United States Government Accountability Office

Report to Congressional Committees

MISSILE DEFENSE

Assessment of Testing Approach Needed as Delays and Changes Persist

Accessible Version

July 2020

GAO-20-432

GAO Highlights

Highlights of GAO-20-432, a report to congressional committees

July 2020

MISSILE DEFENSE

Assessment of Testing Approach Needed as Delays and Changes Persist

Why GAO Did This Study

For over half a century, the Department of Defense (DOD) has funded efforts to defend the United States from ballistic missile attacks. From 2002 through 2018, MDA has received about $152 billion to develop the BMDS and requested about $47 billion from fiscal year 2019 through fiscal year 2023. The BMDS consists of diverse and highly complex land-, sea-, and space-based systems and assets located across the globe.

Congress included a provision in statute that GAO annually assess and report on MDA's progress. This, our 17th annual review, addresses for fiscal year 2019 (1) the progress MDA made in achieving delivery and testing goals; (2) the extent to which MDA's annual test plan is executable; and (3) broad challenges that could impact MDA's portfolio. GAO reviewed the planned fiscal year 2019 baselines, along with test plans since 2010, and other program documentation and assessed them against program and baseline reviews. GAO also interviewed officials from MDA and DOD agencies, including the office of the Director, Operational Test and Evaluation, Undersecretary of Defense for Research and Engineering, and the BMDS Operational Test Agency.

What GAO Recommends

GAO recommends that MDA ensure an independent assessment is conducted of its process for developing and executing its annual BMDS flight test plan. DOD concurred with the recommendation.

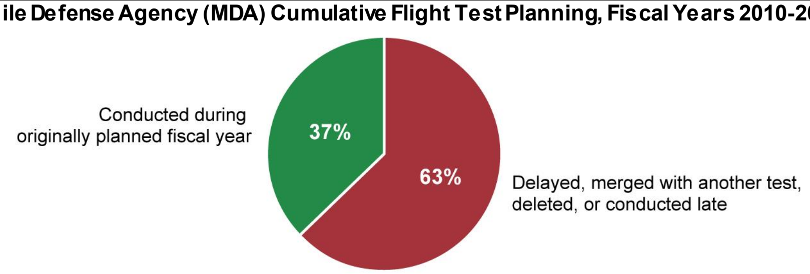
View GAO-20-432. For more information, contact William Russell at (202) 512-4841 or Russellw@gao.gov

What GAO Found

In fiscal year 2019, the Missile Defense Agency (MDA) delivered many of the Ballistic Missile Defense System (BMDS) assets it planned and conducted key flight tests, but did not meet all of its goals for the year. For example, MDA successfully delivered interceptors for use by warfighters and conducted a salvo test (which involves launching two interceptors at an incoming target) for the Ground-based Midcourse Defense program. However, MDA did not meet all of its goals for delivering assets or testing. For example, MDA completed only two of seven planned flight tests, plus eight additional flight tests that were later added for fiscal year 2019.

MDA did not fully execute its fiscal year 2019 flight testing, continuing a decade-long trend in which MDA has been unable to achieve its fiscal year flight testing as scheduled. Although MDA revised its approach to developing its annual test plan in 2009 to ensure the test plan was executable, over the past decade MDA has only been able to conduct 37 percent of its baseline fiscal year testing as originally planned due to various reasons including developmental delays, range and target availability, or changing test objectives. In addition, MDA has not conducted an assessment to determine whether its current process for developing and executing its annual test plan could be improved to help ensure its executability. Without an independent assessment, MDA will continue down the same path, increasing the risk of the same outcomes from the past decade—less testing than originally planned, resulting in less data to demonstrate and validate capabilities.

Missile Defense Agency (MDA) Cumulative Flight Test Planning, Fiscal Years 2010-2019



Source: GAO analysis of MDA data. | GAO-20-432

Note: This graphic is a compilation of each individual fiscal year's flight test schedule. As such, if a flight test was planned for a particular fiscal year but then delayed to a later fiscal year, it would be counted both times.

MDA is currently at a pivotal crossroads, needing to balance its ability to pursue new and advanced efforts while also maintaining its existing portfolio of BMDS elements that have not transferred to the military services as originally planned. The new and advanced efforts, such as the Next Generation Interceptor—a new interceptor for homeland defense—are research and development-intensive tasks, which carry significant technical risks and financial commitments. As MDA takes on these new efforts, it is increasingly important that the agency establish and maintain a sound and disciplined acquisition approach for these efforts to be successful and within anticipated costs and timeframes.

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Abbreviations

AA	Adversarial Assessment
AAW	Anti-Air Warfare
Aegis BMD	Aegis Ballistic Missile Defense
AN/TPY-2	Army Navy/Transportable Radar Surveillance and Control Model-2
AWS	Aegis Weapon System
BAR	BMDS Accountability Report
BL	Baseline
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
CE I	Capability Enhancement I
CE II	Capability Enhancement II
CNET	Classified Network
CU	Capability Upgrade
CVPA	Cooperative Vulnerability and Penetration Assessment
DOD	Department of Defense
DODI	Department of Defense Instruction
DP/SP	Data Processor/Signal Processor
DOT&E	Director, Operational Test and Evaluation
EKV	Exo-atmospheric Kill Vehicle
EPAA	European Phased Adaptive Approach
ER	Engineering Release
FY	Fiscal Year
GBI	Ground-based Interceptor
GMD	Ground-based Midcourse Defense
GT	Ground Test
GTD	Ground Test Distributed
GTI	Ground Test Integrated
HBTSS	Hypersonic and Ballistic Tracking Space System
HCM	Hypersonic Cruise Missile
HGV	Hypersonic Glide Vehicle
IAMD	Integrated Air and Missile Defense
ICBM	Intercontinental Ballistic Missile
IDA	Institute for Defense Analyses
IMTP	Integrated Master Test Plan

IRBM	Intermediate-Range Ballistic Missile
LRDR	Long Range Discrimination Radar
MDA	Missile Defense Agency
MRBM	Medium-Range Ballistic Missile
NATO	North Atlantic Treaty Organization
NDAA	National Defense Authorization Act
NGI	Next Generation Interceptor
OC	Object Classification
OTA	Operational Test Agency
RKV	Redesigned Kill Vehicle
SBX	Sea Based X-Band
SDA	Space Development Agency
SM	Standard Missile
SRBM	Short-Range Ballistic Missile
TADIL	Tactical Digital Information Link
THAAD	Terminal High Altitude Area Defense
UEWR	Upgraded Early Warning Radar
USD (A&S)	Under Secretary of Defense for Acquisitions and Sustainment
USD (R&E)	Under Secretary of Defense for Research and Engineering
VITLS	Variable Message Format Interface Translator Library Segment

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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July 23, 2020

Congressional Committees

The Missile Defense Agency's (MDA) mission is to develop an integrated and layered Ballistic Missile Defense System (BMDS) to defend the United States, its deployed forces, allies and friends. In order to meet this mission, MDA is developing a highly complex system that includes land-, sea-, and space-based systems and assets located across the globe. These individual systems—known as elements—are planned to combine and integrate to create the BMDS.

Since its initiation in 2002, MDA has been given a significant amount of flexibility in executing its development and fielding of the BMDS. To enable MDA to field a missile defense system quickly, the Secretary of Defense, in 2002, delayed the entry of the BMDS program into the Department of Defense's (DOD) traditional acquisition process until a mature capability was ready to be handed over to the military services for production and operation. From 2002 through 2018, MDA has received approximately $152 billion and has planned to spend approximately $47 billion from fiscal year 2019 through fiscal year 2023 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.[1]

For 16 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 year our 17th annual report addresses: (1) the extent to which MDA achieved fiscal year 2019

[1]Pub. L. No. 112-81, § 232(a) (Dec. 31, 2011). The National Defense Authorization Act for Fiscal Year 2016 extended our reviews through fiscal year 2020. Pub. L. No. 114-92, § 1688 (Nov. 25, 2015).

delivery and testing goals for BMDS elements, as stated in reported baselines; (2) the extent to which MDA's annual test plan is executable; and (3) broad challenges that could impact MDA's portfolio and any actions the agency has taken to address them. In addition, appendices I-VIII contain more detailed information on eight of the nine BMDS elements assessed in the report and their fiscal year 2019 activities.[2]

To assess the extent to which MDA achieved its fiscal year 2019 goals, we focused our assessment on MDA's planned delivery and testing baselines as expressed in the BAR for fiscal year 2019, approved March 9, 2018, as well as the Integrated Master Test Plan (IMTP) and its mid-year update. We compared these plans against previous years' plans as well as those for 2019, as they became available. We compared MDA's plans to the agency's actual delivery and testing achievements recorded in agency documents. We discussed the agency's plans and performance in interviews with agency officials, contractors, and officials in the Department of Defense's (DOD) Office of the Director of Operational Test and Evaluation (DOT&E), as well as officials from the Undersecretaries of Defense for Research and Engineering and Acquisitions and Sustainment. For the nine elements covered in this report, we also provided detailed questionnaires to the MDA programs included in the BAR on these programs' accomplishments as well as challenges encountered during the course of fiscal year 2019.

To assess the extent to which MDA's flight testing plan is executable, we reviewed MDA's IMTP for fiscal years 2010 through fiscal year 2019, as well as mid-year updates to these plans. We traced the flight tests for the IMTP that were scheduled from fiscal year 2010 through fiscal year 2019 to determine whether the test was conducted, delayed, merged with another test, or canceled. We compared the planned tests to the flight testing achievements recorded in agency documents. We leveraged our prior reporting on the agency's flight testing performance against our work on best practices for scheduling, and continued our assessment of MDA's ability to achieve testing as detailed in their IMTP development.[3] We

[2]Aegis Ashore is continuing the construction of the site in Poland. As we reported in June 2019, construction delays resulted in the delay until May 2020. See GAO, *Missile Defense: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability,* GAO-19-387 (Washington, D.C.: June 6, 2019). In fiscal year 2019, Aegis Ashore was working towards completing construction and integrating its capability with the Aegis Weapon System. Consequently, we no longer have a separate appendix on Aegis Ashore.

[3]*GAO Schedule Assessment Guide: Best Practices for Project Schedules,* GAO-16-89G (Washington, D.C.: Dec. 22, 2015).

assessed the agency's flight testing performance against our work on best practices for scheduling and MDA's guidance for the IMTP development. We reviewed our prior findings on MDA's flight testing since fiscal year 2010 to assess whether progress has been made. We discussed MDA's flight testing and progress implementing improvements to cybersecurity in interviews with agency officials in the office of DOT&E, Operational Test Agency (OTA), and MDA's Testing Directorate.

To assess steps MDA has taken to address broader challenges and risks that could impact the agency's portfolio, we provided detailed question sets to appropriate MDA Directorates and elements, and the Office of the Under Secretary of Defense (USD) for Research and Engineering (R&E) and Acquisitions and Sustainment (A&S). Specifically, we requested information on new and advanced efforts, congressionally- and DOD-directed reviews, as well as the steps taken to prepare for the transfer of BMDS elements to the military services. We discussed their responses, along with available documentation, with officials from MDA, the military services, and the office of the USD (R&E) and (A&S). We evaluated MDA's progress, where possible, by comparing the steps that the agency has taken against existing legislative and policy requirements.

We conducted this performance audit from May 2019 to July 2020 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 ballistic missile attacks. MDA's mission is to combine these elements into an integrated system-of-systems, known as the Ballistic Missile Defense System. The goal of the BMDS 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 BMDS-level capabilities. Table 1 provides a list and description of the nine elements included in our review.

Table 1: Description of Ballistic Missile Defense System (BMDS) Elements

BMDS 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 BMDS 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 use 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) one boost vehicle and Capability Enhancement (CE)-I kill vehicle; 16 interceptors equipped with the C1 boost vehicle and CE-II kill vehicle; and eight 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 and GMD, or (2) terminal mode—to support Terminal High Altitude Area Defense.
Long Range Discrimination Radar (LRDR)	LRDR will be an S-band radar and will provide capabilities to track incoming missiles and discriminate the warhead-carrying vehicle from decoys and other non-lethal objects for GMD. Construction and integration activities were ongoing in fiscal year 2019, with initial fielding planned for fiscal year 2021 and transfer to the Air Force planned for fiscal year 2022.[b]
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 United States and is considered a critical sensor for GMD, in part because it is able to provide tracking information to the GMD interceptor as it targets an incoming threat missile.
Upgraded Early Warning Radars (UEWR)	UEWR is a solid-state, phased-array, long-range radar that detects land- or sea-launched long- and intermediate-range ballistic missiles. Three UEWRs were upgraded and integrated into the BMDS to improve sensor coverage by providing critical early warning, tracking, object classification, and cueing data. They were transferred to the U.S. Air Force in October 2013 and are located in Beale, California; Fylingdales, United Kingdom; and Thule, Greenland. Modernization efforts for UEWRs located in Clear, Alaska and Cape Cod, Massachusetts are ongoing.

BMDS element[a]	Description
Targets and Countermeasures[c]	Targets and Countermeasures provides a variety of highly complex short-, medium-, intermediate-, and intercontinental-range targets to represent realistic threats during BMDS 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 based of Missile Defense Agency data. | GAO-20-432

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

[b]According to information provided by MDA in June 2020, all LRDR construction and integration activities ceased in March 2020 due to Coronavirus Disease 2019 (COVID-19). As a result, initial fielding is delayed and transfer to the Air Force is now expected in late fiscal year 2023. These developments occurred late in our review and, as such, we were not able to assess the impact and incorporate it into our report.

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

MDA's New Responsibility for Addressing Hypersonic Threats

Over the past three years, MDA's mission has expanded beyond regional and homeland defense against ballistic missiles. Specifically, the Director of MDA is now the executive agent for defense against hypersonic glide vehicles.

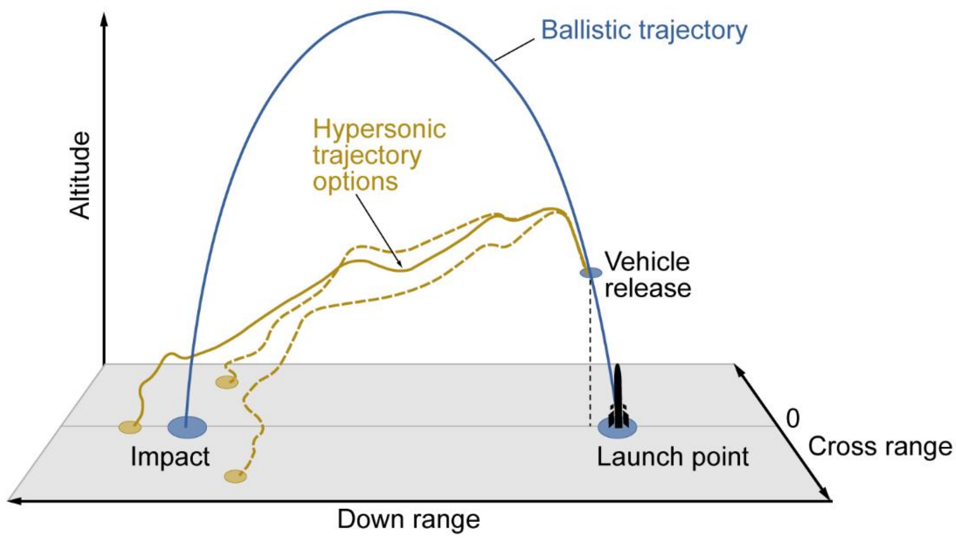
Hypersonic vehicles are capable of flight at speeds five times the speed of sound (Mach 5) or greater. There are generally two types of hypersonic systems: hypersonic cruise missiles (HCM) and hypersonic glide vehicles (HGV).[4]

- HCMs resemble conventional cruise missiles, except that they employ a unique type of high-speed jet engine known as a scramjet. HCMs generally fly at lower altitudes as compared to HGVs.
- HGVs resemble ballistic missiles in that they consist of a payload launched on a powerful rocket. Whereas a ballistic missile payload will continue on a ballistic trajectory following the burnout of the rocket, an HGV payload is designed to glide on the upper edges of the atmosphere and is capable of maneuvering or changing

[4]Hypersonic glide vehicles are also sometimes called hypersonic "boost-glide" systems.

direction on the way to its target. HGVs can provide several advantages over ballistic missiles by making tracking difficult and obscuring the intended target. Both of these features greatly complicate the objective of intercepting the HGV in flight (see fig. 1).

Figure 1: Traditional Ballistic Versus Hypersonic Glide Vehicle Trajectory



Source: GAO. | GAO-20-432

The fiscal year 2017 National Defense Authorization Act designated the Director of the Missile Defense Agency as the executive agent in charge of developing defensive capabilities against HGVs, and authorized the Director to develop supporting architectures in support of that capability.[5] The 2019 Missile Defense Review confirmed MDA's lead role in developing defenses against HGVs, as well as MDA's responsibility for developing a space-based sensor network to support this capability. According to MDA officials, fully achieving this capability will require the development of wholly new intercept systems, supporting technologies, and a new sensor architecture.

[5]National Defense Authorization Act for Fiscal Year 2017, Pub. L. No. 114-328, § 1687 (Dec. 23, 2016).

Transfer of BMDS Elements in Production or Beyond to the Military Services

In 2002, when MDA was established, the agency was given the flexibility to rapidly develop BMDS elements that could then transfer to lead military services that would assume responsibility for operating, sustaining, and funding them. Transfer was to occur at the milestone C (i.e., production start), after certain criteria had been met.[6] Statute requires that the criteria, at a minimum, address the following:[7]

- technical maturity of the program,
- availability of facilities for production, and
- commitment of the military service to fund the program.

Most BMDS elements are in production, according to MDA's fiscal year 2019 BAR, but none of the major systems—Aegis BMD, GMD, THAAD—have transferred to a military service.[8] The National Defense Authorization Acts (NDAA) for Fiscal Years 2007 and 2008 included requirements for MDA to report annually through 2013 on its transfer progress and for the Secretary of Defense to enter into an agreement with a federally funded research and development center to conduct an independent study on MDA's future structure, roles, and mission, including transfer.[9] MDA's final annual report in 2013 indicated that none of the BMDS elements were planned for transfer, as originally intended. However, the 2008 independent study conducted by the Institute for Defense Analyses (IDA) found, among other things, that MDA should immediately transfer a number of BMDS elements and there was nothing

[6]SECDEF Memo, "Missile Defense Program Direction," January 2, 2002. See also John S. McCain National Defense Authorization Act for Fiscal Year 2019, Pub. L. No. 115-232, § 1679 (Aug. 13, 2018) (amending the law to require transfer of an MDA missile defense program that received milestone C "or equivalent" approval).

[7]10 U.S.C. § 224.

[8]Patriot transferred to the Army in 2003. According to MDA officials, two radars—UEWR and Cobra Dane—have transferred to the Air Force.

[9]John Warner National Defense Authorization Act for Fiscal Year 2007, Pub. L. No. 109-364, § 226 (Oct. 17, 2006) (this reporting requirement lasted through 2013); National Defense Authorization Act for Fiscal Year 2008 Pub. L. No. 110-181, § 222 (Jan.28, 2008) (requiring an independent study to assess the "transition and transfer of missile defense capabilities to the military departments," among other things).

precluding the agency from doing so.[10] Later, the fiscal year 2018 NDAA required MDA to transfer the acquisition and total obligational authority of certain BMDS elements in production or beyond to the military services no later than the President's Budget Submission for fiscal year 2021.[11] The NDAA also required MDA to provide a detailed report to Congress on the status of transfers by December 2018. In its report accompanying the fiscal year 2020 NDAA, the Senate Committee on Armed Services stated the expectation that the THAAD program transfer from MDA to the Army.[12] According to MDA, instead of compelling transfers, DOD revised its definition of transfer, whereby BMDS elements are deemed to be transferred if they are available to military services for operational use and the military services and MDA have assumed their respective funding responsibilities in accordance with the transfer agreement and DOD direction.[13] According to officials from OUSD (R&E) and (A&S), DOD is seeking relief from the applicable legislation and report language.

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 ballistic 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

[10]Institute for Defense Analyses (IDA), *Study on the Mission, Roles, and Structure of the Missile Defense Agency (MDA)*, IDA Paper P-4374 (Alexandria, VA: Aug. 28, 2008).

[11]Transferrable BMDS elements consisted of MDA missile defense programs that received Milestone C or equivalent approval in accordance with 10 U.S.C. § 2366 by the time the President's fiscal year 2021 budget was submitted (no later than February 3, 2020). National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91, § 1676 (Dec. 12, 2017), amended by Pub. L. No. 115-232, § 1679; 31 U.S.C. § 1105 (a).

[12]S. Rept. No. 116-48, at 16, 32, 125, 132, 336-37 (2019). See also H. Rept. No.116-333, at 1549, 1586 (2019) (reflecting a THAAD program transfer from MDA to Army).

[13]DOD's June 10, 2011 memorandum on *Funding Responsibilities for Ballistic Missile Defense System (BMDS) Elements* outlines the military services' and MDA's respective funding responsibilities. According to MDA, BMDS elements are deemed to be transferred if: 1) the system is available to military services for operational use, 2) the s ervices have assumed budgeting and responsibility for operation and sustainment of the system, and 3) MDA has retained budgeting and responsibility for missile defense unique item production, development of capability upgrades and sustainment support to Se rvices.

is ready to be handed over to a military service for production and operation. Some of the laws and policies include:

- obtaining the approval of a higher-level acquisition executive before making changes to an approved baseline,[14]
- reporting certain increases in unit cost measured from the original or current baseline,[15]
- obtaining an independent life-cycle cost estimate prior to beginning system development and/or production and deployment, and [16]
- regularly providing detailed program status information to Congress, including specific costs, in Selected Acquisition Reports.[17]

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.[18] MDA reported its newly established baselines to Congress for the first time in its June 2010 BMDS Accountability Report. Since that time, Congress has required more details for the content of these baselines.[19]

Additionally, to enhance oversight of the information provided in the BMDS Accountability Report, MDA continues to incorporate our recommendations. However, not all of our recommendations have been fully implemented. For example, in April 2013, we recommended that

[14]DODI 5000.02T, Enc. 1 para. 4 and Table 4.

[15]10 U.S.C. § 2433.

[16]10 U.S.C. § 2434.

[17]10 U.S.C. § 2432.

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

[19]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.

MDA stabilize its acquisition baselines so that meaningful comparisons could be made over time to support oversight. MDA stated that the information presented in the BAR is sufficient.[20] We continue to believe that the lack of stable baselines makes comparison difficult and in some instances, impossible.

Flight, Ground, and Cybersecurity Testing within MDA

Testing, in general, is performed to collect critical data on individual elements or the integrated BMDS to: (1) determine whether they are properly designed, built, and integrated; (2) understand performance, including capabilities and limitations; and (3) support next steps and decisions. MDA's testing, specifically, is both developmental and operational. The former verifies that the design is built correctly and the latter demonstrates that 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 BMDS'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. These flight tests are, however, an essential tool used to both validate performance of the elements and BMDS. Flight tests are also necessary to anchor models and simulations to ensure they accurately reflect performance.[21] Non-intercept and target-only tests enable evaluation of specific performance aspects or scenarios and potentially reduce risks for future tests. 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 BMDS-level performance during testing.
- Ground Testing–utilizes modeling and simulations, which are computer representations that simulate the system's performance

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

[21]GAO, *Defense Acquisitions: Charting a Course for Improved Missile Defense Testing,* GAO-09-403T (Washington, D.C.: Feb. 25, 2009).

to assess the capabilities and limitations of how elements or the BMDS 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 BMDS-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 BMDS-level, each undergoes verification, validation, and accreditation—an official certification that it operates as intended in representative, real-world conditions. The BMDS OTA—an independent assessor—performs the verification, validation, and accreditation. In 2019, MDA began transitioning to a new ground testing approach, foregoing large scale ground test campaigns, for smaller, but more focused ground-test sprints, which are meant to allow MDA more flexibility in test design.

- Cybersecurity Testing–includes a Cooperative Penetration and Vulnerability Assessment (CVPA) and an Adversarial Assessment (AA). These assessments are intended to identify cyber vulnerabilities, examine attack paths, evaluate operational cyber defense capabilities, and establish operational mission effects (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 issues and to develop the subsequent AA. The AA characterizes the operational effects caused by threat representative cyberattack and the effectiveness of defensive capabilities.

MDA's testing baseline–the IMTP–designates all of the agency's element- and BMDS-level testing for the upcoming and future fiscal years and supports its funding requests. Specifically, the IMTP 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.

This approach to test planning was implemented in 2009 to address concerns that we and DOD had expressed that the original test plan was not effective for management and oversight, in part, because it was revised frequently.[22] As we reported in March 2011, frequent revisions hindered the ability to track funding allocated for testing and to track testing progress and system performance.[23]

MDA Delivered Assets and Conducted Several Tests, but Did Not Meet Its Fiscal Year 2019 Goals

MDA delivered many planned fiscal year 2019 assets and conducted two planned flight tests, but some were delayed from previous fiscal years and MDA did not meet all fiscal year 2019 goals detailed in its BAR. Specifically, MDA continued to deliver Aegis BMD SM-3 missiles and THAAD interceptors for use by the warfighter. However, the GMD program is adjusting its plans due to the August 2019 cancellation of its planned interceptor. In addition, MDA conducted just two of seven planned flight tests. However, one flight test was significant, involving the first ever GMD salvo intercept of an intercontinental ballistic missile (ICBM). MDA also conducted eight additional tests that were added to its fiscal year baseline, including a THAAD intercept test demonstrating a new capability expected to address an urgent regional need. Further, MDA conducted several ground tests and initiated a new approach expected to allow for more flexibility in scheduling. While MDA also took several steps to enhance cybersecurity, it was not able to complete cyber testing as planned in fiscal year 2019.

MDA Delivered Many BMDS Element Assets as Planned Although Some Were Delayed From Previous Years

In fiscal year 2019, MDA achieved many planned asset deliveries although some of the deliveries had been planned for prior fiscal years. Specifically, as Table 2 shows, MDA delivered Aegis BMD SM-3 interceptors as planned, which included 50 Aegis BMD SM-3 Block IB and two Aegis BMD SM-3 Block IIA interceptors. In addition, THAAD delivered 53 of 60 planned interceptors.

[22]GAO, *Defense Acquisitions: Missile Defense Transition Provides Opportunity to Strengthen Acquisition Approach,* GAO-10-311 (Washington, D.C.: Feb. 25, 2010).

[23]GAO, *Missile Defense: Actions Needed to Improve Transparency and Accountability,* GAO-11-372 (Washington, D.C.: Mar. 24, 2011).

Table 2: Missile Defense Asset Deliveries in Fiscal Year 2019

Asset	Planned delivery	Status
Standard Missile-3 Block IB	36 interceptors	50 delivered. This includes several delayed from the previous fiscal year, as well as several delayed into fiscal year 2020.
Standard Missile-3 Block IIA	11 interceptors	Two delivered. Delivery of nine interceptors was delayed following the failure of FTM-29 and requirements for subsequent analysis.
Ground Based Interceptors	0 interceptors	The Ground-based Midcourse Defense program did not plan to or deliver any tactical interceptors in fiscal year 2019. However, one interceptor that was planned for delivery in fiscal year 2018 continues to be delayed to the fourth quarter of fiscal year 2020.
Terminal High Altitude Area Defense (THAAD) Interceptors	60 interceptors[a]	53 delivered.

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

[a]The THAAD program originally planned to deliver 60 interceptors in fiscal year 2019; however, the program rebaselined and adjusted the total to be delivered to 45 interceptors.

Although MDA completed a number of deliveries, some of these deliveries were planned from prior fiscal years and ongoing delays continue. For example, we reported in June 2019 that the Aegis BMD SM-3 IB program has experienced persistent technical problems since 2015, which has affected production and resulted in delays to deliveries and the full-rate production decision.[24] The program resolved these technical issues and received authorization for full-rate production in December 2017. Despite the approval to proceed into full-rate production, the program has experienced recurrent production issues requiring remediation. Additionally, the planned delivery of 11 Aegis BMD SM-3 Block IIA interceptors predates the interceptor's flight test failure in FTM-29, after which MDA delayed production plans to accommodate new tests and further studies. Moreover, due to ongoing delays in construction of the Aegis Ashore site in Poland, MDA delayed the expected delivery by 18 months from its original plan of December 2018 to May 2020.[25] However, the Poland schedule is under review given slower-than-expected military construction progress, which increases the risk of

[24]For further details, see GAO-19-387.

[25]MDA did not deliver Aegis Ashore Poland in May 2020. Ongoing construction delays have further delayed its delivery until at least 2022.

achieving the current overall project schedule.[26] For additional information on the Aegis BMD efforts, see appendices I, II, and III.

The GMD program did not plan to deliver any tactical interceptors in fiscal year 2019, but the delivery of one interceptor is still outstanding from fiscal year 2018. The GMD program previously planned to deliver its 58th interceptor in fiscal year 2018. However, as we found in June 2019, a boost vehicle contractor mishandled a critical avionics component, which subsequently had to be replaced. The contractor experienced extensive delays producing the new component, which has ultimately delayed delivery of the interceptor until the fourth quarter of fiscal year 2020. Although MDA experienced extensive delays delivering this interceptor, the delay has had no effect on operational readiness or flight testing, according to GMD documentation.

MDA also procured two spare CE-II Block I kill vehicles in fiscal year 2019. According to the program, the agency assessed additional kill vehicle production capabilities and determined sufficient hardware is available to deliver two additional CE-II Block I kill vehicles. The program plans to integrate these two kill vehicles with new Configuration 2 boost vehicles and field them for operational use. In doing so, the program will remove two of the older interceptors that were previously fielded, which will be available as spares and future test assets.

The GMD program had also planned to make significant progress in fiscal year 2019 recovering from technical issues for the Redesigned Kill Vehicle (RKV), but the Under Secretary of Defense (USD) for Research and Engineering (R&E), with the support of the Deputy Secretary of Defense and in coordination with the USD for Acquisition and Sustainment (A&S), ultimately decided to terminate the program. As we found in June 2019, MDA encountered design, systems engineering, quality assurance, and manufacturing issues with RKV.[27] These issues prompted the USD (R&E) to direct MDA to stop all work on RKV in May 2019. During the pause, USD (R&E) worked with MDA to identify corrective and alternative courses of action, which were evaluated by other DOD offices and federally funded research and development centers, according to DOD officials. USD (R&E) determined that the

[26]For further details on the Aegis Ashore delays, see GAO-19-387. MDA and the Army Corps of Engineers are currently assessing their program schedule and although construction is ongoing, no deliveries occurred in fiscal year 2019. Therefore, we do not include a separate appendix on Aegis Ashore in this year's review.

[27]GAO-19-387.

technical problems with RKV were so significant as to be either insurmountable or cost-prohibitive to correct and therefore decided to terminate the RKV program in August 2019 with the support of the Deputy Secretary of Defense and in coordination with the USD (A&S). DOD subsequently announced its intentions to pursue a new homeland defense interceptor, called the Next Generation Interceptor (NGI). See appendix V for additional information on the RKV termination and new NGI effort.

Our prior missile defense reports have identified areas within the GMD program that should be improved as MDA moves forward with NGI. MDA has recognized the need for greater department-wide coordination on its new programs, and the USD (R&E) and USD (A&S) reviewed and approved MDA's acquisition plan for NGI in April 2020–consistent with a recommendation we made in May 2017.[28] Our prior reports have also emphasized the challenges associated with MDA and stakeholders imposing deadlines and resorting to high risk acquisition practices, such as starting production ahead of completing development and reducing flight testing, in order to maintain schedule.[29]

Flight Tests Did Not Achieve All Fiscal Year Goals and Exceeded Cost Estimates

MDA successfully conducted two flight tests as planned in fiscal year 2019, including a salvo test for the GMD program where two interceptors were launched at an incoming target. However, MDA delayed five planned tests to future fiscal years, and one of the two tests conducted was scaled down from its original plan.[30] For fiscal year 2019, the test plan was influenced by target issues, range availability, and shifting priorities. Table 3 provides an overview of these seven flight tests and also indicates whether each was a backlogged test–that is, a test that had already been delayed at least once from a previous fiscal year. All seven planned tests from fiscal year 2019 fell into this category.

[28]GAO-17-381.

[29]For examples, see GAO-18-324; GAO, *Missile Defense: Assessment of DOD's Reports on Status of Efforts and Options for Improving Homeland Missile Defense*, GAO-16-254R (Washington, D.C.: Feb. 17, 2016); and *Missile Defense: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency*, GAO-12-486 (Washington, D.C.: Apr. 20, 2012).

[30]One of the five delayed tests was later deleted. See FTO-03 (FTO-03 E2) in Table 3 for more details.

Table 3: Planned Fiscal Year (FY) 2019 Flight Tests

Name of planned test		Flight test type	Conducted (yes or no)	Status and description	Backlogged test[a]
1	FTG-11	Intercept	Yes	**Met test objectives.** The first Ground-based Midcourse Defense (GMD) salvo test in which multiple ground-based interceptors (GBIs) were fired against a single intercontinental ballistic missile (ICBM) target.	yes
2	FTI-03 (FTO-03 E1)	Intercept	Yes	**Met test objectives.** The Aegis Weapon System's Engage-on-Remote capability tracked and intercepted an intermediate range ballistic missile (IRBM) target with an Aegis Ashore-launched Standard Missile-3 Block IIA interceptor utilizing European Phased Adaptive Approach (EPAA) Phase 3 architecture. The initial plan was an intercept of two IRBM targets, but it was scaled down 4 weeks prior to the flight test due range safety issues.	yes
3	FTM-31 E1 (FTM-31)	Intercept	No	**Delayed until FY2020** due to technical issues with the target.	yes
4	FTM-32	Intercept	No	**Delayed until FY2023** due to test range conflicts and to align with Sea-Based Terminal Increment 3. Was initially delayed until FY2020 due to FTM-31 test analysis requirements.	yes
5	FTM-33	Intercept	No	**Delayed until FY2021** due to test range conflicts. Was initially delayed until FY2020 due to FTM-31 test analysis requirements.	yes
6	FTO-03 (FTO-03 E2)	Intercept	No	**Deleted** due to the loss of Army support for both a Patriot unit and Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) radar. Was initially delayed until FY2020 due to the addition of FTT-23 in support of an urgent regional need and as a result of test execution deconfliction with GM CTV-03+.	yes
7	FTX-23	Non-intercept	No	**Delayed until FY2023** due to target issues and competing priorities.	yes

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

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) have been omitted from the totals included in this report.

[a]Backlogged tests are tests that had already been delayed at least once from a previous fiscal year. These backlogged tests are marked with a ✓ in the table.

MDA also conducted eight additional tests that were added to the schedule after the IMTP for fiscal year 2019 was published. These tests are listed in Table 4.

Table 4: Fiscal Year (FY) 2019 Flight Tests Added to Schedule after Publication of FY2019 Integrated Master Test Plan

	Name of added test	Flight test type	Conducted (yes or no)	Status and description	Backlogged test[a]
1	FS-19 E1	Non-intercept	Yes	**Met test objectives.** Consisted of five independent event scenarios, including live launches of two separate Standard Missile (SM)-3 Block IA missiles against two separate simulated short-range ballistic missile (SRBM) threats. Both missiles were nearing the end of service life and were used to provide data for stockpile reliability assessments.	**na**
2	FS-19 E2	Non-intercept	Yes	**Met test objectives.** Consisted of four independent event scenarios, including simulated engagements by Aegis Baseline 9.C2 and 4.1 ships with SM-3 Block IIAs against a live SRBM target. The ships communicated with Aegis Ashore to initiate the Engage-on-Remote capability, in support of the European Phased Adaptive Approach Phase 3 risk reduction.	**na**
3	FS-19 E3	Non-intercept	Yes	**Met test objectives.** Consisted of two independent event scenarios, including a tracking exercise of an unguided single stage Orion, a new advanced air defense target.	**na**
4	FS-19 E4	Non-intercept	Yes	**Met test objectives.** Consisted of three independent event scenarios, including Aegis Ashore receiving remote targeting data from Aegis Ballistic Missile Defense (BMD) ships and a demonstration of its Engage-on-Remote capability using a simulated SM-3 Block IIA against a guided SRBM target.	**na**
5	FTM-31 E2	Intercept	Yes	**Met test objectives.** Aegis BMD demonstrated an intercept of an air-breathing target with an SM-6 Dual II interceptor.	**na**
6	FTM-45	Intercept	Yes	**Met test objectives.** The USS John Finn detected and tracked an MRBM target with its onboard AN/SPY-1 radar. Upon acquiring and tracking the target, the ship launched an SM-3 Block IIA guided missile which intercepted the target.	**na**
7	FTT-23	Intercept	Yes	**Met test objectives.** Terminal High Altitude Area Defense (THAAD) demonstrated an engagement firing against a medium-range ballistic missile (MRBM) target using the remote launcher capability.[b] This capability is one of multiple expected to address an urgent regional need.	**na**
8	FTX-34	Non-intercept	Yes	**Met test objectives.** Tracking exercise used SPY-6 radar to collect data of an SRBM target with countermeasures.	**yes**

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

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) have been omitted from the totals included in this report.

[a]Backlogged tests are tests that had already been delayed at least once from a previous fiscal year. These backlogged tests are marked with a ✓ in the table.

[b]The remote launcher capability allows THAAD launchers to be deployed beyond the current limits, increasing defended areas.

In our May 2017 report, we found that it was difficult to determine the costs associated with MDA's flight testing due to consistency and transparency issues, including the lack of or unclear documentation, inconsistent inputs and outputs, and a lack of traceability.[31] DOD, however, stated that MDA's approach toward assigning resources to its tests was adequate, and its processes for cost estimating aligned with best practices and did not need to be modified. According to MDA, a process to capture costs per flight test began with the President's 2019 budget request and this information is provided annually to Congressional staff.

For fiscal year 2019, the 10 flight tests that were conducted cost $537.3 million, approximately $90 million (or 20 percent) higher than the $445.3 million that MDA estimated, as shown in Table 5 below.

Table 5: Fiscal Year 2019 Executed Flight Test Cost Estimates and Actuals (Dollars in Millions)

Name of executed test	Cost estimate ($M)	Cost actual ($M)
FTM-45	31.979	45.8
FTI-03 (FTO-03 E1)[a]	151.037	150.3
FTX-34	1.183	1.2
FTG-11	151.487	210.2
FS-19 E1/E2/E3/E4	16.535	18.4
FTM-31 E2	0.1	9.0
FTT-23	92.964	102.4
Total	**445.285**	**537.3**

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

Notes: Cost estimates and actuals include test execution and target hardware. Interceptor costs and infrastructure (fixed) costs such as range sustainment, test equipment, and engineers are excluded.

FTI-03 and FTG-11 were planned tests and the cost estimates are derived from the Integrated Master Test Plan (IMTP) 19.1, which aligns with the fiscal year 2019 budget request. The remaining tests were added after IMTP 19.1, so no estimates aligned with the fiscal year 2019 budget exist; these estimates are derived from IMTP 20.1.

[a]FTI-03 was initially planned as a near-simultaneous intercept of two intermediate range ballistic missile (IRBM) targets, but it was scaled back to one IRBM target four weeks prior to the test. The cost estimate for FTI-03 reflects the plan for two targets, while the actual cost reflects the use of one. The target used cost $27.8 million.

While there are valid reasons for certain cost increases, such as adding test objectives or test assets to gather additional data, as we found in

[31]GAO-17-381.

May 2017, the inability to accurately estimate what will be spent on individual tests hinders transparency and the ability to track how MDA is spending appropriated test funding. Moreover, in June 2019 we found that MDA canceled FEV-01 in fiscal year 2018 and reallocated the target for a higher priority test, FTM-45, which was required after the failure of FTM-29.[32] MDA officials stated they received an additional $106.5 million for FTM-45, but after a review of the test objectives, it was determined that some had been met during the failed test and the actual cost of FTM-45 was only $45.8 million. According to MDA, the $60.7 million balance was approved by Congress to be used for other agency priorities such as conducting a space sensor study, improvements to test infrastructure, and cyber test support.

New Approach to Ground Testing Contributed to More Test Completions, but Some Objectives Deferred and Model Limitations Reduce Confidence in Results

MDA successfully conducted six ground tests in fiscal year 2019, demonstrating capabilities for the defense of the homeland, and defense of U.S. forces and regional allies. However, MDA's fiscal year 2019 ground testing schedule underwent significant changes that included delaying and adding new tests. In addition, certain planned ground tests reallocated objectives to different tests. These changes were made in response to development delays, prior testing disruptions, and to accommodate new testing requirements. They also reflect MDA's transition to a new ground testing approach–called ground-test sprints–that focuses on smaller tests, allowing for more targeted assessments. Although the executed tests demonstrated key improvements for planned capabilities, modeling issues continue to limit confidence in the extent to which demonstrated performance reflects real life. Table 6 provides an overview and status of fiscal year 2019 ground tests.

Table 6: Fiscal Year 2019 Ground Tests

Ground Test (GT) planned for 2019	Tests executed in fiscal year 2019	Status
GTD-07b for Northern and Indo-Pacific Commands (N/I)	GTD-07b N/I	**Completed.** Demonstrated capabilities for the defense of homeland and defense of key areas in the Asia-Pacific.

[32] GAO-19-387. Additionally, according to MDA officials, savings from the FEV-01 cancellation (which MDA estimated would be $39.4 million) were reallocated to cover a portion of the increased costs associated with other flight tests.

Ground Test (GT) planned for 2019	Tests executed in fiscal year 2019	Status
GTI-07c	na	**Delayed beyond 2019** to accommodate prior year's testing disruptions and addition of new tests.
GTI-19	na	**Delayed beyond 2019** to accommodate development delays of Aegis BMD 4.1 and renamed to GTI-20 Sprint 1.
GTI-Israel-18	na	**Delayed assessment of objectives beyond 2019** due to resource and schedule constraints.
na	GTI-18 Sprint 3 (Added September 2018)	**Completed.** Added to gather data that was initially planned for 2018 in GTI-07b.
na	GTI-19 Sprint 1 (Added September 2018)	**Completed.** Added to gather data that was initially planned for 2018 in GTI-07b.
na	GTI-19 Sprint 2 (Added September 2018)	**Completed.** Added to assess new capabilities for the Korean Peninsula.
na	GTI-19 Sprint 3 (Added June 2019)	**Completed.** Added in response to warfighter request to assess changes to Northern Command shot doctrine.
	GTI-19 Sprint 4 (Added September 2019)	**Completed.** Added in response to a warfighter request to analyze changes to sensor architecture in the Central Command's area of responsibility.

Legend:

BMD - Ballistic Missile Defense

GT - Ground Test

GTD - Ground Test Distributed

GTI - Ground Test Integrated

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

As shown in Table 6, all of the ground tests added to the fiscal year 2019 test baseline were sprints, reflecting MDA's ongoing transition to this approach. According to MDA officials, the agency is moving away from the larger ground test campaigns to the smaller ground-test sprints. These sprints, according to the officials, allow more flexibility in test design, including the ability to reconfigure tests in the face of development delays and to adjust developmental and operational test periods, as necessary. However, while the transition to sprints may provide benefits, testing officials raised concerns about the increased pace of testing. For example, according to BMDS OTA officials, sprint testing to date has revealed a number of challenges:

- Limited test cases resulted in small sample sizes and thus less data to assess the results.
- The testing outpaced the availability of software and data needed to validate and accredit models and simulations used in these tests.

- Sprints' compressed timelines reduced schedule margin for some activities that require longer lead times, including scenario analysis and development of the threat representations used in these tests.
- Testing periods that required support from combatant commanders often overlapped, which created staffing issues as the number of sprints increased.

MDA is currently developing its guidance for sprints and has been collaborating with other DOD stakeholders to address concerns. For instance, MDA plans to limit the number of ground tests to four per year, pairing each combatant command with an event every other quarter, potentially mitigating some of the staffing issues. MDA also set aside the minimum time between events and established timelines for assessments, reducing some of the concurrency in sprint activities. According to DOT&E and BMDS OTA officials, however, the increasing complexity of the BMDS will require increased efforts to validate and accredit models in time to support the increased pace of sprint testing.

MDA has also continued to make progress addressing modeling and simulations limitations; however, some challenges continue to limit integrated BMDS assessments, and some challenges are likely to continue. For instance, in May 2018 we found that the majority of BMDS models were not accredited for operational assessment. This was largely due to the lack of evidence substantiating demonstrated model performance, modeling errors, and the lack of traceability between the threat model used to simulate the test and the original intelligence about the nature of the threat.[33] According to DOT&E and BMDS OTA officials, the number of models accredited has steadily risen over the last 3 years as MDA has removed some model limitations and completed studies to quantify the effect of other limitations. Nonetheless, full performance assessments of an integrated BMDS are still not possible, and the complexity of missile defense capabilities, for which models need to be validated and accredited, continues to grow. For instance, while the BMDS threats and communication pathways are planned to expand in the coming years, some of these models remained unaccredited in fiscal year 2019. This reduces confidence in the demonstrated capability and will require significant updates.

[33] GAO-18-324.

MDA Continued Efforts to Develop Cybersecurity Guidance, and to Assess and Fix Cyber Vulnerabilities, but Did Not Meet Some Cyber Testing Goals

MDA continues to take steps to improve its cybersecurity but did not meet most of its fiscal year 2019 goals for operational cyber assessments.[34] MDA is incorporating lessons learned from prior cyber activities, improving its guidance and its cybersecurity testing. For example, according to DOT&E, the THAAD program, in collaboration with other stakeholders, completed a comprehensive cybersecurity test plan. MDA stakeholders are utilizing lessons learned from this process to develop cyber-plans for other programs. At the agency level, MDA is also developing a Cybersecurity Strategy to codify its long-term approach to cybersecurity throughout each element's life cycle.

Moreover, MDA continues to address issues discovered in prior testing, improving its overall cybersecurity survivability. For instance, the fiscal year 2019 cybersecurity assessments informed the network defense posture in U.S. Northern Command and provided data on how to reduce mission risk for these elements operating in a cyber-contested environment. One of these assessments was the largest combined cooperative cyber assessment in MDA's history, and the first operational adversarial assessment of GMD integrated with the SBX sensor.

While MDA has been improving its cybersecurity development efforts and testing, it did not meet its fiscal year 2019 goals. Specifically, as shown in Table 7, MDA planned 16 element-level operational cooperative and adversarial assessments. However, only two of these elements completed cyber assessments in fiscal year 2019–GMD and C2BMC. MDA also completed three additional assessments for two sensors.

[34]Operational cybersecurity testing consists of two types of assessments: a Cooperative Penetration and Vulnerability 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 cyber-attack and the effectiveness of defensive capabilities.

Table 7: Operational Cybersecurity Assessments in Fiscal Year 2019

Element	Planned for Fiscal Year 2019		Completed in Fiscal Year 2019	
	Cooperative Vulnerability and Penetration Assessment	Adversarial Assessment	Cooperative Vulnerability and Penetration Assessment	Adversarial Assessment
Aegis Ballistic Missile Defense (BMD)	3	1	na	na
Terminal High Altitude Area Defense (THAAD)	1	1	na	na
Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2)	3	1	na	na
Command and Control Battle Management and Communications (C2BMC)	3	1	na	1
Ground-based Midcourse Defense (GMD)	1	1	1	1
Sea-based X-band Radar (SBX)	na	na	1	1
Upgraded Early Warning Radar (UEWR)	na	na	1	na
Total	**11**	**5**	**3**	**3**

Source: GAO analysis of Missile Defense Agency and Director, Operational Test and Evaluation data. | GAO-20-432

Note: A Cooperative Vulnerability and Penetration Assessment for C2BMC was conducted in 2018.

Moreover, in fiscal year 2019, MDA still has not completed the cybersecurity testing for capabilities delivered in 2017 and 2018. According to DOT&E and BMDS OTA, more detailed cybersecurity testing for each BMDS element is needed to ensure BMDS cybersecurity problems are found and fixed for future but also for current BMDS capability increments. Such continued testing is critical in order to eliminate vulnerabilities that could result in disruption of operations by an adversary.

Changes to MDA's Test Schedule Persist, Affecting Execution of Planned Testing

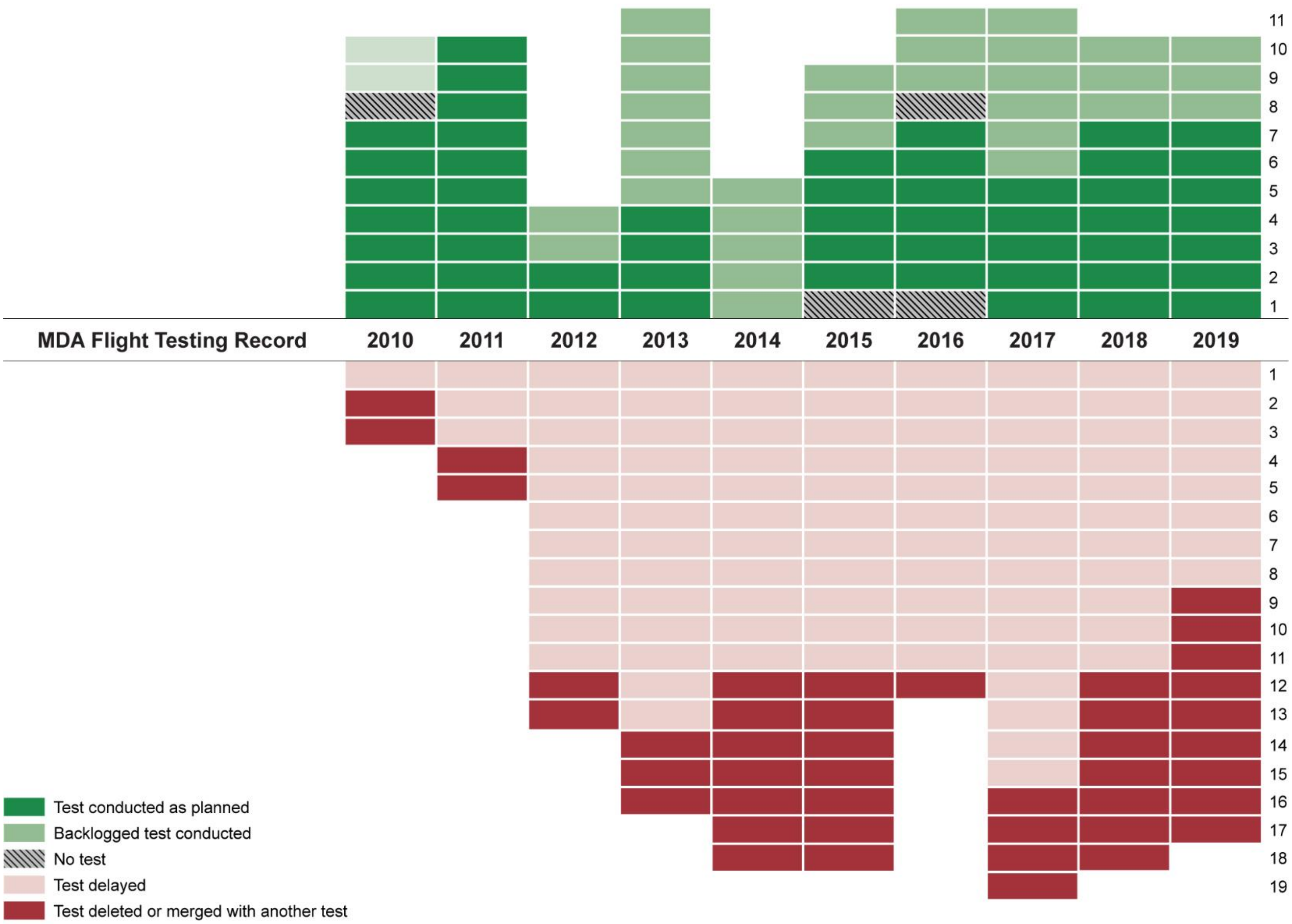
In fiscal year 2019, five planned flight tests were delayed to future fiscal years continuing a decade-long trend of flight test schedule instability and suggesting that MDA's approach to developing these test plans is not adequate. Over the past decade, MDA and DOD stakeholders have developed annual IMTPs that stakeholders deemed affordable and executable, but which have not been fully carried out each fiscal year. In

February 2010, we found that MDA revised its approach to developing its annual test plan after we and DOD raised concerns.[35] Specifically, the prior approach to developing the test schedule was not effective for management and oversight, in part, because it was frequently revised. MDA changed the substance of the tests, changed the timing of the tests, or added tests to the baseline. MDA also provided plans only through the following fiscal year. MDA's revisions to its test plan approach (i.e., the IMTP), which were announced in June 2009, included basing test scenarios on modeling and simulation needs, and extending the test baseline to allow for a better estimation of test target, range, and asset needs to support a more stable baseline.[36] After 10 years under this IMTP process, however, MDA has conducted only 37 percent of its planned testing as originally scheduled due to various reasons such as developmental delays, range and target availability, or changing test objectives. In addition, we found that MDA is still consistently revising its test schedule by adding new tests and deleting or delaying the tests that were initially planned–in some cases multiple times, further into future fiscal years. See figure 2 below.

[35]GAO-10-311.

[36]GAO-10-311. The number of fiscal years covered by the IMTPs has varied since MDA implemented the changes. For example, the September 2019 IMTP included tests spanning 8 fiscal years and the March 2017 IMTP included tests spanning 11 fiscal years.

Figure 2: Missile Defense Agency (MDA) Cumulative Flight Test Planning, Fiscal Years 2010-2019



Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

Notes: This analysis includes flight tests for Aegis, Terminal High Altitude Area Defense (THAAD), Ground-based Midcourse Defense (GMD), and the Sensors program, as w ell as operational tests, that w ere included in the Integrated Master Test Plans (IMTPs) for fiscal years 2010-2019. As in our prior reports on MDA's annual progress, tests where MDA participated but did not possess the primary system under test (e.g. Army's Patriot program or Israel's Iron Dome) have been omitted from the totals.

"No Test" is declared w hen a target malfunctions and no interceptor is launched.

We have reported since 2011 on some of the reasons for such changes, such as MDA's concurrent acquisition strategies, developmental delays, and its aggressive schedule.[37] In addition to these challenges, we previously identified that target availability, range availability and test objective modifications also contributed to the delays. Moreover, in May 2017, we found that MDA's test schedule includes too many tests with little to no schedule margin between them, and later found, in June 2019, that MDA was also leaving little time to analyze past test results and address issues when they come up.[38]

According to best practices identified in GAO's schedule assessment guide, the success of a program depends, in part, on having a reliable schedule that is as logical and realistic as possible. Activity durations should be estimated under normal conditions, not optimal or "success-oriented" conditions, which we found, in 2011, was MDA's practice.[39] In May 2015, we reported that MDA officials told us they do not plan for target failures, test failures, or potential retests when developing the test plan, and there is no flexibility to absorb these issues.[40]

According to MDA's guidance for IMTP development, test data are used by external stakeholders to assess the overall performance of the BMDS, and testing is a means to exercise warfighter tactics, techniques, and procedures.[41] The flight test data help build confidence in the capabilities, improve strategic deterrence, and provide data necessary for anchoring

[37]GAO, *Missile Defense: Actions Needed to Improve Transparency and Accountability,* GAO-11-372 (Washington, D.C.: Mar. 24, 2011); For additional GAO reporting on MDA's test delays, see *Missile Defense: Opportunities Exist to Reduce Acquisition Risk and Improve Reporting on System Capabilities,* GAO-15-345 (Washington, D.C.: May 6, 2015); *Missile Defense: Ballistic Missile Defense System Testing Delays Affect Delivery of Capabilities,* GAO-16-339R (Washington, D.C.: Apr. 28, 2016); GAO-17-381; and GAO-19-387.

[38]GAO-17-381; GAO-19-387.

[39]GAO-16-89G; GAO-11-372.

[40]GAO-15-345.

[41]The Chairman of the Joint Chiefs of Staff Manual on joint doctrine development procedures defines "tactics" as the employment and ordered arrangement of forces in relation to each other; "techniques" as non-descriptive ways or methods used to perform missions, functions or tasks; and "procedures" as standard, detailed steps that prescribe how to perform specific tasks.

models and simulations.[42] BMDS Warfighter Capability Acceptance guidelines similarly state that testing is fundamental to ensuring that DOD acquires a system that meets operational needs, and to provide data necessary to characterize the system's operational effectiveness.

Testing disruptions, such as the delays and removals experienced since 2010, result in assets and capabilities that are subsequently delayed, or delivered with less data than planned due to reduced testing. For example, in June 2019, we found that flight testing to demonstrate EPAA Phase 3 performance against IRBMs had been reduced by 80 percent, and MDA no longer planned to conduct a flight test against a raid–reflective of a real-world threat scenario–prior to delivery.[43] A lack of raid flight testing also prevented the accreditation of Aegis BMD models for assessment under those circumstances–an issue for all fiscal year 2019 ground tests that included Aegis BMD.

In March 2009, as MDA was revising its IMTP development approach, we found that less testing was being conducted than planned and the test plans were being revised often. With over a decade of additional data since then, the same issues exist with MDA's current process and the test schedule has still not stabilized. However, MDA has not conducted an assessment of its test plan development process despite continually falling short in executing the schedules it deemed executable.

Moving forward, MDA will likely be expected to take on additional responsibilities to respond to an ever-evolving threat space. As part of these new responsibilities, MDA will need to conduct testing to demonstrate and validate any new capabilities. According to MDA, it plans to incorporate best practices, such as "fly before you buy," for its NGI, because sufficient testing prior to production start will be critical during the development to avoid testing compromises the RKV program resorted to prior to its cancellation in 2019. To this end, MDA plans to successfully execute two intercept flight tests before starting the first lot of NGI production.

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[42] As we reported in May 2018, MDA utilizes models and simulations because of the system's complexity and certain scenarios cannot be tested due to safety concerns. Consequently, MDA relies on models and simulations to supplement flight test data. To ensure that the models and simulations accurately represent the real-world operational BMDS capabilities and that the limitations of the model are understood, they are verified, validated, and accredited by the BMDS OTA.

[43] GAO-19-387.

Similarly, less testing data than planned due to frequent delays and cancellations can hinder MDA's ability to transition or transfer systems to the military services, an issue discussed later in this report. According to Department Defense Directive 5134.09, MDA must work with other offices and departments to ensure that adequate integrated developmental and operational testing is performed to verify operational performance prior to element transition or transfer. Without an independent assessment of its process for developing and executing its annual BMDS flight test plan that involves relevant stakeholders, MDA will continue down the same path, increasing the risk of the same outcomes it has experienced for years–less testing than originally planned, resulting in less data available to demonstrate and validate delivered capabilities.

MDA Is Facing Challenges with the Balance and Affordability of Its Portfolio Amid Ongoing Congressional and DOD Reviews Intended to Inform the Agency's Future

MDA is at a pivotal crossroads in terms of balancing its ability to pursue new and advanced efforts while also maintaining its existing portfolio of BMDS elements that have not transferred to the military services as originally planned. The new and advanced efforts, such as hypersonic defense and the NGI for GMD, are research and development-intensive tasks, which carry significant technical risks and financial commitments. MDA's existing portfolio of BMDS elements will continue to consume a growing portion of the agency's budget, as they move further into production and operations and sustainment. MDA and the military services have taken some actions to prepare for transferring the BMDS elements to the military services, as initially planned. However, the actions have not enabled some transfers to occur to date, primarily due to a lack of early and frequent coordination, according to OUSD (R&E) and (A&S) officials. Consequently, there are overarching concerns related to transfer that have not been resolved. For example, MDA and the military services are concerned about the effects to their respective budgets if BMDS elements are transferred in or out, and how to distribute their remaining budget among competing priorities. Congress and the Secretary of Defense have directed reviews to determine how to address these and other concerns and chart a path forward for MDA.

MDA's New and Advanced Efforts Have Technical Risks and Will Require Significant Financial Commitments Moving Forward

Hypersonic Defense Will Be Technically Challenging to Operationalize

Recent legislation and executive direction have added the responsibility for providing hypersonic defense to MDA's portfolio.[44] MDA officials stated that it will require the development of a wholly new interceptor integrated with space-based sensors to meet this responsibility and fully achieve the capability. The new interceptor will need to operate in a hypersonic flight profile and outperform the main characteristics of adversaries' hypersonic capabilities, such as speed and maneuverability. MDA officials also stated that, in September 2018, the agency awarded 21 contracts for the development of a variety of concepts for systems capable of intercepting hypersonic weapons, including kinetic and non-kinetic interceptors.[45] In addition, MDA officials stated that in August and September 2019, the agency awarded five contracts for further study and refinement based on contractor proposals. However, Cost Assessment and Program Evaluation (CAPE) and DOD officials have expressed concerns that simply building a weapon capable of operating in a hypersonic flight profile pushes multiple scientific boundaries, especially in the survivability of materials during exposure to extreme g-forces and high temperatures. Thus, building a weapon that outperforms existing or potential hypersonic weapons by significant margins, will be difficult.

In order to have global, persistent tracking of an incoming hypersonic threat, MDA plans to develop specialized space-based sensors through its Hypersonic and Ballistic Tracking Space Sensor (HBTSS) program. MDA officials envision using new space-based sensors versus existing ground-based sensors due to the gap in coverage of detection and tracking, as most ground-based radars track flight paths at much higher altitudes than a hypersonic interceptor flies. However, the use of space-based sensors will require the development of improved image processing algorithms to distinguish the threat from the surface of the

[44]Pub. L. No. 114-328, § 1687. See also DOD, *Missile Defense Review 2019* (January 17, 2019).

[45]A kinetic interceptor seeks to disable an incoming missile with the force of a direct impact. A non-kinetic interceptor works by getting close enough to an incoming missile to disable it with either an explosive blast or some other effect.

earth, which is warm and irregular, versus a ground-based sensor looking up against the cold and featureless background of space.

There are additional technical challenges for the HBTSS program in terms of deployment of the space-based sensors and cooperation with other DOD space-based satellites, according to MDA and DOD officials. Specifically, MDA officials stated that they envision deploying HBTSS on a network of small satellites in low-earth orbit versus the traditional approach of using a few large satellites that occupy more distant orbits.[46] MDA officials said this architecture leverages advances in the commercial space and satellite sector. MDA will have to work with the newly created Space Development Agency (SDA), whose mission is to unify and integrate space-based efforts across DOD. MDA and SDA are still defining the division of responsibilities, budget, and the overall working relationship. SDA has articulated a unified, next-generation space architecture to meet DOD's needs, consisting of six distinct satellite constellations, of which HBTSS would be one. According to SDA and MDA officials, these systems must have a high degree of interoperability in order to be maximally effective, which will require close coordination.

MDA Is Developing an Advanced Interceptor to Expand Inventory and Replace the Aging GMD Fleet Due to Redesigned Kill Vehicle Cancellation

MDA is developing an advanced interceptor to expand and replace GMD's aging fleet of interceptors for homeland defense, which will be a significant undertaking for the agency. In the wake of DOD's decision to cancel the troubled Redesigned Kill Vehicle program in August 2019, MDA took initial steps to engage industry on a new, more capable homeland defense interceptor–NGI. This new interceptor will have a focus on survivability in all environments, capability against a broader range of missile threats, and adaptability to counter future threats. The fielded GMD interceptor has demonstrated the capability to defend the United States homeland from a small number of intermediate-range or intercontinental ballistic missiles equipped with simple countermeasures, according to DOT&E.[47] Although MDA maintains that these interceptors

[46]Satellites travel around the Earth at various altitudes and angles relative to the equator. Low Earth orbit is the region of space up to an altitude of approximately 1,500 miles.

[47]Director, Operational Test and Evaluation, *FY 2019 Annual Report*, (Dec. 20, 2019). The "fielded GMD interceptor" is called the Ground-Based Interceptor (GBI) and consists of a boost vehicle and a payload called the Exoatmospheric Kill Vehicle (EKV).

have kept pace with the threat, the agency has stated that a more innovative interceptor solution is needed to meet the emerging threat. However, MDA continues to encounter technical challenges developing the fielded GMD interceptor; thus, developing an advanced interceptor that can defeat complex missile threats has the potential to be considerably more difficult.[48] In addition, there is an urgency to complete the development of the advanced interceptor to replace the aging GMD fleet or risk potential gaps in homeland defense. See appendix V for additional information on the NGI.

MDA Is Beginning to Fund These New and Advanced Efforts Which Will Require Significant Research and Development Financial Commitments as They Progress

DOD has directed MDA to develop hypersonic defense and an advanced GMD interceptor (the NGI), but the technical challenges associated with these efforts will necessitate considerable financial commitments. We have previously reported on MDA's past attempts to quickly develop and field capabilities that were unsuccessful and costly, primarily due to moving forward without a sound acquisition approach.[49] The soundness and discipline of MDA's approach for these efforts, in terms of maturing technologies, promoting competition, and ensuring departmental buy-in, will ultimately determine their success and associated costs. MDA is still determining the acquisition approach for these new efforts. While MDA has not released a formal cost estimate for counter-hypersonic systems, the agency's budget request for fiscal year 2021 showed that the agency planned to spend $659 million dollars through 2025 on efforts to develop and demonstrate hypersonic defeat capabilities. Also, initial cost estimates for the NGI generally anticipate a cost of several billions of dollars. In both instances, these initial cost estimates and plans are only for a portion of the effort and not the total program, which could be considerably more. Through fiscal year 2024, MDA plans to devote just over $2.3 billion of its total budget, or about 5 percent each year, to these new and advanced efforts. However, as these efforts progress, the budgetary needs are expected to increase.

[48]The GMD program experienced technical challenges preparing for FTG-11, which was conducted in March 2019. For more information on these challenges, see GAO-19-387. Technical challenges for NGI may vary depending on which concept(s) MDA selects.

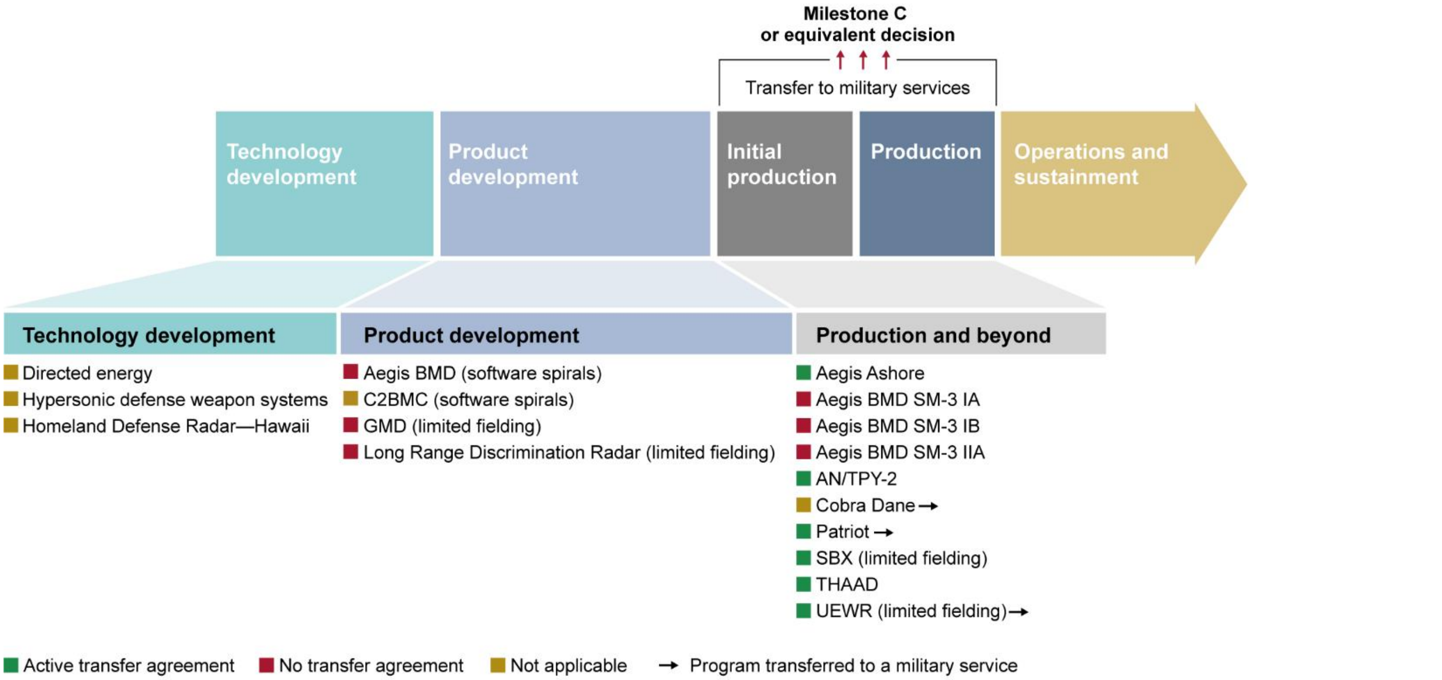
[49]For further details on MDA's programs that were initiated with high levels of technological and development risk that resulted in significant cost growth before being subsequently cancelled, see GAO-11-372, GAO-13-432, and GAO-17-381.

MDA's Current BMDS Elements Will Consume a Growing Portion of the Agency's Overall Budget if Not Transferred to the Military Services, per DOD Policy and Congressional Direction

Congress and the Secretary of Defense are currently considering whether existing BMDS elements that are in production or beyond (fielding, operations, and sustainment) should transfer to the military services, as originally intended by the Secretary of Defense and per legislative direction, or remain with MDA for the foreseeable future. In 2002, DOD issued direction establishing MDA and specifying that the agency would transfer BMDS elements to the military services for production, operation, and sustainment at a milestone C.[50] Milestone C or an equivalent decision is generally when production begins. However, at this point, 18 years later, most BMDS elements are in production or beyond, but MDA has only transferred a few of them, as shown in figure 3. Existing policy and legislation require transfers to occur, but at this juncture, MDA has not yet charted a path that would enable it to do so for major BMDS elements, such as Aegis BMD, GMD, and THAAD.

[50]Department of Defense, Secretary of Defense, *Missile Defense Program Direction,* (Washington D.C.: Jan. 2, 2002).

Figure 3: Ballistic Missile Defense System Elements' Acquisition Life Cycle Status



AN/TPY-2 = Army Navy/Transportable Radar Surveillance and Control Model-2
BMD = Ballistic Missile Defense
C2BMC = Command, Control, Battle Management and Communications
CPD = Capability Production Document
GMD = Ground-based Midcourse Defense
MDA = Missile Defense Agency
LRDR = Long Range Discrimination Radar
OUSD (A&S) = Office of the Undersecretary of Defense for Acquisition and Sustainment
PATRIOT = Phased Array Tracking Intercept of Target
SBX = Sea-based X-Band
THAAD = Terminal High Altitude Area Defense
UEWR = Upgraded Early Warning Radar

Source: GAO analysis of MDA data. | GAO-20-432

Transfer Hindered by Lack of Early and Frequent Coordination between MDA and the Military Services

MDA and the military services have taken some actions to prepare for transfer; however, the preparation has been hindered by a lack of early and frequent coordination between these entities, according to OUSD (R&E) and (A&S) officials. For example, MDA has established a transfer policy, created agreements with the military services on transfer, and established forums to discuss and resolve aspects of transfer. These actions, while positive, have not ensured the transferability of the BMDS elements. We previously reported that MDA and the military services were not routinely working together on transfer, resulting in inconsistencies in the preparedness for transfer and a lack clear funding responsibilities.[51] Similarly, at this point, discussions between MDA and the military services on transfer have been inconsistent and some aspects of funding responsibilities remain unclear. For example, MDA officials told us that the number of times that the primary forums have convened to discuss transfer over the last 6 years has varied by military service, with some meeting more frequently than others. In addition, not all BMDS elements have a transfer agreement in place, as shown in figure 3 above. Thus, there are unresolved aspects of transfer, such as the establishment and funding of hybrid program offices to facilitate transfer. Hybrid program offices, per MDA policy, are an integrated program management structure, consisting of MDA and military service officials, who are encouraged to co-locate, wherein the mass of personnel, resources, and responsibilities shift from MDA to the military service at transfer.[52] OUSD (R&E) and (A&S) officials said that the lack of clarity on funding responsibilities between MDA and the military services is why the hybrid programs have not been established as defined in MDA policy.

Regarding the transfer of mature BMDS elements in production, MDA and the military services identified overarching concerns in four areas–budget, prioritization, control, and performance.[53] For example, we have previously reported on the impasse between MDA and the Army over the transfer of THAAD and AN/TPY-2 due to mission requirement shortfalls that would necessitate an estimated $10.1 billion investment or more to resolve.[54] MDA has stated that it is not willing to fund these shortfalls if elements are transferred to the Army, and Army officials have expressed reservations about taking on such a significant financial burden. Therefore, the Army has been reluctant to assume full responsibility for THAAD and AN/TPY-2. A 2008 congressionally directed independent study on transfer found that there should be increased interaction between MDA and the military services on transfer and improved DOD

[51]GAO, *Missile Defense: Actions Needed to Improve Planning and Cost Estimates for Long-Term Support of Ballistic Missile Defense,* GAO-08-1068 (Washington, D.C.: Sept. 25, 2008).

[52]MDA Directive 5010.19, *Ballistic Missile Defense System Capability Transition and Transfer Policy* (May 2014).

[53]Department of Defense, Secretary of Defense, *Missile Defense Program Direction* (Washington D.C.: January 2, 2002).

[54]GAO-18-324; and GAO-19-387.

oversight to ensure preparation and progress.[55] OUSD (R&E) and (A&S) officials told us that, with respect to transfer, they are working to address interaction, oversight, and accountability moving forward. Figure 4 illustrates the concerns related to transferring BMDS elements to the military services.

Figure 4: Overarching Concerns Identified by the Missile Defense Agency (MDA) and the Military Services Related to Transferring Ballistic Missile Defense System (BMDS) Elements in Production

	If transferred	If not transferred
Budget	Military services may to devote comparable resources to the BMDS element, which could hinder future development and upgrades to keep pace with existing and emerging threats. However, offloading the BMDS element to the military service would free up resources in MDA's budget to pursue new and advanced efforts.	MDA will be responsible for an increasing amount of production, operation, and sustainment, which could grow to levels that are untenable due to fiscal constraints. This will limit the agency's ability to budget for new and advanced efforts in accordance with its original mission.
Prioritization	Military services will not likely have the same level of prioritization for the BMDS elements, as each has a much broader portfolio of weapon systems and missions that the BMDS element would have to compete with (i.e., 1 system among 100s).	MDA can maintain a higher level of prioritization for the BMDS element because the agency's portfolio is smaller and more focused (i.e., 1 system among about 10), according to DOD officials.
Control	Military services could opt out of testing, providing personnel, or pursuing advancements that they do not deem critical or high priority, which could limit MDA's ability to use that BMDS element as part of the current or future missile defense architecture.	MDA will retain control over development and upgrades to BMDS elements to keep pace with existing and emerging threats, irrespective of any potential military services' pushback or limitations.
Performance	Military services must contend with the risks associated with BMDS elements that have been developed and tested outside the robust standards and oversight (DOD 5000) designed to ensure weapon systems provide the needed capability and are safe when placed in the hands of the warfighter. BMDS elements will likely require additional investment and rework.	MDA may continue to provide BMDS elements that are conditionally released to the military services for operational use (i.e., with risks) with a recurring cycle of upgrades or retrofits.

Source: GAO analysis of MDA data. | GAO-20-432

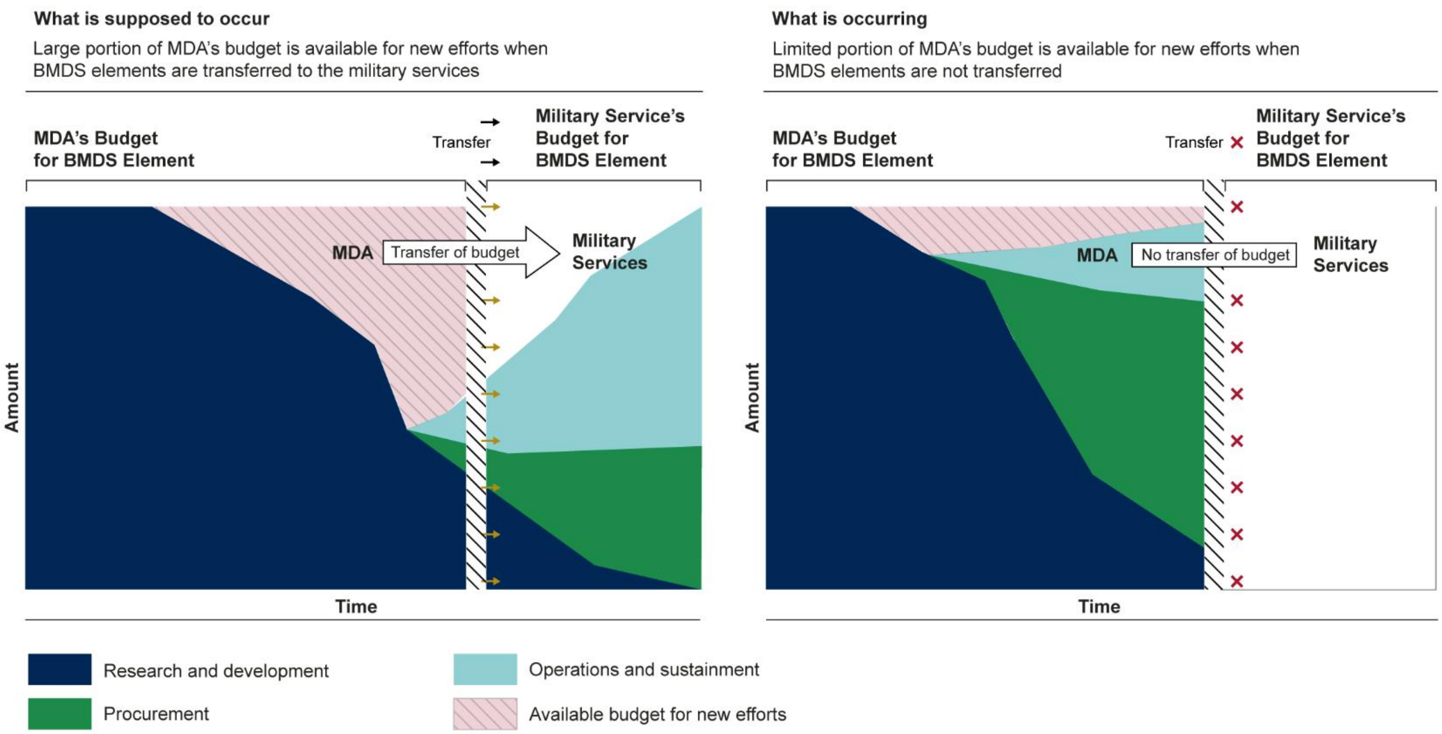
Note: The above statements are based on discussions with officials within MDA and the military service.

[55]Institute for Defense Analyses (IDA), *Study on the Mission, Roles, and Structure of the Missile Defense Agency (MDA)*, IDA Paper P-4374 (Alexandria, VA: Aug. 28, 2008).

Without Transfer of BMDS Elements in Production, Portfolio Balance Will Determine the Budget Available for Other Priorities

The most prominent overarching concern related to transfer, according to OUSD (R&E) and (A&S) officials, is how MDA and the military services will balance their respective portfolios within their prescribed budget–research and development; procurement; and operations and sustainment. For example, if MDA does transfer BMDS elements to the military services as originally intended, portions of MDA's budget dedicated to research and development, procurement, and operations and sustainment for those BMDS elements will be freed up for new efforts, as notionally depicted in figure 5.

Figure 5: Notional Depiction Comparing the Missile Defense Agency's Budget Availability for New Efforts Based on the Transfer Status of Ballistic Missile Defense System Elements in Production



BMDS = Ballistic Missile Defense System
MDA = Missile Defense Agency

Source: GAO analysis of MDA data. | GAO-20-432

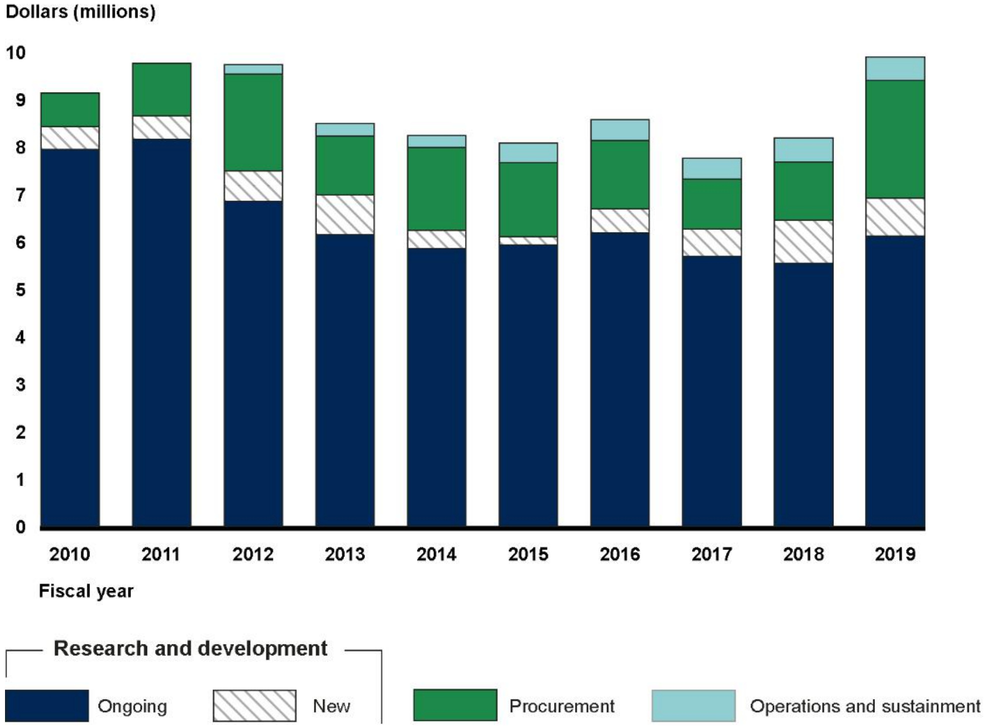
Note: This notional figure is based on the assumption that MDA's research and development budget level will remain relatively consistent and depicts the transfer of BMDS elements that received Milestone C or equivalent approval, as well as the acquisition and total obligation authority, to the military services in accordance with 10 U.S.C. § 2366 by no later than February 3, 2020. National

Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91, § 1676 (Dec. 12, 2017); 31 U.S.C. § 1105 (a).

However, if BMDS elements do not transfer to the military services, MDA will have to devote an increasing amount of its budget to procurement and operations and sustainment. While MDA's overall budget has recently been increased to better balance the investments across these funding accounts, the agency recognizes that there are fiscal constraints on how much its overall budget can grow to accommodate the demand for increasing investments irrespective of funding accounts. Thus, one funding account's gain could result in a corresponding loss in another. Officials from the military services expressed concern over how each would absorb the considerable operations and sustainment costs if BMDS elements in production do transfer. We have previously found that these costs can comprise over 70 percent of a weapon systems total cost over its life.[56] As one of DOD's largest weapon system investments, the BMDS is likely to incur billions of dollars in operations and sustainment. Therefore, responsibility for operations and sustainment costs could affect either MDA's or the military services' ability to budget for other priorities. Figure 6 shows the amount of funding for procurement and operations and sustainment in MDA's budget which has generally grown since fiscal year 2010, as the agency has not transferred the BMDS elements in production to the military services.

[56] GAO-08-1068.

Figure 6: The Missile Defense Agency's Budget by Funding Type, Fiscal Years 2010-2019



Source: GAO anlaysis of Missile Defense Agency budget data. | GAO-20-432

Multiple Departmental Reviews Are Ongoing to Determine MDA's Path Forward

Congress and the Secretary of Defense have recognized the aforementioned issues and overarching concerns and directed reviews to determine how to address them, where possible. For example, the fiscal year 2018 NDAA directed DOD to transfer MDA programs that have received Milestone C to the military services and provide a corresponding report, including the programs designated for transfer and the associated funding and timeline.[57] In addition, the fiscal year 2020 NDAA directed DOD to contract for an independent study on MDA's acquisition process and oversight. Specifically, this independent study is to explore the risks and benefits of placing MDA under DOD Instruction (DODI) acquisition processes (DODI 5000) and determine the most appropriate oversight

[57]Pub. L. No. 115-91, § 1676(b).

structure for MDA within DOD.[58] Lastly, in January 2019, DOD initiated a review of MDA's requirements generation process–an area we previously identified as needing improvement–to identify improvements that will enable the military services to set needed performance requirements and the conditions and timeline for transferring a BMDS element as early as possible in the process.[59]

As of July 2020, all of these reviews were either ongoing or the results were awaiting final leadership decision. In the meantime, DOD is seeking relief from the legislative requirement to transfer. Instead of compelling transfers, DOD revised its definition for transfer, whereby BMDS elements are deemed to be transferred if they are available to the military services for operational use and the military services and MDA have assumed their respective funding responsibilities in accordance with the transfer agreement and DOD direction.[60] Whether or not Congress will agree with DOD's proposed course of action on transfer is still being determined.

Conclusions

During fiscal year 2019, MDA made progress in addressing its mission to defend the United States and its allies from enemy ballistic missiles, including delivering planned assets and conducting a significant test demonstrating a capability to defend the United States. In the meantime, MDA has not been able to successfully conduct planned flight tests designed to demonstrate to decision makers and warfighters that the delivered weapons can achieve its mission–defend the U.S. homeland, our allies, and deployed forces when faced with a threat. Year after year, MDA determines what tests it needs, then struggles to conduct those tests, deferring or deleting them as the year progresses. This pattern demonstrates a fundamental disconnect between planning and execution. Without assessing with relevant stakeholders whether its approach could be improved, MDA risks further testing frustration and less-than-optimal data for the warfighters responsible for missile defense.

[58]National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92, § 1688 (Dec, 20, 2019).

[59]GAO-17-381; DOD, *Missile Defense Review 2019* (Washington, D.C.: January 2019).

[60]DOD's June 10, 2011 memorandum on *Funding Responsibilities for Ballistic Missile Defense System (BMDS) Elements* outlines the military services' and MDA's respective funding responsibilities.

Recommendation for Executive Action

The Director, MDA, should ensure an independent assessment is conducted of the agency's process for developing and executing its annual BMDS flight test plan. (Recommendation 1)

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for review and comment. DOD provided written comments on our report, which are reprinted in appendix IX. DOD concurred with our recommendation to ensure an independent assessment of the agency's process for developing and executing its annual BMDS flight test plan. DOD also provided technical comments, which were incorporated as appropriate.

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

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

W. William Russell IV

W. William Russell
Director, Contracting and National Security Acquisitions

List of Committees

The Honorable James M. Inhofe
Chairman
The Honorable Jack Reed
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United States Senate

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The Honorable Pete Visclosky
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The Honorable Ken Calvert
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Committee on Appropriations
House of Representatives

Appendix I: Aegis Ballistic Missile Defense (BMD) Weapons System

Figure 7: Aegis Ballistic Missile Defense (BMD) Weapons System, Appendix I

Highlights of GAO's review for Fiscal Year 2019

- Aegis Ballistic Missile Defense (BMD) demonstrated key capabilities and achieved model accreditation, but challenges continue.
- Next generation of Aegis BMD capabilities remained on schedule in fiscal year 2019.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-20-432

Program Overview:

Aegis Ballistic Missile Defense is the naval component of the Missile Defense Agency's (MDA) Ballistic Missile Defense System. It consists of the Aegis combat system, including a radar, and Standard Missile-3 (SM-3) interceptors.[1] MDA is developing the Aegis BMD in versions called spirals that expand on preceding capabilities. Since 2015, MDA has been delivering Aegis BMD spirals that are integrated with capabilities developed by the Navy. These jointly developed Aegis Weapons System Baselines (AWS BL) allow for Integrated Air and Missile Defense (IAMD) where ballistic missiles and air threats (i.e., cruise missiles) can be engaged at the same time. Table 8 identifies Aegis BMD spirals,

[1]A combat system is an architecture that uses computers to integrate sensors, such as a radar with shipboard weapon systems, and can recommend weapons to the sailor through a command and control function.

associated integrated Aegis Weapons System Baselines and key capabilities, and their delivery date.

Table 8: Aegis Ballistic Missile Defense (BMD) Spirals with Associated Aegis Weapons System Baselines and Capabilities

Aegis BMD spirals[a]	Associated integrated Aegis Weapon System Baselines (BL)	Key Ballistic Missile Defense Capabilities	Delivery date
BMD 5.0 Capability Upgrade (CU)	BL 9.C1	• Addition of Standard Missile-3 (SM-3) Block IB Threat Upgrade interceptor • Launch on Remote[b] • Improved discrimination using infrared and radio wave data • Capability against more advanced threats • Ship battle group defense capability using Standard Missile-6 (SM-6) Dual I[c]	2015 (delivered)
BMD 5.0 Capability Upgrade (CU)	BL 9.B1	• BMD 5.0 CU capabilities for Aegis Ashore in Romania without Standard Missile (SM-6) Dual I	2015 (delivered)
BMD 5.1	BL 9.C2	• Addition of SM-3 Block IIA • Engage on Remote[d] • Ship battle group defense capability using Standard Missile (SM-6) Dual II[c]	2019 (delivered)
BMD 5.1	BL 9.B2	• BMD 5.1 capabilities for Aegis Ashore in Romania and Poland[e]	2019 (delivered)
BMD 4.1	BL 5.4	• Similar capabilities to BMD 5.0 CU capabilities, installed on legacy hardware	2020
BMD 4.2	BL 5.4.1	• Aegis SPY-1 radar refurbishment for improved tracking capability	2023
BMD 6.0	BL 10.0	• New SPY-6 increased radar sensitivity, extended detection ranges, and simultaneous sensor support of ballistic missile and air defense missions. • Performance against larger raids • Improved missile communications	2023

Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-20-432

[a]MDA is developing the Aegis BMD in versions called spirals that expand on preceding capabilities.

[b]Launch on Remote allows Aegis BMD to launch its interceptor on tracks provided by off board sensor before its own radar acquires the threat, but the intercept itself is executed based on onboard the Aegis SPY-1 radar.

[c]SM-6 Dual I and SM-6 Dual II allow a ship to defend itself and other nearby ships in a battle group. SM-6 Dual I and II baselines are not included in the Ballistic Missile Defense Accountability Report and, thus, fall outside the scope of this review.

[d]Engage on Remote increases the area defended by the Ballistic Missile Defense System, by allowing Aegis BMD to intercept a threat before it is visible to its own radar, based entirely on tracks from a forward-based sensor. While the Aegis Weapons System element delivered the capability, the delivery of Standard Missile-3 Block IIA interceptors is still needed to complete Engage on Remote.

[e]MDA completed the development of Aegis Weapons System version for Poland in 2019; however, as we reported in June 2019, due to ongoing delays in construction of the Aegis Ashore site in Poland, MDA delayed the expected delivery 18 months to May 2020. Currently, the Poland schedule is under review given slower-than-expected military construction progress, which increases the risk of achieving the current overall project schedule.

As indicated by Table 8 above, the first suite of integrated ballistic missile defense and anti-air warfare (AAW) capabilities was delivered with AWS Baseline 9.C1/B1 in 2015, which included an overhaul of Aegis computing architecture.[2] Merging the anti-air and missile defense missions on a single ship allows the Navy to reduce the number of ships needed for defense against these threats, thus freeing some to perform other missions. However, in order to expand the number ships with IAMD, MDA also began a program to integrate Aegis BMD 5.0 CU capabilities with the legacy AWS architecture. While initially scheduled for delivery in 2015, Aegis BMD 4.1 was delayed multiple times, and, in 2017, delivery was split into two phases. The first interim phase was completed in 2017, providing BMD capabilities similar to Aegis BMD 5.0CU, but did not provide integration between BMD and AAW capabilities. The second phase will integrate BMD and AAW, and is currently planned for delivery in 2020. Additional upgrades capitalizing on Navy's improvements to the AWS Baseline 5.4 computing architecture are planned for delivery in 2023.

The program is also developing Aegis BMD 5.1 with capabilities to support the final phase of European Phased Adaptive Approach.[3] This spiral is designed to control the new Standard Missile-3 Block IIA and to intercept intermediate-range ballistic missiles. It also includes the Engage on Remote capability, where Aegis BMD intercepts a threat before it is visible to its own radar, based entirely on tracks from a forward-based sensor. Aegis BMD 5.1 is integrated with AWS Baseline 9.C2/B2.

[2]Anti-air warfare includes capabilities against threats in the atmosphere, such as cruise missiles.

[3]European Phased Adaptive Approach (EPAA) integrates the upgrades to Aegis BMD Weapon System, Aegis BMD interceptors, Command and Control, Battle Management and Communications (C2BMC) and sensors, and was originally planned for delivery in four phases of increasing capability. In March 2013, the Secretary of Defense cancelled the fourth phase, which was intended to provide an additional layer for defense of the United States against intercontinental ballistic missiles. The cancellation was driven, in part, by affordability concerns, schedule delays, and technical risks associated with these programs. We have reported schedule, technical, and performance issues associated with EPAA phases in multiple reports, (e.g.,: see GAO, *Missile Defense: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency,* GAO-12-486 (Washington, D.C.: Apr. 20, 2012); *Regional Missile Defense: DOD's Report Provided Limited Information; Assessment of Acquisition Risks is Optimistic*, GAO-14-248R (Washington, D.C.: Mar. 14, 2014); *Missile Defense: Ballistic Missile Defense System Testing Delays Affect Delivery of Capabilties*, GAO-16-339R (Washington, D.C.: Apr. 28, 2016); *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); and *Missile Defense: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability*, GAO-19-387 (Washington, DC.: Jun. 6, 2019).

Additionally, MDA and the Navy are developing the AWS Baseline 10.0, which will capitalize on the Navy's effort to replace the Aegis SPY-1 radar with a more capable SPY-6, and to overhaul the entire Aegis combat system. AWS Baseline 10.0 includes Aegis BMD 6.0 capabilities, which is planned to counter larger raids, provide better discrimination, and improve communication with its interceptors. AWS Baseline 10.0 is planned for delivery in 2023. For details on the Aegis SM-3 interceptors, see appendices II and III. Table 9 provides key fiscal year 2019 AWS program facts.

Table 9a: Fiscal Year 2019 – Key Aegis Ballistic Missile Defense (BMD) Program Facts (Notable Deliveries)

Aegis BMD Spiral	Delivery
Aegis BMD 5.1	Missile Defense Agency (MDA) delivered Aegis BMD 5.1 in May 2019

Table 9b: Fiscal Year 2019 – Key Aegis Ballistic Missile Defense (BMD) Program Facts (Flight Testing)

Test Name	Test Objectives	Participating Aegis BMD Spirals[a]
FTI-03	Aegis Weapon System's Engage-on-Remote capability tracked and intercepted an intermediate-range ballistic missiles target with an Aegis Ashore-launched Standard Missile (SM)-3 Block IIA interceptor utilizing European Phased Adaptive Approach Phase 3 architecture.	Aegis BMD 5.1
FTG-11	Ground-based Midcourse Defense (GMD) salvo test in which multiple ground-based interceptors (GBIs) were fired against a single intercontinental ballistic missile (ICBM) target. Aegis conducted a simulated engagement against the ICBM, as a risk reduction for a future intercept test.	Aegis BMD 5.1
FS-19 (multiple events)	Assessed message exchange and network performance of the United States European Command (USEUCOM) Tactical Digital Information Link (TADIL) network in a simulated war time Ballistic Missile Defense (BMD) and Integrated Air And Missile Defense (IAMD) environments.	Aegis BMD 5.1 Aegis BMD 4.1
FTM-31 Event 2	Aegis BMD demonstrated an intercept of an air-breathing target with an SM-6 Dual II interceptor.	Aegis BMD 5.1
FTX-34	Tracking exercise using SPY-6 radar to collect data of a short-range ballistic missiles target with countermeasures.	Aegis BMD 6.0

Table 9c: Fiscal Year 2019 – Key Aegis Ballistic Missile Defense (BMD) Program Facts (Ground Testing (GT))

Test Name	Test objectives	Participating Aegis BMD Spirals
GT Distributed (GTD)-07b for Northern and Indo-Pacific Commands (N/I)	Demonstrated capabilities for defense of the homeland and defense of key areas in the Asia-Pacific.	Aegis BMD 5.1 Aegis BMD 4.1
GT Integrated (GTI)-18 Sprint 3	Demonstrated capabilities for defense of the homeland and defense of key areas in the Asia-Pacific.	Aegis BMD 5.1 Aegis BMD 5.0 Capability Upgrade Aegis BMD 4.1
GTI-19 Sprint 1	Demonstrated capabilities for defense of the homeland and defense of key areas in the Asia-Pacific.	Aegis BMD 5.1 Aegis BMD 4.1
GTI-19 Sprint 2	Demonstrated capabilities developed for the Korean Peninsula.	Aegis BMD 4.1
GTI-19 Sprint 4	Assessed sensor architecture options in the Central Command's area of responsibility.	Aegis BMD 5.1 Aegis BMD 4.1

Table 9d: Fiscal Year 2019 – Key Aegis Ballistic Missile Defense (BMD) Program Facts (Completed Operational Cybersecurity Assessments[b])

Aegis BMD Spiral	Assessments
na	MDA did not conduct cyber assessments for Aegis BMD in Fiscal Year 2019

Source: GAO analysis based on MDA data. | GAO-20-432

[a]MDA is developing the Aegis BMD in versions called spirals that expand on preceding capabilities.

[b]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 cyber-attack and the effectiveness of defensive capabilities.

Aegis BMD Demonstrated Key Capabilities and Achieved Model Accreditation, but Challenges Continue

Aegis BMD demonstrated various capabilities in fiscal year 2019 tests and achieved independent accreditation for all its models used in operational ground tests. The Missile Defense Agency (MDA) conducted five Aegis Ballistic Missile Defense (BMD) intercept flight tests in fiscal year 2019, successfully intercepting two ballistic missile targets and three cruise missiles. Additionally, MDA also conducted Aegis BMD non-intercept flight tests with live or simulated interceptors and targets, as well as five model-based ground tests that provided data on Aegis BMD interoperability and weapon system functionality in various regional and Homeland Defense scenarios. Notable testing accomplishments for Aegis BMD in fiscal year 2019 include:

- **Aegis Engage on Remote (EOR) capability.** MDA demonstrated this capability for the first time during Flight Test Integrated-03 (FTI-03) in December 2018, where the Aegis Ashore at the Pacific Missile Range Facility in Kauai, Hawaii, intercepted an intermediate-range ballistic missiles target using the SM-3 Block IIA. While, as we found in June 2019, because a test named FTM-29 did not exercise all aspects of communication in the later stages of the engagement due to an Aegis BMD SM-3 Block IIA malfunction, Aegis BMD 5.1 had only partially demonstrated EOR capability. MDA demonstrated all aspects of EOR in FTI-03 and completed the delivery of Aegis BMD 5.1 in May 2019.
- **Integrated Air and Missile Defense.** During Formidable Shield-19 (FS-19) in May 2019, an Aegis destroyer intercepted a cruise missile with a live SM-2 missile while simultaneously engaging a

simulated ballistic missile target with a live SM-3 Block IA missile in Event 1, while in Event 4, an Aegis destroyer intercepted a cruise missile target with a live SM-2 missile while tracking a live SRBM target

- **Integration with other elements and allies.** According to the Director, Operational Test and Evaluation (DOT&E), in fiscal year 2019, Aegis BMD exercised rudimentary engagement coordination with Terminal High-Altitude Area Defense firing units. Additionally, during the four events that comprised FS-19 cruise missile and ballistic missile engagements, the MDA also demonstrated Aegis BMD interoperability with North Atlantic Treaty Organization (NATO) partners over the U.S. European Command Operational Tactical Data Link communication architecture.
- **Accredited models and simulations.** The BMDS Operational Test Agency and the Navy Commander, Operational Test and Evaluation Force accredited all participating Aegis BMD modeling and simulation (M&S) for the regional and strategic scenarios assessed in fiscal year ground testing, although with a notable limitation. This is an important achievement since MDA, independent DOD testing organizations, and the warfighter rely heavily on model and simulation representations of the integrated BMDS, rather than live tests, to assess the operational performance of the whole BMDS.

Aegis BMD testing also had some limitations. For instance, while most testing limitations are classified, DOT&E noted in its fiscal year 2019 assessment of Aegis BMD that MDA ground tests have routinely shown the need for improved inter-element coordination and interoperability to enhance engagement efficiency. Moreover, for the second year in a row, DOT&E noted that flight testing and models and simulations did not address all expected threat types, ground ranges, and raid sizes for Aegis BMD. For instance, while Aegis BMD M&S tools were accredited for many scenarios, there were limitations for raid engagements due to the lack of validation data from live fire raid engagements and lack of post-intercept debris modeling. As we reported in June 2019, MDA planned to assess Aegis BMD 5.1 raid performance for the first time in December 2018, but the test was de-scoped to a single intercept due, in part, to a test range safety asset malfunction.[1] While MDA planned to conduct a

[1]GAO, *Missile Defense: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability,* GAO-19-387 (Washington, D.C.: June 6, 2019).

raid the fourth quarter of fiscal year 2020, according to technical comments we received from MDA at the end of our audit, that plan has been canceled. In the meantime, the warfighter will have reduced information about how Aegis BMD 5.1 performs in these real-world-like scenarios.

Next Generation of Aegis BMD Capabilities Remained on Schedule in Fiscal Year 2019

MDA stayed on track to deliver the next generation of Aegis BMD capabilities. For instance, MDA plans to deliver BMD 6.0 in the 2023 time frame to provide capabilities against larger raids, better discrimination, and improved communication with its interceptors. Additionally, BMD 6.0 takes advantage of the Navy's effort to replace the Aegis AN/SPY-1 radar with a more capable AN/SPY-6 (V)1 and to overhaul the entire Aegis combat system. As we reported in June 2019, MDA and the Navy re-planned AWS Baseline 10.0, after a funding reduction of $31.45 million against BMD 6.0[2]. While the reduction resulted in delays to completion of some technical content, its delivery time frame did not change. In fiscal year 2019, the program remained on schedule, completing a planned review and participated in a Navy-funded developmental test of AN/SPY-6(V)1 and FTX-34, demonstrating ballistic missile tracking capabilities. MDA efforts to deliver integrated AWS Baseline 5.4 were also on track in fiscal year 2019 after the program readjusted its schedule in fiscal year 2018.[3]

[2]GAO-19-387.

[3]GAO-19-387.

Appendix II: Aegis Ballistic Missile Defense (BMD) Standard Missile-3 (SM-3) Block IB

Figure 8: Aegis Ballistic Missile Defense (BMD) Standard Missile-3 (SM-3) Block IB, Appendix II

Highlights of GAO's review for Fiscal Year 2019

- A planned multi-year procurement was delayed by a lack of appropriated funds.
- Parts quality issues and difficulty achieving planned multi-year procurement constitute risks for the program.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-20-432

Program Overview

The Aegis BMD Standard Missile-3 (SM-3) Block IB is a ship- and shore-based missile defense interceptor designed to intercept short- to intermediate-range ballistic missiles during the middle stage of their flight. The Aegis BMD SM-3 interceptor has multiple versions in development production, or sustainment: the SM-3 Blocks IA, IB, and IIA. Compared to the SM-3 Block IA, the Block IB features an enhanced seeker for improved target discrimination, better engagement coordination capabilities, an improved throttleable divert and attitude control system for adjusting its course, and increased range. The SM-3 Block IB interceptor is linked with Aegis Ballistic Missile Defense (BMD) Weapons System 4.0.2, Aegis BMD 5.0 Capability Upgrade, and Aegis Ashore. For additional information about the Aegis Weapon Systems, see Appendix I.

Since fiscal year 2015, SM-3 Block IB production has been delayed by several technical issues. In response to our 2014 recommendation, program officials, in 2015, delayed the decision to enter full-rate production until they could implement further testing and design changes.[1] Subsequent test failures delayed the transition to full production until fiscal year 2018, though yearly, incremental production continued in the interim. Table 10 provides key fiscal year 2019 Aegis BMD SM-3 Block IB program facts.

Table 10a: Aegis Ballistic Missile Defense Standard Missile-3 Block IB Program Facts

Major Assets Delivered in Fiscal Year 2019
Delivered 50 SM-3 IB Interceptors in fiscal year 2019 against 36 planned deliveries (This includes several delayed from the previous fiscal year, and several planned for this year were delayed into fiscal year 2020)

[1] *Missile Defense: Mixed Progress in Achieving Acquisition Goals and Improving Accountability*. GAO-14-351 (Washington, D.C.: April 2014).

Table 10b: Aegis Ballistic Missile Defense Standard Missile-3 Block IB Program Facts

Flight Test Performance
No test flights in fiscal year 2019

Source: GAO analysis of Missile Defense Agency data | GAO-20-432

A planned multi-year procurement was delayed by a lack of appropriated funds

MDA planned to award two Aegis BMD SM-3 IB contracts in fiscal year 2019: one for sustaining engineering and product support, and a multi-year procurement production contract covering the full production phase of the program. Neither contract was awarded in fiscal year 2019, though according to MDA, negotiations for both are ongoing. MDA had previously sought multi-year procurement authority shortly after full production authorization in fiscal year 2018, seeking to procure up to 204 interceptors through 2023.[1] While MDA requested and Congress provided multi-year procurement authority, officials said the program did not receive the funding requested in the President's budget to award a contract in fiscal year 2019.

Parts quality issues and difficulty achieving planned multi-year procurement constitute risks for the program

According to MDA, the Aegis BMD SM-3 Block IB program considers the schedule for awarding a multi-year procurement contract, and enduring subcontractor quality issues, to be the two main risks facing the program. MDA officials stated that they expected to award the multi-year procurement contract in the first quarter, fiscal year 2020. MDA had also stated that a delay in the award could cause production delays both to the United States and to foreign military sales. MDA's current plans call for the multi-year procurement award in the second quarter, fiscal year 2020.

In addition, as we reported in 2019, MDA officials have noted that the Aegis BMD SM-3 Block IB's prime contractor has had difficulty ensuring

[1] Multi-year procurement allows the Department of Defense to contract for the purchase of more than one year's requirements of supplies or services, which may result in cost savings.

that all subcontracted components meet defined specifications.[2] Similar issues occurred in fiscal year 2019, each of which required resolution on a case-by-case basis. For example, MDA officials reported that an important actuator was found to have contaminated lubricant, requiring the source of the contamination to be tracked to a specific facility within the supply chain and the procurement of new hardware. In addition, a divert valve was experiencing an increased reject rate, slowing down deliveries of the Third Stage Rocket Motor. The program and the contractor developed and implemented three corrective actions to address this issue and accelerate deliveries. Even so, problems such as these can result in months-long delays, and MDA reported that the introduction of improved quality controls drove up costs in fiscal year 2019.

[2] GAO, *Missile Defense: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability*, GAO-19-387 (Washington, D.C.: June 6, 2019).

Appendix III: Aegis Ballistic Missile Defense (BMD) Standard Missile-3 (SM-3) Block IIA

Figure 9: Aegis Ballistic Missile Defense (BMD) Standard Missile-3 (SM-3) Block IIA, Appendix III

Highlights of GAO's review for Fiscal Year 2019

- The Aegis SM-3 Block IIA successfully returned to flight in two tests, including one which demonstrated the Engage on Remote capability for the first time.
- Testing and quality issues delayed authorization for initial production, pending the completion of further studies.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-20-432

Program Overview

The latest development in the Aegis BMD Standard Missile-3 (SM-3) family, the Aegis BMD SM-3 Block IIA interceptor provides increased speed, more sensitive seeker technology, and a more advanced kinetic warhead as compared to previous versions of the Aegis BMD interceptors. It is expected to defend against short-, medium-, and intermediate-range ballistic missiles, and will have significantly increased range compared to earlier Aegis BMD SM-3 models. Additionally, most of the Aegis BMD SM-3 Block IIA components will differ from other standard missile versions and therefore require new technology being developed specifically for them. For additional information on the Aegis BMD SM-3 Block IB interceptor, see Appendix II.[1]

Initiated in 2006 as a cooperative development program with Japan, the Aegis BMD SM-3 Block IIA program is an essential component of the European Phased Adaptive Approach (EPAA) Phase 3 architecture, particularly its ability to defend against longer-range threats. According to program officials, the Aegis BMD SM-3 Block IIA interceptor's range exceeds that of its native radar, thus, the only way to make use of its extended range is by relying on remote sensor data.[2] For additional information on Aegis Weapon Systems, see appendix I. Table 11 provides key fiscal year 2019 Aegis SM-3 Block IIA program facts.

Table 11a: Aegis Ballistic Missile Defense (BMD) Standard Missile-3 (SM-3) Block IIA Program Facts for Fiscal Year 2019

Major Assets Delivered in Fiscal Year 2019
Delivered two interceptors against 11 planned

[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.

[2]This specific capability, where the threat is intercepted before it is visible to its own radar is called Engage on Remote (EOR). For further details on EOR capability, see GAO *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 2018).

Table 11b: Aegis Ballistic Missile Defense (BMD) Standard Missile-3 (SM-3) Block IIA Program Facts for Fiscal Year 2019 (Flight Test Performance)

Test Name	Test Date	Test Result
FTM-45	October 2018	**Intercept successful.** The USS John Finn fired a Standard Missile 3 (SM-3) Block IIA interceptor at a Medium-Range Ballistic Missile (MRBM) target and successfully intercepted it. This test validated corrective actions implemented in the wake of the failure of the previous flight test, named FTM-29.
FTI-03	December 2018	**Intercept successful.** The Aegis Ashore facility in Hawaii fired a Standard Missile 3 (SM-3) Block IIA interceptor at an Intermediate-Range Ballistic Missile (IRBM) target. The intercept was guided by remote data from other radars and was successful. Originally conceived as FTO-03 Event 1 before being scaled back.

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

The Aegis SM-3 Block IIA successfully returned to flight in two tests, including one which demonstrated the Engage on Remote capability for the first time

Following the failure of FTM-29 in January 2018, MDA re-organized the SM-3 Block IIA schedule to allow it to identify the cause of the failure, implement changes, and then test these changes to validate their efficacy. As we reported in May 2019, as a result of the test failure, MDA and the government of Japan convened a failure review board to investigate the causes of the test failure. The board's conclusions identified the source of the failure.[1]

To test the fixes identified through the FTM-29 failure review board, MDA added a new flight test to its schedule, FTM-45. Despite criticism from Department of Defense stakeholders that FTM-45 would not be taxing enough to make up for the failure of FTM-29, MDA successfully conducted the test, and thus validated the corrective actions, in October 2018.

Two months later, in December 2018, MDA conducted FTI-03, the first successful SM-3 Block IIA intercept of an Intermediate-Range Ballistic Missile (IRBM), and the first successful SM-3 Block IIA intercept to use remote sensor data to guide the engagement, known as Engage on

[1]For further details on the FTM-29 failure, including the specific causes, see GAO, *Missile Defense: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability,* GAO-19-387 (Washington, D.C.: June 6, 2019).

Remote.[2] However, as mentioned previously, the test's initial plan was an intercept of two targets, but it was scaled down due to range safety issues.

Testing and quality issues delayed authorization for initial production, pending the completion of further studies

MDA achieved its objective in FTI-03 by intercepting the target, but a more detailed review of the system's performance revealed at least one issue. During the interceptor's flight, the attitude control system in the third stage rocket motor experienced a fault whereby a valve failed to respond to electronic instructions. A failure review board isolated the fault to a specific component failing to provide adequate electric current. Seeking to avoid unnecessary work, the prime contractor temporarily suspended its operations in order to identify the root cause and then develop and implement corrective actions. This suspension has affected delivery schedules for both third stage rocket motors and completed interceptors.

MDA originally planned for an initial production decision in December 2018, but two issues delayed this decision. First, owing to the fact that the canceled Redesigned Kill Vehicle re-used parts from the SM-3 Block IIA program, the Undersecretary of Defense for Research and Engineering requested a study to determine if the SM-3 Block IIA could be affected by the issues which resulted in the RKV's cancellation. Second, DOD officials recommended against any initial production decision until the issue observed in FTI-03 was resolved.

MDA documents indicated that its officials believed an initial production decision was possible before the end of fiscal year 2019. The SM-3 Block IIA received a positive initial production decision in October 2019.

[2]EOR allows Aegis BMD to intercept a threat before it is visible to its own radar, based entirely on tracks from a forward-based sensor.

Appendix IV: Command, Control, Battle Management, and Communications (C2BMC)

Figure 10: Command, Control, Battle Management, and Communications (C2BMC), Appendix IV

Highlights of GAO's review for Fiscal Year 2019

- MDA fielded Spiral 8.2-3, but testing will continue as capabilities from other elements become available.
- New development approach for Spiral 8.2-5 could shorten timelines, but challenges increase risk to planned delivery.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-20-432

Program Overview

C2BMC is a global system of hardware—workstations, servers, and network equipment—and software that integrates all missile defense elements of the Ballistic Missile Defense System (BMDS). Specifically, it allows users to plan operations, see the battle develop, and manage BMDS sensors. As the integrator, C2BMC enables the defense of a larger area than the individual BMDS elements operating independently and against more missiles simultaneously, thereby conserving interceptor inventory. C2BMC is fielded at U.S. Strategic Command, U.S. Northern Command, U.S. European Command, U.S. Indo-Pacific Command, and U.S. Central Command. MDA is developing C2BMC in spirals, or software and hardware upgrades, that build upon prior capabilities to improve various aspects of the integrated BMDS performance. C2BMC

Spirals deliveries are associated with BMDS Overhead Persistent Infrared Architecture (BOA) upgrades—a system within the C2BMC enterprise. BOA receives spaced-based sensor information on boosting and midcourse ballistic objects and feeds that data to C2BMC for use in cueing BMDS sensors and weapon systems, and for situational awareness. The agency completed fielding of Spiral 8.2-1 with BOA 5.1 to U.S. Northern Command and U.S. Indo-Pacific Command in January 2018, and Spiral 8.2-3 with BOA 6.1 to U.S. European Command and U.S. Central Command in December 2018. Spiral 8.2-3 replaced Spiral 8.2-1 at the U.S. Northern Command and U.S. Indo-Pacific Command in the third quarter of Fiscal Year 2019. The next Spiral 8.2-5 is being developed to provide various capabilities in support of Homeland Defense, including control of the Long Range Discriminating Radar (LRDR), planned for delivery by fiscal year 2021. Table 12 provides an overview of C2BMC Spiral upgrades, fielding time frames, and associated capabilities; while Table 13 provides key fiscal year 2019 C2BMC program facts.

Table 12: Command, and Control, Battle Management and Communications (C2BMC) Spirals, and Ballistic Missile Defense System (BMDS) Overhead Persistent Infrared Architecture (BOA) Fielding Overview

C2BMC Spiral /BOA	Spiral 8.2-1/ BOA 5.1	Spiral 8.2-3/ BOA 6.1	Spiral 8.2-5 BOA 7.0	Spiral 8.2-7/ BOA 7.1
Fielding time frame (fiscal year)	2018 (delivered)	2019 (delivered)	2021	2024
Supported capabilities	Enhanced Homeland Defense	European Phased Adaptive Approach Phase 3 Engage on Remote and additional BMDS upgrades	Long Range Discriminating Radar (LRDR) command and control for Homeland Defense and additional BMDS upgrades	System Track for Homeland Defense[a]

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

[a]System track involves C2BMC integrating ballistic track information from multiple radars in order to pass that information to missile defense interceptor systems. The Spiral 8.2-7 system track upgrade is also planned to improve discrimination for Ground-based Midcourse Defense engagements and tracking of additional threats, including hypersonic. Spiral 8.2-7 is early in development and, thus, has not yet developed acquisition baselines.

Table 13a: Fiscal Year 2019 – Command and Control, Battle Management and Communications (C2BMC) Accomplishments (Notable Deliveries)

C2BMC Spiral	Delivery
Spiral 8.2-3	The Missile Defense Agency delivered Spiral 8.2-3 to U.S. European and Central Commands in December 2018 and to the U.S. Northern and Indo-Pacific Commands in June 2019.

Table 13b: Fiscal Year 2019 – Command and Control, Battle Management and Communications (C2BMC) Accomplishments (Flight Testing)

Test Name	Test Description	Participating C2BMC Spiral
FTI-03	Aegis Weapon System's Engage on Remote capability tracked and intercepted an intermediate-range ballistic missile target with an Aegis Ashore-launched SM-3 Block IIA interceptor utilizing European Phased Adaptive Approach Phase 3 architecture. C2BMC provided threat track data from sensors to Aegis Ballistic Missile Defense (BMD).	Spiral 8.2-3
FTG-11	Ground-based Midcourse Defense (GMD) salvo test against a single intercontinental ballistic missile (ICBM) target. C2BMC provided cues and track data to various sensors and GMD.	Spiral 8.2-3
FS-19 multiple events	Assessed message exchange and network performance of the U. S. European Command (USEUCOM) Tactical Digital Information Link (TADIL) network in a simulated wartime Ballistic Missile Defense (BMD) and Integrated Air And Missile Defense (IAMD) environments.	Spiral 8.2-3

Table 13c: Fiscal Year 2019 – Command and Control, Battle Management and Communications (C2BMC) Accomplishments (Ground Testing)

Test Name	Test Description	Participating C2BMC Spiral
GT Distributed (GTD)-07b for Northern and Indo-Pacific Commands (N/I)	Demonstrated capabilities for defense of the homeland and defense of key areas in the Asia-Pacific.	Spiral 8.2-3
GT Integrated (GTI)-18 Sprint 3	Demonstrated capabilities for defense of the homeland and defense of key areas in the Asia-Pacific.	Spiral 8.2-3
GTI-19 Sprint 1	Demonstrated capabilities for defense of the homeland and defense of key areas in the Asia-Pacific.	Spiral 8.2-3
GTI-19 Sprint 2	Demonstrated capabilities developed for the Korean Peninsula.	Spiral 8.2-3
GTI-19 Sprint 3	Added in response to warfighter request to assess changes to Northern Command shot doctrine	Spiral 8.2-3
GTI-19 Sprint 4	Assessed sensor architecture options in the Central Command's area of responsibility.	Spiral 8.2-3

Table 13d: Fiscal Year 2019 – Command and Control, Battle Management and Communications (C2BMC) Accomplishments (Completed Operational Cybersecurity Assessments[a])

C2BMC Spiral	Assessments
Spiral 8.2-3	C2BMC Spiral 8.2-3 completed Adversarial Assessment in May 2019

Source: GAO analysis based on Missile Defense Agency data. | GAO-20-432

[a]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 cyber-attack and the effectiveness of defensive capabilities.

MDA fielded Spiral 8.2-3, but testing will continue as capabilities from other elements become available

As noted above in table 13, MDA completed the fielding of C2BMC Spiral 8.2-3 across the Combatant Commands and continues to demonstrate increased sensor integration. Specifically, MDA delivered Spiral 8.2-3 to U.S. European and Central Commands in December 2018, and to the U.S. Northern and Indo-Pacific Commands in June 2019. Additionally, the Army conducted a cybersecurity Adversarial Assessment on C2BMC Spiral 8.2-3 in May 2019 at the request of the MDA and in support of fielding this software to U.S Northern and Indo-Pacific Commands. MDA plans to use Spiral 8.2-3 in fiscal year 2020 tests to assess additional capabilities, including the Aegis BMD intercept of an ICBM and integration of new Aegis Ashore.

New development approach for Spiral 8.2-5 could shorten timelines, but challenges increase risk to planned delivery

In fiscal year 2019, the program achieved important milestones, including developing acquisition baselines early in the fiscal year and beginning the transition to a new development approach. Namely, beginning with Spiral 8.2-5, C2BMC is transitioning to an iterative software development. According to the program, this approach has been developed to increase program flexibility, improve software quality, and shorten development and fielding timelines. This development approach requires significant automation and connectivity between the development and test environments. It is also designed to improve cybersecurity baseline configuration management, timely hardware or software updates, and reduce differences between development, test, and operational cyber architectures. However, the transition has had some challenges and the program is facing risks that could impact the delivery of capabilities:

- Development of infrastructure for the new iterative software development has not achieved the needed cybersecurity certification. According to program officials, the contractor that is building the automated development environment needed for the new process did not achieve cybersecurity certification that was planned for the end of fiscal year 2019. As a result, the program may not be able to execute some early integration and verification testing, and may delay operational fielding of the Spiral 8.2-5.
- Moreover, delays in availability of models representing some elements also planned for 2021 could further disrupt the schedule. While the C2BMC program has been coordinating with the other BMDS programs that will be integrated by C2BMC, program management documentation notes that timely availability of complete models is at risk, thus reducing the time to find and address issues discovered in testing.

Appendix V: Ground-based Midcourse Defense (GMD)

Figure 11: Ground-based Midcourse Defense, Appendix V

Highlights of GAO's review for Fiscal Year 2019

- Recent salvo test proved insightful but plans for future tests are uncertain.
- Missile Defense Agency (MDA) and contractors had multiple opportunities to address issues that led to the Redesigned Kill Vehicle's (RKV) cancellation.
- RKV cost more than tripled and was delayed by over 4 years prior to cancellation.
- Lessons learned from RKV are informing the Next Generation Interceptor.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-20-432

Program Overview

GMD is a missile defense interceptor system designed to defend the United States against a limited intermediate and intercontinental ballistic missile attack from rogue states, such as North Korea and Iran. To counter such threats to the homeland, GMD, in conjunction with a network of ground-, sea-, and space-based sensors, launches interceptors from missile fields based in Fort Greely, Alaska, and Vandenberg Air Force Base, California. After launching from in-ground silos, the interceptor boosts towards the predicted location of an incoming enemy missile and releases an Exoatmospheric Kill Vehicle (EKV) to find and destroy the threat using only the kinetic force of direct collision. MDA is building a new Ground-Based Interceptor (GBI) field in Ft. Greely (see fig. 12 below) and plans to eventually increase the number of deployed GBIs from 44 to 64. GMD also has ground systems consisting of redundant fire-control consoles, interceptor launch facilities, and a communications network, which the warfighter uses to operate the system. GMD ground systems also interface with the Command and

Control, Battle Management and Communications element of the Ballistic Missile Defense System (BMDS) to obtain data from sensors that are not directly connected to GMD ground systems.

Figure 12: Ongoing Construction of Missile Field 4 at Fort Greely, Alaska (July 16, 2019)

Source: GAO. | GAO-20-432

The GMD program experienced significant changes in fiscal year 2019. Table 14 provides an overview of key GMD program facts for fiscal year 2019, including planned deliveries, flight testing, key accomplishments, and main focus areas for the program in the near-term. The Redesigned Kill Vehicle (RKV) program encountered several development issues in early fiscal year 2019, the most significant of which pertained to RKV's use of commercially off-the-shelf parts and re-use of Aegis Standard Missile-3 (SM-3) Block IIA components. DOD cancelled the RKV program in August 2019 and initiated an effort to pursue a new, more advanced interceptor, called the Next Generation Interceptor (NGI). According to

MDA, NGI will provide the GMD program a cost-effective solution that is survivable across all environments, capable of defeating complex missile threats, and adaptable to address future threats. MDA plans to award contracts to two contractors in July 2020 to begin developing separate NGI solutions with interceptor production beginning in the late-2020s.

Table 14a: Ground-based Midcourse Defense Program Facts for Fiscal Year 2019 (Major Assets Delivered in Fiscal Year (FY) 2019)

Planned Delivery	Delivery Status
Ground-Based Interceptors (GBI): None (1 GBI delayed from FY 2018)	**Delayed.** The Ground-based Midcourse Defense (GMD) program previously planned to deliver one GBI equipped with the Capability Enhancement (CE)-II Block I kill vehicle and Configuration (C)2 boost vehicle in the fourth quarter of FY 2018. However, the program experienced production challenges with the boost vehicle and, therefore, did not deliver the GBI in either FY 2018 or 2019. Delivery is currently planned for the fourth quarter of FY 2020.

Table 14b: Ground-based Midcourse Defense Program Facts for Fiscal Year 2019 (Flight Test Performance in FY 2019)

Test Name	Test Date	Test Result
Flight Test GMD Weapon System (FTG)-11	March 2019	**Success.** GMD demonstrated a salvo intercept. The leading interceptor destroyed the target representing an intercontinental ballistic missile equipped with countermeasures designed to complicate missile defense operations. With the target reentry vehicle destroyed, the trailing interceptor struck one of the remaining objects, as it was designed to do.

Table 14c: Ground-based Midcourse Defense Program Facts for Fiscal Year 2019

Other Key Accomplishments in FY 2019
• Definitized a $4.14 billion modification to the Development and Sustainment Contract • Continued construction of Missile Field 4 at Fort Greely, Alaska • Conducted a critical design review for the C2 boost vehicle's stage-selectable software • Performed first system-level operational cybersecurity test in addition to other assessments • Completed multiple integrated and distributed ground test events

Table 14d: Ground-based Midcourse Defense Program Facts for Fiscal Year 2019

Near-Term Focus Areas

- Initiating development of the Next Generation Interceptor
- Managing the termination of the Redesigned Kill Vehicle
- Conducting GBI aging and obsolescence efforts to maintain existing fleet of 44 GBIs
- Continuing to plan and conduct flight, ground, and cybersecurity tests
- Addressing obsolescence and modernizing GMD ground system components
- Producing two additional CE-II equipped GBIs

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

Recent salvo test proved insightful but plans for future tests are uncertain

The GMD program achieved a major milestone in March 2019 when it successfully conducted the first salvo flight test of the system. One of the objectives for the test, called FTG-11, was to demonstrate GMD's functionality to perform an end-to-end, multiple-GBI engagement to negate a target representing that of an intercontinental ballistic missile equipped with countermeasures. MDA successfully demonstrated this functionality by firing a CE-II Block I-equipped interceptor followed by a CE- II-equipped interceptor. The leading interceptor destroyed the target and the trailing interceptor struck one of the remaining objects, as it was designed to do. With the successful execution of FTG-11, the GMD system has now successfully executed three consecutive intercept tests and increased the system's overall test success rate for intercepts to 63 percent, as seen in table 15 below.

Table 15: Test Record for the Ground-based Midcourse Defense System (2007-2019)

Interceptor Configuration: Kill vehicle	Interceptor Configuration: Boost vehicle	Total number of intercept tests[a]	Number of successful intercepts	Number of failed intercepts	Intercept success rate (percentage)
Capability Enhancement (CE)-I	Configuration (C)1	3	2	1	67
CE-II	C1	3	1	2	33
CE-II Block I	C2	2	2	0	100
		8 (combined)	**5 (combined)**	**3 (combined)**	**63 (combined)**

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

[a]Flight tests that occurred prior to FTG-02 were not operationally configured interceptors and were therefore excluded, in addition to FTG-02, FTG-03, and all other non-intercept flight tests. FTG-02 was a data collection flight and was not a planned intercept test but the kill vehicle hit the target.

However, the Director, Operational Test and Evaluation has reported that the hit would not have resulted in a kill. FTG-03 was excluded since the target failed and no interceptor was launched.

MDA also gained insight into potential areas for improving the GMD system based on its performance during FTG-11, demonstrating the usefulness of continuing to flight test the GMD system. For example, the program observed some unexpected results during post-flight test analysis, some of which were assessed as having a minor effect on the mission. The results did not affect overall mission accomplishment but they did prompt DOT&E to recommend further examination, the details of which are classified. Testing GMD's salvo functionality was pivotal because, during a ballistic missile attack, the warfighter intends to launch a number of interceptors to increase the probability of successfully intercepting the incoming missile(s).

Further GMD testing is needed, but the program's future test plan is uncertain due to a limited number of interceptors that are available for use in testing. MDA, operational testers, and warfighters have identified other GMD capabilities and scenarios that need to be flight tested, such as performing an intercept at night and intercepting an incoming missile raid. The program has yet to complete its test plan for the current fleet configuration, in part, because of GMD's relatively slow rate of testing. As we found in June 2019, GMD has historically averaged less than one test per year despite initial program plans projecting up to four flight tests per year.[1] Moreover, MDA is required by law to annually conduct a GMD flight test, subject to several exceptions.[2] However, interceptors available for testing are limited because MDA has few spare GBIs available in the near term as a result of the RKV cancellation and NGI production is not expected to start until later this decade. BMDS Operational Test Agency (OTA) officials told us that they are concerned about the aging GBI fleet and lack of GMD flight test events to demonstrate new capabilities against operationally realistic threats.

[1]GAO, *Missile Defense: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability,* GAO-19-387 (Washington, D.C.: June 6, 2019).

[2]National Defense Authorization Act for Fiscal Year 2017, Pub. L. No. 114-328, § 1689 (Dec. 23, 2016).

MDA and contractors had multiple opportunities to address issues that led to the Redesigned Kill Vehicle's cancellation

MDA and contractors did not adequately address technical risks despite numerous warnings from subject matter experts and officials within and outside of the RKV program about the performance issues which later resulted in the program's cancellation. The most significant issue that led to RKV's cancellation pertained to the program's use of commercial off-the-shelf parts and re-use of Aegis SM-3 Block IIA components. MDA chose to use these parts in the RKV design because of their perceived maturity and cost savings as compared to those used in the EKV design. However, specific performance risks were identified at multiple junctures in the SM-3 Block IIA and RKV programs over the past ten years.[3]

- **SM-3 Block IIA Technical Interchange Meeting (May 2010):** Subject matter experts from Johns Hopkins University Applied Physics Laboratory provided the contractor with a briefing describing specific performance risks. Despite multiple efforts made by MDA's engineering directorate to enforce requirements that would have necessitated design changes to address the performance risks, the program received formal agency approval in June 2015 to waive the requirements. MDA and contractors justified the waiver on the basis that performing a redesign after critical design review would have imposed significant program costs and schedule delays.
- **RKV System Requirements Review (November 2015):** The program identified and assessed performance risks as having a high likelihood of occurrence with major consequences. The program indicated in the design review briefing that it could make design changes later in the development process or seek waivers if the design mitigations were insufficient to address the performance risks. Contractors told us that changes in MDA leadership in 2017 brought about changes in priorities, the former of which emphasized RKV and the SM-3 commonality and the latter emphasizing requirements compliance.

[3]The "performance risks" cited in this section all refer to the same set of performance risks stemming from the use of commercial off-the-shelf parts and re-use of Aegis SM-3 Block IIA components, the details of which are classified. According to OUSD(R&E) officials, RKV had other performance risks that were not directly associated with USD(R&E)'s decision to terminate RKV.

- **RKV Preliminary Design Review (March 2017):** The program concluded that RKV's hardware reuse was vigorously vetted, its design was appropriate for its requirements, and that the performance risks would be mitigated almost entirely. DOD officials stated that during the design review, a red team panel member warned the program that its schedule did not allow for sufficient time to resolve any issues if design mitigations proved insufficient. The panel member who raised the concern later became the Under Secretary of Defense (USD) for Research and Engineering (R&E) in February 2018.
- **RKV Critical Design Review "Go/No-Go" Briefing (October 2018):** The program held a briefing with senior leadership to discuss the program's readiness to conduct a critical design review. The program presented its preliminary analysis of parts testing data, which indicated significant performance risk. MDA and the contractor decided to postpone the critical design review to fiscal year 2021 and continued to perform assessments and testing of suspect components. In May 2019, USD (R&E) directed MDA to stop work on RKV and initiate an effort to identify alternative courses of action. In August 2019, USD (R&E) decided to terminate RKV and the Deputy Secretary of Defense concurred with decision.

Moving forward, MDA indicated to industry that it intends to address from the very start of the NGI program the performance risks that led to RKV's cancellations. An August 2019 assessment from IDA tasked by USD (R&E) noted that it will be critical to have the correct human capital resources throughout the program, including government oversight and program management, in order to implement a cost-effective approach to address the performance risks.

RKV cost more than tripled and was delayed by over 4 years prior to cancellation

The cost to develop RKV and complete initial production more than tripled and its schedule was lengthened by over 4 years prior to DOD cancelling the program. The program experienced significant cost and schedule increases over the span of 5 years, some of which occurred in the months leading up to the May 2019 stop-work order MDA was directed by USD (R&E) to issue. According to MDA, the program's financial challenges were primarily due to design rework, advance material purchases, schedule recovery efforts, and a large increase in staffing. These challenges alone increased RKV's cost by $612 million and delayed the program by approximately 2 years. At the time DOD cancelled the RKV program in August 2019, MDA had spent a total of $1.21 billion on RKV development—$340 million more than the agency's original estimate for the entire RKV development effort, including eight initial production kill vehicles. Table 16 demonstrates how RKV's total estimated cost increased by over 230 percent from 2015 to 2019. Although initial production quantities increased from 8 to 20 when MDA accelerated the program in 2017, our analysis of MDA's acquisition plans indicated that the quantity increase accounted for less than 15 percent of the increase in RKV's cost and schedule estimates.

Table 16: Redesigned Kill Vehicle (RKV) Development and Initial Production Cost and Schedule Growth

Year	Program plan	Total estimated cost (dollars in billions)	Total time to complete (years)
2015	Original DOD-approved plan	0.87	6.5
2017	Acceleration plan	2.30	8.75
2019	Remediation plan	2.91	10.75
na	na	**2.04 billion (cumulative increase)**	**4.25 years**

Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-20-432

Note: MDA originally planned to produce an initial 8 RKVs under the 2015 acquisition plan but later increased the quantity to 20 RKVs as part of its acceleration plan. The cost estimate for the 2015 acquisition plan would have increased from $0.87 billion to $1.11 billion if the cost of 12 additional RKV production units were added to the estimate, based on the average procurement unit cost stated in the 2015 acquisition plan. Similarly, the objective schedule described in the 2015 acquisition plan would have been extended by approximately 2 years to produce 12 additional RKV production units, based on the production rate indicated in the 2015 acquisition plan. However, if initial production start was accelerated to the critical design review—as was done in the 2017 acceleration plan—then the schedule described in the 2015 acquisition plan would have only been extended by approximately 6 months.

Lessons learned from RKV are informing the Next Generation Interceptor

MDA's general acquisition approach for NGI includes some lessons learned from the cancelled RKV program. MDA released a draft request for proposals to industry on August 23, 2019, followed by a kick-off industry day event a few days later. MDA provided industry participants with a briefing describing the agency's acquisition approach for NGI. The acquisition approach includes contractual, programmatic, and technical provisions that indicate MDA is attempting to prevent issues that proved problematic for the RKV program:

- **Competition:** MDA plans to competitively award two NGI development contracts that will leverage competition among the awardees prior to preliminary design review and possibly through critical design review. In May 2017, we found that MDA decided against conducting a full and open competition for RKV.[4] Instead, MDA pursued a "best-of breed" approach that merged multiple contractors' kill vehicle concepts into a single design. In doing so, we found that MDA missed some of the potential benefits typically achieved through competition.
- **Early parts testing:** MDA plans to reduce technical risk via early testing. Under the RKV program, MDA conducted a series of critical parts testing after the preliminary design review. As the program approached the critical design review in early fiscal year 2019, the parts testing revealed technical design problems that would require significant re-design work. For NGI, MDA plans to complete this same series of parts testing prior to the preliminary design review.
- **Flight testing:** MDA plans to successfully execute two intercept flight tests before starting the first lot of NGI production. MDA initially proposed starting NGI production after successfully executing a single, non-intercept test. However, after consulting with DOT&E staff, MDA revised its plans to include two intercept tests prior to starting NGI production. MDA previously produced CE-I, CE-II, and CE-II Block I EKVs intended for operational use prior to demonstrating them in a respective intercept flight test. MDA planned to do the same for RKV as well. In doing so, MDA risked discovering design flaws after production was already underway, resulting in costly, time-consuming retrofit efforts and potential product wastage.[5]

MDA plans to use event driven, performance-based knowledge points to assess contractors' progress and compliance with NGI program objectives. These knowledge points align with our body of work that has

[4]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).

[5]MDA incurred a $186 million cost increase to retrofit previously fielded CE-II interceptors with hardware corrections to address a design flaw discovered during FTG-06a. According to the GMD prime contractor, it currently has thousands of RKV hardware items in its inventory, some of which are being assessed for use on the SM-3 Block IIA.

shown that attainment of knowledge at key points during the acquisition process reduces risk and drives positive program outcomes.[6]

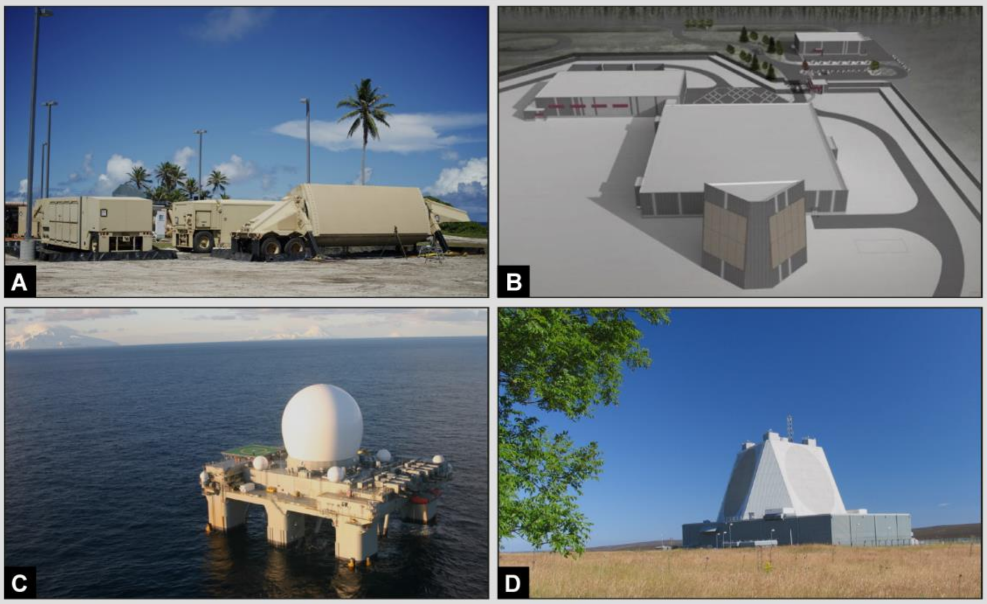
In addition, the offices of the USD (R&E) and USD for Acquisition and Sustainment are working closely with MDA on the NGI acquisition approach. Our prior work on defense acquisitions has shown that establishing buy-in from decision makers is a key enabler of achieving better acquisition outcomes because DOD components provide varying perspectives due to their unique areas of expertise and experience.[7] MDA officials told us in March 2020 that the agency has drafted a formal acquisition strategy for NGI that is currently undergoing departmental review and is expected to be signed by early April 2020. MDA's Acquisition Management Instruction specifically notes that a program must approve an acquisition strategy and complete the acquisition planning process prior to the release of the request for proposals and any resulting contract award.

[6]GAO, *Best Practices: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed*, GAO-10-439 (Washington, D.C.: Apr. 22, 2010); *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009); *Defense Acquisitions: A Knowledge-Based Funding Approach Could Improve Major Weapon System Program Outcomes*, GAO-08-619 (Washington, D.C.: July 2, 2008); *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, GAO-02-701 (Washington, D.C.: July 15, 2002); *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001); and *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, NSIAD-99-162 (Washington, D.C.: July 30, 1999).

[7]GAO-17-381.

Appendix VI: Sensors

Figure 13: Sensors, Appendix VI



Highlights of GAO's Fiscal Year 2019 Review

A Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) software updates and processor upgrades delivered.

B Long Range Discrimination Radar (LRDR) demonstrates hardware and software maturity as it moves into full-rate manufacturing, but risks being monitored ahead of key milestone.

C Sea Based X-Band (SBX) moves forward with software development and works through legacy software challenges.

D Upgraded Early Warning Radar (UEWR) capability deliveries begin after years of delays.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-20-432

Program Overview

The current generation of Ballistic Missile Defense System (BMDS) sensors includes the following:

- **Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2)** is a transportable X-band, high resolution, phased-array radar that is capable of tracking all classes of ballistic missiles. AN/TPY-2 in the forward-based mode is capable of detecting and tracking ballistic missiles and providing threat missile data to support Aegis Ballistic Missile Defense (BMD) and Ground-based Midcourse Defense (GMD) engagements. AN/TPY-2 in the terminal mode can track missiles in the later stages of flight to support Terminal High Altitude Area Defense (THAAD) engagements. Five AN/TPY-2 radars for use in forward-based mode and two AN/TPY-2 radars for use in terminal mode are deployed to support regional defense. The program is developing and fielding software upgrades; most recently it released software upgrade CX 3.1.

- **Long Range Discrimination Radar (LRDR)** will be an S-band radar and will provide capabilities to track incoming missiles and discriminate the warhead-carrying vehicle from decoys and other non-lethal objects for GMD. Construction and integration activities were ongoing in fiscal year 2019, with initial fielding planned for fiscal year 2021 and transfer to the Air Force planned for fiscal year 2022.[1]
- **Sea Based X-Band (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 United States and is considered a critical sensor for GMD, in part, because it is able to provide tracking information to the GMD interceptor as it targets an incoming threat missile.
    - SBX had last been reported in the 2012 BMDS Accountability Report (BAR) after completing development and production. SBX re-entered product development in July 2017, primarily for software spiral updates, and was re-added to the BAR in March 2018.
- **Upgraded Early Warning Radar (UEWR)** is a solid-state, phased-array, long-range radar that detects land- or sea-launched long- and intermediate-range ballistic missiles. Three of these radars were upgraded and integrated into the BMDS to improve sensor coverage by providing critical early warning, tracking, object classification, and cueing data. They were transferred to the U.S. Air Force in October 2013 and are located in Beale, California; Fylingdales, United Kingdom; and Thule, Greenland. Modernization efforts for UEWRs located in Clear, Alaska, and Cape Cod, Massachusetts, are ongoing.

[1]According to information provided by the Missile Defense Agency (MDA) in June 2020, all LRDR construction and integration activities ceased in March 2020 due to Coronavirus Disease 2019 (COVID-19). As a result, initial fielding is delayed and transfer to the Air Force is now expected in late fiscal year 2023. These developments occurred late in our review and, as such, we were not able to assess the impact and incorporate it into our report.

Table 17a: Fiscal Year 2019 – Sensors Program Testing (Flight Testing[a])

Test Name	Test objectives	Sensors participating
FTI-03	Aegis Weapon System's Engage on Remote capability tracked and intercepted an intermediate-range ballistic missile (IRBM) target with an Aegis Ashore-launched Standard Missile (SM)-3 Block IIA interceptor utilizing European Phased Adaptive Approach Phase 3 architecture.	Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) forward-based mode (Software CX 3.0.0)
FTG-11	Ground-based Midcourse Defense (GMD) salvo test in which multiple ground-based interceptors (GBIs) were fired against a single intercontinental ballistic missile (ICBM) target.	AN/TPY-2 forward-based mode (Software CX 3.0.0) Sea Based X-Band (SBX) (Software XBR 3.3.5)
FS-19 (multiple events)	Assessed message exchange and network performance of the U.S. European Command (USEUCOM) Tactical Digital Information Link (TADIL) network in simulated wartime Ballistic Missile Defense (BMD) and Integrated Air and Missile Defense (IAMD) environments.[b]	Upgraded Early Warning Radar (UEWR) Fylingdales (Software 8.4.2)
FTT-23	Terminal High Altitude Area Defense (THAAD) demonstrated an engagement firing against a medium-range ballistic missile (MRBM) target using the remote launcher capability.	AN/TPY-2 terminal mode (Software CX 3.1.0)

Table 17b: Fiscal Year 2019 – Sensors Program Testing (Ground Testing)

Test Name	Test objectives	Sensors participating
GTD-07b for Northern and Indo-Pacific Commands (N/I)	Demonstrated capabilities for defense of the homeland and defense of key areas in the Asia Pacific.	AN/TPY-2 (Software CX 3.0) SBX (Software XBR 4.0.1) UEWR (Software 9.0.7/8.4.2)
GTI-18 Sprint 3	Demonstrated capabilities for defense of the homeland and defense of key areas in the Asia Pacific.	AN/TPY-2 (Software CX 3.0) SBX (Software XBR 4.0) UEWR (Software 9.0.7)
GTI-19 Sprint 1	Demonstrated capabilities for defense of the homeland and defense of key areas in the Asia Pacific.	AN/TPY-2 (Software CX 3.0) SBX (Software XBR 4.0.0) UEWR (Software 9.0.7)
GTI-19 Sprint 2	Demonstrated capabilities developed for the Korean Peninsula.	AN/TPY-2 (Software CX 3.0)
GTI-19 Sprint 3	Assessed shot doctrine options for defense of the homeland.	AN/TPY-2 (Software CX 3.0)
GTI-19 Sprint 4	Assessed sensor architecture options in the Middle East.	AN/TPY-2 (Software CX 3.0)

Table 17c: Fiscal Year 2019 – Sensors Program Testing (Completed Operational Cybersecurity Assessments[c])

Sensor	Assessments
SBX	SBX with software XBR 4.0 completed one Cooperative Penetration and Vulnerability Assessment (CVPA) and one Adversarial Assessment (AA), which included integrated assessments with the Ground-based Midcourse Defense element.
UEWR	UEWR with software 9.0.7 completed one CVPA.

Source: GAO analysis of MDA data | GAO-20-432

[a]The sensors program participated in additional flight tests in fiscal year 2019. The flight tests included here are those that w ere included in the MDA test baseline and covered in this report.

[b]TADIL is a standardized communications link suitable for transmission of digital information. It interfaces two or more command and control or w eapon systems via a single or multiple netw ork architecture and multiple communication media.

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

AN/TPY-2 met some fiscal year 2019 development and delivery goals

AN/TPY-2 had some success in meeting testing and delivery goals for fiscal year 2019. Specifically, MDA participated in an Aegis test named FTI-03 and GMD test named FTG-11. In FTI-03, the Aegis Engage on Remote capability was demonstrated in an intercept of an intermediate-range ballistic missile (IRBM) target, and AN/TPY-2 detected, tracked, and forwarded target data while in forward-based mode.[1] However, according to BMDS Operational Test Agency (OTA), the warfighter was not able to learn more about the AN/TPY-2's ability to track two threats simultaneously. FTI-03 was originally planned as a near-simultaneous intercept of two IRBMs but because it was scaled back to only a single IRBM intercept, this opportunity was missed. In FTG-11, the first GMD salvo intercept of an intercontinental ballistic missile (ICBM), AN/TPY-2 provided data in forward-based mode.

In addition, AN/TPY-2 delivered two software upgrades. Software update CX 3.0 was planned for the fourth quarter of fiscal year 2019 but was accelerated to the first quarter due to the inclusion of changes to both the

[1]Engage on Remote (EOR) is a BMDS capability that integrates Aegis BMD with radars that are not located on the Aegis ships and with Command, Control, Battle Management, and Communications (C2BMC) to allow the warfighter to acquire and intercept an enemy missile sooner and, consequently, defend a larger area.

software and hardware architecture. It was fielded to U.S. European Command and U.S. Central Command, as part of BMDS Increment 5, and performed successfully during two fiscal year 2019 tests.[2] Another software update, CX 3.1, was released for testing in the third quarter of fiscal year 2019 in support of an urgent regional need. In FTT-23, AN/TPY-2 successfully demonstrated an ability to detect, track, and discriminate a medium-range ballistic missile (MRBM) threat in terminal mode with THAAD in a remote launcher configuration.[3]

Lastly, two upgraded x86 Electronic Equipment Units (EEUs) were also delivered: one to the forward-based mode Shariki site and one to a U.S.-based THAAD Battery currently awaiting deployment to a U.S. Central Command location.[4] The Shariki upgrade was initially planned for fiscal year 2018, but was delayed 8 months during shipment when the unit was delayed with Customs in another country due to political instability.

A third x86 upgrade, which had been accelerated 12 months to the first quarter of fiscal year 2019, was delayed to fiscal year 2020 due to Combatant Command reprioritization.

LRDR made progress in fiscal year 2019 but has little margin for error ahead of key milestone

The LRDR program completed its assessment of the system prototype in an operational environment in fiscal year 2019, which demonstrated hardware and software maturity prior to full rate manufacturing. The assessment was delayed from fiscal year 2018 after testing took longer than expected and required antenna reconfigurations and software fixes to complete. These testing complexities resulted in a cost overrun of approximately $25 million and delayed closure of a developmental step related to satellite tracking, planned for fiscal year 2018, due to the additional time needed to review the testing data.

[2]MDA capability deliveries are organized around Increments, or sets of capabilities, which are realized by upgrading and integrating BMDS elements, such as sensors.

[3]The remote launcher configuration enables THAAD launchers to be deployed beyond the current limits, increasing defended areas.

[4]The Electronic Equipment Unit houses the AN/TPY-2 processors, which enable the system to discriminate threats from non-threats and enhance radar performance during missile raids.

While LRDR construction was ongoing in fiscal year 2019, the program was monitoring risks that could threaten the upcoming transfer of LRDR custody and ownership to the government.[5] Specifically, the program was focusing on manufacturing of the Array Panels, Sub Array Assembly Suite modules, and Auxiliary Power Group cabinets, as well as ensuring integration on site. Issues in these areas depleted schedule margin on the path towards the transfer, which was scheduled for the fourth quarter of fiscal year 2020.[6] See figure 14 for the LRDR construction site.

[5]All LRDR construction and integration activities ceased in March 2020 due to COVID-19.

[6]In January 2020, transfer of LRDR custody to the government was delayed until the first quarter of fiscal year 2021 due to radar component productions issues.

Figure 14: Long Range Discrimination Radar Construction at Clear Air Force Station, Alaska (July 15, 2019)

Source: GAO. | GAO-20-432

Looking ahead, the current test plan for LRDR has just one flight test scheduled in the third quarter of fiscal year 2021, which takes place after two ground tests. As we reported in May 2018, MDA utilizes models and simulations in ground testing to assess the BMDS because of the system's scope and complexity, and safety constraints.[7] However, in order to ensure that these ground tests provide reliable performance data, they must be assessed against real world data and validated by BMDS OTA. Key aspects of this data are captured by flight tests. By having two ground tests before the only flight test, it increases the likelihood that the models will not be accredited when testing is complete. As a result, performance analysis and the majority of model validation and accreditation will have to be made concurrently, just prior to the LRDR Technical Capability Declaration, which is also scheduled for the third quarter of fiscal year 2021. This increases the risk of discovering issues late in development, which could result in performance reductions or delivery delays.

SBX moves ahead with software development and overcomes legacy communication software challenges

SBX completed installation of the x86 software upgrade aboard SBX and made progress on its software development program during fiscal year 2019. The x86 upgrade replaces obsolete signal and data processing equipment to support testing prior to the expected delivery of new homeland defense capability in June 2021. Software updates XBR 4.0 and XBR 4.1 build upon earlier software builds and will include improvements such as enhanced discrimination capabilities.

In fiscal year 2019, software update XBR 4.0.1 was formally released and demonstrated for the first time during a flight test. In both GT-229 and GT-230, the performance of the XBR 4.0.1 software was assessed while detecting, tracking, and performing discrimination on the Minuteman III ICBM. Objectives were achieved for both tests.

The first two engineering releases (ER) of software update XBR 4.1 were also delivered for testing. ER1 was delayed from fiscal year 2018, and ER2 was limited due to challenges with the government-furnished Variable Message Format Interface Translator Library Segment (VITLS).

[7] GAO, *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).

According to BMDS OTA, VITLS formats the messages between GMD and sensor components utilizing the Variable Message Format. It was developed in the early 2000s and did not require any updating until the new capabilities were defined for XBR 4.1. Due to the long period of time between updates, the ability to regenerate the tool had to be developed and tested to ensure legacy functionality. As of October 2019, the VITLS software was approximately 2 years behind schedule. However, according to MDA officials, VITLS 2.7 was delivered for XBR 4.1 ER4 and pairwise integration testing was completed in December 2019 with no issues identified.[8]

UEWR capability deliveries to warfighter begin after long delays

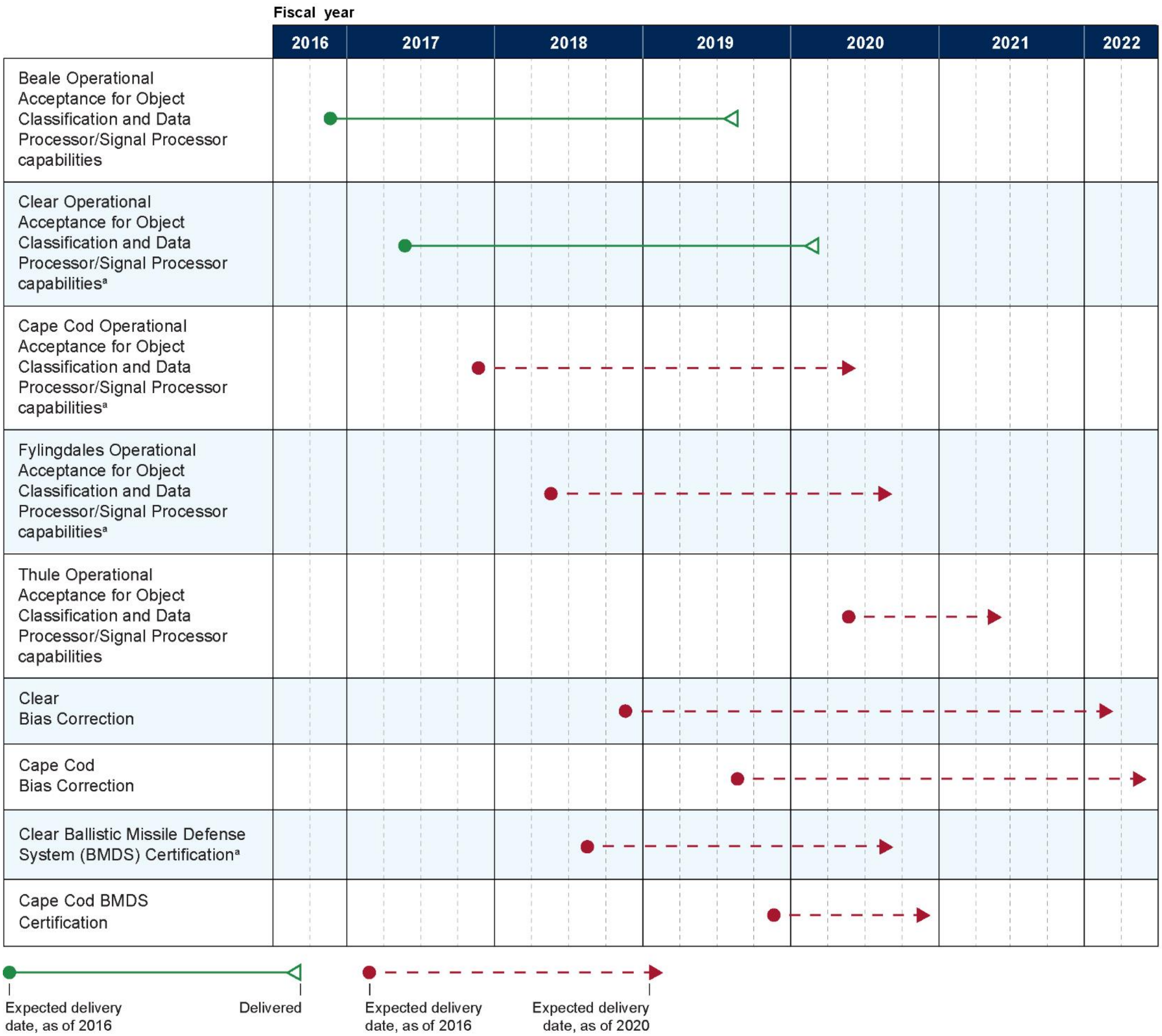
UEWR made developmental progress at its Beale location in fiscal year 2019, but delays persisted at the other UEWR sites. Object Classification (OC) and Data Processor/Signal Processor (DP/SP) capability upgrades, designed to address emerging threats, were operationally accepted at Beale by Air Force Space Command in the third quarter of fiscal year 2019. As we reported in May 2018, Beale's operational acceptance for the OC and DP/SP upgrades was originally scheduled for fiscal year 2016, but Beale has experienced multiple delays.[9]

The Beale operational acceptance delays had resulted in cascading delays for OC and DP/SP upgrades to the Clear, Cape Cod, and Fylingdales radars, as well as Clear and Cape Cod Bias Correction upgrades, and Clear and Cape Cod BMDS certifications. A historical look at the delays since 2016 are shown in figure 15 below; delays impacting the planned activities from fiscal year 2019 are explained further in Table 18 below.

[8]According to BMDS OTA, integration testing reduces the risk of issues during a ground test by providing confirmation of interoperability prior to connecting the full architecture.

[9]GAO, *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).

Figure 15: Cascading Delays since Fiscal Year 2016 for Upgraded Early Warning Radar Capability Deliveries



Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

[a]Planned for fiscal year 2019 in the Ballistic Missile Defense System (BMDS) Accountability Report (BAR) from March 2018.

Table 18: Upgraded Early Warning Radar Events Delayed from Fiscal Year 2019

Event[a]	Cause(s) for Delay
Clear Operational Acceptance for Object Classification and Data Processor/Signal Processor capabilities	Delayed in part due to a request for additional training. **Operationally accepted during the first quarter of fiscal year 2020.**
Cape Cod Operational Acceptance for Object Classification and Data Processor/Signal Processor capabilities	Delayed due to completion of cyber testing and a request for additional training. **Operational acceptance planned for the second quarter of fiscal year 2020.**
Fylingdales Operational Acceptance for Object Classification and Data Processor/Signal Processor capabilities	Delayed due to late receipt of the Fylingdales Classified Network (CNET) connection (planned for October 2018 but not implemented until June 2019) and additional site testing needs. **Operational acceptance planned for the third quarter of fiscal year 2020.**
Clear Ballistic Missile Defense System (BMDS) Certification	Delayed due to the Clear operational acceptance delays. **BMDS certification planned for the third quarter of fiscal year 2020.**

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

[a]Planned for fiscal year 2019 in the Ballistic Missile Defense System (BMDS) Accountability Report (BAR) from March 2018.

Appendix VII: Targets and Countermeasures

Figure 16: Targets and Countermeasures, Appendix VII

Highlights of GAO's review for Fiscal Year 2019

- Targets program met some of its fiscal year 2019 goals and completed other goals recently added or delayed from prior fiscal years.
- Availability risk for intermediate–and intercontinental-range targets was mitigated by cancellation of the Ground-based Midcourse Defense's Redesigned Kill Vehicle effort, but other challenges have emerged.
- Targets program considering a revised acquisition approach to enable faster development and reduced costs.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-20-432

Program Overview

The Missile Defense Agency's (MDA) Targets and Countermeasures program (hereafter referred to as Targets program) procures missiles to serve as targets during the developmental and operational testing of independent or integrated ballistic missile defense system (BMDS) elements. Specifically, this program supplies MDA with short-, medium-, intermediate-, and intercontinental-range targets to test, verify, and validate the BMDS elements' performance in threat relevant environments.[1] As targets are solely test assets, they are not operationally fielded.

The number of targets that the program supplies vary based on each element's requirements and testing schedule. While some targets have

[1]The target ranges are as follows: short (less than 1000 Kilometers), medium (1000-3000 Kilometers), intermediate (3000-5500 Kilometers), and intercontinental (greater than 5500 Kilometers).

been used for years, others have been recently added or are now being developed to more closely represent current and future threats. The quality and availability of these targets is instrumental to the execution of MDA's flight test schedule. Table 19 provides information on the Targets program's performance in fiscal year 2019.

Table 19: Targets and Countermeasures Program's Fiscal Year 2019 Performance (Major Deliveries)

Planned Delivery	Delivery Status
2 SRBM	**Delayed.** Two SRBM T4-G targets were delayed to fiscal year 2021, in part, due to availability of contractor personnel and technical challenges associated with developing this new target.
3 MRBM	**Partially delivered.** One of the three different MRBM targets was delivered and flown and the others were delayed. The MRBM T1/T2 was delivered and successfully flown in FTT-23, which was the first flight of this target.[a] The MRBM T3c2 was delayed due to reallocation of the initial target's components to a higher priority classified program. The MRBM T4-B was delayed to fiscal year 2022 due to development issues.
3 IRBM	**Partially delivered.** One IRBM, delayed from fiscal year 2018, was successfully flown in FTI-03.[b] The remaining two IRBMs were ready for delivery, but postponed due to changes in the flight test schedule.
1 ICBM	**Delivered.** One ICBM was successfully flown in FTG-11, a major intercept test to demonstrate the Ground-based Midcourse Defense interceptor's performance during a salvo launch—use of multiple interceptors to engage a single target.
Total targets planned: 9	**Total targets delivered: 3**

Legend:

Short-range ballistic missile (SRBM)

Medium-range ballistic missile (MRBM)

Intermediate-range ballistic missile (IRBM)

Intercontinental-range ballistic missile (ICBM)

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

[a]The first MRBM T1/T2 target was originally scheduled to fly in FTO-03 E2—a major operational test for the Ballistic Missile Defense System (BMDS); however, MDA made revisions to its flight test schedule which added a test for the Terminal High Altitude Area Defense (THAAD) program—FTT-23—in support of urgent warfighter need. Thus, the MRBM T1/T2 was reallocated from FTO-03 E2 to FTT-23.

[b]FTO-03 Event 1 was originally planned as a near simultaneous launch of two IRBMs; however, one IRBM was removed from the test due to the availability of safety platforms to support the test. Also, this test was designated as an integrated test versus an operational test. For additional information, see GAO, *Missile Defense: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability*, GAO-19-387 (Washington, D.C.: June 6, 2019).

Targets program met some of its fiscal year 2019 goals and completed other goals recently added or delayed from prior fiscal years

The Targets program delivered and flew three of the nine targets planned for fiscal 2019, and delayed the remaining targets due to technical challenges or test schedule changes. Among these three targets, one–the MRBM T1/T2–flew for the first time during FTT-23, an intercept test for the THAAD program in support of urgent warfighter needs.[2] We have previously reported on the high risks that the agency assumes when it uses a new target during an intercept test.[3] While the target did perform as needed during the recent FTT-23 flight test, we have reported on past experiences where the other new targets have not.[4] For example, in 2015, MDA used a new IRBM T1 target in an operational test, which failed and resulted in significant cost increases, delays to other important tests, and changes that reverberated throughout the test schedule. These type of test schedule changes can delay or increase the risks associated with the delivery of capabilities and assets to the warfighter. Thus, we previously recommended that MDA fly new target types in a non-intercept test to verify their performance and reduce risk prior to their use in an intercept test.[5] However, the agency has not implemented this recommendation, and over the next few years it is planning to use other new targets for the first time in intercept tests. For example, MDA is currently planning to fly the new SRBM T4-G and MRBM T3c2 targets during intercept tests in fiscal years 2021 and 2020, respectively.

The Targets program recently completed the critical design reviews (CDR) for the new SRBM T4-G and MRBM T3c2 targets, although these reviews were either delayed from a prior fiscal year or added in fiscal year 2019. Otherwise, the Targets program did not have any development milestones, such as a CDR, planned for fiscal year 2019. A system-level

[2]For further details on the THAAD program, see appendix VIII.

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

[4]GAO, *Missile Defense: Ballistic Missile Defense System Testing Delays Affect Delivery of Capabilities,* GAO-16-339R (Washington, D.C.: Apr. 28, 2016) and *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).

[5]GAO-13-432.

CDR, typically a single event, assesses the final design of a target, among other things, to ensure that it can proceed into production and testing and can meet its stated performance requirements within cost, schedule, and risk. The CDRs for both of these new targets led to the addition of another event (or part) to address technical and other challenges. In addition, the first flight test using either of these targets has been delayed by a year or more. For example, the first flight test with the SRBM T4-G target has been delayed by more than three years, thereby postponing an Aegis program's demonstration of performance against the threat this new target is intended to represent. The Targets program attributes the delays in the SRBM T4-G target's CDR, and subsequent delay of its first flight test, to technical challenges and the contractor's limited staffing, which we have previously reported.[6] Specifically, the contractor uses the same, small team of personnel for both target development (designing and building a target) and mission execution (flying a target in a test). This requires the contractor's personnel to stop working on the development of one or more efforts in order to support the execution needs of the contractor's numerous customers across the Department of Defense (DOD) and the National Aeronautics and Space Administration.

Availability risk for intermediate- and intercontinental-range targets mitigated by cancellation of GMD's RKV effort, but other challenges have emerged

We previously reported a risk to the availability of the intermediate- and intercontinental-range targets due to limitations with pre-flight testing, storage, and transport that necessitate specific time spacing between flight tests; however, the recent cancellation of the GMD program's RKV effort has mitigated this risk by removing tests from an aggressive test schedule.[7] The GMD program encountered design issues with the RKV effort that DOD determined were so significant as to either be insurmountable or cost-prohibitive to correct, which led to the cancellation of the effort.[8] As a result, at least four tests for the GMD program through fiscal year 2023, which use either intermediate- or intercontinental-range targets, have been deleted. These deletions and other test schedule

[6]We previously reported on the SRBM T4-G's technical challenges and its contractor's staffing shortages in GAO-19-387.

[7]GAO-19-387.

[8]For more information on the GMD program and RKV cancellation, see appendix V.

changes have decreased the agency's overall number of planned flight tests with intermediate- and intercontinental-range targets from 16 to 10 over this timeframe (fig. 17). This reduction in flight tests has created a significantly less aggressive schedule, which the contractor for the intermediate- and intercontinental-range targets stated is more in line with historical norms and thus, doable.

Figure 17: Changes to Intermediate- and Intercontinental-Range Targets' Delivery Schedule, through Fiscal Year 2023

		FY2019				FY2020				FY2021				FY2022				FY2023			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
FY18 Target delivery Schedule	Intermediate Range Ballistic Missile		××		×				×		×	×			×		×			×××	
	Intercontinental Ballistic Missile	×				×							×				×				×
Current Target delivery Schedule	Intermediate Range Ballistic Missile	××									××		×								
	Intercontinental Ballistic Missile	×					×			×							×				

× = Target delivery FY = Fiscal year

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

Although the cancellation of the RKV effort reduced the aggressiveness of the flight test schedule, the sudden and drastic change in the flight test schedule has led to other challenges that the Targets program will have to contend with. For example, use of the targets that were built-up for the now-deleted flight tests has shifted beyond the 5-year window of their ordnance shelf-life, which necessitates testing to ensure their usability in future flight tests. This testing, according to the contractor, is required to assess each target's condition and if and how long their shelf-life can be extended. According to the contractor, the shelf-life for a target can typically be extended 3 to 5 years, but it varies by component and is based on whether or not each component passes testing. This testing would be at an additional cost to the Targets program and could be up to approximately $2 million in total, according the contractor. As another option, the agency is considering using some of these targets in new tests before their shelf-life becomes an issue. For example, in June 2019 we recommended that MDA conduct additional testing for the European Phased Adaptive Approach Capability Phase 3 using intermediate-range targets to thoroughly assess any capabilities and limitations prior to delivery in May 2020.[9] MDA has not yet implemented this

[9] GAO-19-387.

recommendation, but MDA officials indicated that using these targets in new tests such as the aforementioned European Phased Adaptive Capability Phase 3 testing is one of the options under consideration given the current shelf-life issue.

Targets program considering a revised acquisition approach to enable faster development and reduced costs

Over the years the Targets program has adjusted its acquisition approach several times to address reliability, development time, and costs, and is currently considering a revision to its acquisition approach. We have previously reported on reliability improvements based on reduction in failures during flight tests; however, development time and costs have continued to be an issue.[10] Specifically, the average development time for most of the medium to longer-range targets has been about 5 years, with an average cost of nearly $100 million by their first flight (fig. 18).[11] Extended development time has led to some targets not being available for testing as originally planned, which has delayed testing by years in some instances or necessitated substitute targets to fill the void. Escalating costs for other targets has led to multiple rebaselines, and in some instances, reductions in quantities. We have previously found that many factors contribute to a target's extended development time and escalating costs, such as the increased complexity of the targets to better reflect an evolving threat.[12] However, there are other factors as well, such as aggressive and concurrent development schedules, which we have reported on in the past.[13]

[10]GAO, *Missile Defense: Opportunities Exist to Reduce Acquisition Risk and Improve Reporting on System Capabilities,* GAO-15-345 (Washington, D.C.: May 6, 2015), GAO-16-339R, *Missile Defense: The Warfighter and Decision Makers Would Benefit from Better Communication about the System's Capability and Limitations*, GAO-18-324 (Washington, D.C.: May 30, 2018), and GAO-19-387.

[11]Development time is from contract award to first flight of the target. Average cost includes the non-recurring engineering to design the target and per target costs, such as the build cost for an individual target and execution cost to use the target during a flight test.

[12]GAO, *Defense Acquisitions: Sound Business Case Needed to Implement Missile Defense Agency's Targets Program,* GAO-08-1113 (Washington, D.C.: Sept. 26, 2008).

[13] GAO-19-387.

Figure 18: Development Time and Cost for Some Missile Defense Targets

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

In terms of an acquisition approach, the Targets program has either used a single contractor to lead the development of a family of targets with common components to interchange across all targets (former approach) or disparate contractors to design and build various targets (current approach). Moving forward, the Targets program is considering a revision that would leverage aspects of both the former and current approach, where possible. For example, the Targets program, rather than a contractor, serves as the lead, with the intention of promoting competition among contractors while also maximizing the use of common components and interfaces to enable interchangeability across targets, if and when needed. The Targets program is also considering the use of an agile contracting structure to reconfigure or assemble available target components to be responsive to rapidly evolving threats and flexible order quantities. The Targets program is still determining the specific aspects of the revised acquisition approach, but with the ultimate goal of reducing delivery time and costs.

Appendix VIII: Terminal High Altitude Area Defense (THAAD)

Figure 19: Terminal High Altitude Area Defense (THAAD), Appendix VIII

Highlights of GAO's review for Fiscal Year 2019

- Terminal High Altitude Area Defense (THAAD) continued interceptor deliveries and conducted a flight test in fiscal year 2019.
- Members of Congress expect MDA to transfer the procurement, operation, and maintenance of THAAD to the Army, but transfer is unlikely to occur.
- THAAD is exploring potential for homeland defense contributions.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-20-432

Program Overview

THAAD is a rapidly-deployable, globally-transportable, ground-based system able to defend against short-, medium-, and limited intermediate-range ballistic missile attacks through a threat missile's middle to end stages of flight. A THAAD battery is comprised of five major components: (1) launchers, (2) a fire control unit, (3) communications system, (4) a radar, and (5) interceptors. The current program of record includes a total of seven batteries and 688 interceptors.

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. Table 20 provides key fiscal year 2019 THAAD program facts.

Table 20a: Terminal High Altitude Area Defense's (THAAD) Fiscal Year 2019 Performance (Major Deliveries)

Planned Delivery	Delivery Status
60 Interceptors[a]	**Partially delivered.** THAAD delivered 53 interceptors. Some interceptors were delayed to resolve a cabling issue discovered on operationally deployed interceptors.
THAAD Software Build 3.2	**Delayed.** Software build 3.2 provides the initial remote launcher capability—THAAD launchers deployed beyond current limits to increase defended area—to meet an urgent warfighter need. Issues with this software build were discovered during ground testing, which necessitated an update to the software, additional testing, and a delay to its operational availability.

Table 20b: Terminal High Altitude Area Defense's (THAAD) Fiscal Year 2019 Performance (Flight Tests)

Test name	Test type	Test date	Test result
FTO-03 E2[b]	Intercept	Not applicable	**Delayed.** A major operational test of the Ballistic Missile Defense System, with THAAD engaging an intermediate-range ballistic missile target, was delayed to fiscal year 2020 to deconflict other testing, including the addition of FTT-23 to support an urgent warfighter need.
FTT-23	Intercept	Aug. 2019	**Met objectives.** A THAAD test engaging a medium-range ballistic missile target to demonstrate the remote launcher capability—an urgent warfighter need.

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

[a]The THAAD program originally planned to deliver 60 interceptors in fiscal year 2019 based on the difference between the cumulative totals of 216 and 276, for fiscal years 2018 and 2019, respectively. According to THAAD program officials, these cumulative totals were adjusted to 221 and 266 for each of these fiscal years based on a rebaseline of the program, resulting in a difference of 45 interceptors. Thus, at least five interceptors were delivered early and remaining interceptors that were a part of the original plan were delayed to a future fiscal year.

[b]FTO-03 E2 was renamed FTO-03, but was recently deleted from the flight test schedule.

THAAD Continued Interceptor Deliveries and Conducted a Flight Test in Fiscal Year 2019

THAAD delivered 53 of 60 planned interceptors in fiscal year 2019. Some of the remaining interceptors, according to program officials, were not delivered in fiscal year 2019 as planned because the program prioritized reworking an internal cabling issue discovered on at least 30 interceptors already operationally deployed. Program officials explained that the rework includes physical inspections, adjustments and a software upload for interceptors identified as having the cabling issue, and any necessary transportation of the interceptors. Program officials noted that the cost associated with the rework to date is approximately $2.3 million, but the final cost is unknown until all interceptors have been inspected and reworked. Moving forward, the program expects to be able to meet planned interceptor deliveries based on contractor-led adjustments to tooling and suppliers to increase production throughput.

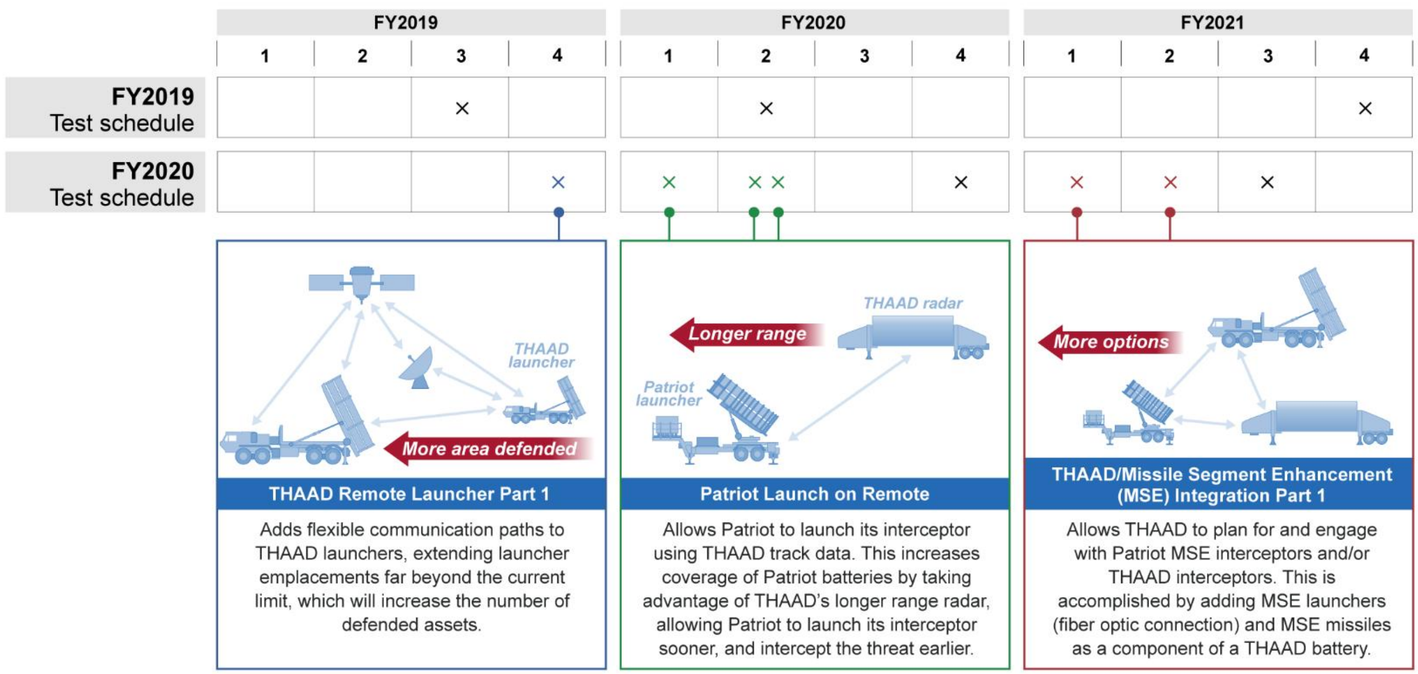
THAAD conducted one flight test—FTT-23—in fiscal year 2019 in support of an urgent warfighter need, which delayed FTO-03 E2, a major operational test of the Ballistic Missile Defense System (BMDS). FTT-23 demonstrated THAAD's ability to intercept an incoming threat missile using a launcher that has been located beyond the immediate proximity of the THAAD radar and fire control unit, known as remote launcher capability. The location of the launcher beyond the immediate proximity enables the warfighter to defend larger areas. The program planned to use the THAAD 3.2 software build upgrade during this test, but to avoid delaying the flight test, the program used a non-operational version of this software instead due to issues discovered with the software build during ground testing. THAAD has incorporated fixes into the THAAD 3.2 software build, which are being verified through follow-on ground testing.

THAAD has an aggressive flight test schedule through fiscal year 2021 in support of additional upgrades for the urgent warfighter need and other requirements (see fig. 20). In June 2019, we reported that THAAD's flight testing had nearly tripled between fiscal years 2019 and 2021, and that the program would face challenges meeting its aggressive flight test schedule.[1] Specifically, we noted the decreased schedule margin, funding concerns, and complexity of some tests, which put the flight test schedule at risk of not being completed as planned. As noted above for FTT-23, when issues arise, like the readiness of a specific software build, the program must determine whether to conduct the test or delay it in order to address the issues. If this test had been delayed, it would have likely had reverberating effects on other flight tests in the schedule, but since it was not delayed, the performance of the software build upgrades must be verified by other means, such as laboratory or ground testing. We have previously noted that if THAAD does not conduct flight testing as planned, it will forego the demonstration and confirmation of an upgrade's performance, which leaves the warfighter with the decision to either not use the upgrade or use it with an increased risk that it may not perform as intended.[2]

[1]GAO, *Missile Defense: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability,* GAO-19-387 (Washington, D.C.: June 6, 2019).

[2]GAO-19-387.

Figure 20: Terminal High Altitude Area Defense's (THAAD) Aggressive Flight Test Schedule and Upgrades to Meet Urgent Warfighter Needs



× = Flight test FY = Fiscal year

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

Note: The tests depicted include those exclusive to THAAD as well as Patriot-led tests with THAAD as a participant and do not reflect any recent changes to the test schedule.

Members of Congress Expect MDA to Transfer the Procurement, Operation, and Maintenance of THAAD to the Army, but Transfer is Unlikely to Occur

In the National Defense Authorization Act (NDAA) for Fiscal Year 2018, Congress mandated that MDA transfer the acquisition and total obligation authority of certain BMDS elements that received Milestone C approval to the military services no later than the President's Budget Submission for fiscal year 2021.[3] In line with this direction, the Senate report

[3]National Defense Authorization Act for Fiscal Year 2018, Pub. L. No. 115-91 § 1676 (b) (Dec. 12, 2017). Transferable BMDS elements consisted of MDA missile defense programs that received Milestone C approval in accordance with 10 U.S.C. § 2366 by the time the President's fiscal year 2021 budget was submitted (no later than February 3, 2020).

accompanying the fiscal year 2020 NDAA, described the movement of THAAD procurement, operation, and maintenance funding from MDA to the Army, as its production is nearing completion.[4] Specifically, THAAD has delivered all seven batteries and 274 of the 688 total planned interceptors, and remaining efforts are primarily software upgrades. The congressional expectation that MDA will transfer THAAD to the Army is in line with the original intent for MDA to use existing and new technologies to rapidly develop weapon systems for the warfighter and, once mature, transfer the weapon systems to a military service for production, operation, and sustainment.[5]

MDA and the Army have taken steps to prepare for the transfer of THAAD, but there are some steps that have not yet been completed (table 21). For example, they have established a THAAD-specific transfer agreement. Per MDA's transfer policy, transfer should include an event-driven process and criteria.[6] However, this THAAD-specific transfer agreement outlines broad activities such as budgeting or testing, rather than events, like a review or milestone such as production start.[7] Basically, an activity occurs over time, whereas an event occurs at a set point in time and has no duration, as either something starts, finishes, or occurs. In addition, the broad activities included in the THAAD-specific transfer agreement are lacking details and dates. Consequently, it is not clear how success will be measured or when it will occur.

[4]S. Rept. No. 116-48, at 16, 32, 125, 132, 336-37 (2019). See also H. Rept. No. 116-333, at 1549, 1586 (2019) (reflecting a THAAD program transfer from MDA to the Army).

[5]Department of Defense, Secretary of Defense, *Missile Defense Program Direction* (Washington, D.C.: Jan. 2, 2002).

[6]MDA Directive 5010.19, *Ballistic Missile Defense System Capability Transition and Transfer Policy* (May 2014).

[7]*Ballistic Missile Defense System United States Army and Missile Defense Agency Overarching Memorandum of Agreement, Annex (THAAD)* (Mar. 24, 2014).

Table 21. Status of Some of the Steps to Enable the Transfer of Terminal High Altitude Area Defense (THAAD) System to the Army

Step to Enable Transfer	Completion Status	Details
Forum to discuss transfer established	Yes	Has discussed transfer 12 times since 2014.
Overarching memorandum of agreement between the Missile Defense Agency (MDA) and the Army established	Yes	January 2009
THAAD-specific transfer agreement in place	Yes	March 2014
Responsibilities, funding, and resources determined	Yes	Information is outlined in the THAAD-specific transfer agreement.
Technology maturity independently assessed	Yes	October 2019
Joint cost estimate developed	Yes	January 2017
Lifecycle sustainment plan developed	Yes	November 2019
Event-driven criteria established	No	Some broad activities are identified in the THAAD-specific transfer agreement, but no explicit events or associated timelines.
Developmental and operational testing completed	No	Ongoing
Transfer schedule exists	No	No transfer schedule has been prepared to-date.

Source: GAO analysis of Missile Defense Agency data. | GAO-20-432

Although MDA and the Army have taken steps to prepare for the transfer of THAAD, MDA officials told us the Department of Defense (DOD) is seeking relief from the congressional expectation that transfer will happen in fiscal year 2020. At this point, there are steps to enable transfer that are still in progress that will take time for MDA and the Army to resolve. In addition, there has been an ongoing impasse between MDA and the Army over the transfer of THAAD due to mission requirement shortfalls that would necessitate an estimated $10.1 billion investment or more to resolve, which we have previously reported on.[8] MDA is not willing to fund the shortfalls if transferred to the Army, and the Army is not prepared to take on such a significant financial burden. Therefore, the Army has been reluctant to assume full responsibility for THAAD and recently stated that it prefers for THAAD to remain with MDA. In light of the additional steps needed to prepare for transfer and the impasse, MDA officials told us in February 2020 that DOD adjusted its position on transfer. Instead of compelling the transfer, officials said DOD has revised its definition of transfer, whereby a BMDS element will be deemed transferred if available

[8]GAO, *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 GAO-19-387.

to the military service for operational use and the military services and MDA have assumed their respective funding responsibilities in accordance with the transfer agreement and DOD direction.[9] Essentially, there would be no effective change from the current status for existing BMDS elements. Whether or not Congress will agree with DOD's proposed course of action on transfer is still being determined.

THAAD Exploring Potential for Homeland Defense Contributions

As described above, THAAD is a rapidly-deployable and globally-transportable system that is sent where it is needed at the time. Recently, the House Committee on Armed Services requested a report on how THAAD can contribute to homeland defense.[10] Homeland defense involves the protection of the United States, primarily from intermediate- and intercontinental-range threats. The Ground-based Midcourse Defense program is the principal provider of homeland defense, but this committee request asks for detailed analysis on how THAAD can provide defensive capabilities as an underlay to the Ground-based Midcourse Defense program. The committee noted that THAAD has previously been deployed to perform homeland defense in Hawaii when the threat dictated the need. THAAD officials explained that they had generated some initial analysis that shows THAAD capability for homeland defense exists and could be improved with additional development.

[9]DOD's June 10, 2011 memorandum on *Funding Responsibilities for Ballistic Missile Defense System (BMDS) Elements* outlines the military services' and MDA's respective funding responsibilities.

[10]H. Rpt. No. 116-120 (2019). This report accompanied H.R. 2500, which was never enacted into law.

Appendix IX: Comments from the Department of Defense

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3030 DEFENSE PENTAGON
WASHINGTON, DC 20301-3030

RESEARCH
AND ENGINEERING

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

Dear Mr. Russell:

Thank you for the opportunity to review the Department of Defense's response to the Government Accountability Office (GAO) Draft Report GAO-20-432, "MISSILE DEFENSE: Assessment of Testing Approach Needed as Delays and Changes Persist," dated March 12, 2020 (GAO Code 103535). The Department is providing the attached official written comments for inclusion in the report. My point of contact for this action is Mr. Kimo Hollingsworth, Director of Congressional Affairs, Missile Defense Agency, at 571-231-8105 or Kimo.Hollingsworth@mda.mil.

Sincerely,

Griffin.Michael.D.1281658677 Digitally signed by Griffin.Michael.D.1281658677 Date: 2020.06.12 11:45:31 -04'00'

Michael D. Griffin

Enclosure:
As stated

DEPARTMENT OF DEFENSE
RESPONSE TO
GOVERNMENT ACCOUNTABILITY OFFICE
REQUEST FOR INFORMATION
"FY19 MANDATE AUDIT" #103535
DEPARTMENT OF DEFENSE RESPONSE TO REPORT RECOMMENDATION

REQUEST: Provide the Department of Defense (DoD) response to GAO's recommendation in the Draft Report.

GAO recommendation: the Director, MDA, should ensure an independent assessment is conducted of the agency's process for developing and executing its annual Ballistic Missile Defense System flight test plan.

RESPONSE: Concur.

The current MDA Integrated Master Test Plan (IMTP) planning process includes participation, oversight, assessment and final approval from numerous external stakeholders including Director, Operational Test and Evaluation (DOT&E), Director, Developmental Test, Evaluation and Prototyping (DT&E), Service Operational Test Agencies (OTAs), and Commander, Joint Functional Component Command for Integrated Missile Defense. Each of these stakeholders provide continuous independent assessment of the Missile Defense System, which includes insight, input and oversight for the development and execution of the IMTP.

MDA meets weekly with all of these external stakeholders to review planning updates and gather input to inform program-specific executive decisions, facilitate continuous process improvement, and best maintain the strategic pathway. This forum culminates with a three-star level Executive Panel Review across the same community of interest prior to the signature and publication of the IMTP. This same community of external stakeholders participate in each pre- and post-test ground and flight test technical review and executive review.

In order to be adaptable to a real and rapidly-evolving threat, MDA purposefully develops an aggressive test program in full collaboration with the Office of Secretary of Defense, Service OTAs, and Combatant Commands to address future Warfighter needs at the speed of relevance. Pacing, and outpacing the threat presents risk to development and test plans and related initiatives. The Agency has procedures in place to respond to changes in a research and development program that is not ready for test as well as to real world operations limiting Warfighter support (e.g. FTO-03 was cancelled due to the loss of Army support for both a Patriot unit and AN/TPY-2 radar required for real world operations). Our current approach is fiscally responsible and meets the needs of the Agency, the Department, and the Warfighter.

However, MDA will ensure an independent assessment of the IMTP process is conducted, as recommended. MDA will contact GAO and request a short list of potential qualified organizations to conduct this assessment.

Appendix X: GAO Contact and Staff Acknowledgements:

GAO contact

W. William Russell (202) 512-4841 or Russellw@gao.gov

Staff Acknowledgments

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

Appendix XI: Accessible Data

Data Tables

Accessible Data for Missile Defense Agency (MDA) Cumulative Flight Test Planning, Fiscal Years 2010-2019

Category	Percentage
Conducted during originally planned fiscal year	37
Delayed, merged with another test, deleted, or conducted late	63

Accessible Data for Figure 2: Missile Defense Agency (MDA) Cumulative Flight Test Planning, Fiscal Years 2010-2019

Category	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019
Planned Tests	10	14	14	17	13	15	12	12	21	13
Backlogged Tests	3	1	3	10	10	12	12	18	7	14
Test conducted as planned	7	10	2	4	0	5	6	5	7	7
Backlogged test conducted	2	0	2	7	5	3	3	6	3	3
No Test	1	0	0	0	0	1	2	0	0	0
Test delayed	1	3	11	13	11	11	11	15	11	8
Test deleted or merged with another test	2	2	2	3	7	7	1	4	7	9

Accessible Data for Figure 4: Overarching Concerns Identified by the Missile Defense Agency (MDA) and the Military Services Related to Transferring Ballistic Missile Defense System (BMDS) Elements in Production

Category	If transferred	If not transferred
Budget	Military services may to devote comparable resources to the BMDS element, which could hinder future development and upgrades to keep pace with existing and emerging threats. However, offloading the BMDS element to the military service would free up resources in MDA's budget to pursue new and advanced efforts.	MDA will be responsible for an increasing amount of production, operation, and sustainment, which could grow to levels that are untenable due to fiscal constraints. This will limit the agency's ability to budget for new and advanced efforts in accordance with its original mission.
Prioritization	Military services will not likely have the same level of prioritization for the BMDS elements, as each has a much broader portfolio of weapon systems and missions that the BMDS element would have to compete with (i.e., 1 system among 100s).	MDA can maintain a higher level of prioritization for the BMDS element because the agency's portfolio is smaller and more focused (i.e., 1 system among about 10), according to DOD officials.
Control	Military services could opt out of testing, providing personnel, or pursuing advancements that they do not deem critical or high priority, which could limit MDA's ability to use that BMDS element as part of the current or future missile defense architecture.	MDA will retain control over development and upgrades to BMDS elements to keep pace with existing and emerging threats, irrespective of any potential military services' pushback or limitations.
Performance	Military services must contend with the risks associated with BMDS elements that have been developed and tested outside the robust standards and oversight (DOD 5000) designed to ensure weapon systems provide the needed capability and are safe when placed in the hands of the warfighter. BMDS elements will likely require additional investment and rework.	MDA may continue to provide BMDS elements that are conditionally released to the military services for operational use (i.e., with risks) with a recurring cycle of upgrades or retrofits.

Accessible Data for Figure 6: The Missile Defense Agency's Budget by Funding Type, Fiscal Years 2010-2019

Fiscal Year	New (Research and Development)	Ongoing (Research and Development)	Procurement	Operations and Sustainment (O&S)
2010	$482,537.58	$7,945,122.50	$697,151.00	$0
2011	$487,920.63	$8,162,153.63	$1,105,767.00	$0
2012	$651,877.35	$6,845,056.42	$2,027,514.00	$202,758
2013	$843,020.77	$6,147,089.28	$1,240,303.00	$259,975
2014	$394,051.78	$5,846,429.52	$1,743,034.00	$256,201
2015	$183,073.98	$5,926,846.14	$1,552,440.00	$416,644
2016	$510,062.72	$6,183,688.37	$1,443,522.00	$432,068
2017	$575,632.11	$5,689,925.57	$1,051,040.00	$446,975
2018	$911,790.47	$5,539,219.73	$1,225,930.00	$504,058
2019	$793,011.02	$6,119,778.66	$2,480,624.00	$499,817
Total:	$5,832,978.41	$64,405,309.81	$14,567,325.00	$3,018,496.00

Accessible Data for Figure 7: Aegis Ballistic Missile Defense (BMD) Weapons System, Appendix I

Highlights of GAO's review for Fiscal Year 2019

- Aegis Ballistic Missile Defense (BMD) demonstrated key capabilities and achieved model accreditation, but challenges continue.
- Next generation of Aegis BMD capabilities remained on schedule in fiscal year 2019.

Accessible Data for Figure 8: Aegis Ballistic Missile Defense (BMD) Standard Missile-3 (SM-3) Block IB, Appendix II

Highlights of GAO's review for Fiscal Year 2019

- A planned multi-year procurement was delayed by a lack of appropriated funds.
- Parts quality issues and difficulty achieving planned multi-year procurement constitute risks for the program.

Accessible Data for Figure 9: Aegis Ballistic Missile Defense (BMD) Standard Missile-3 (SM-3) Block IIA, Appendix III

Highlights of GAO's review for Fiscal Year 2019

- The Aegis SM-3 Block IIA successfully returned to flight in two tests, including one which demonstrated the Engage on Remote capability for the first time.
- Testing and quality issues delayed authorization for initial production, pending the completion of further studies.

Accessible Data for Figure 10: Command, Control, Battle Management, and Communications (C2BMC), Appendix IV

Highlights of GAO's review for Fiscal Year 2019

- MDA fielded Spiral 8.2-3, but testing will continue as capabilities from other elements become available.
- New development approach for Spiral 8.2-5 could shorten timelines, but challenges increase risk to planned delivery.

Accessible Data for Figure 11: Ground-based Midcourse Defense, Appendix V

Highlights of GAO's review for Fiscal Year 2019

- Recent salvo test proved insightful but plans for future tests are uncertain.
- Missile Defense Agency (MDA) and contractors had multiple opportunities to address issues that led to the Redesigned Kill Vehicle's (RKV) cancellation.
- RKV cost more than tripled and was delayed by over 4 years prior to cancellation.
- Lessons learned from RKV are informing the Next Generation Interceptor.

Accessible Data for Figure 13: Sensors, Appendix VI

Highlights of GAO's Fiscal Year 2019 Review

A. Army Navy/Transportable Radar Surveillance and Control Model 2 (AN/TPY-2) software updates and processor upgrades delivered.

B. Long Range Discrimination Radar (LRDR) demonstrates hardware and software maturity as it moves into full-rate manufacturing, but risks being monitored ahead of key milestone.

C. Sea Based X-Band (SBX) moves forward with software development and works through legacy software challenges.

D. Upgraded Early Warning Radar (UEWR) capability deliveries begin after years of delays.

Accessible Data for Figure 16: Targets and Countermeasures, Appendix VII

Highlights of GAO's review for Fiscal Year 2019

- Targets program met some of its fiscal year 2019 goals and completed other goals recently added or delayed from prior fiscal years.
- Availability risk for intermediate–and intercontinental-range targets was mitigated by cancellation of the Ground-based Midcourse Defense's Redesigned Kill Vehicle effort, but other challenges have emerged.
- Targets program considering a revised acquisition approach to enable faster development and reduced costs.

Accessible Data for Figure 17: Changes to Intermediate- and Intercontinental-Range Targets' Delivery Schedule, through Fiscal Year 2023

na	na	FY2019				FY2020				FY2021				FY2022				FY2023			
Category	**Subcategory**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
FY18 Target delivery Schedule	Intermediate Range Ballistic Missile		XX		X				X		X	X			X		X			XXX	
FY18 Target delivery Schedule	Intercontinental Ballistic Missile	X				X							X				X				X
Current Target delivery Schedule	Intermediate Range Ballistic Missile	XX									XX		X								
Current Target delivery Schedule	Intercontinental Ballistic Missile	X					X			X							X				

X = target delivery
FY = fiscal year

Accessible Data for Figure 18: Development Time and Cost for Some Missile Defense Targets

(Costs converted to FY20 dollars)

Extended Long Range Air Launch Target
E-LRALT

- Contract award: 2008
- 1st flight: 2012
- Time between contract award and 1st flight: 4.33 years
- Initial cost: $102.38
- Current cost: $58.00

Extended Medium Range Ballistic Missile
eMRBM

- Contract award: 2008
- 1st flight: 2013
- Time between contract award and 1st flight: 4.92 years
- Initial cost: $65.36
- Current cost: $105.93

Medium Range Ballistic Missile Type 1/Type 2
MRBM T1/T2

- Contract award: 2013
- 1st flight: 2019
- Time between contract award and 1st flight: 5.83 years
- Initial cost: $31.56
- Current cost: $43.18

Medium Range Ballistic Missile Type 3 Configuration 1
MRBM T3c1

- Contract award: 2011
- 1st flight: 2014

- Time between contract award and 1st flight: 3.25 years
- Initial cost: $63.12
- Current cost: $37.87

Intermediate Range Ballistic Missile Type1/Type2
IRBM T1/T2
- Contract award: 2011
- 1st flight: 2015
- Time between contract award and 1st flight: 4.25 years
- Initial cost: $62.33
- Current cost: $48.15

Intercontinental Ballistic Missile Type 1/Type 2
ICBM T1/T2
- Contract award: 2012
- 1st flight: 2017
- Time between contract award and 1st flight: 4.58 years
- Initial cost: $60.36
- Current cost: $95.69

Launch Vehicle-2
LV-2
- Contract award: 2003
- 1st flight: 2010
- Time between contract award and 1st flight: 7 years
- Initial cost: $101.20
- Current cost: $305.36

Average cost: $69.47 - $99.17 million
Average development time: 4.88 years

Accessible Data for Figure 19: Terminal High Altitude Area Defense (THAAD), Appendix VIII

Highlights of GAO's review for Fiscal Year 2019

- Terminal High Altitude Area Defense (THAAD) continued interceptor deliveries and conducted a flight test in fiscal year 2019.
- Members of Congress expect MDA to transfer the procurement, operation, and maintenance of THAAD to the Army, but transfer is unlikely to occur.
- THAAD is exploring potential for homeland defense contributions

Accessible Data for Figure 20: Terminal High Altitude Area Defense's (THAAD) Aggressive Flight Test Schedule and Upgrades to Meet Urgent Warfighter Needs

na	FY2019				FY2020				FY2021			
Category	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
FY19 Test Schedule			X			X						X
FY20 Test Schedule				X	X	XX		X	X	X	X	

Agency Comment Letter

Accessible Text for Appendix IX Comments from the Department of Defense

Page 1

Mr. Walter Russell

Director

Contracting and National Security Acquisitions

U.S. Government Accountability Office

441 G Street, NW

Washington, DC 20548

Dear Mr. Russell:

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Sincerely,

Michael D. Griffin

Enclosure:

As stated

Page 2

DEPARTMENT OF DEFENSE

RESPONSE TO GOVERNMENT ACCOUNTABILITY OFFICE

REQUEST FOR INFORMATION "FY19 MANDATE AUDIT" #103535

DEPARTMENT OF DEFENSE RESPONSE TO REPORT RECOMMENDATION

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However, MDA will ensure an independent assessment of the IMTP process is conducted, as recommended. MDA will contact GAO and request a short list of potential qualified organizations to conduct this assessment.

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