD's performance and make it capable of performing such a mission. THAAD officials noted that they are leveraging foreign military sales with Saudi Arabia for some of these needed changes to offset the costs.

Appendix VII: GAO Contact and Staff Acknowledgments

GAO contact

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

Staff Acknowledgments

In addition to the contact named above, LaTonya Miller, Assistant Director; Matthew Ambrose; Pete Anderson; Jasmina Clyburn; Lori Fields; Cody Gesuelli; Helena Johnson; Joe Kirschbaum; Kaelin Kuhn; Jennifer Leotta; Michael Moran; Wiktor Niewiadomski; Miranda Riemer; Sylvia Schatz; Steven B. Stern; Brian Tittle; Hai V. Tran; and Alyssa Weir made key contributions to this report.

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