



June 2019

MISSILE DEFENSE

Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability

Accessible Version

GAO Highlights

Highlights of [GAO-19-387](#), a report to congressional committees

View [GAO-19-387](#). For more information, contact Cristina Chaplain at (202) 512-4841 or Chaplainc@gao.gov.

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 to 2017, MDA has received about \$142 billion and has requested 46.7 billion through fiscal year 2023 to develop the BMDS. The BMDS consists of diverse and highly complex land-, sea-, and space-based systems and assets located across the globe, including planned sites in Romania and Poland to protect United States forces and allies in Europe.

The National Defense Authorization Act for Fiscal Year 2012, as amended, included a provision that GAO annually assess and report on MDA's progress. Among other objectives, this report addresses for fiscal year 2018 (1) the progress MDA made in achieving delivery and testing goals and (2) the extent to which MDA made progress in developing and delivering integrated regional BMDS capabilities. GAO reviewed the planned fiscal year 2018 baselines and other program documentation and assessed them against program and baseline reviews and GAO's acquisition best practices guides, and interviewed officials from relevant agencies.

What GAO Recommends

GAO is recommending that MDA use the schedule margin afforded by the European Phased Adaptive Approach Phase 3 delay to conduct testing necessary to more thoroughly assess, prior to delivery, the capabilities and limitations of Phase 3 against the expected missile threat. DOD partially concurred with our recommendation. GAO continues to believe the recommendation is valid.

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What GAO Found

In fiscal year 2018, the Missile Defense Agency (MDA) made progress toward achieving its delivery and testing goals for some of the individual systems—known as elements—that combine and integrate to create the Ballistic Missile Defense System (BMDS). MDA is also making progress testing for integrated capabilities, which are achieved by combining BMDS elements. However, MDA did not meet its planned goals. The figure below shows MDA's progress delivering assets and conducting tests against its fiscal year 2018 plans.

Proportion of Missile Defense Agency Planned Deliveries and Tests Completed for Fiscal Year 2018



Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Data table for Proportion of Missile Defense Agency Planned Deliveries and Tests Completed for Fiscal Year 2018

	Number	Percentage
Assets delivered	68 of 97 planned	70%
Tests conducted	7 of 11 planned	64%

- MDA delivered a significant integrated capability for defending the United States, meeting a goal set by the Secretary of Defense in March 2013 to increase the inventory of ground-based interceptors by December 2017.
- Other on-time deliveries included software upgrades and additional assets. However, developmental challenges and testing failures contributed to MDA being unable to deliver all assets as planned.
- MDA completed four of eight flight tests. MDA successfully conducted testing to support a production decision; however, it was unable to complete its annual test plan due to failures, cancellations, and delays.

MDA has delayed the delivery of the BMDS's European Phased Adaptive Approach (EPAA) Phase 3—which is intended to protect allies from Iranian threats—until 2020. Construction contractor issues at the planned Aegis Ashore site in Poland drove the delay. At the same time, testing for EPAA Phase 3 against planned threats has been substantially reduced and other vital testing has been deferred until after delivery. MDA officials consider EPAA testing for Phase 3 delivery complete. However, DOD guidance and acquisition best practices stress the importance of testing to understand the extent of capabilities and how to deploy them. The 18-month delay to EPAA Phase 3 provides MDA an opportunity to conduct additional testing and collect more performance data. This testing could provide the warfighter with more information and confidence in the system's ability to protect our allies against expected ballistic missile threats.

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Abbreviations

Aegis BMD	Aegis Ballistic Missile Defense
AN/TPY-2	Army Navy/Transportable Radar Surveillance and Control Model- 2
AAW	Anti-Air Warfare
AWS	Aegis Weapon System
BAR	BMDS Accountability Report
BMD	Ballistic Missile Defense
BMDS	Ballistic Missile Defense System
BOA	BMDS Overhead Persistent Infrared Architecture
C2BMC	Command, Control, Battle Management, and Communications
CAPE	Cost Assessment and Program Evaluation
CE-I	Capability Enhancement-I
CE-II	Capability Enhancement-II
CU	Capability Upgrade
DCMA	Defense Contract Management Agency
DFARS	Defense Federal Acquisition Regulation Supplement
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
EKV	Exoatmospheric Kill Vehicle
EOR	Engage on Remote

EPAA	European Phased Adaptive Approach
FRB	Failure Review Board
FY	Fiscal Year
GBI	Ground-based Interceptor
GMD	Ground-based Midcourse Defense
HAFD	Hybrid Arm Fire Device
IAMD	Integrated Air and Missile Defense
ICBM	Intercontinental Ballistic Missile
IRBM	Intermediate-Range Ballistic Missile
JEON	Joint Emergent Operational Needs
LRDR	Long Range Discrimination Radar
MDA	Missile Defense Agency
MDDE	Missile Defeat and Defense Enhancements
MRBM	Medium-Range Ballistic Missile
NTE	Not-to-Exceed
RKV	Redesigned Kill Vehicle
SM-3	Standard Missile-3
TDACS	Throttleable Divert and Attitude Control System
THAAD	Terminal High Altitude Area Defense
TSRM	Third Stage Rocket Motor
UCA	Undefinitized Contract Actions
USFK	United States Forces Korea

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June 6, 2019

Congressional Committees

For over half a century, the Department of Defense (DOD) has been funding efforts to develop, field, and maintain a system to detect, track, and defeat enemy ballistic missiles—this system is known as the Ballistic Missile Defense System (BMDS). The BMDS includes a diverse collection of land-, sea-, and space-based systems and assets located across the globe. From 2002 to 2017, the Missile Defense Agency (MDA)—the agency charged with developing and integrating the BMDS—has received approximately \$142 billion. MDA requested \$7.9 billion in fiscal year 2018 and an additional \$46.7 billion through fiscal year 2023 to continue development, production of additional assets and capabilities, and maintenance of fielded assets. However, in December 2017, Congress passed and the President signed into law additional appropriations totaling approximately \$2 billion for missile defeat and defense enhancements that DOD used to expand and accelerate several MDA programs.

Since 2002, various National Defense Authorization Acts have included provisions for us 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.

For 15 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.¹ This year, our 16th annual report addresses, for fiscal year 2018: (1) the progress MDA and its missile defense programs made in achieving delivery and testing goals; (2) how MDA responded to budget changes; and (3) the extent to which MDA made progress in developing and delivering integrated regional BMDS capabilities. In addition, appendixes I-VIII contains more detailed information on BMDS elements assessed in the report and their fiscal

¹Related GAO products are listed at the end of this report.

year 2018 activities. We plan to issue a separate report later in 2019 on the extent to which MDA made progress in developing capabilities to address the emerging threats on the Korean Peninsula.

We focused our assessment on MDA's progress towards achieving its delivery and testing goals. To evaluate asset delivery and testing goals, we reviewed MDA's planned baselines as expressed in the BMDS Accountability Report, approved June 15, 2017, as well as the Integrated Master Test plan. We compared these plans against MDA's actual delivery and testing achievements recorded in agency documents and through interviews with agency officials, contractors, and relevant officials in the Department of Defense's (DOD) Office of the Director of Operational Test and Evaluation (DOT&E) and the BMDS Operational Test Agency as well as officials from U.S. Northern Command and the Joint Functional Component Command for Integrated Missile Defense.² We also provided detailed questionnaires on the fiscal year 2018 progress and challenges to the 9 MDA programs included in this report. We assessed the agency's performance in view of GAO's work on best practices for knowledge-based defense acquisition, Department of Defense Acquisition Regulations, and the Defense Federal Acquisition Regulation Supplement (DFARS).³

To review changes MDA made in response to budget changes from a supplemental appropriation in fiscal year 2018, we reviewed budget submissions and legislative language. We compared these revised plans, once enacted, to MDA's existing baselines, and included questions about revised schedules and contracting strategies in our questionnaires submitted to MDA programs. We also interviewed MDA contracting officials and reviewed documentation relating to MDA's use of contract actions for which contract terms, specifications, or price are not agreed

²Led by U.S. Strategic Command, the Joint Functional Component Command for Integrated Missile Defense comprises warfighter personnel from the military services and is tasked with synchronizing missile defense plans, conducting missile defense operations support, and advocating for missile defense capabilities.

³GAO, *Federal Acquisitions: Congress and the Executive Branch Have Taken Steps to Address Key Issues, but Challenges Endure*, [GAO-18-627](#), (Washington, D.C.: Sep. 12, 2018); *Defense Acquisitions: DOD's Revised Policy Emphasizes Best Practices, but More Controls are Needed*, [GAO-04-53](#), (Washington, D.C.: Nov. 10, 2003). Also see US Department of Defense, "Department of Defense Instruction 5000.1: Operation of the Defense Acquisition System", 31 Aug 2018 and US Department of Defense, "Defense Federal Acquisition Regulation Supplement," (DFARS).

upon before work is begun, known as “undefinitized contract actions” in programs affected by mid-year appropriations.

To determine what progress MDA achieved in developing and delivering capabilities and assets to support an integrated BMDS, we reviewed and analyzed relevant policies and guidance, including the Defense Acquisition Guidebook and the BMDS Warfighter Capability Acceptance guidance, and asset delivery goals baselined in the March 2017 BAR. Additionally, we reviewed available system engineering and integration planning documents—including prior years’ Master Integration Plans—as well as program management and testing documentation. To discuss the progress of developing an integrated capability and the delivery of assets, we met with officials from MDA’s Directorate for Engineering, MDA’s Directorate for Testing, individual element program offices, as well as DOD’s independent testers the United States Northern Command and the Joint Functional Component Command for Integrated Missile Defense. In addition, we interviewed officials from United State Forces Korea.

We conducted this performance audit from June 2018 to June 2019 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 elements included in our review.

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

BMDS elements	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.
<ul style="list-style-type: none"> Aegis BMD Standard Missile-3 (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.
<ul style="list-style-type: none"> 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.
<ul style="list-style-type: none"> 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.
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 Ground-based Midcourse Defense, or (2) terminal mode—to support Terminal High Altitude Area Defense.
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 (BOA), 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)1 boost vehicle and Capability Enhancement (CE)-I kill vehicle; 16 interceptors equipped with the C1 boost vehicle and CE-II kill vehicle; and 8 interceptors equipped with the C2 boost vehicle and CE-II Block I kill vehicle.
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. It is currently being designed while construction activities continue at Clear Air Force Station, Alaska. MDA plans on operationalizing the radar in fiscal year 2020.
Targets and Countermeasures ^a	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- and medium-range threats using a battery that consists of interceptors, launchers, a radar, and fire control and communication systems.

Source: GAO analysis of MDA data. | GAO-19-387

Note: 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.

^aTargets and Countermeasures provide assets to test the performance and capabilities of the BMDS elements, but these testing assets are not operationally fielded.

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

When MDA was established in 2002, it was granted exceptional flexibilities to set requirements and manage the acquisition of the BMDS—developed as a single program—that allow MDA to expedite the fielding of assets and integrated 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 is ready to be handed over to a military service for production and operation. Some of the laws and policies include such things as:

- obtaining the approval of a higher-level acquisition executive before making changes to an approved baseline,⁴
- reporting certain increases in unit cost measured from the original or current baseline,⁵
- obtaining an independent life-cycle cost estimate prior to beginning system development and/or production and deployment, and ⁶
- regularly providing detailed program status information to Congress, including specific costs, in Selected Acquisition Reports.⁷

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.⁸ 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

⁴ DOD Instruction 5000.02, Operation of the Defense Acquisition System, Enc. 1 para. 4 and Table 3. (Jan. 7, 2015) (incorp. change 4, eff. Aug. 31, 2018).

⁵ 10 U.S.C. § 2433.

⁶ 10 U.S.C. § 2434.

⁷ 10 U.S.C. § 2432.

⁸ National Defense Authorization Act for Fiscal Year 2008, Pub. L. No. 110-181, § 223(g), repealed by Pub. L. No. 112-81, § 231(b)(2) (2011).

more details for the content of these baselines.⁹ Additionally, to enhance oversight of the information provided in the BMDS Accountability Report, MDA continues to incorporate suggestions and recommendations from GAO. However, not all of our recommendations have been fully implemented. For example, in April 2013, we recommended that MDA stabilize its acquisition baselines so that meaningful comparisons can be made over time to support oversight. MDA stated that the information presented in the BAR is sufficient; however, we continue to find that the lack of stable baselines makes comparison difficult and in some instances, impossible.¹⁰

MDA's Process for Delivering Capabilities

MDA develops capabilities and then delivers them to the military services. Using this process, MDA declares an asset or capability ready for delivery for potential operational use while communicating the capabilities and limitations of the asset. Representatives from the receiving military service or combatant command then have the ability to assess this evidence and decide whether to accept the new capability.¹¹ Because the military services conduct minimal missile defense testing of their own, this process is one of the only ways to convey vital performance information. The accuracy of this information is especially important as it informs training materials, doctrine, and deployment decisions and provides evidence supporting these assertions.

MDA supports its assertions of capabilities with evidence from three sources: models and simulations, ground testing, and flight testing. Ground tests and models and simulations permit more flexibility in

⁹See, e.g., the National Defense Authorization Act for Fiscal Year 2012, Pub. L. No. 112-81, § 231, codified at 10 U.S.C. § 225, that requires 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.

¹⁰GAO, *Missile Defense: Opportunity to Refocus on Strengthening Acquisition Management*, [GAO-13-342](#), (Washington, D.C.: April 26, 2013).

¹¹There are ten combatant commands that either control all operational forces within a geographic area of responsibility, such as the U.S. European Command, or the U.S. Pacific Command, or have a functional responsibility with a global scope, such as the U.S. Transportation Command, or the U.S. Strategic Command (for nuclear forces).

scheduling and design, but both are dependent on logistically more difficult flight tests to provide real-world performance data. As a result, MDA's ability to organize, conduct, and evaluate flight tests is one of the most important factors in whether MDA is able to adhere to its schedule and declare an asset or capability ready for delivery.¹²

MDA's Contracting Practices

Though MDA has flexibilities in managing the acquisition process, it must follow the same contracting regulations that apply to DOD, including the Federal Acquisition Regulation and the Defense Federal Acquisition Regulation Supplement (DFARS).¹³ For this report, we reviewed MDA's use of a particular type of contract action that authorizes a contractor to begin work before contract terms, specifications, or price have been agreed upon. These "undefinitized contract actions" are permitted by the DFARS, with certain limitations.¹⁴ Undefinitized contract actions are generally used when negotiation of a definitive contract action is not possible in sufficient time to meet the government's requirements and the government's interest demands that the contractor be given a binding commitment so that contract performance can begin immediately. Under the DFARS, undefinitized contract actions must include a specific "not-to-exceed" price.¹⁵ Once the action's terms, specifications, and price have

¹²For further details about MDA's Capability process, 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 30, 2018). For further details on MDA's testing process, see GAO, *Missile Defense: Some Progress Delivering Capabilities, but Challenges with Testing Transparency and Requirements Development Need to Be Addressed*, [GAO-17-381](#) (Washington, D.C.: May 30, 2017).

¹³The Federal Acquisition Regulation prescribes uniform policies and procedures for acquisition by all executive agencies and the DFARS is DOD's implementation and supplementation of the FAR which governs DOD acquisitions.

¹⁴DFARS § 217.7400. Undefinitized contract actions are any contract action for which the contract terms, specifications or price are not agreed upon before performance is begun under the action. Contract modifications for additional supplies or services and task and delivery orders are considered contract actions. DFARS § 217.7401.

¹⁵DFARS 2 § 17.7404-2.

been agreed upon or determined, a process known as definitization, the contract action converts to a “definitive” contract.¹⁶

Under the DFARS, undefinitized contract actions must contain definitization schedules that provide for definitization by the earlier of (1) 180 days after issuance or (2) the date on which the amount of funds obligated under the action is more than 50 percent of the not-to-exceed price.¹⁷ Once the government has received a qualifying proposal from the contractor, however, the government can extend the undefinitized period another 180 days. Similarly, the government may obligate up to 75 percent of the not-to-exceed price, if the contractor submits the qualifying proposal before 50 percent of the not-to-exceed price has been obligated.¹⁸

MDA’s Regional Efforts in Europe and Korea

DOD’s regional Ballistic Missile Defense (BMD) effort consists of a number of specific weapon systems or elements that compose the BMD system as a whole. According to DOD, various versions of these weapon systems are being deployed in Europe, Korea and other regions. The European effort known as the European Phased Adaptive Approach (EPAA) integrates the upgrades to Aegis BMD Weapon System, Aegis BMD interceptors, C2BMC and sensors, and was originally planned for delivery in four phases.¹⁹ Additionally, each phase is designed to rely on increasingly capable missiles, sensors, command and control, and

¹⁶We have conducted a number of reviews of the use of undefinitized contract actions within the Department of Defense, including, most recently, GAO, *Defense Contracting: Observations on Air Force Use of Undefinitized Contract Actions*, GAO 15-496R (Washington, D.C.: May 18, 2015); *Defense Contracting: DOD Has Enhanced Insight into Undefinitized Contract Action Use, but Management at Local Commands Needs Improvement*, [GAO-10-299](#) (Washington, D.C.: Jan. 28, 2010); and *Defense Contracting: Use of Undefinitized Contract Actions Understated and Definitization Timeframes Often Not Met*, [GAO-07-559](#) (Washington, D.C.: June 19, 2007).

¹⁷DFARS § 217.7404-3.

¹⁸DFARS § 217.7404-4. A qualifying proposal is one which contains data sufficient for DOD to perform complete and meaningful analyses and audits of both the data in the proposal; and any other data that the contracting officer determines the government needs to review in connection with the contract.

¹⁹In March 2013, the Secretary of Defense canceled 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.

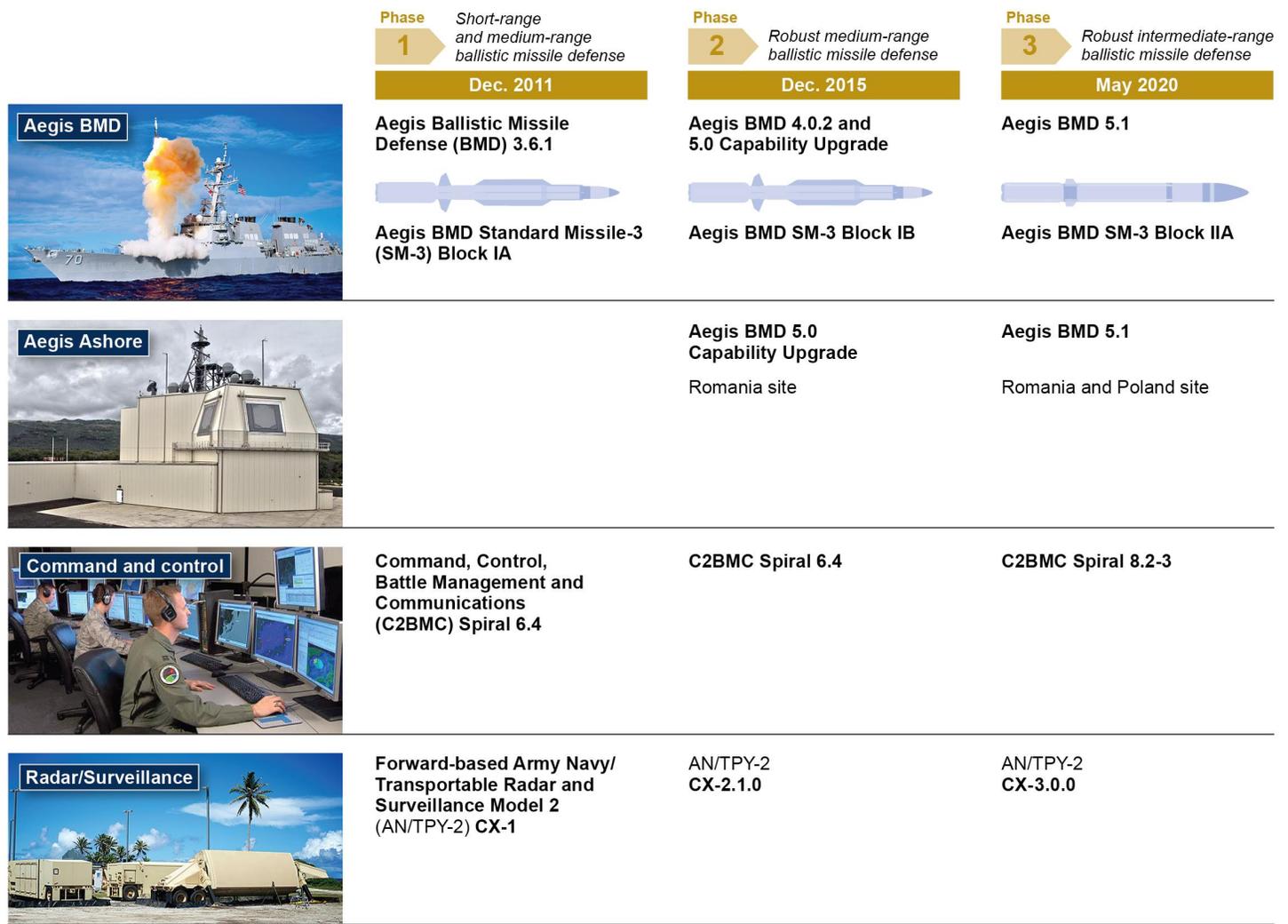
integration to defend Europe against increasingly longer range ballistic missiles.

DOD delivered the first phase, for short- and medium-range defense of Europe, in December 2011, and delivered the second phase for medium-range missiles in December 2015.²⁰ Its efforts for both of these phases were also characterized by schedule delays, technical challenges that led to reductions in the scope of capability delivered, as well as testing reductions, which reduced confidence in capabilities that had been delivered.²¹ According to its capability plans, the purpose of EPAA Phase 3 is to provide a “robust Intermediate-Range Ballistic Missile (IRBM) defense.” Figure 1 depicts the weapon systems that DOD deployed in support of the European Phased Adaptive Approach capability.

²⁰The target ranges are as follows: short (Less than 1000 kilometers), medium (1000 to 3000 kilometers), intermediate (3000 to 5500 kilometers), and intercontinental (greater than 5500 kilometers).

²¹For further details on EPAA, 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 Capabilities*, [GAO-16-339R](#) (Washington, D.C.: Apr . 28, 2016); and [GAO-17-381](#).

Figure 1: Elements and Delivery Timeframes for European Phased Adaptive Approach Capabilities



Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Data for Figure 1: Elements and Delivery Timeframes for European Phased Adaptive Approach Capabilities

	Phase 1: Short-range and medium-range ballistic missile defense	Phase 2: Robust medium-range ballistic missile defense	Phase 3: Robust intermediate-range ballistic missile defense
Delivery Timeframe	Dec. 2011	Dec. 2015	May 2020
Aegis BMD	Aegis Ballistic Missile Defense (BMD) 3.6.1 Aegis BMD Standard Missile-3 (SM-3) Block IA	Aegis BMD 4.0.2 and 5.0 Capability Upgrade Aegis BMD SM-3 Block IB	Aegis BMD 5.1 Aegis BMD SM-3 Block IIA
Aegis Ashore	NA	Aegis BMD 5.0 Capability Upgrade Romania site	Aegis BMD 5.1 Romania and Poland site
Command and control	Command, Control, Battle Management and Communications (C2BMC) Spiral 6.4	C2BMC Spiral 6.4	C2BMC Spiral 8.2-3
Radar/Surveillance	Forward-based Army Navy/ Transportable Radar and Surveillance Model 2 (AN/TPY-2) CX-1	AN/TPY-2 CX-2.1.0	AN/TPY-2 CX-3.0.0

As we have previously reported, MDA encountered numerous challenges in an effort to meet its original EPAA goals and we have made several recommendations to improve MDA’s management of its integrated capability efforts, including EPAA, to reduce risk for individual elements and to improve testing practices overall. For instance:

- In January 2011, we recommended that DOD develop life-cycle cost estimates and establish an integrated schedule for EPAA. DOD partially concurred and concurred, respectively, to the recommendations. An independent life cycle cost estimate was prepared, however an integrated schedule that produced sufficient detail was never completed.²²
- In April 2012, we recommended that DOD assess the extent to which the dates announced by the President in 2009 are contributing to concurrency and recommend schedule adjustments where significant benefits can be obtained. DOD did concur with this recommendation,

²²GAO, *Ballistic Missile Defense: DOD Needs to Address Planning and Implementation Challenges for Future Capabilities in Europe*, [GAO-11-220](#) (Washington, D.C.: Jan. 26, 2011).

however never included a specific assessment of the extent to which capability delivery dates for the European Phased Adaptive Approach announced by the president in 2009 were contributing to concurrency; instead, it asserts that BMDS technology development is fundamentally driven by completion of technical milestones, not schedule declarations.²³

- In May 2017, we recommended that MDA address deficiencies in its testing scheduling policy to better align it with best practices for scheduling. DOD did not concur with this recommendation.²⁴ Consequently, the department continues to allow MDA to schedule and plan its test program without risk analyses, or assigning resources to each test. Unless the department takes action to address these challenges, the department should continue to expect MDA to fall further behind in its test program.

In fiscal year 2018, MDA focused additional regional capability efforts on the Korean Peninsula. This new effort was requested by the United States Forces Korea in December 2017 to counter North Korean ballistic missiles. Capabilities for the Korean effort are currently planned for delivery between February 2018 and April 2021, and are based on element-level upgrades as well as integration enhancements between THAAD and Patriot.²⁵

MDA Made Progress Delivering Capabilities and Assets and Conducting Tests but Fell Short of Its 2018 Goals

In fiscal year 2018, MDA delivered several significant capabilities and assets. These successful deliveries included a significant asset delivery milestone for MDA's homeland defense mission, as well as several element-level software updates, and, in one case, making up for backlogs in asset deliveries from the previous year. However, MDA did not meet most of its asset delivery goals as described in the BAR that laid out plans for fiscal year 2018. In addition, in fiscal year 2018, MDA conducted

²³[GAO-12-486](#).

²⁴[GAO-17-381](#).

²⁵We have initiated a separate review on MDA's status on providing these capabilities and how they align to counter the threat.

seven of the eleven flight tests laid out in its baseline Integrated Master Test Plan in part due to test delays, cancellations, and failures

MDA Delivered Several Important Capabilities According to Its Planned Baseline, but Did Not Meet Most of Its Asset Delivery Goals

In December 2017, MDA achieved a significant asset delivery milestone, completing the deployment of 44 operational ground-based interceptors (GBI). In deploying these interceptors, MDA also fulfilled a goal set by the Secretary of Defense in March 2013 to increase the inventory of GMD interceptors from 30 to 44 by the end of December 2017. Although MDA achieved this goal, it did not deliver two of the four GBIs planned for fiscal year 2018. One of the GBIs is intended for use in an upcoming flight test that was delayed to fiscal year 2019. The other delayed GBI delivery was the result of the boost vehicle contractor mishandling the booster avionics module—a critical component that houses the flight computer and navigation systems. The contractor is working on replacing the component but the rework has delayed delivery of the final GBI to fiscal year 2020.

Other on-time capability deliveries included the release of new software versions for several major BMDS elements, including C2BMC (Spiral 8.2-3), BOA 6.1, THAAD (THAAD 3.0), AN/TPY-2 (CX 3.0), and GMD (GS 7A). Another expected software release was Aegis Weapon System (BL 9.2), but that was delayed to at least March 2019 to accommodate verification and validation of models and simulations and to accompany the delivery of the Aegis BMD SM-3 Block IIA. In terms of asset deliveries, specifically interceptors used to counter enemy missiles, MDA successfully delivered all 53 THAAD interceptors specified in the baseline for fiscal year 2018, as well as an additional five interceptors the delivery of which had been delayed from the previous year. For a summary of MDA’s asset delivery status for fiscal year 2018, see table 2.

Table 2: Missile Defense Asset Deliveries in Fiscal Year 2018

Element	Planned delivery	Status
Standard Missile -3 Block IB	36 interceptors	12 delivered. Further deliveries suspended after discovery of parts quality issue pending investigation (see Appendix III).
Standard Missile – 3 Block IIA	4 interceptors	1 delivered. Deliveries of additional test articles suspended following failure of the flight test named FTM-29.

Element	Planned delivery	Status
Ground Based Interceptors	4 interceptors	2 delivered, 2 delayed due to contractor and test delays. However, no impact on 44-interceptor goal.
Terminal High Altitude Area Defense Interceptors	53 interceptors	58 delivered.

Source: GAO analysis of MDA data. | GAO-19-387

Although MDA made a number of deliveries, including all planned THAAD interceptors, it did not meet its fiscal year 2018 asset delivery goals due to a variety of factors. The Aegis BMD SM-3 Block IB program, which received full production authority early in fiscal year 2018 after years of delays, delivered 12 of 36 planned interceptors in fiscal year 2018. This shortfall was due to the discovery of a parts quality issue that necessitated suspending deliveries until MDA could complete an investigation of the issue’s impact on the interceptor’s performance. In addition, the Aegis BMD SM-3 Block IIA program delivered one of four planned test interceptors due to a flight test failure early in the year suspending further deliveries pending completion of a failure review board.

Moreover, according to MDA officials, construction contractor performance issues will result in the Aegis Ashore Missile Defense System Complex—Poland not being delivered until at least 18 months after the planned December 2018 date. As discussed later in this report, this facility is central to MDA’s plans for the EPAA Phase 3, such that a delay in the completion of this facility resulted in a delay in the planned EPAA Phase 3 delivery to the warfighter.

MDA Conducted Seven of Eleven Flight Tests Planned for Fiscal Year 2018, One of Which Failed

MDA conducted seven fiscal year 2018 flight tests as planned, and during one of those seven the interceptor failed. According to MDA’s Integrated Master Test Plan, MDA scheduled eleven flight tests of the systems included in our review. MDA’s ability to adhere to its flight test schedule for fiscal year 2018 was hampered by several issues, including technical challenges, test failures requiring new tests to be inserted into the schedule, and range and target availability. Of the four tests not conducted, MDA delayed two to future fiscal years, and deleted two, with their objectives planned to be mostly fulfilled by separate events. Table 3 highlights MDA’s fiscal year 2018 flight tests.

Table 3: Fiscal Year 2018 Flight Tests

	Name of Planned Test	Flight test type	Conducted (yes or no)	Status and Description
1	FE-1	Non-intercept	Yes	Met objectives. Test in which an Aegis BMD-equipped ship conducted data collection against a prototype intermediate range glide body.
2	FEV-01	Non-intercept	No	Test canceled. Flight experiment to evaluate airborne missile-tracking sensor technology. Deleted upon MDA's conclusion that sufficient data had been collected in previous tests. Planned MRBM target assigned to FTM-45.
3	FS-17-2	Non-intercept (simulated)	Yes	Met objectives. Test in which an Aegis Ballistic Missile Defense (BMD)-equipped ship tracked and engaged a short-range ballistic missile (SRBM) with a simulated Aegis BMD Standard Missile 3 (SM-3) Block IA.
4	FS-17-4	Intercept	Yes	Met objectives. Test of Aegis BMD SM -3 Block IB Threat Upgrade against a Medium-range ballistic missile (MRBM) target to support full production decision. Intercept successful.
5	FTG-11	Intercept	No	Delayed to fiscal year 2019. Developmental test of the Ground-based Midcourse Defense (GMD) system, as well as first salvo test in which multiple interceptors are fired against a single target. Delayed in part due to technical challenges upgrading software and range availability.
6	FTM-29	Intercept	Yes	Test failure. First test of Aegis BMD SM-3 Block IIA missile's ability to engage an intermediate-range ballistic missile (IRBM) target using remote sensor data. This test demonstrated related capabilities for the AN/TPY- 2 radar, Command and Control, Battle Management and Communications (C2BMC) and the Aegis Weapon System, but the Aegis BMD SM- 3 Block IIA interceptor's third-stage rocket motor failed to ignite, resulting in test failure. A failure review investigation has led to a significant re-plan of the Aegis BMD SM-3 Block IIA's test program.
7	FTO-03 Event 1 ^b	Intercept	No	Delayed to fiscal year 2019. Intercept test providing first operational test of the European Phased Adaptive Approach Phase 3 architecture, involving two Aegis SM-3 Block IIA missile fired against two IRBM targets. Delayed to accommodate new tests added to the schedule.
8	FTX-35	Non-Intercept	Yes	Met objectives. Terminal High Altitude Area Defense (THAAD) and Patriot tracked a ballistic missile target, exchanged messages over tactical datalinks, and conducted simulated engagements of the target. ^a
9	FTX-36	Non-Intercept	No	Test canceled. Test objectives moved to FTX-35 and achieved.
10	JFTM-05 Event 1	Non-intercept (simulated)	Yes	Met objectives. Test of Aegis BMD in which a Japanese navy vessel simulated an engagement firing an Aegis SM-3 Block IB against an SRBM.
11	JFTM-05 Event 2	Intercept	Yes	Met objectives. Intercept test of Aegis BMD SM-3 Block IB Threat Upgrade from a Japanese Navy vessel against short-range ballistic missile target. Intercept achieved.

Source: GAO analysis based on MDA data | GAO-19-387

Note: As in previous years, we have not reviewed tests in which MDA participated but whose primary system under test has already been turned over to one of the services, such as the Patriot program. We also did not review tests in which MDA participated where the primary system under test is that of a foreign partner, such as Israel's Iron Dome.

^aAlthough Patriot is not covered in this report, this test was designed to demonstrate interoperability between Patriot and THAAD.

^bFTO-03 Event 1 was subsequently de-scoped and re-named FTI-03. This test was conducted successfully in December 2018.

MDA also added several test events to its schedule over the course of fiscal year 2018. They are listed below in table 4.

Table 4: Added Fiscal Year 2018 Flight Tests

	Name of Added Test	Flight test type	Conducted (yes or no)	Status and Description
1	SM CTV-03	Non-intercept	Yes	Met objectives. Test of Aegis BMD-equipped ship firing a Standard-Missile 6 (SM-6) and exercising control post-launch.
2	FTX-33	Non-intercept	Yes	Met objectives. Tracking exercise to collect data in support of threat model validation, detection, tracking, and simulated engagement concept evaluation.
3	Pacific Dragon 2018	Non-intercept (simulated)	Yes	Met objectives. Simulated engagement of a short-range ballistic missile target with a simulated Aegis BMD SM-3 Block IB Threat Upgrade from an Aegis BMD-equipped Japanese navy vessel.

Source: GAO analysis based on MDA data. | GAO-19-387

The two most significant flight tests scheduled for fiscal year 2018 were delayed into fiscal year 2019. Specifically, FTG-11, GMD’s first salvo test (launching multiple interceptors at a single target), was delayed until the second quarter of fiscal year 2019 to accommodate other BMDs testing priorities while GMD fixed software issues uncovered during pre-test planning. In addition, FTO-03 Event 1, a test designed to assess the Aegis BMD SM-3 Block IIA capability against an IRBM was to be the first (and only) operational test of the EPAA Phase 3 architecture before MDA delivered the capability. This test was delayed to accommodate the demand for range and test assets following the insertion of a new test into the schedule.

Mid-Year Budget Changes Significantly Affected MDA’s Future-Year Plans

Fiscal year 2018 legislation expanded and accelerated several MDA programs. In December 2017, Congress passed and the President signed into law the Department of Defense Missile Defeat and Defense Enhancements Appropriations Act, 2018 (MDDE), which increased

missile defense appropriations.²⁶ The MDDE provided approximately \$2 billion in appropriations for missile defense. MDDE provided funds in support of plans that would expand and accelerate several missile defense programs beyond the agency's previous baselines. According to MDA, the administration directed the Secretary of Defense to develop options for accelerating missile defense capabilities in response to North Korea flight testing a new intercontinental ballistic missile in July 2017. According to MDA, it collaborated with Office of the Secretary of Defense and the Joint Chiefs of Staff to identify programs and capabilities that could be accelerated and delivered within the current Future Years Defense Plan and directly address the North Korean missile threat. DOD then took those options back to the administration to finalize the MDDE plan, which was subsequently presented to Congress. These plans most significantly affected the GMD program and the Aegis BMD SM-3 Block IIA.

Under the plans and with the funds provided by MDDE, the GMD program will increase its inventory from 44 GBIs to 64 GBIs by 2023. Each of these new interceptors will be equipped with the Redesigned Kill Vehicle (RKV), accelerating the latter program's schedule by approximately one year.²⁷

MDA also intends to use \$451 million from MDDE to procure 16 additional Aegis BMD SM-3 Block IIA interceptors. The Aegis BMD SM-3 Block IIA program was still in development at the time, and these funds represented the first time Congress appropriated procurement funds, and not research and development, for the program.

²⁶The act can be found at Division B of Public Law 115-96, Third Continuing Appropriations for Fiscal Year 2018, Missile Defense, Health Provisions, Other Matters, and Budgetary Effects.

²⁷ On May 24, 2019, MDA directed the GMD prime contractor, Boeing, to stop all work for the Redesigned Kill Vehicle. This action occurred a few days before the issuance of our report and, as such, we were not able to assess the effects and incorporate this information into our report.

Programs Accelerated and Expanded by the Fiscal Year 2018 Missile Defeat and Defense Enhancement Amendments Subsequently Experienced Challenges

RKV

The RKV program, in part to support the accelerated schedule, adopted a new program schedule that required concurrency in some areas. As we previously reported, the original RKV strategy avoided concurrency by aligning production decisions with flight testing.²⁸ However, to accommodate the newly accelerated schedule, the program began procuring some components before completing qualification testing.²⁹ Under this new plan, qualification testing would only be completed around the same time as the planned first flight test.

MDA's contracting plans for the RKV have been closely aligned to the test schedule, to the point that MDA will have more than half of its planned RKV buy under contract before conducting a successful intercept test. The program planned to award a production contract for Lot 1 and the long-lead materials contract for Lot 2 following a major design review, but before the first flight test. Following the first flight test (CTV-03+) in first quarter fiscal year 2020, the program planned to award a production contract for Lot 2 and long-lead materials for Lot 3. Upon completion of the first intercept test (FTG-17) in the first quarter of fiscal year 2021, the program planned to award the production contract for the final planned lot, Lot 3.

Through the course of fiscal year 2018, the RKV program has been unable to meet its cost and schedule milestones. Specifically, the prime contractor has reported accumulating negative cost and schedule variances with no signs of arresting these trends. The contractor also reported inefficiencies stemming from bringing large numbers of new staff onto the project, as well as requiring more personnel for the project than they originally anticipated. According to MDA, as fiscal year 2018

²⁸ [GAO-17-381](#); [GAO-18-324](#)

²⁹ Qualification testing is performed to verify the design and manufacturing process.

progressed, the program discovered that some components would not meet performance requirements. MDA therefore postponed the critical design review from fiscal year 2018 to fiscal year 2021. Moreover, MDA no longer plans to achieve its goal of fielding 64 interceptors by 2023. In addition, MDA anticipates RKV's total cost has increased by nearly \$600 million as a result of the design issues. See appendix VI for information on RKV and the GMD program.³⁰

Aegis BMD SM-3 Block IIA

The Aegis BMD SM-3 Block IIA schedule planned for an initial production decision in fiscal year 2018, but one month after the MDDE's enactment, the program experienced its second consecutive failure in a significant flight test—FTM-29—that introduced significant uncertainty into the Aegis BMD SM-3 Block IIA's schedule. In an effort to maintain the program's schedule, the Undersecretary of Defense for Acquisition and Sustainment in an Acquisition Decision Memorandum provided selective authorization to use procurement funds. The memorandum placed a cap on how much the program could spend, and had a list of approved "pacing items" (which excluded parts still under investigation for the test failure) on which the funds could be spent. Under the terms of the memorandum, MDA would have to meet a series of requirements to lift these limitations, such as completion of the failure review board and implementation and demonstration of corrective actions. MDA operated under these limitations for the remainder of the fiscal year.

MDA Relied on Undefined Contract Actions to Achieve Its Acquisition Goals

MDA used undefinitized contract actions (UCA) in fiscal year 2018, particularly in programs receiving MDDE appropriations. In May 2018, we found that MDA's use of UCAs in recent years had increased in both total not-to-exceed value and in the length of the undefinitized period.³¹ While MDA improved its performance in timely definitization of these contract actions in fiscal year 2018, the total not-to-exceed value of the

³⁰ On May 24, 2019, MDA directed the GMD prime contractor, Boeing, to stop all work for the RKV. This action occurred a few days before the issuance of our report and, as such, we were not able to assess the effects and incorporate this information into our report.

³¹ [GAO-18-324](#)

undefinitized contract actions MDA initiated in 2018 far exceeded previous years we reviewed.

UCAs allow work to begin on a program before the government and contractor have agreed to all contract terms, such as price or scope. MDA states that undefinitized contract actions are necessary, particularly in the case of programs accelerated by the MDDE appropriation, because they allow work to begin immediately. Coming to agreement on all terms before beginning work would have added months to program schedules that, MDA stated, could not accommodate such a delay. Undefinitized contract actions are permitted under the Defense Federal Acquisition Regulation Supplement, but we have found in the past that the use of these contracts can pose particular risks for the government.

Examples of recent UCAs follow:

- In October 2017, MDA issued a sole source undefinitized contract action for \$60 million (according to DOD and MDA, the value was later increased to \$88 million) for the purposes of transitioning the Aegis BMD SM-3 Block IIA program from development to production. This work will improve the manufacturing readiness of the contractor's production facilities, with the goal of eventually supporting a production rate of two interceptors per month.

According to MDA officials, definitizing this contract action proved difficult. The contractor's initial cost and fee position were substantially higher than MDA's and independent government estimates, even after those estimates were revised upwards when they were found not to include costs specific to the Aegis BMD SM-3 Block IIA. MDA initially planned for a definitization in April 2018. By that time, all terms had been agreed to except for the contractor's fee. According to MDA officials, the parties deadlocked until August 2018, when, with the authorization of the Director, MDA, contracting officials "unilaterally definitized" the contract. MDA officials told us that when a unilateral definitization occurs, the government essentially imposes its terms on a "take-it-or-leave-it" basis, effectively halting negotiations. According to MDA officials, in this case, the contractor acceded to the government's terms and continued work on the project. When asked about possible consequences to this action, MDA officials stated that it is possible for contractors in this situation to seek administrative relief, but in this case, they stated such an appeal would be unlikely to succeed, and believed the contractor would be unlikely to pursue it. It is also possible, officials said, that the contractor would either be

reluctant or refuse to accept an undefinitized contract action from MDA in the future.

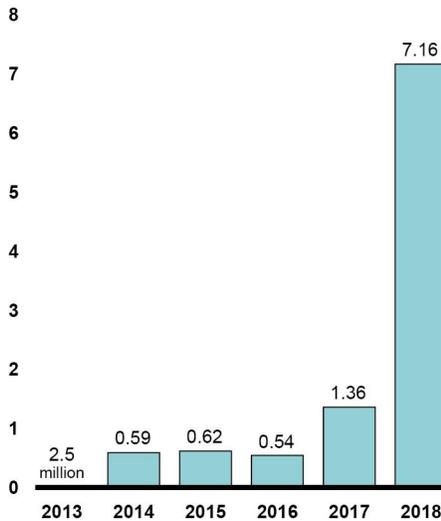
- In fiscal year 2017, MDA issued a sole source undefinitized contract action for the design and initial production of the RKV. This contract had a not-to-exceed value of \$1.1 billion. MDA issued the contract with an estimated definitization date of May 14, 2018. Despite the issues encountered by the RKV program described above, MDA reported that it definitized this contract action on schedule in May 2018, for the same price as the original not-to-exceed value, \$1.1 billion.
- MDA issued several undefinitized contract actions in 2018. For example, in April 2018, MDA issued a sole source undefinitized contract action for the production of Aegis BMD SM-3 Block IIA “pacing items”, with a not-to-exceed value of \$387 million. The Undersecretary of Defense for Acquisition and Sustainment issued a memorandum stating the circumstances under which MDA could obligate additional procurement, defense wide funds. MDA officials stated that “pacing items” were those items whose lead times were not long enough to qualify for long-lead procurement, but which were still substantial enough (more than 2 years) to cause delays if their production waited until the successful completion of operational testing. These officials also explained that the pacing items excluded any components which were still under investigation for the failure of FTM-29. Before that test’s failure and the ensuing involvement of the Undersecretary, MDA planned for a not-to-exceed value of \$672 million. MDA initially planned for a definitization date of December 2018, but it has since been delayed.
- MDA issued its largest undefinitized contract action for the fiscal year (as measured by its not-to-exceed value of \$6.56 billion) in January 2018. For the past several years, the GMD program planned to transition away from its all-inclusive contract to a structure involving three new contracts: one for systems engineering, integration, and testing; one for ground systems readiness, operations, and support; and one for all-up round interceptors. This Development, Operations and Sustainment, and Production approach would have been a significant undertaking. It would have required that MDA take control of the technical baseline for the entire program. MDA also believed that this strategy would provide for enhanced competition and reduced organizational conflicts of interest.

With the MDDE appropriation and associated program acceleration, the Director, MDA decided that managing the transition to this new

contracting strategy, in addition to fielding 20 new ground-based interceptors was too risky. Thus, MDA issued an undefinitized contract action that provided a six-year extension to the main development and sustainment contract for GMD. The contract action has a not-to-exceed value of \$6.56 billion, a value higher than that for all undefinitized contract actions issued by MDA in the previous 5 years combined. MDA was able to definitize most elements of this contract in March 2019. Figure 2 illustrates MDA’s increasing use of undefinitized contracts as measured by the sum of their not-to-exceed values.

Figure 2: Sum of Missile Defense Agency’s Reported Undefinitized Contract Actions’ Not-To-Exceed Values, by Fiscal Year.

Total Not-to-Exceed Value (in billions of dollars)



Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Data table for Figure 2: Sum of Missile Defense Agency’s Reported Undefinitized Contract Actions’ Not-To-Exceed Values, by Fiscal Year.

Year	Total Not-to-Exceed Value (in millions of dollars)
2013	2.515
2014	589.978
2015	616.197
2016	543.338
2017	1361.16
2018	7164.79

MDA Completed Some Key Milestones for Integrated Regional BMDS Capabilities, but Key Aspects of Its European Effort Have Been Deferred and Testing De-scoped

In fiscal year 2018, MDA delivered regional capabilities to counter threats from North Korea, but did not meet all of its 2018 goals for its effort in Europe to counter intermediate-range ballistic missile (IRBM) threats from Iran, known as the European Phased Adaptive Approach (EPAA) Phase 3. Specifically, the agency delivered planned upgrades and additional assets for the Korean Peninsula—an effort it began in 2017. However, the delivery of the third and final phase of the EPAA has been delayed by 18 months. Despite this delay, testing intended to demonstrate EPAA Phase 3 capability has been significantly reduced and de-scoped or deferred past the new delivery date, which reduces the warfighter’s insight on the system’s capabilities and limitations.

MDA Met Its Fiscal Year 2018 Goals for Capabilities in the Korean Peninsula

MDA delivered upgrades on time to the Korean Peninsula in February and September 2018. Notably, the upgrades provided initial integration between THAAD and Patriot—key elements of the effort in Korea—improving THAAD and Patriot’s ability to coordinate during engagements. MDA also delivered element-level upgrades for THAAD, including additional interceptors, as well as a new software release that expanded THAAD’s ability to counter new threats and improved its performance in the presence of debris. These upgrades were assessed in an April 2018 flight test that demonstrated interoperability between THAAD and Patriot by exchanging Link-16 messages over tactical data links while tracking a missile target, and an April 2018 BMD-level ground tests that provided further performance data for these upgrades in a simulated environment. MDA plans to deliver additional capabilities for the Korean Peninsula in the future. We currently have ongoing work related to these areas. Details will be included in a future report.

European Phased Adaptive Approach Capability against Intermediate-Range Threats Has Been Delayed

MDA's effort to deliver the third and last phase of the EPAA has been delayed from December 2018 to May 2020. MDA planned to deliver the EPAA Phase 3, for defense against IRBM threats, at the end of calendar year 2018, but construction delays for Aegis Ashore, the linchpin of Phase 3, delayed its completion by 18 months.

In fiscal year 2018, the delay for EPAA Phase 3 was caused by challenges at the construction site for Aegis Ashore in Poland. According to MDA officials, delays to the Aegis Ashore were primarily driven by military construction contractor performance issues. As these delays continued to accumulate, MDA initially planned to make up for them by increasing concurrency between the construction phase and the installation and checkout phases of the project, and concurrently working at the sites in Romania and in Poland. As we previously reported, these increasing levels of concurrency posed a growing risk for the program and its ability to achieve its target delivery date.³² In March 2018, MDA officials recognized that plans for Aegis Ashore had become untenable, and the project's schedule would have to be extended. This plan required the development of a new delivery schedule for EPAA Phase 3 resulting in delivery in May 2020.³³

Despite the Delays, Delivery of EPAA Phase 3 Will Occur with Less Robust Testing than Originally Planned

MDA experienced testing disruptions throughout the EPAA Phase 3 development, including delays and failures, but overcame some of them in fiscal year 2018. The consequence of the testing disruptions is that EPAA Phase 3 will be delivered to the warfighter with less data than planned about performance against planned threats. According to DOD's

³²See [GAO-17-381](#) and [GAO-18-324](#).

³³We also found the number of EPAA Phase 3 capabilities has also been reduced, and subsequently, the scope of its sole new capability, Engage on Remote, was split into two smaller capabilities, the second of which is planned for delivery in 2025. 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.

acquisition guidance and the BMDs Warfighter Capability Acceptance document, testing is fundamental to ensuring that DOD acquire a system that works, and to provide data necessary to characterize the system's effectiveness in operational settings. Thus, the warfighter relies on testing to understand the system's capabilities and limitations and therefore how to fight with what MDA has built.

As we previously found, EPAA Phase 3 testing disruptions started in 2016, when MDA delayed the first and second intercept flight tests of the Aegis BMD SM-3 Block IIA, the interceptor planned for fielding in EPAA Phase 3.³⁴ Although this test was successfully conducted in February 2017, testing difficulties continued when it failed the second intercept flight test.³⁵

MDA continued to experience challenges with testing necessary to demonstrate the EPAA Phase 3 capability in fiscal year 2018, which resulted in less robust testing. Specifically, as we discussed earlier in this report, the interceptor failed its first intercept test, FTM-29, against an intermediate range target, EPAA Phase 3's intended threat. Following a failure investigation, and developmental work, MDA rectified the Aegis BMD SM-3 Block IIA design flaws and successfully demonstrated them against a medium-range ballistic missile target in October 2018, during FTM-45. MDA decided to use a medium range target in this test and concluded that it was sufficient to assess Aegis BMD SM-3 Block IIA fixes. However, according to MDA documentation, the test against a medium range target does not provide the same challenges as an intermediate range target. In December 2018, it successfully demonstrated for the first time an intercept of an IRBM during a test called FTI-03, previously called FTO-03 Event 1. While this test was successful, its scope was reduced from an attempt against a raid of two targets to instead a single intercept, in part, due to a test range safety asset malfunction. With these flight tests, according to MDA officials, it completed its flight testing requirements for EPAA Phase 3 delivery and that adding additional tests would be disruptive to their overall test plan.³⁶

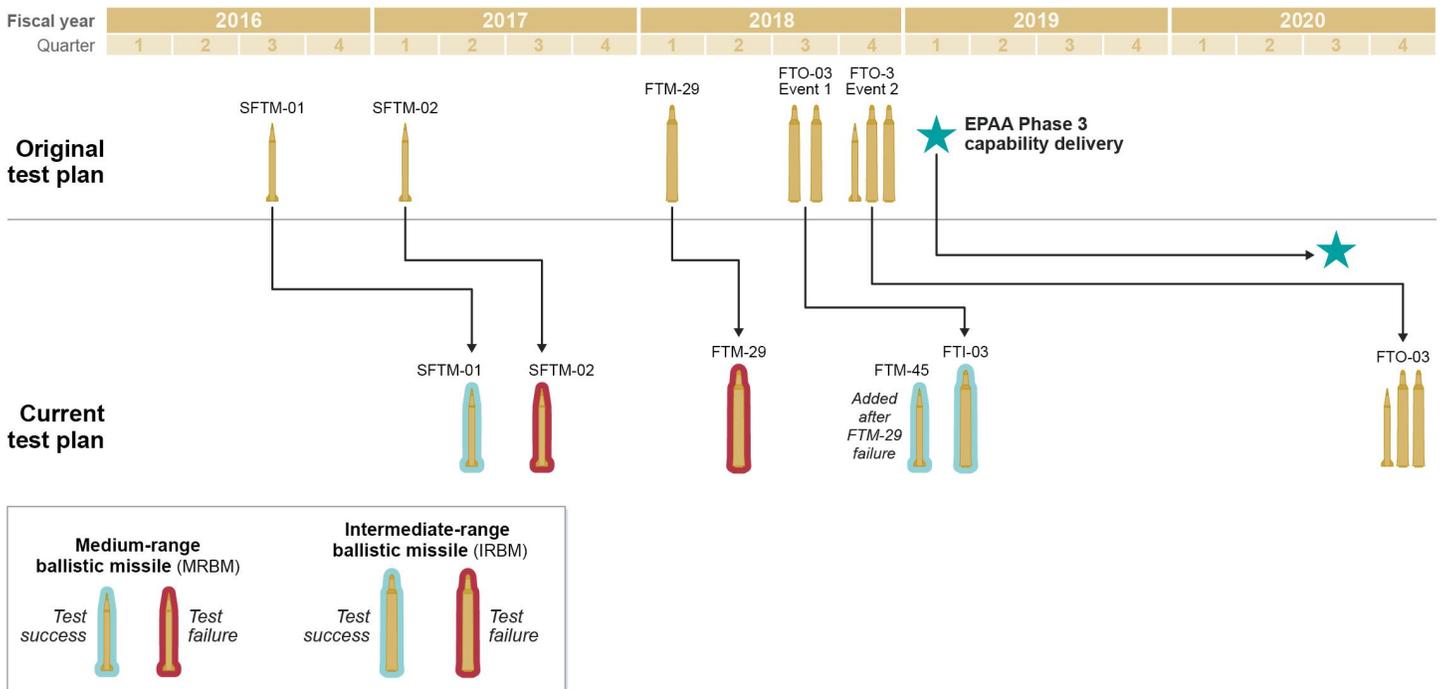
³⁴[GAO-17-381](#).

³⁵For additional specifics on these two flight tests—SFTM-01 and SFTM-02, see [GAO-17-381](#) and [GAO-18-324](#).

³⁶Rescoping the test was due in large part to the breakdown of key test range assets outside of MDA control.

Our analysis indicates that flight testing to demonstrate EPAA Phase 3 performance against IRBMs—the goal of Phase 3—has been reduced by 80 percent and even with the added 18-month delay, MDA no longer plans to conduct a flight test against a raid prior to delivery in fiscal year 2020. Figure 3 shows both the original and current plans for demonstrating EPAA Phase 3 performance through flight testing.

Figure 3: Missile Defense Agency’s Decrease in Flight Testing for European Phased Adaptive Approach (EPAA) Phase 3



Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Data for Figure 3: Missile Defense Agency’s Decrease in Flight Testing for European Phased Adaptive Approach (EPAA) Phase 3

Event	Original test plan	Current test plan (Result)
SFTM-01	3 rd quarter FY2016 (1 MRBM)	2 nd quarter FY 2017 (1 MRBM Success)
SFTM-02	1 st quarter FY2017 (1 MRBM)	3 rd quarter FY2017 (1 MRBM Failure)
FTM-29	1 st quarter FY2018 (1 IRBM)	2 nd quarter FY 2018 (1 IRBM Failure)

Event	Original test plan	Current test plan (Result)
FTM-45	Added after FTM-29 failure	1 st quarter FY2019 (1 MRBM Success)
FTO-03 Event 1	3 rd quarter FY2018 (2 IRBMs)	1 st quarter FY2019 (1 IRBM Success)
FTO-03 Event 2	4 th quarter FY2018 (1 MRBM, 2 IRBMs)	4 th quarter FY2020 (1 MRBM, 2 IRBMs planned)
EPAA Phase 3 capability delivery	1 st quarter FY2019	3 rd quarter FY2020

FY= Fiscal Year; MRBM = Medium-range ballistic missile; IRBM= Intermediate-range ballistic missile

Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Figure 3 above shows that the original plan included five IRBM intercepts across three tests, including tests to assess capability against small raids requiring simultaneous intercepts of multiple missiles—a likely tactic in a real-world attack— prior to delivery of EPAA Phase 3. However, as figure 3 also depicts, the current plan reduces the number of intercept tests against an IRBM and does not include a flight test against a raid until after EPAA Phase 3 capability is declared. Although the delivery has been delayed 18 months, in part due to the delay in construction at the Aegis Ashore site in Poland, the current plan significantly reduces the amount of data needed to support the EPAA Phase 3 capability and limitation assertions. As we previously reported, test and evaluation activities are an integral part of developing and producing weapon systems, as they provide knowledge of a system’s capabilities and limitations as it matures and is eventually delivered for use by the warfighter.³⁷ Consequently, the 18-month delay provides an opportunity to add in additional tests and an ability to provide further data to the warfighter or to make any design changes discovered during testing. As we previously reported, delivering capability before testing is complete has led to performance unknowns

³⁷GAO, *DOD Operational Testing: Oversight Has Resulted in Few Significant Disputes and Limited Program Cost and Schedule Increases*, [GAO-15-503](#), (Washington, D.C.: June 2, 2015).

and increases the likelihood of cost increases if future testing discovers any design flaws.³⁸

Conclusions

MDA made further progress in fiscal year 2018 in its mission to defend the United States and its allies from enemy ballistic missiles, including achieving a significant integrated capability milestone for defending the United States. However, MDA did not meet all of its goals for the fiscal year. Specifically, not all programs delivered all planned assets in fiscal year 2018 and shortfalls were attributed to developmental delays and testing challenges. The acceleration of several programs following a budget increase in December 2017 introduced concurrency, which indicates a familiar risk: accounting for insufficient margin in an effort to meet schedule-driven milestones, rather than pursuing a knowledge-based approach. Construction delays related to another integrated capability, EPAA Phase 3, may, in fact, present an opportunity to build more knowledge in that area. EPAA Phase 3 intends to provide a robust defense against IRBM and raids of multiple targets, but tests to demonstrate that capability have been reduced from five to one with the test against the raid scenario not occurring before the capability is delivered. Our prior work has shown that proceeding with limited test data can result in late, and costly, discovery of performance problems. More thorough assessment of the capabilities and limitations of the system could mitigate that risk by building a more solid base of knowledge.

Recommendation for Executive Action

We are making one recommendation to MDA:

The Director, MDA, should utilize additional schedule margin afforded by the EPAA Phase 3 delay to conduct additional testing necessary to thoroughly assess the capabilities and limitations of Phase 3 against IRBMs and a raid scenario prior to delivery. (Recommendation 1)

³⁸[GAO-12-486](#), [GAO-18-324](#).

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for comment. DOD's comments are reproduced in appendix IX. DOD and MDA also provided technical comments, which were incorporated as appropriate.

In its comments, DOD partially concurred with our recommendation to utilize additional schedule margin afforded by the 18-month delay to the EPAA Phase 3 delivery to conduct additional testing necessary to thoroughly assess the capabilities and limitations against IRBMs and a raid scenario prior to delivery. DOD stated that all EPAA Phase 3 BMDS functions requiring a flight test environment were already successfully demonstrated and MDA has addressed the intent of our recommendation by adding ground tests to further assess EPAA Phase 3 capabilities. However, in order for the agency to meet the full intent of our recommendation, additional flight testing to demonstrate capability against EPAA Phase 3 threats is necessary.

Flight testing against IRBM threats and raid scenarios could provide additional confidence in modeled performance, even for aspects of the model that have the achieved accreditation threshold. Our finding is supported by MDA's own assessment of testing needed for EPAA Phase 3, which originally included five IRBM intercepts and two raid flight tests. These testing requirements were reduced even after EPAA Phase 3 flight test failures and delays. Specifically, our analysis indicates that flight testing to demonstrate EPAA Phase 3 performance against an IRBM has been reduced 80 percent. Moreover, MDA will not conduct a flight test against a raid—a likely tactic in a real-world attack—prior to delivery.

As we identified in this report, MDA experienced testing disruptions throughout the EPAA Phase 3 development, which resulted in significant data collection reductions, especially regarding performance against planned threats. According to the Director, Operational Test and Evaluation (DOT&E), these testing challenges, in large part, precluded MDA from testing Aegis BMD against some expected threat types, ranges, and raid sizes. Consequently, the use of models and simulations-based ground tests to supplement such significant reduction in real-world data collections could be problematic. Specifically, we have previously reported that some of MDA's models and simulations used in its ground tests do not provide realistic representation of the BMDS, the environments it encounters, or the modeled threats. This year, we found that as a result of testing perturbations, certain aspects of Aegis BMD 5.1

will not be validated until after EPAA Phase 3 delivery. Relying on unaccredited models increases chances for modeling errors, and a single undetected modeling error can distort the results for the entire assessment.

Lastly, DOD stated that the demands on the test program due to the evolutionary nature of the BMDS acquisition leave no margin (cost or schedule) for adding additional flight tests. While we agree that adding a flight test requires additional costs and coordination, the reductions to EPAA Phase 3 testing constitute a significant reduction in performance data and decreases warfighter's knowledge base about how best to deploy a system under operationally realistic conditions, such as raids. We continue to believe the 18-month delay affords the schedule to conduct additional flight testing.

We are sending copies of this report to the appropriate congressional committees, the Acting Secretary of Defense, the Undersecretary of Defense for Research and Engineering, 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 chaplainc@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.



Cristina Chaplain
Director, Contracting and National Security Acquisitions

List of Committees

The Honorable James M. Inhofe
Chairman

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

The Honorable Richard Shelby
Chairman

The Honorable Dick Durbin
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Adam Smith
Chairman

The Honorable Mac Thornberry
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Pete Visclosky
Chairman

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

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



Source: Missile Defense Agency (MDA). | GAO-19-397

Key findings for Fiscal Year 2018

- Aegis Ballistic Missile Defense (BMD) demonstrated integration with allies.
- Aegis BMD 5.1 demonstrated increased capability, but testing disruptions delayed its delivery to March 2019 and deferred raid assessment to 2020.
- MDA re-planned schedules for some future Aegis capabilities due to funding challenges.

Source: GAO analysis of Missile Defense Agency programs. | GAO-19-387

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 5 identifies Aegis BMD spirals, associated integrated Aegis Weapons System Baselines and key capabilities, and their delivery date.

¹A 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.

Table 5: Aegis Ballistic Missile Defense (BMD) spirals with associated Aegis Weapons System Baselines and capabilities.

Aegis BMD spirals	Associated integrated Aegis Weapon System Baselines (BL)	Key Ballistic Missile Defense Capabilities	Delivery date
BMD 5.0 Capability Upgrade (CU)	BL 9.C1	<ul style="list-style-type: none"> Addition of Standard Missile-3 (SM-3) Block IB Threat Upgrade interceptor Launch on Remote^a Improved discrimination using infrared and radio wave data Capability against more advanced threats Ship battle group defense capability using Standard Missile (SM-6) Dual I^b 	2015
	BL 9.B1	<ul style="list-style-type: none"> BMD 5.0 CU capabilities for Aegis Ashore in Romania without Standard Missile (SM-6) Dual I 	2015
BMD 5.1	BL 9.C2	<ul style="list-style-type: none"> Addition of SM-3 Block IIA Engage on Remote^c Ship battle group defense capability using Standard Missile (SM-6) Dual II^b 	2019
	BL 9.B2	<ul style="list-style-type: none"> BMD 5.1 capabilities for Aegis Ashore in Romania and Poland 	2019
BMD 4.1	BL 5.4	<ul style="list-style-type: none"> Similar capabilities to BMD 5.0 CU capabilities, installed on legacy hardware 	2020
BMD 4.2	BL 5.X	<ul style="list-style-type: none"> Aegis SPY-1 radar refurbishment for improved tracking capability 	2023
BMD 6.0	BL 10.0	<ul style="list-style-type: none"> New SPY-6 radar with increased radar capacity and discrimination Performance against additional threats and larger raids Improved missile communications 	2023

Source: GAO analysis of MDA data | GAO-19-387

^aLaunch 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.

^bSM-6 Dual I and SM-6 Dual II allow 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.

^cEngage on Remote increases the area defended by the BMDS, 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.

The first suite of integrated ballistic missile defense and anti-air warfare (AAW) capabilities was delivered with AWS Baseline 9.C1/B1, which included an overhaul of Aegis computing architecture.² 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

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

architecture. While initially scheduled for delivery in 2015, Aegis BMD 4.1 was delayed multiple times, and finally in 2017 the delivery was split into two phases. The first interim phase was completed in 2017, 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. 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 (EOR) 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. Additionally, MDA and the Navy are developing 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 more threat types, larger raids, better discrimination, and improved communication with its interceptors. AWS Baseline 10.0 is planned for delivery in 2023. For specifics on Aegis Ashore and the Aegis SM-3 interceptors, see appendixes II, III and IV, respectively. Table 6 provides key fiscal year 2018 AWS program facts.

Table 6: Aegis Ballistic Missile Defense (BMD) Weapons System Program Facts for Fiscal Year 2018

Major Assets Delivered in Fiscal Year 2018

No new Aegis BMD spirals were delivered in fiscal year 2018

Flight Test Performance in Fiscal Year 2018

Test Name	Test Date	Test Result
Formidable Shield – 17-4	October 2017	Demonstrated capabilities for Aegis BMD 4.0.3 and BMD 5.0 Capability Upgrade (CU)
Standard Missile Control Test Vehicle-03	October 2017	Demonstrated capabilities for Aegis BMD 4.1
Flight Test Mission-29	January 2018	Failed intercept but partially demonstrated capabilities for Aegis BMD 5.1
Flight Test Other (FTX)-33	March 2018	Demonstrated capabilities for Aegis BMD 5.1
Pacific Dragon	August 2018	Demonstrated capabilities for Aegis BMD 5.1
Japanese Flight Test Mission (JFTM)-5 Events 1 and 2	September 2018	Demonstrated capabilities for Aegis BMD 5.0 CU
FTM-45	October 2018	Demonstrated capabilities for Aegis BMD 5.1

Source: GAO analysis of MDA data. | GAO-19-387

Aegis BMD demonstrated integration with allies

In fiscal year 2018, MDA demonstrated the ability of Aegis BMD to engage some simple and complex threats as well as integration with European and Asia-Pacific allies for new and legacy spirals. As table 5 above shows, Aegis BMD participated in a number of flight tests and exercises, which provided additional information about its capabilities and interoperability with allies in two regions, where MDA is currently focusing its regional integrated capability efforts. For example:

- Formidable Shield-17 demonstrated the ability of Aegis BMD 4.0.3, which was delivered in fiscal year 2015, to interoperate with North Atlantic Treaty Organization partners using communication architectures during cruise missile and ballistic missile engagements, and to use remote data provided by NATO partners to conduct remote engagements.
- Pacific Dragon demonstrated interoperability between U.S. Aegis BMD assets, Japanese destroyers, and Republic of Korea naval assets.
- JFTM-05 Event 2 demonstrated coordination between U.S. and Japanese destroyers using communications architecture to conduct ballistic missile engagements.

Aegis BMD 5.1 demonstrated increased capability, but testing disruptions delayed its delivery to March 2019 and deferred raid assessment to 2020

MDA demonstrated some aspects of Aegis BMD EOR, as well as the ability of Aegis BMD 5.1 to engage a medium range and an intermediate range ballistic threat, but testing disruptions delayed data available to inform capabilities and limitations of the Aegis BMD 5.1, contributing to a 3-month delivery delay.³ MDA encountered challenges during tests for Aegis BMD 5.1, which resulted in a reduction of flight tests and delays in collecting data needed to accredit models for a system-level assessment. Specifically, during the conduct of FTM-29, Aegis BMD partially demonstrated EOR capability, lacking full demonstration because the weapon system did not exercise all aspects of communication in the later stages of the engagement due to an Aegis BMD SM-3 Block IIA malfunction.⁴ MDA decided not to retest FTM-29 and adjusted its test plan to only demonstrate the fixes to the SM-3 Block IIA in a new test called FTM-45, deferring a full EOR assessment by about a year to the subsequent test named FTI-03.⁵

This reduction in flight tests affected MDA's ability to collect data for model verification which in turn, delayed the delivery of Aegis BMD 5.1. A model is a representation of an actual system that involves computer simulations and is used to predict how the system might perform or survive under various conditions. MDA, as well as independent DOD testing organizations, and the warfighter rely heavily on models to test operational performance that cannot be completely assessed using intercept flight tests because of the system's scope and complexity and safety constraints. Flight tests, however, provide important information

³Engage on Remote increases the area defended by the BMDS, 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. FTI-03, conducted in December 2018, was the first test to assess all aspects of Engage on Remote performance data.

⁴Aegis BMD 5.1 is designed to control the SM-3 Block IIA. Flight tests of the SM-3 Block IIA also assess commutations between Aegis BMD 5.1 and SM-3 Block IIA and the ability of the Aegis combat system to steer the interceptor to the target.

⁵For further details on the Aegis BMD SM-3 Block IIA see appendix IV.

about real-world performance that is used to verify models.⁶ In order to ensure that key aspects of Aegis BMD 5.1 performance are well understood at delivery, MDA delayed the spiral from December 2018 to March 2019. This was done in part to allow for analysis from FTM-45 (conducted in October 2018) and FTI-03 (conducted in December 2018). According to the BMDS Operational Test Agency, data from these tests provided key information about Aegis BMD EOR performance—a key capability for Aegis BMD 5.1—that was used to verify its models, which were used to more thoroughly assess the extent of that capability.

While EOR data will support Aegis BMD 5.1 delivery, another key aspect of its performance will not be verified until late in fiscal year 2020. Specifically, 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. The next planned raid assessment is scheduled for the fourth quarter of fiscal year 2020, well after Aegis BMD 5.1 delivery.

According to the Director, Operational Test and Evaluation (DOT&E) these testing challenges, in large part, precluded MDA from testing Aegis BMD against some expected threat types, ranges and raid sizes. While some of them were outside of MDA's control, others stem from decisions about its test plan. For instance, MDA's inability to assess Aegis BMD 5.1 against an IRBM raid resulted from the malfunction of test range safety assets; however, according to DOT&E, FTM-29 failure is an example of insufficient development testing that should have discovered the SM-3 Block IIA issue prior to the flight test. DOT&E officials told us that they are currently working with MDA to ensure sufficient developmental testing is scheduled and conducted prior to undertaking operational tests.

Funding challenges contributed to the delay for certain Aegis BMD capabilities

In fiscal year 2018, funding challenges contributed to the delay of MDA and the Navy's effort to develop integrated AWS Baseline 5.4 and AWS

⁶While no model is perfect, in general, more data available to refine it, affords greater confidence that the model does in fact represents real-world performance. For further details on GAO assessment of MDA models to assess operational performance, 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, DC: May 30, 2018).

Baseline 10.0. According to MDA program documentation, the delays resulted from funding reductions in fiscal year 2018. However, while AWS Baseline 5.4—which includes BMD 4.1—was delayed entirely from 2019 to 2020, AWS Baseline 10.0 – which includes BMD 6.0—delayed completion of some technical content, but its delivery timeframe did not change. Specifically:

- Integrated AWS Baseline 5.4 was originally planned to be completed in September 2019, but MDA and the Navy delayed its certification to March 2020.⁷ While MDA delivered Aegis BMD 4.1 capabilities in fiscal year 2017, subsequent efforts focused on integrating the ballistic missile defense with the remaining suite of AWS Baseline 5.4 capabilities. According to MDA, the delay to this effort was driven by a \$14 million funding reduction to the Navy’s Program Executive Office Integrated Warfare System, which is jointly funding this baseline. As a result of the reduction, MDA received \$16 million from the Navy, rather than \$32 million it was expecting, to continue work on Baseline 5.4. According to Aegis BMD program officials, to mitigate the nine month delay, MDA renegotiated the associated contract, but it is anticipating approximately \$1.5 million increase in fiscal year 2019 and approximately \$4 million to fiscal year 2020 costs.
- MDA and the Navy re-planned AWS Baseline 10.0, after a funding reduction of \$31.45 million against BMD 6.0. According to Aegis BMD program documentation, the BMD 6.0 development efforts stopped between January 2018 and May 2018. Program officials indicated that MDA renegotiated the associated contract to reflect the reduced funding, but the stop work and consequent restart incurred additional costs. Specifically, the program estimated that the disruption resulted in cost growth of approximately \$51 million across the development timeline between fiscal year 2019 and 2024.

⁷Certification for Aegis spirals is a process to assess and validate the system’s readiness for use or integration with the larger Aegis suite capabilities, with all risks understood and deemed acceptable.

Appendix II: Aegis Ashore



Source: Missile Defense Agency (MDA). | GAO-19-397

Key findings for Fiscal Year 2018

- According to Missile Defense Agency officials, deficiencies in the performance of the military construction contractor resulted in a significant delay and increased cost for the Aegis Ashore facility in Poland.
- The program continues to make progress despite challenges at both the Poland and Romania sites.

Source: GAO analysis of Missile Defense Agency programs. | GAO-19-387

Program Overview

Aegis Ashore is a land-based, or ashore, version of the ship-based Aegis Ballistic Missile Defense (BMD). Aegis Ashore is designed to track and intercept ballistic missiles in the middle of their flight using Aegis BMD Standard Missile-3 (SM-3) interceptors. Key components include a vertical launching system, interceptors, and an enclosure, called a deckhouse, that contains the SPY-1 radar and command and control system.

Aegis Ashore will share many components with the sea-based Aegis BMD and will use future versions of the Aegis weapon system currently in development, including the SM-3 Block IIA interceptor. The Missile Defense Agency (MDA) plans to equip Aegis Ashore with a modified version of the Aegis weapon system software that will share many components with the sea-based Aegis BMD. DOD constructed an Aegis Ashore test facility in Hawaii in April 2014. The test facility has been used to flight test Aegis Ashore, and in some cases, Aegis BMD SM-3 interceptors. MDA deployed its first operational site in Romania in fiscal year 2016 as part of the European Phased Adaptive Approach (EPAA) Phase II. A second site in Poland was scheduled for delivery in 2018 as part of EPAA Phase III. Both operational sites are intended to provide additional coverage for the defense of Europe.

The Poland site experienced construction delays over several years until March 2018, when MDA determined with stakeholders that the site would not be complete in time for the EPAA Phase III deadline. MDA has since

established a new schedule baseline which delays the delivery of the site by 18 months, to May 2020.

For further details on the Aegis Weapon System and Aegis BMD interceptors, see appendixes I, III and IV. Table 7 provides key fiscal year 2018 Aegis Ashore program facts.

Table 7: Aegis Ashore Program Facts for Fiscal Year 2018

Major Assets Delivered

No assets delivered in fiscal year 2018

Flight Test Performance

Test Name	Test Date	Test Result
FTM-29	January 2018	Intercept Failed. 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 interceptor’s third-stage rocket motor failed to ignite, causing the interceptor to fall short of the target.

Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

According to Missile Defense Agency officials, deficiencies in the performance of the military construction contractor resulted in a significant delay and an increased cost for the Aegis Ashore facility in Poland

According to MDA officials, construction of the Aegis Ashore site in Poland has failed to meet schedule milestones from the start of the contract. According to officials, prior to this year, MDA and the Army Corps of Engineers, which manages military construction at the site, have undertaken a number of measures to mitigate or reverse these delays, including modifying contracts to permit joint occupancy of the site, modifying the main contract to provide more granular project data to the Army Corps of Engineers, moving key personnel on site, and adding a second shift. Program officials stated that they also withheld some award fees from the contractor as a result of these delays. Despite these efforts, MDA has found the contractor’s performance is still particularly poor in the areas of construction management, identification, procurement, timely delivery of important materials, and timely hiring of staff with appropriate skills.

To make up for these delays, MDA introduced increasing levels of concurrency into its schedule, and shortened key phases of the delivery process. Activities such as Installation and Checkout were shortened from 16.5 months to 6.5 months, and would occur concurrently with the final phases of construction at the site. As recently as last year, GAO reported that additional delays or concurrency at the site would threaten the scheduled delivery date.¹

Through the first quarter of fiscal year 2018, the contractor's performance did not improve. According to program officials, in December 2017, MDA participated in a meeting with the Army Corps of Engineers, the Navy, and other government stakeholders, and concluded that the schedule for delivery had become untenable and schedule recovery was not possible. MDA later concluded that the site would not be ready for delivery until May 2020, a delay of 18 months.

The costs of this delay will be significant. Following the determination of the new delivery date, MDA developed a new project schedule that, officials stated, incorporated historical data from the Romania site, independent outside analysis, trends in the contractor's performance over time, and the resources that would be required at each stage of the schedule. MDA estimated that the additional efforts by MDA, the Army Corps of Engineers, and the Navy to mitigate the delay and provide assistance through the completion of the project totaled at least \$90 million. According to program officials, the construction contract provides for significant liquidated damages, with the current daily assessment in excess of \$125,000.

The program continues to make progress despite facing challenges at both the Romania and Poland sites

MDA continues to oversee work at the Aegis Ashore site in Romania, despite the Navy's acceptance of the site for operational use. MDA continues work on a variety of remaining items such as seismic hardening, shielding electrical infrastructure against high-energy electromagnetic pulses, and cooling systems. In the case of cooling systems, the work is the result of the system failing to perform to specifications.

¹GAO, *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).

MDA has yet to assess the full cost, schedule, and performance impacts of the necessary repairs and modifications, but MDA reported that none of the above issues had any impact on the Romania sites operational availability or performance.

In the case of the Poland site, MDA sought to secure the permission of the Polish government to operate the facility's SPY-1 radar in the 3.1 to 3.5 GHz radio frequency spectrum. This section of the spectrum is important to the full functioning of the Aegis Ashore system, but portions of it have been allocated for commercial use in Poland. MDA was able to de-conflict the operations of its radar with other systems on these frequencies, and in March 2018 secured the approval of the Polish government to operate the SPY-1 radar across the full range of frequencies.

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



Source: Missile Defense Agency (MDA). | GAO-19-397

Key findings for Fiscal Year 2018

- The Aegis Ballistic Missile Defense (BMD) Standard Missile-3 Block IB program received authorization for full production this year and performed successful intercepts in flight tests.
- Discovery of a parts quality issue partway through the year forced the program to suspend deliveries and thus miss most of its delivery target for fiscal year 2018.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-19-387

Program overview

The Aegis 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 SM-3 interceptor has multiple versions in development or production: 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, and Aegis Ashore. For additional information about the Aegis Weapon Systems, see Appendix I and for Aegis Ashore, see Appendix II.

Since fiscal year 2015, Aegis BMD SM-3 Block IB production has been delayed by several technical issues. Program officials, in 2015, delayed the decision to enter full-rate production until they could implement further

testing and design changes, a decision consistent with a GAO recommendation at the time.¹ In fiscal year 2016, two failures during testing forced a suspension of interceptor deliveries, though the program made up for this backlog in fiscal year 2017. Table 8 provides key fiscal year 2018 Aegis BMD SM-3 Block IB program facts.

Table 8: Aegis Ballistic Missile Defense (BMD) Standard Missile-3 (SM-3) Program Facts

Major Assets Delivered in Fiscal Year 2018

Delivered 12 Aegis BMD SM-3 IB Interceptors in fiscal year 2018 against 36 planned deliveries

Flight Test Performance

Test Name	Test Date	Test Result
FS-17-4	October 2017	Met Objectives. Test of Aegis (BMD) SM-3 Block IB against a Medium-range Ballistic Missile (MRBM) target to support full production decision. Intercept successful.
JFTM-05 Event 2	September 2018	Met Objectives. Intercept test of Aegis BMD SM-3 Block IB Threat Upgrade from a Japanese Navy vessel against an MRBM target. MDA observed and supported. Intercept successful.

Source: GAO analysis of MDA data. | GAO-19-387

The Aegis BMD SM-3 Block IB program received authorization for full production this year and performed several successful intercepts in flight tests

In February 2017, the Undersecretary of Defense for Acquisition, Technology, and Logistics issued an Acquisition Decision Memorandum requesting an additional flight test for the Aegis BMD SM-3 Block IB before authorizing a full production decision, as well as several independent supporting analyses. The memorandum issued these requirements in support of a planned full production decision in the first quarter of fiscal year 2018. As we previously reported, MDA has delayed full production multiple times over the life of the Aegis BMD SM-3 Block IB which was initially scheduled for fourth quarter, fiscal year 2012.²

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

²For further details, 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 30, 2018).

MDA completed the requested intercept test, known as FS-17-4 in October 2017. The test was undertaken as part of NATO's Formidable Shield naval exercises. In this test, an Arleigh Burke-class destroyer in the northern Atlantic fired an Aegis BMD SM-3 Block IB Threat Upgrade at an MRBM target and successfully intercepted it. With this result, the interceptor was approved for full production. In September 2018, MDA participated in JFTM-05 Event 2, a joint flight test with the Japanese navy, in which a Japanese ship successfully fired an Aegis BMD SM-3 Block IB Threat Upgrade interceptor at a simple separating short-range ballistic missile. MDA participated in and supported the engagement.

Upon full production authorization, MDA sought to pursue a multi-year procurement with the prime contractor for 204 interceptors through 2023.³ While MDA requested and the 2019 National Defense Authorization Act and the Defense Appropriations Act, 2019 authorized this procurement, the program did not receive the funding to support the request. Program officials state that they are still evaluating the impacts on their plan. MDA estimates the procurement will have a projected price of \$2.021 billion.

Discovery of a parts quality issue partway through the year forced the program to suspend deliveries and thus miss most of its delivery target for fiscal year 2018

During routine component testing, MDA discovered an issue with the Aegis BMD SM-3 Block IB's throttleable divert and attitude control system (TDACS) resulting in delays of interceptors in fiscal year 2018. According to program officials, MDA employs a "manufacturing surveillance unit" whose purpose is to pro-actively assess component performance and quality at various stages of unit production. Program officials stated that the unit discovered, in January 2018, that one of several thrusters on the TDACS did not perform to specification. In response to this finding, MDA suspended deliveries of the interceptor until it could determine the impact of the deficiency on the interceptor's performance.

³Multi-year procurements allow DOD to contract for the purchase of more than one year's requirements of supplies or services. The key distinguishing difference between multi-year contracts and ordinary multiple year contracts is that multi-year contracts buy more than 1 year's requirement without establishing and having to exercise an option for each program year after the first.

According to program officials, MDA contracted with the Applied Physics Laboratory to act as an independent technical authority for the investigation, which took approximately six months. Once concluded, the investigation found that the performance of the component, while below the defined specification, did not endanger the overall operation of the system. The component's performance was accommodated within the margin the government and contractor built into the overall design, and was acceptable as built as a result. The investigation reached this conclusion in August 2018. MDA closely monitored the function of the component in JFTM-05, during which the system performed nominally.

Program officials reported that the prime contractor has experienced similar issues defining and communicating important specifications to subcontractors at various levels of its supply chain. Similarly, the contractor has also had difficulty ensuring that all subcontracted components meet defined specifications. Program officials stated that they continue to take measures to mitigate these issues, including using the manufacturing surveillance team.

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



Source: Missile Defense Agency (MDA). | GAO-19-397

Key findings for Fiscal Year 2018

- A mid-year funding increase accelerated the program's schedule and increased the number of interceptors.
- The Aegis Ballistic Missile Defense (BMD) Standard Missile - 3 (SM-3) Block IIA experienced a test failure, leading to significant changes to the test plan.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-19-387

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 III.¹

¹We 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.

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 full use of its extended range is by relying on remote sensor data.² For additional information on Aegis Weapon Systems, see Appendix I. Table 9 provides key fiscal year 2018 Aegis BMD SM-3 Block IIA program facts.

Table 9: Aegis Ballistic Missile Defense (BMD) Standard Missile-3 (SM-3) Block IIA Program Facts for Fiscal Year 2018

Major Assets Delivered

Fiscal Year 2018

N/A

Flight Test Performance

Test Name	Test Date	Test Result
FTM-29	January 2018	Intercept Failed. The Aegis Ashore facility in Hawaii fired an Aegis BMDSM-3 Block IIA interceptor at an Intermediate-range Ballistic Missile (IRBM) target. The interceptor’s third-stage rocket motor failed to ignite, causing the interceptor to fall short of the target.

Source: GAO analysis of MDA data. | GAO-19-387

A mid-year funding increase accelerated the program’s schedule and increased the number of interceptors

In December 2017, Congress passed and the President signed the “Department of Defense Missile Defeat and Defense Enhancements Appropriations Act, 2018”, as part of a larger continuing resolution which significantly increased missile defense appropriations. According to program officials, the impetus for seeking these additional appropriations was increased levels of missile development and testing activity from North Korea. MDA intends to use \$451 million in procurement funds for the purchase of 16 additional Aegis BMD SM-3 Block IIA interceptors.

²This specific capability, where the threat is intercepted before it is visible to its own radar is called Engage on Remote. For further details on Engage on Remote 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 30, 2018).

These were the first procurement funds the program had received. The program had yet to receive an initial production authorization, so all previous manufacturing activity occurred using research and development funds.³

To this point, however, the Aegis BMD SM-3 Block IIA interceptor had succeeded in only one of its two intercept flight tests, and its ability to engage a longer-range target using remote sensor data, known as “engage on remote”, had yet to be tested.

The following month, in January 2018, the interceptor failed an important intercept test, causing significant disruption to the program’s schedule which is discussed below. The Undersecretary of Defense for Acquisition and Sustainment subsequently released an acquisition decision memorandum which laid out near-term limitations on the use of procurement funds for the Aegis BMD SM-3 Block IIA, as well as providing for a series of steps MDA needed to take in order to obligate the remaining funds. These measures included the completion of an independent cost estimate, independent technical risk assessment, the successful completion of a replacement flight test, and the successful completion of the planned operational flight test scheduled for the first quarter of fiscal year 2019.

Until MDA could meet these requirements, the Undersecretary authorized MDA to obligate only \$162 million for the purchase of a limited subset of “pacing items.” According to program officials, “pacing items” are those with longer lead times for production, but which fall short of the threshold for long-lead procurement. Program officials also stated that the list of pacing items was restricted to components not implicated in the recent test failure.

Program officials stated that they expected the Undersecretary to certify that these requirements had been met in the third quarter of fiscal year 2019.

³Under DOD budget guidance, Research, Development, Test and Evaluation funds should be used to design prototypes, develop major upgrades increasing the performance envelope of existing systems, purchase test articles, and conduct developmental testing and/or initial operational test and evaluation prior to system acceptance.

The Aegis BMD SM-3 Block IIA experienced a test failure, leading to significant changes to the test plan

In January 2018, MDA conducted flight test FTM-29. In this test, the Aegis Ashore facility in Hawaii fired an Aegis BMD SM-3 Block IIA interceptor at an intermediate-range ballistic missile (IRBM), using remote sensor data, for the first time. After the interceptor launched, its third-stage rocket motor (TSRM) failed to ignite. As a result, the interceptor had inadequate thrust to complete the engagement and failed its objective to intercept the target. As a result of this test failure, MDA faced two challenges: first, identifying and remedying the source of the failure through a failure review board, and second, adjusting the program's schedule to provide opportunities to confirm these mitigations.

MDA and the government of Japan convened a failure review board (FRB) to investigate the causes of the test failure. The board's conclusions found that the TSRM failed to ignite due to a combination of a faulty arm-fire device (AFD), which initiates the TSRM's firing, and incorrect programming of the TSRM ignition sequence. In the case of the Aegis BMD SM-3 Block IIA, the AFD contains two linear "chains" of explosive pellets, which then ignite the rocket motor. MDA documents state that the AFD's manufacturer expects a missile to ignite both chains simultaneously to ensure the highest degree of reliability.

The FRB found that the Aegis BMD SM-3 Block IIA's programming did not fire the AFD's two chains simultaneously, but one after the other, or "sequentially". When fired in this manner, quality issues with the AFD that would not have any material impact in a simultaneous firing can cause the AFD to malfunction when firing one after the other. The FRB concluded that the most likely cause of the AFD's failure was a missing explosive charge in the first explosive chain. When this chain ignited, it fizzled and failed to ignite the TSRM. The fizzle was powerful enough to disrupt the functioning of the second explosive chain, however, which subsequently failed to ignite the TSRM as well.

To correct for this error, MDA has changed the programming of the Aegis BMD SM-3 Block IIA to fire the AFD simultaneously. MDA has also instituted new quality measures at the assembly line for the AFD. These measures include additional quality assurance checks to ensure that all explosive pellets are present in both chains, as well as the use of X-ray-

like scanners which can look inside a completed AFD to confirm the presence of all of the explosive pellets.⁴

Having identified the source of the failure, MDA had to choose what form any new test would take, and how it would impact the remaining schedule, in particular the first operational test of the Aegis BMD SM-3 Block IIA, which also happened to be the first operational test of the European Phased Adaptive Approach (EPAA) Phase III, and the only such test scheduled before MDA declared it ready for delivery. This test, then known as FTO-03 Event 1 (and subsequently re-named FTI-03) was scheduled for the first quarter of fiscal year 2019.

One option was for MDA to schedule a scaled-back test, known as FTM-45, of an Aegis BMD SM-3 Block IIA against a medium-range target. MDA stated that though FTM-29 failed, analysis of sensor data and missile telemetry indicated that the Engage on Remote capability would have succeeded had the interceptor reached the target. Therefore, FTM-45 could be an “organic” engagement, using only the radar co-located with the interceptor. FTM-45 would need only to test that the mitigations identified by the FRB worked, as well as testing the final phases of the interceptor’s operations which had been interrupted in FTM-29. MDA had a medium-range ballistic missile (MRBM) target it could repurpose for this test, which would limit testing disruptions by not further delaying FTO-03 E1/FTI-03. FTM-45 was MDA’s preferred course of action

FTM-45 lacked the support of several external, Department of Defense stakeholders, such as the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation, Joint Functional Component Command Integrated Missile Defense, and Office of the Director, Operational Test and Evaluation. These offices asserted that a complete re-test of FTM-29, known as FTM-29a, provided the most risk reduction in advance of FTO-03 / FTI-03. .

MDA opted not to pursue FTM-29a, and cited several reasons. MDA acknowledged the differences between intermediate-range and medium-range engagements, but determined that the actual differences between FTM-45 and FTM-29a were within acceptable margins. FTM-29a would also prove more expensive and more logistically difficult. MDA concluded

⁴MDA officials stated that the average cost for an arm-fire device is about \$276,000. Officials stated that they did not expect the new quality assurance measures to affect this price to such a degree that it significantly increases the cost of interceptors.

that FTM-45 met the requirements for risk reduction at the least disruption to the program's schedule.

MDA conducted FTM-45 in October 2018 and FTI-03 in December 2018. Initial reports indicate both were successful.

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



Source: Missile Defense Agency (MDA). | GAO-19-397

Key findings for Fiscal Year 2018

- MDA re-planned schedules for some future Aegis capabilities due to funding challenges. MDA delivered Spiral 8.2-1 providing significant performance and cyber improvements, but some fixes were required after fielding.
- MDA mitigated prior challenges with Spiral 8.2-3 and demonstrated capability upgrades.
- Uncertainty in Ballistic Missile Defense System-level requirements could disrupt Spiral 8.2-5 schedule.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-19-387

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. The spiral delivered in fiscal year 2018 includes BMDS Overhead Persistent Infrared Architecture (BOA) — 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 and transition to operations 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 will replace Spiral 8.2-1 at the U.S. Northern Command and U.S. Indo-Pacific Command in the third quarter of Fiscal Year 2019. Table 10 provides an overview of C2BMC Spiral upgrades, planned fielding timeframes and associated capabilities, and Table 11 provides key fiscal year 2018 C2BMC program facts.

Table 10: Command, and Control, Battle Management and Communications Spirals and Ballistic Missile Defense System (BMDS) Overhead Persistent Infrared Architecture (BOA) Fielding Overview

C2BMC Spiral /BOA	Spiral 6.4	Spiral 8.2-1/ BOA 5.1	Spiral 8.2-3/ BOA 6.1	Spiral 8.2-5 ^a / BOA 7.0
Fielding timeframe (fiscal year)	2011	2018	2019	2021
Supported capabilities	European Phased Adaptive Approach (EPAA) Phase 1 and Phase 2, and Near Term Discrimination Improvements for Homeland Defense	Enhanced Homeland Defense	EPAA Phase 3 Engage on Remote and additional BMDS upgrades	Long Range Discriminating Radar control for Homeland Defense and additional BMDS upgrades

Source: GAO analysis of MDA data. | GAO-19-387

^aThe C2BMC program has identified element level requirements for Spiral 8.2-5, but requirements for BMDS-level level capabilities associated with this spiral are still under development, which may delay efforts to complete the development of the spiral. MDA plans to report Spiral 8.2-5 acquisition baselines for the first time in the 2019 BMDS Accountability Report.

Table 11: Command, and Control, Battle Management and Communications Program Facts

Major Assets Delivered in Fiscal Year 2018

Spiral 6.4 remained operational at U.S. European and U.S. Central Commands^a

Spiral 8.2-1 replaced Spiral 6.4 at the U.S. Northern and Indo-Pacific Commands

Flight Test Performance in Fiscal Year 2018

Test Name	Test Date	Test Result
FS-17	September through October 2017	Met objectives
FTM-29 ^b	January 2018	Intercept failed but C2BMC demonstrated key aspects of engage on remote capability
JFTM-5 Event 1	September 2018	Met objectives
JFTM-2 Event 2	September 2018	Met objectives

Ground Test (GT) Performance in Fiscal Year 2018^c

Test Name	Test Date	Test Result
GT-07a for U.S. Northern and Indo-Pacific Commands	November 2016 through October 2017	<ul style="list-style-type: none"> • Demonstrated interoperability between new Spiral 8.2-1 and additional sensors, including use of space-based Ballistic Missile Defense System (BMDS) Overhead Persistent Infrared (OPIR) Architecture (BOA) 5.1 to cue land-based radars for early acquisition • Demonstrated Spiral 8.2-1 ability to integrate data from multiple sensors and generated tracks with discrimination for use by other elements • Demonstrated radar discrimination tasking
GT-18 Sprint 1	March 2018	<ul style="list-style-type: none"> • Demonstrated C2BMC communication upgrades delivered with Spiral 8.2-1 in support of defense of Korea
GT-07b for U.S. European and Central Commands (E/C)	April through October 2018	<ul style="list-style-type: none"> • Demonstrated Spiral 8.2-3 and BOA 6.1 ability to provide tracks to Aegis BMD for Engage on Remote capability, enabling engagement based entirely on forward-based sensors • Demonstrated improved space-based sensor capabilities, including better tracking and cuing • Demonstrated raid handling
GT-18 Sprint 2	July 2018	<ul style="list-style-type: none"> • Demonstrated Spiral 8.2-3 use of BOA 6.1 to cue land-based and sea-based radars for engagements with Aegis BMD Standard Missile (SM)-3 Block IIA and SM-6 Dual II interceptors during defense of United States and areas in U.S. Indo-Pacific Command's domain

Source: GAO analysis of MDA data | GAO-19-387

^aWhile Spiral 8.2-1 replaced Spiral 6.4 at the U.S. Northern and Indo-Pacific Commands, Spiral 6.4 remained operational at the European and Central Commands, until it was replaced by Spiral 8.2-3 in December 2018.

^bFTM-29 was the first flight test of Engage on Remote (EOR) capability. 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.

^cWhile C2BMC supports multiple flight tests, its capabilities are primarily assessed via ground tests. Ground tests utilize modeling and simulations which are computer representations that simulate the system's performance to assess the capabilities and limitations of how elements perform under a wider variety of conditions than can be accomplished through the limited number of flight tests conducted.

MDA delivered Spiral 8.2-1 providing significant performance and cyber improvements, but some fixes were required after fielding

In January 2018, C2BMC completed fielding and transition to operations of Spiral 8.2-1 providing a significant overhaul of the BMDS command

and control hardware infrastructure.¹ Spiral 8.2-1, replaced the legacy Spiral 6.4, at the U.S. Northern Command and U.S. Indo-Pacific Command. Spiral 8.2-1 improves sensor coverage, ballistic missile track management, and cyber security, optimizing raid size tracking capability and capability for processing new threats to support the defense of United States. Further details on these capabilities follow:

- Spiral 8.2-1 delivery includes the BOA 5.1, which provides improvements in early missile launch detection, allowing more time for all subsequent BMDS actions. It cues land-based sensors allowing them to acquire threats sooner, allowing them longer time to track and thus improving engagement probability.
- Spiral 8.2-1 expands the capability for processing of threat tracks, called System Track, from a single sensor—the Army/Navy Transportable Radar Surveillance-2 (A/N TPY-2)—to include additional sensors for homeland defense and BOA. This allows for additional data sources about threat characteristics that C2BMC subsequently provides to other BMDS elements.
- The delivery of Spiral 8.2-1 also improves cybersecurity. Spiral 8.2-1 replaced Spiral 6.4, which, as we found in May 2018, had cyber vulnerabilities that, if exploited, could have degraded mission capabilities like BMD planning, radar control, track reporting, and situational awareness.²
- Lastly, the program also delivered additional upgrades, to specifically augment BMDS capabilities for the Korean Peninsula. These upgrades were delivered in December 2017 and June 2018, to provide improvements in communication between THAAD and Patriot, and improved cybersecurity in that region.

¹Spiral 8.2-1 was originally planned for delivery in December 2017. However, as we previously reported, according to MDA officials, the delivery was delayed to allow additional time for assessment of results from a BMD system-level ground test campaign called Ground Test-07a. 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, 30, 2018).

²Spiral 6.4 remained operational at U.S. European and U.S. Central Commands until December 2018. In fiscal year 2018, MDA continued efforts to characterize and mitigate associated cyber risks. These activities informed the network defense posture of parts of the BMDS in Europe and provided data on how to reduce mission risk for these elements operating in a cyber-contested environment. Specific test data and resulting assessments are classified.

MDA demonstrated Spiral 8.2-1 upgrades in Ground Test-07a and Ground Test-18 Sprint 1. Table 11 above provides an unclassified overview of C2BMC testing completed in support of fiscal year 2018 deliveries.

While MDA delivered these upgrades and overcame development challenges, some fixes had to be implemented after deployment. Specifically, as we found in May 2018, MDA identified performance risks for Spiral 8.2-1 that could have affected interoperability with other elements and threat tracking and delayed the delivery to address these challenges.³ According to MDA's fiscal year 2018 program management documentation, the program implemented the necessary mitigations to address these challenges; however fixes were also needed to be implemented after the Spiral was delivered. Moreover, the post-deployment fixes required diversion of resources from the subsequent Spiral 8.2-3, delaying demonstration of a certain aspect of that effort.

MDA mitigated prior challenges with Spiral 8.2-3, and demonstrated capability upgrades

In fiscal year 2018, MDA completed most of its development effort for its next spiral named Spiral 8.2-3. In addition, MDA completed a test, demonstrating new capabilities and mitigations to earlier development challenges. As we found in May 2018, in fiscal year 2017, the program was tracking two element level risks to C2BMC capability needed for EPAA Phase 3 called Engage on Remote.⁴ Specifically, program documentation indicated that processing of data about threat missile flight paths, known as threat tracks, had issues that could reduce the likelihood of the successful engagements utilizing Aegis BMD in Engage on Remote scenarios. C2BMC has faced similar challenges with threat tracking capabilities for prior spirals, which required delaying certain aspects of integration with Aegis BMD until fixes were implemented.

While the program was addressing the aforementioned performance risks in fiscal year 2018, it encountered additional challenges. First, it needed to divert some resources from Spiral 8.2-3 to implement fixes to Spiral

³[GAO-18-324](#).

⁴Engage on Remote is expected to increase the area defended by the BMDS, 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. See [GAO-18-324](#).

8.2-1 that were needed after it was deployed. Second, the program needed to divert additional resources to meet a new Warfighter request for geographic redundancy. Specifically, while the original concept was to have 8.2-3 for Central and European Command at the same location, MDA met the Warfighter request by installing the spiral at different locations so that losing one location would not result in the loss of all capability for the Warfighter. Finally, once a key mitigation was completed, the program encountered delays in availability of laboratories needed to assess it. As result, MDA decided to test the mitigation during the GT-07b campaign, along with other Spiral 8.2-3 capabilities. While assessing mitigations for the first time in a large scale campaign is risky – should the mitigation be insufficient or have underseen downstream effects – initial results from GT-07b campaign indicate they were successful. The test demonstrated successful collaboration between Spiral 8.2-3 and Aegis BMD in support the Engage on Remote, as well as other capabilities. Table 11 provides additional information on capabilities demonstrated during GT-07b.

Uncertainty in Ballistic Missile Defense System-level requirements could disrupt Spiral 8.2-5 schedule

While C2BMC program has identified element level requirements for Spiral 8.2-5, requirements for BMDS-level capabilities associated with this spiral are still under development. This Spiral is intended to integrate the Long Range Discriminating Radar (LRDR) and provide additional BMDS-level planning, track processing, and battle management capabilities, in the fiscal year 2021 timeframe, and its acquisition baselines are expected to be included for the first time in the upcoming BMDS Accountability Report. However, according to the November 2018 program execution review, emerging BMDS-level requirements may delay efforts to complete the development of the spiral in time to support LRDR functionality in 2021. Program documentation also indicates that some BMDS capabilities as well as future C2BMC spirals could be at risk of deferral, including the subsequent Spiral 8.2-7.

Appendix VI: Ground-based Midcourse Defense (GMD)



Source: Missile Defense Agency (MDA). | GAO-19-397

Key findings for Fiscal Year 2018

- MDA continues to increase GMD capacity and reliability.
- GMD issues uncovered during salvo test planning demonstrate the value of rigorous and frequent testing.
- MDA recently uncovered major design concerns with the Redesigned Kill Vehicle.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-19-387

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 incoming enemy missile and releases an Exoatmospheric Kill Vehicle to find and destroy the threat. GMD also has ground support and fire control capabilities that the warfighter uses to operate the system. Table 12 provides key fiscal year 2018 GMD program facts.

Table 12: Ground-based Midcourse Defense Program Facts for Fiscal Year 2018

Major Assets Delivered in Fiscal Year 2018		
2 interceptors equipped with the Capability Enhancement-II Block I kill vehicle and Configuration 2 boost vehicle ^a		
Version 7A upgrade to the system's fire control software		
Flight Test Performance in Fiscal Year 2018		
Test Name	Test Date	Test Result
FTG-11	4th quarter of fiscal year 2018	Delayed to March 25, 2019 and was successfully executed. ^b

Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

^aMDA also delivered an additional interceptor in fiscal year 2018 that was previously planned to be delivered in fiscal year 2017.

^bAccording to MDA, FTG-11 was delayed due to competing priorities in the agency's overall test schedule. MDA stated that the delay to FTG-11 did not affect the test schedule for fiscal year 2019.

MDA continues to increase GMD capacity and reliability

MDA fielded three new upgraded interceptors in early fiscal year 2018, meeting its directive from the Secretary of Defense to increase the total number of fielded interceptors to 44 by the end of 2017. The new interceptors are equipped with an upgraded version of the kill vehicle, called the Capability Enhancement (CE)-II Block I, and boost vehicle, called the Configuration 2. MDA completed production and fielded eight of these new interceptors after successfully conducting its first intercept flight test of the upgraded interceptor in May 2017.

Although the program encountered some production challenges with the C2 boost vehicle, such as multiple components initially failing qualification testing, the issues were not significant enough to prevent the program from meeting its December 2017 fielding goal. The upgraded interceptors were designed to be more reliable than their predecessors and their addition to the fleet is intended to improve overall system reliability, as the older interceptors have a greater risk of experiencing in-flight reliability failures. Table 13 below describes the current fleet of 44 fielded interceptors and plans to field an additional 20 interceptors equipped with the Redesigned Kill Vehicle (RKV) and modified Configuration 2 boost vehicle.¹ MDA also successfully completed two ground tests in fiscal year

¹On May 24, 2019, MDA directed the GMD prime contractor, Boeing, to stop all work for the Redesigned Kill Vehicle. This action occurred a few days before the issuance of our report and, as such, we were not able to assess the effects and incorporate this information into our report.

2018 to provide performance assessment data; develop interceptor shot doctrine and tactics, techniques, and procedures; and assess recent performance upgrades to GMD’s fire control software.²

Table 13: Current and Future Fleet of Ground-based Midcourse Defense Interceptors

Total fielded	Fielding dates	Interceptor configuration		Description
		Kill Vehicle	Boost Vehicle	
20	Fiscal Year (FY) 2004-2007	Capability Enhancement (CE)-I	Configuration 1	Prototype kill vehicle design with 3-stage boost vehicle based on legacy avionics and Orion rocket motors
16	FY 2009-2017	CE-II	Configuration 1	Kill vehicle with limited upgrades and heritage boost vehicle
8	FY 2017-2018	CE-II Block I	Configuration 2	Upgraded kill vehicle and boost vehicle for obsolescence, reliability, and survivability improvements
20	FY 2023-2026	Redesigned Kill Vehicle	Configuration 2+	Kill vehicle with improved cost-effectiveness and modified boost vehicle for obsolescence

Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Note: Each of the 20 fielded interceptors equipped with CE-I kill vehicles are unique because they do not have a common configuration. On May 24, 2019, MDA directed the GMD prime contractor, Boeing, to stop all work for the Redesigned Kill Vehicle. This action occurred a few days before the issuance of our report and, as such, we were not able to assess the effects and incorporate this information into our report.

In addition to adding more CE-II Block I interceptors, in fiscal year 2018, MDA accelerated RKV development and initiated plans to increase the total number of fielded interceptors to 64 by the end of 2023 in response to a North Korean missile threat escalation in 2017. In November 2017, DOD requested \$2 billion for what it called the Missile Defeat and Defense Enhancements, \$774 million of which was designated for GMD to: (a) build a new 20-silo missile field at Fort Greely, Alaska; (b) procure long-lead components for four additional interceptors; (c) continue booster development; (d) accelerate RKV development; and (e) add a target to an initial non-intercept RKV flight test. MDA subsequently issued an undefinitized contract action in the form of a sole-source contract modification to Boeing in January 2018 to extend the current GMD

²Ground testing utilizes modeling and simulations which are computer representations that simulate the system’s performance to assess the capabilities and limitations of how elements perform under a wider variety of conditions than can be accomplished through the limited number of flight tests conducted. In addition, DOD defines tactics, techniques, and procedures as follows: tactics are the employment and ordered arrangement of forces in relation to each other; techniques are ways or methods used to perform missions, functions, or tasks; and procedures are standard, detailed steps that prescribe how to perform specific tasks.

development and sustainment contract.³ The contract modification was awarded with a total maximum value not to exceed \$6.565 billion for efforts pertaining to the Missile Defeat and Defense Enhancements and extended the current contract's period of performance 2023. In March 2019, MDA definitized \$4.141 billion of the contract to build the new missile field, among other items, but deferred the production of 20 additional interceptors. According to MDA, this contract modification brings the total cumulative value of the GMD development and sustainment contract, including options, to \$10.8 billion.

GMD issues uncovered during salvo test planning demonstrate the value of rigorous and frequent testing

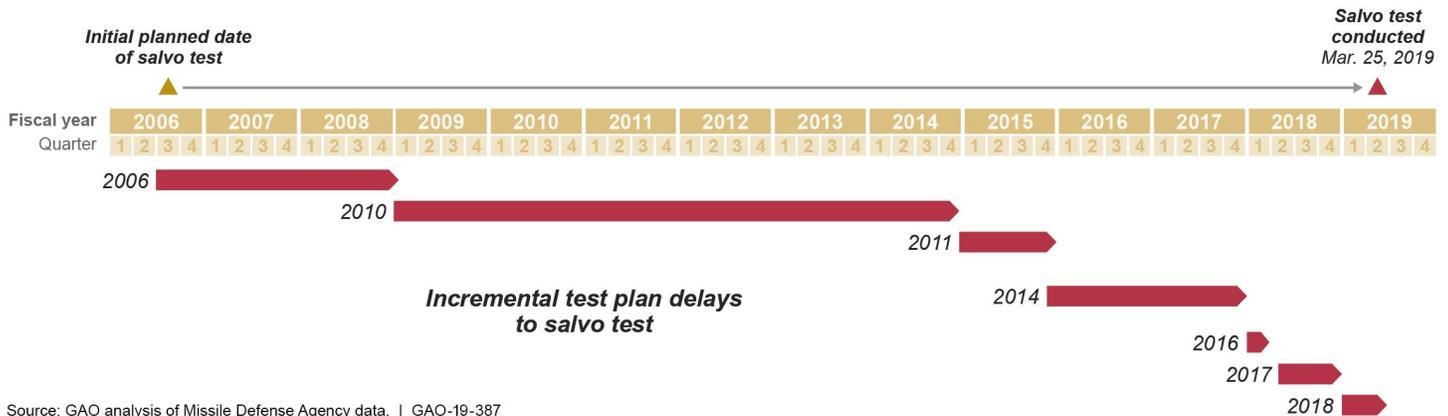
MDA conducted its first salvo flight test of the GMD system, called Flight Test Ground-based Interceptor (FTG)-11 on March 25, 2019 after nearly three decades of GMD development. GMD demonstrated a salvo intercept by firing a CE-II Block I-equipped interceptor followed by a CE-II-equipped interceptor. 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. Demonstrating a salvo capability is particularly important 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).

FTG-11 was further delayed from the end of fiscal year 2018 to mid-fiscal year 2019 to accommodate other BMDS testing priorities while GMD fixed software issues uncovered during pre-test planning. MDA initially planned to conduct the salvo test in fiscal year 2006 but subsequent test failures, developmental challenges, and fielding priorities delayed the salvo test to fiscal year 2018. Figure 4 below provides an overview of the multiple times MDA has delayed the salvo test over the years. By mid-2017, GMD began experiencing delays developing a software upgrade that is intended to provide the kill vehicle with the functionality needed for FTG-11. Around that same time, MDA also realized that its BMDS-level integrated test schedule could not be executed as planned due to a lack

³An undefinitized contract action is a contract vehicle where contract terms, specifications, or price are not agreed upon before work is begun.

of test range and asset availability. According to a May 2018 report MDA submitted to Congress, the agency delayed FTG-11 from the fourth quarter of fiscal year 2018 to the second quarter of fiscal year 2019 to de-conflict the integrated test schedule. Around the time MDA submitted the report to Congress, the GMD program also uncovered performance concerns with the kill vehicle software upgrade that further delayed the software’s completion. As such, the delay to FTG-11 to accommodate other BMDS testing priorities also afforded MDA the time necessary to complete the software improvements and pre-test planning.

Figure 4: Delays to Ground-based Midcourse Defense Salvo Test, Fiscal Year 2009-2019



Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Data for Figure 4: Delays to Ground-based Midcourse Defense Salvo Test, Fiscal Year 2009-2019

Initial planned date of salvo test: 3rd quarter 2006

- First delay (in 2006): Salvo test now 4th quarter of 2008
- Second delay (in 2010): Salvo test now 4th quarter of 2014
- Third delay (in 2011): Salvo test now 4th quarter of 2015
- Fourth delay (in 2014): Salvo test now 4th quarter of 2017
- Fifth delay (in 2016): Salvo test now 1st quarter of 2018
- Sixth delay (in 2017): Salvo test now 4th quarter of 2018
- Seventh delay (in 2018): Salvo test now 3rd quarter of 2019

Salvo test conducted: Mar. 25, 2019

Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

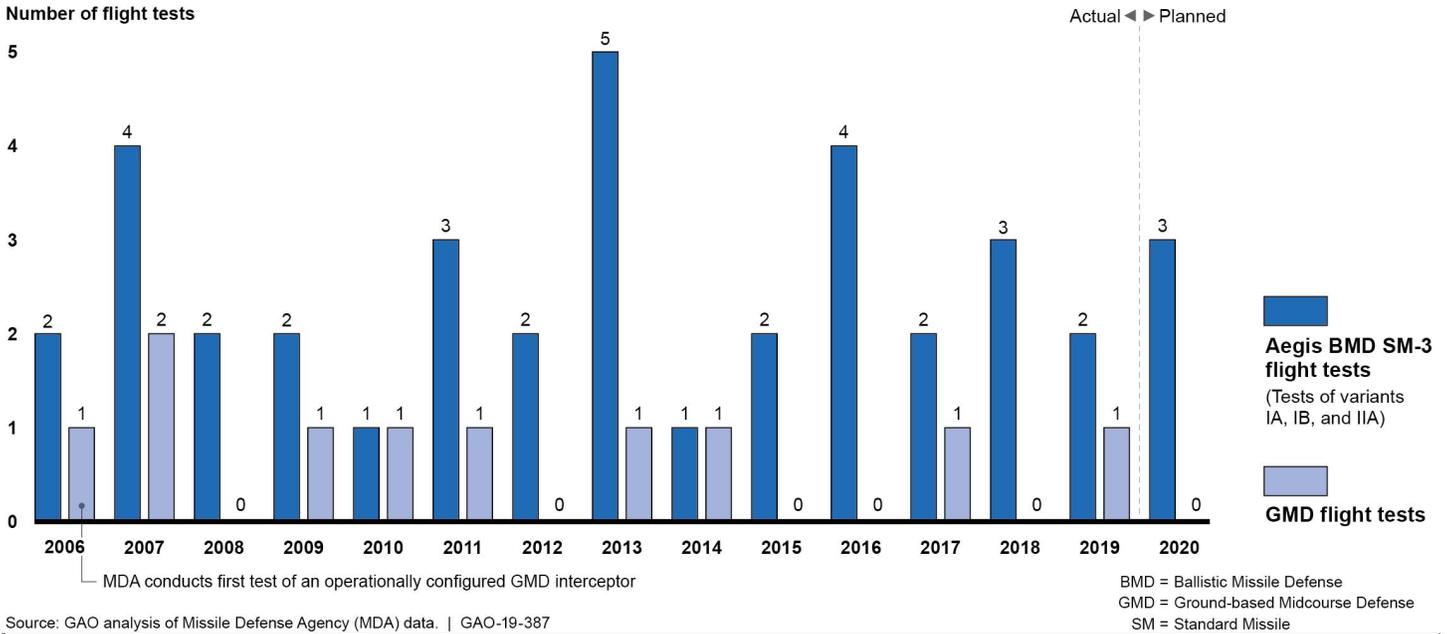
The performance issues MDA uncovered in pre-test planning for FTG-11 demonstrate the value of rigorous and frequent GMD testing. Congress and DOD have recognized the need for rigorous, operationally realistic GMD testing, including conducting a salvo test.⁴ Congress also passed legislation and the president signed into law a requirement for an annual GMD flight test, subject to several exceptions.⁵ However, GMD has historically averaged less than 1 test per year whereas Aegis Ballistic Missile Defense (BMD) Standard Missile (SM)-3 averaged over 2.5 tests per year (see figure 5 below). Moreover, GMD's prior tests achieved less than 50 percent operational realism whereas Aegis BMD SM-3 averaged over 70 percent, according to Director for Operational Test and Evaluation assessments.⁶ The warfighter relies on testing to understand GMD's capabilities and limitations. Without this knowledge, the warfighter lacks the information to operate GMD effectively and efficiently.

⁴For examples, see Department of Defense, *Ballistic Missile Defense Review Report*, (Feb. 2010); Pub. L. No. 112-239, § 228(a); and Office of the Secretary of Defense, *2019 Missile Defense Review*, (Jan. 17, 2019).

⁵Pub. L. No. 114-328, § 1689

⁶Director, Operational Test and Evaluation, *2018 Assessment of Ballistic Missile Defense System (BMDS)*, (Feb. 2019); *2017 Assessment of Ballistic Missile Defense System (BMDS)*, (Feb. 2018); *2016 Assessment of Ballistic Missile Defense System (BMDS)*, (Apr. 2017); and *2015 Assessment of the Ballistic Missile Defense System (BMDS)*, (Apr. 2016).

Figure 5: Comparison of Ground-based Midcourse Defense (GMD) and Aegis Ballistic Missile Defense (BMD) Standard Missile (SM)-3 Intercept Flight Testing Pace



Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-19-387

Data for Figure 5: Comparison of Ground-based Midcourse Defense (GMD) and Aegis Ballistic Missile Defense (BMD) Standard Missile (SM)-3 Intercept Flight Testing Pace

Year	Number of Aegis Ballistic Missile Defense Standard Missile-3 flight tests (Tests of variants IA, IB, and IIA)	Number of Ground-based Midcourse Defense flight tests
2006	2	1 (first test of an operationally configured GMD interceptor)
2007	4	2
2008	2	0
2009	2	1
2010	1	1
2011	3	1
2012	2	0
2013	5	1
2014	1	1
2015	2	0
2016	4	0
2017	2	1
2018	3	0
2019	2	1

Year	Number of Aegis Ballistic Missile Defense Standard Missile-3 flight tests (Tests of variants IA, IB, and IIA)	Number of Ground-based Midcourse Defense flight tests
2020 (Planned)	3	1

MDA recently uncovered major design concerns with the Redesigned Kill Vehicle

Although MDA attempted to accelerate RKV development as part of the Missile Defeat and Defense Enhancements, the program accepted too much risk and has since experienced development challenges that set the program back likely by over two years and increased the program’s cost by nearly \$600 million, according to the agency. In response to advancements in the North Korean missile threat, MDA accelerated RKV development by concurrently performing development and production and reducing the number of necessary flight tests to produce and field new RKV-equipped interceptors. Moreover, the RKV had already experienced development delays prior to the acceleration and was operating with no schedule margin for any further delays as it approached a critical design review in October 2018. The program subsequently encountered design, systems engineering, quality assurance, and manufacturing issues, which resulted in the program postponing the critical design review.

The most significant development issue that emerged in 2018 pertained to RKV’s performance and its planned use of commercial off-the-shelf hardware and re-use of Aegis SM-3 Block IIA components. In multiple previous reports, we raised concerns regarding MDA’s use of these components as well as RKV’s aggressive development schedule.⁷ In our May 2017 report, we also recommended that DOD perform a comprehensive review of the RKV. Although such a review could have potentially provided DOD with a better understanding of RKV’s technical and schedule risks, DOD indicated in its response that the comprehensive review we recommended was unnecessary and therefore

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); *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: 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).

did not perform the review.⁸ Even though some of these risks have since manifested, we continue to believe an independent, thorough vetting of RKV's acquisition risks is necessary, as we previously recommended.⁹

Although RKV continued to carry significant acquisition risks, MDA implemented a recovery plan that attempted to minimize the addition of further risks by opting to prioritize controlling technical risks over preserving the 2023 fielding goal via an aggressive schedule. At the time of our review, the program projected that it would conduct a critical design review for RKV in early fiscal year 2021 followed by a non-intercept flight test in fiscal year 2022, an intercept test in fiscal year 2023, and deployment starting a few months later. The extended design period provided the program additional time to source or design new components before moving forward with testing and production. Production decision gates also remained aligned to the critical design review and subsequent flight tests. The recovery plan also placed greater emphasis on addressing technical risks rather than fielding deadlines to determine RKV's path forward. Our prior work has shown that stabilizing system design before making major production commitments and relying on knowledge rather than deadlines to make acquisition decisions at key milestones are best practices of successful product developers.¹⁰ MDA'S Deputy Director stated during a March 2019 press briefing that "the best thing to do was to go back and assess that [RKV] design and take the time to do it right." The Deputy Director also acknowledged that it would have been the wrong step to do "what the Missile Defense Agency did

⁸DOD stated in its response to our May 2017 report that the Joint Staff, Office of the Secretary of Defense, and Office of Cost Assessment and Program Evaluation (CAPE) conducted a comprehensive review of the RKV acquisition strategy before it was approved by departmental leadership. We agreed that the RKV acquisition strategy was reviewed before it was approved, but the review they performed was not comparable to the type of in-depth review we recommended. The type of review we recommended was modeled after a 2013 CAPE study of the Precision Tracking Space System, which included an analysis of the program's cost, schedule, technical design, and acquisition strategy. This review helped uncover significant technical, programmatic, and affordability risks. For more information on the 2013 CAPE study, see GAO, *Missile Defense: Precision Tracking Space System Evaluation of Alternatives*, [GAO-13-747R](#) (Washington, D.C.: July 25, 2013).

⁹[GAO-17-381](#)

¹⁰For examples of GAO reports that identify knowledge-based acquisition practices, see GAO, *Defense Acquisitions: Risks Posed by DOD's New Space Systems Acquisition Policy*, [GAO-04-379R](#) (Washington, D.C.: Jan. 29, 2014); and *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, [GAO-02-701](#) (Washington, D.C.: July 15, 2002).

years ago, which is to go ahead and produce what we've got and then deal with reliability issues in the fleet and erode the confidence of the warfighter.”

On May 24, 2019, MDA directed the GMD prime contractor, Boeing, to stop all work for the RKV. This action occurred a few days before the issuance of our report and, as such, we were not able to assess the effects and incorporate this information into our report.

Appendix VII: Targets and Countermeasures



Source: Missile Defense Agency (MDA). | GAO-19-397

Key findings for Fiscal Year 2018

- Targets program met some of its fiscal year 2018 goals.
- Target availability will be a risk for the Missile Defense Agency's aggressive test schedule through 2021.
- Medium Range Ballistic Missile T1/T2 target's continued cost growth and schedule delays have led to limited testing.

Source: Missile Defense Agency (MDA) and GAO analysis of MDA data. | GAO-19-387

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 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 14 provides information on the Targets program's performance in fiscal year 2018.

¹The target ranges are as follows: short (Less than 1000 kilometers), medium (1000 to 3000 kilometers), intermediate (3000 to 5500 kilometers), and intercontinental (greater than 5500 kilometers).

Table 14: Targets and Countermeasures Program’s Fiscal Year 2018 Performance

Major Deliveries	
Planned Delivery	Delivery Status
3 SRBM	Delivered. The Targets program delivered the three SRBMs and successfully flew two of the three SRBMs in flight tests JFTM-05 E1 and JFTM-05 E2 in September 2018. The third SRBM was a back-up which was not used.
2 MRBM	Partially Delivered. The Targets program delivered one of the two MRBMs as planned, the MRBM T4-E for flight test FEV-01; however, this test was canceled primarily to reallocate the target for a higher priority test called FTM-45. MDA had also determined that this test’s objectives had generally been met through other testing. ^a The other MRBM to support flight test FTM-31 was delayed due to developmental complexities and test range availability.
2 IRBM	Delayed. The two IRBMs scheduled for fiscal year 2018 in support of the Ballistic Missile Defense System-level operational flight test FTO-03 E1 were delayed to the first quarter of fiscal year 2019 to align with changes to the test schedule. ^b The Targets program delivered one IRBM in fiscal year 2018; however, it was originally scheduled for fiscal year 2017 to support flight test FTM-29.
1 ICBM	Delayed. The Targets program planned to deliver the target on-time to support flight test FTG-11; however, delivery of the target was delayed nine months to align with changes to the test schedule for the Ground-based Midcourse Defense program.
Total planned: 8 targets	Total delivered as planned: 4 targets

Flight Tests			
Test name	Test type	Test date	Target Performance
*FS 17-2	Intercept	Oct. 2017	Nominal. One SRBM performed as expected.
*FS 17-4	Intercept	Oct. 2017	Nominal. One MRBM performed as expected.
*FTM-29	Intercept	Jan. 2018	Nominal. One IRBM performed as expected.
*FTX-35	Non-intercept	Apr. 2018	Nominal. One SRBM performed as expected.
JFTM-05 E1	Non-intercept	Sep. 2018	Nominal. One SRBM performed as expected.
JFTM-05 E2	Intercept	Sep. 2018	Nominal. One SRBM performed as expected.

Legend:

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

* The target for the flight test was delivered in a prior fiscal year.

Source: GAO analysis of Missile Defense Agency data. -| GAO-19-387

^aFTM-45 was added to the test schedule after the failure of FTM-29. See Appendix IV.

^bThe two intermediate-range ballistic missiles were delivered October 2, 2018, which is fiscal year 2019.

Targets program met some of its fiscal year 2018 goals

The Targets program delivered four of eight targets as planned for fiscal year 2018, and delayed the remaining targets based on test schedule requirements and developmental complexities. One target, the intercontinental-range ballistic missile, was delayed 9 months, from the third quarter of fiscal year 2018 to the first quarter of fiscal year 2019, to align with changes to the test schedule for the Ground-based Midcourse Defense (GMD) program. The GMD program discovered some software issues with its system during pre-test planning that had to be resolved prior to moving forward with flight test FTG-11, which will use the intercontinental-range ballistic missile.² According to Targets program officials, the Targets program requested that the contractor delay the delivery of the intercontinental-range ballistic missile to avoid dealing with sensitive aspects of the target, such as fueling, that would necessitate special storage of the target. The two intermediate-range ballistic missiles for the BMDS-level operational test FTO-03 E1 were delayed from the second quarter of fiscal year 2018 to the first quarter of fiscal year 2019 to accommodate a new test for the Aegis Ballistic Missile Defense (BMD) Standard Missile-3 Block IIA program following the failure of one of its interceptors during flight test FTM-29. MDA's decision to conduct a new test—FTM 45—to ensure the cause of failure had been resolved created test range and asset availability issues that necessitated delaying the BMDS-level operational test FTO-03 E1, and the targets for the test, to a later point in time.³ The one medium-range ballistic missile for flight test FTM-31 was delayed due to developmental complexities and test range availability.

The Targets program flew a total of six targets in fiscal year 2018 to support MDA's flight test schedule, including four short-range, one medium-range, and one intermediate-range, all of which performed nominally. The risk of a target malfunction or failure was lower in fiscal year 2018 than it has been in previous years, because all of the targets had flown in flight tests previously (i.e., none of the targets were new). However, the Targets program is currently planning to fly two new medium-range targets in fiscal year 2019, and the flight tests with these targets either precede or are adjacent to other important tests in MDA's

²For further details on the GMD program, see appendix VI.

³For further details on the Aegis BMD Standard Missile-3 Block IIA program, see appendix IV.

test plan. We have previously reported that, new, untested targets introduce higher risk for malfunction or failure that can mean costly and time-consuming retests.⁴ Accordingly, we recommended that MDA add a non-intercept flight test for each new target type to verify its performance and reduce risks for future flight tests. MDA has not implemented this recommendation and has continued to use new targets during flight tests.

The Targets program conducted one of two critical design reviews in fiscal year 2018. A critical design review assesses the final design of a target to ensure that it can proceed into production and testing and can meet its stated performance requirements within cost, schedule, and risk. The Targets program conducted a critical design review for the medium-range ballistic missile type 3 configuration two (MRBM T3c2) target in the third quarter of fiscal year 2018. The MRBM T3c2 is a new target that Targets program officials said involves minimal design because it leverages flight-proven hardware and a significant amount of heritage software from the intermediate- and intercontinental-range targets currently in production. However, the Targets program plans to conduct another critical design review for the MRBM T3c2 target in the first quarter of fiscal year 2019 due to the addition of hit detection software which will enable real-time feedback on the target's impact points. The Targets program did not complete the critical design review for the short-range ballistic missile type four G (SRBM T4-G) in the third quarter of fiscal year 2018, after it had been delayed a year, from the third quarter of fiscal year 2017. The Targets program subsequently delayed the critical design review for the SRBM T4-G target another year, to the third quarter of fiscal year 2019. According to the Targets program, the delay in the critical design review for the SRBM T4-G is due to some technical challenges associated with developing the target and the contractor's limited staffing and workload.

⁴GAO, *Missile Defense: Actions Needed to Improve Transparency and Accountability*, [GAO-11-372](#) (Washington, D.C.: Mar. 24, 2011), [GAO-13-432](#), *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); 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).

Target availability will be a risk for MDA's aggressive test schedule through 2021

The Targets program may face challenges providing some targets to support MDA's test schedule due to the aggressiveness and volatility of the test schedule. We have previously found that MDA's test schedule is aggressive, in that it includes too many tests and little to no margin between tests to ensure executability.⁵ Thus, when setbacks occur, such as target or system malfunctions, the margin between tests erodes. MDA relieves pressure in its test schedule by delaying and canceling tests instead of including sufficient schedule margin to ensure executability, as we previously recommended.⁶ When the schedule slips for one test, there are often reverberating impacts to other tests. Consequently, MDA's test plan has continued to be volatile, with frequent delays, cancellations and other changes, which make it challenging for the Targets program to manage all of the resources and schedules for its various targets to ensure successful, on-time availability and execution. When targets are not available for testing as planned, the tests either receive substitute targets which can mean trade-offs in the performance aspects demonstrated during the test or the test is delayed, which prolongs the demonstration of systems for the warfighter.

One way that the Targets program has tried to ensure the availability of targets for MDA's aggressive test schedule is through the use of concurrency—overlap between development, testing, and production—for some targets. We have previously reported that some concurrency is understandable, but committing to production before development and testing is complete is a high-risk strategy that often results in performance shortfalls, unexpected cost increases, schedule delays, and test problems.⁷ The Targets program is using concurrency for the MRBM T3c2 target. According to the Targets program, it is using concurrency for

⁵GAO, *Missile Defense: Actions Needed to Improve Transparency and Accountability*, [GAO-11-372](#) (Washington, D.C.: Mar. 24, 2011); [GAO-15-345](#); *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).

⁶[GAO-11-372](#).

⁷GAO, *Missile Defense: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency*, [GAO-12-486](#) (Washington, D.C.: Apr 14, 2012).

the MRBM T3c2 target due to the urgent need to support essential testing within MDA’s test schedule. The first flight test with the MRBM T3c2 target is FTM-31, which is scheduled for the fourth quarter of fiscal year 2019. Qualification testing and production are ongoing and scheduled to be completed in April 2019 (third quarter of fiscal year 2019). The target must be delivered in advance of the planned test date to complete final preparations for transport to the test site. Thus, the Targets program has very little to no time to resolve any issues prior to delivering it for FTM-31, as shown in figure 6. According to the Targets program, late completion of qualification testing or failures that result in major redesigns may delay FTM-31, as well as significantly impact the cost and schedule for this target.

Figure 6: High Concurrency for the Medium-Range Ballistic Missile Type Three Configuration Two (MRBM T3c2) Target



Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Data for Figure 6: High Concurrency for the Medium-Range Ballistic Missile Type Three Configuration Two (MRBM T3c2) Target

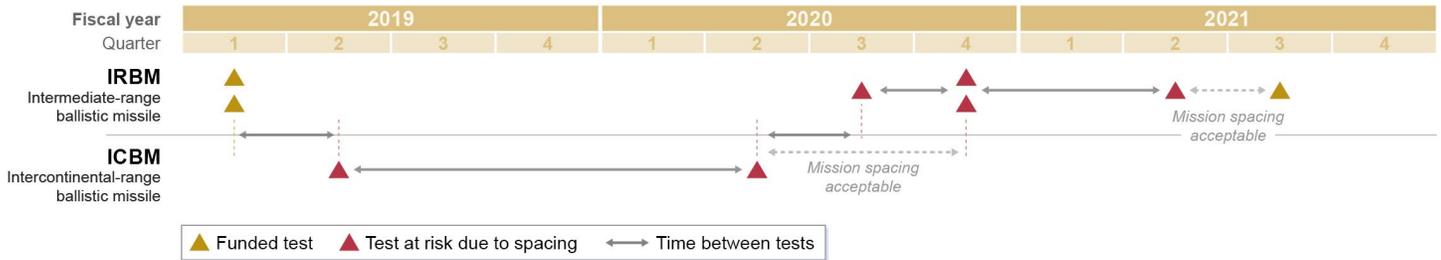
- **Developmental testing:** from before Fiscal Year (FY) 2018 to 2nd quarter of FY2019
- **Qualification testing:** from before FY2018) to 3rd quarter of FY2019
- **Production:** from 4th quarter of FY2018 to 3rd quarter of 2019
- **Target delivered:** 3rd quarter of 2019
- **Test date:** 4th quarter of 2019

Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Another way that the Targets program tries to ensure availability of targets for MDA’s aggressive test schedule is to maintain aggressive delivery schedules for some targets. For example, the Targets program has an aggressive delivery schedule for its intermediate- and intercontinental-range targets through fiscal year 2021. According to the contractor for the intermediate- and intercontinental-range targets, there are specific time-spacing requirements that the contractor needs in order to produce and configure targets for a test in relation to the production

and configuration of targets for other tests. The contractor said that these specific time-spacing requirements are needed due to limitations with the testing, storage, movement, and transport of these targets. Specifically, we observed that the facility where these targets go through final assembly prior to use in a flight test can currently hold two fully assembled intermediate-range targets and the component for one intercontinental-range target which is assembled at the launch site due to its size.

Figure 7: Missile Defense Agency’s Test Schedule for Intermediate- and Intercontinental-Range Ballistic Missiles through Fiscal Year 2021



Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Data for Figure 7: Missile Defense Agency’s Test Schedule for Intermediate- and Intercontinental-Range Ballistic Missiles through Fiscal Year 2021

IRBM= Intermediate-range ballistic missile; ICBM= Intercontinental-range ballistic missile; FY= Fiscal year

Test schedule

- 1st quarter of FY2019: 2 IRBMs
- 2nd quarter of FY2019: 1 ICBM (Test at risk due to spacing)
- 2nd quarter of FY2020: 1 ICBM (Test at risk due to spacing)
- 3rd quarter of FY2020: 1 IRBM (Test at risk due to spacing)
- 4th quarter of FY2020: 2 IRBMs (Test at risk due to spacing)
- 2nd quarter of FY2021: 1 IRBM (Test at risk due to spacing)
- 3rd quarter of FY2021: 1 IRBM (Mission spacing acceptable)

Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

As shown in figure 7, almost all of the tests through fiscal year 2021 are at risk of the target not being available as planned. One of the most severe risks to target availability is in fiscal year 2020 when an

intermediate-range target is scheduled for a test in the third quarter, followed by a test using dual (i.e., two) intermediate-range targets in the following quarter. According to the contractor's specific time-spacing requirements, it needs five months, but the approximate amount of time between these tests is three months. According to the Defense Contract Management Agency (DCMA), if MDA includes multiple intermediate- and intercontinental-range missions in the test plan within close proximity without accounting for the contractor's specific time-spacing requirements, it will be, at best, very challenging for the contractor, and at worst, unachievable.

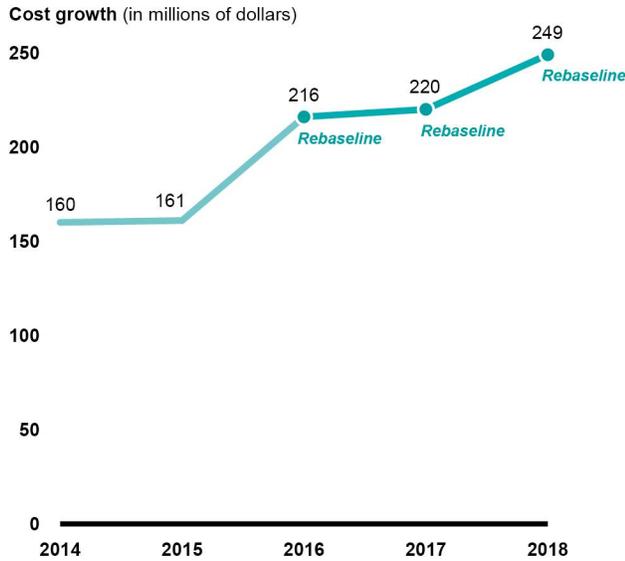
MRBM T1/T2 target's continued cost growth and schedule delays have led to limited testing

The Targets program has a target—the medium-range ballistic missile type one/type two (MRBM T1/T2)—that continues to have cost growth and schedule delays, which we have previously reported.⁸ However, this target's costs have continued to be unstable, and despite changes and rebaselines, the contractor has been unable to meet projections.⁹ Figure 8 below shows the cost growth from 2014 through 2018. In 2017, the Targets program conducted a review of the MRBM T1/T2 target to address significant cost growth and set new projections. Again, in 2018, the Targets program and the contractor planned to conduct another review to address additional cost growth since the prior year's rebaseline. Despite relatively steady periods of performance following a rebaseline, DCMA officials believe that this contractor will continue to have cost growth. The DCMA established that some of the root causes for the cost growth are incomplete contract requirements and program requirements changes. Additionally, MDA and DCMA officials have acknowledged that the contractor did not adequately account for the costs associated with this target at the outset. How much cost growth there will be moving forward is unknown.

⁸GAO-15-345; GAO-16-339R, and *Missile Defense: The Warfighter and Decision Makers Would Benefit from Better Communication about the System's Capabilities and Limitations*, GAO-18-324 (Washington, DC: May 30, 2018).

⁹The purpose of a rebaseline is to realign a program's established plans (i.e., baseline) based on a change in requirements, costs, or schedule.

Figure 8: Cost Growth for the Medium-Range Ballistic Missile Type One/Type Two (MRBM T1/T2) Target, 2014 through 2018



Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Data Table for Figure 8: Cost Growth for the Medium-Range Ballistic Missile Type One/Type Two (MRBM T1/T2) Target, 2014 through 2018

Year	Cost growth (in millions of dollars)
2014	160
2015	161
2016	216 (Rebaseline)
2017	220 (Rebaseline)
2018	249 (Rebaseline)

In addition to cost growth, the MRBM T1/T2 target has continued to have schedule delays due to technical failures, which has led to the decision to forego some testing as a cost-cutting and time-saving measure. For example, the contractor’s first flight of this target has been delayed approximately 5 years beyond the original plan, from third quarter fiscal year 2014 to fourth quarter fiscal year 2019. The primary reason for this delay has been an unusually high number of failures during pre-test qualification testing, according to the DCMA. The DCMA believes that the test failures are due to the elimination of sub-section testing, which it understands the program and contractor initiated as a cost-cutting and time-saving measure. According to DCMA, sub-section testing involves

piecing together different components of the target and then testing that sub-section before the target is fully assembled. This type of testing can help the contractor isolate any integration issues between components in a specific area of the target. However, DCMA said that the contractor is testing the components and then fully assembling the target. Once fully assembled, they are conducting testing and experiencing the unusually high number of failures. When these types of failures occur, according to DCMA, the contractor conducts root cause analysis to make corrections and resolve the issue; however, DCMA officials noted that there is no commonality in the root causes. Thus, the contractor may not understand what steps to take to resolve the issue and ensure that the target performs as expected during a flight test.

It is currently unclear how the MRBM T1/T2 target will perform during upcoming tests, because of the Targets program's decision to forego some qualification testing and not confirming the target's performance through a non-intercept test, as we have previously recommended.¹⁰ However, the Targets program stated it considers the MRBM T1/T2 performance a minimal risk because the MRBM T1/T2 is largely based on a prior target's design which, according to the program, was successfully flown twice. The MRBM T1/T2 is currently scheduled to fly in two critical tests in fiscal year 2019 and 2020. The first is an intercept flight test for the Terminal High Altitude Area Defense (THAAD) program in the fourth quarter of fiscal year 2019, which supports the delivery of an urgent capability to the warfighter. After this first flight test with this target, the next test with this target is MDA's third and largest operational flight test of the BMDS to-date—FTO-03 E2—with five targets flying simultaneously and, three interacting weapon systems—THAAD, Patriot, and Aegis BMD. This test is currently scheduled for the fourth quarter of fiscal year 2020. Both of these tests are important and the use of this new target in these tests increases the risk that the tests will not go as planned and that retests may be necessary; however, a retest for FTO-03 E2 would be extremely costly and very difficult to replan.¹¹

¹⁰[GAO-13-432](#)

¹¹ FTO-03 E2 was renamed FTO-03 following the name change of FTO-03 E1 to FTI-03 in October 2018.

Appendix VIII: Terminal High Altitude Area Defense (THAAD)



Source: Missile Defense Agency (MDA). | GAO-19-397

Key findings for Fiscal Year 2018

- THAAD met most of its fiscal year 2018 delivery and testing goals.
- THAAD is rebaselining to address Joint Emergent Operational Needs for Korea.
- THAAD may face challenges meeting its aggressive flight test schedule through 2021.
- MDA and Army closer to resolving the impasse regarding the transfer of THAAD.

Source: GAO analysis of Missile Defense Agency programs. | GAO-19-387

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 660 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. The Army has THAAD batteries deployed in Guam and South Korea. Table 15 provides key fiscal year 2018 THAAD program facts.

Table 15: Terminal High Altitude Area Defense's (THAAD) Fiscal Year 2018 Performance

Major Deliveries			
Planned Delivery		Delivery Status	
53 Interceptors		Delivered. THAAD delivered 58 interceptors and interceptor production has recovered from a prior parts quality issue.	
Battery 7 components		Delivered. Battery 7 components delivered.	
THAAD Software Build 3.0		Delivered. THAAD Software Build 3.0 to expand THAAD's ability to counter new threats and improve performance in the presence of debris.	
Flight Tests			
Test name	Test type	Test date	Test result
FTX-35	Non-intercept	Apr. 2018	Met Objectives. THAAD and Patriot tracked a ballistic missile target, exchanged messages over tactical datalinks, and conducted simulated engagements of the target to meet requirements for the material release of THAAD 3.0 software and complete annual interoperability testing. ^a
FTX-36	Non-intercept	N/A	Test Canceled. Test objectives were moved to FTX-35.

Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

^aNational Defense Authorization Act for Fiscal Year 2016, Pub. L. No. 114-92, § 1675(b).

THAAD met most of its fiscal year 2018 delivery and flight test goals

THAAD met its fiscal year 2018 goals for deliveries and flight testing. THAAD exceeded the number of interceptors it had originally planned to deliver in fiscal year 2018 because it is recovering from a parts quality issue. The parts quality issue was with a connector in the interceptor, and although THAAD stopped interceptor deliveries in order to resolve the issue, it did not stop interceptor production. Consequently, there was a stockpile of interceptors just awaiting a redesigned connector in order to be delivered. We previously reported on this parts quality issue and noted that interceptor deliveries, with the redesigned connector, resumed in April 2017 and interceptor production and deliveries have been steady since.¹ In addition to delivering the interceptors, THAAD delivered the

¹[GAO-17-381](#) and [GAO-18-324](#).

seventh, and final, battery of equipment. The delivery was later than previously planned to accommodate the Army's operational timelines and a new software upgrade to improve THAAD's performance against certain threats and in the presence of debris during the intercept of a threat missile.²

Although THAAD was successful in delivering its planned assets for fiscal year 2018, it only conducted one of two planned non-intercept tests. Specifically, FTX-36 was canceled due to target availability from an external vendor and its objectives were reassigned to FTX-35, which was successfully conducted in April 2018. FTX-35 supported the material release of the THAAD 3.0 software (i.e., it is available for use by the warfighter) and the requirement for interoperability testing.

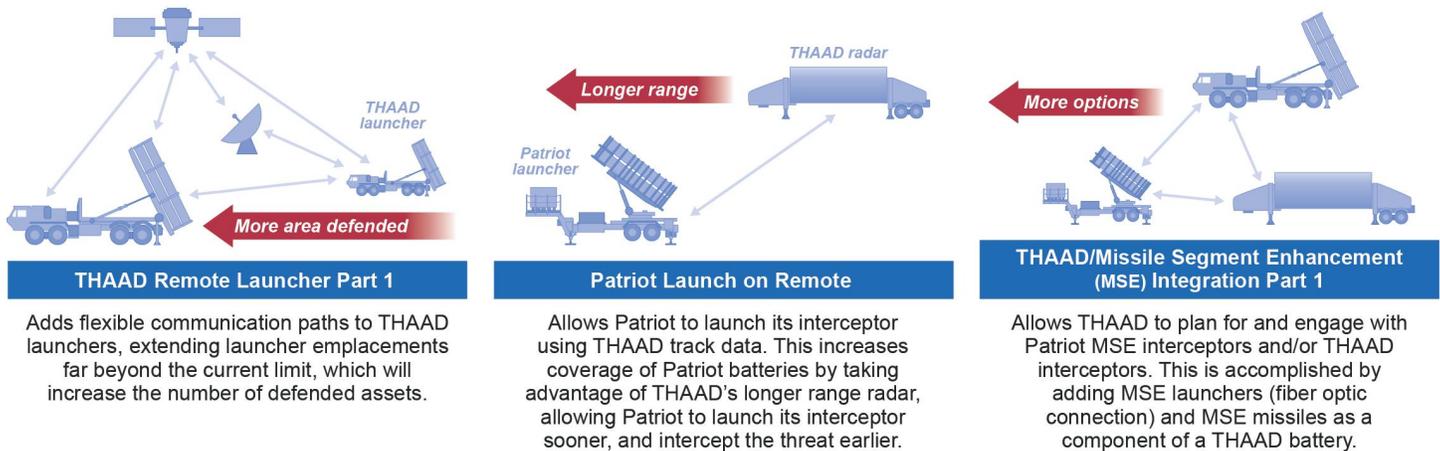
THAAD is rebaselining to address Joint Emergent Operational Needs for Korea

THAAD is in the process of rebaselining from two separate acquisition efforts, known as THAAD I and II, to a single acquisition effort, known as THAAD III, to incorporate changes to address the United States Forces Korea (USFK) Joint Emergent Operational Needs (JEON).³ The purpose of a rebaseline is to update a program's established plans (i.e., baseline) due to a change in requirements, costs, or schedule. USFK JEON is a rapid acquisition effort to field ballistic missile solutions within the next 3 years to improve the defensive posture of Korea. Specifically, the USFK JEON's ballistic missile solutions are focused on improving integration between THAAD and Patriot as shown in figure 9, which could enable the defense of larger areas and more assets and provide the warfighter greater flexibility in planning and executing defensive actions.

²In [GAO-18-324](#), we reported that THAAD's seventh battery of equipment had been delayed, from the third quarter of fiscal year 2017 to the second quarter of fiscal year 2018. The delay was driven by changing Army operational timelines, which postponed the availability of some of THAAD's seventh battery equipment for scheduled upgrades.

³ All remaining efforts from THAAD I and II, primarily hardware production and software enhancements, respectively, will be combined with THAAD III.

Figure 9: Terminal High Altitude Area Defense (THAAD) Upgrades to Address the Joint Emergent Operational Needs (JEON) for Korea



Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Data for Figure 9: Terminal High Altitude Area Defense (THAAD) Upgrades to Address the Joint Emergent Operational Needs (JEON) for Korea

- **THAAD Remote Launcher Part 1 (More area defended)**
Adds flexible communication paths to THAAD launchers, extending launcher emplacements far beyond the current limit, which will increase the number of defended assets.
- **Patriot Launch on Remote (Longer range)**
Allows Patriot to launch its interceptor using THAAD track data. This increases coverage of Patriot batteries by taking advantage of THAAD's longer range radar, allowing Patriot to launch its interceptor sooner, and intercept the threat earlier.
- **THAAD/Missile Segment Enhancement (MSE) Integration Part 1 (More options)**
Allows THAAD to plan for and engage with Patriot MSE interceptors and/or THAAD interceptors. This is accomplished by adding MSE launchers (fiber optic connection) and MSE missiles as a component of a THAAD battery.

Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

In fiscal year 2018, THAAD delivered software upgrades that provided the initial integration between THAAD and Patriot to improve their ability to coordinate when engaging a threat missile, in support of USFK JEON. These upgrades were assessed in an April 2018 flight test—FTX-35—that demonstrated interoperability between THAAD and Patriot by exchanging messages over tactical data links while tracking a missile target, and an

April 2018 BMDS-level ground test which provided further performance data in a simulation environment. THAAD currently plans to deliver USFK JEON upgrades through fiscal year 2021. We currently have ongoing work related to this and details will be included in future reports.

THAAD will face challenges meeting its aggressive flight test schedule through 2021

MDA has nearly tripled THAAD's flight tests—from three to eight—between fiscal years 2019 and 2021 to support both USFK JEON, an urgent operational need for the Army, and interoperability testing.⁴ Consequently, the schedule margin between each test has decreased from more than a year to three to six months. According to our best practices for scheduling, a practical amount of schedule margin is needed to account for risks and uncertainties.⁵ In addition, schedule margin can provide time to analyze the results from the preceding test and correct any identified issues before moving forward with further testing which may be reliant on the results of the preceding test. We have previously reported that MDA leaves little to no schedule margin in its flight test schedule to ensure executability and the test schedule is success-oriented, in that it does not plan for failures which makes it difficult to absorb test failures when they occur.⁶

In addition to the reduced schedule margin between THAAD's tests, some of its tests in this timeframe are higher risk. For example, one test will be flying a new, untested target which increases the risks for that test, and another test will be the largest and most complex operational test to-date, flying five targets simultaneously. Therefore, the test schedule is aggressive, complex, and is at risk of not being completed as planned. However, THAAD has not identified its flight test schedule as a risk. Also, THAAD officials and an official from DOD's Director of Operational Test and Evaluation have asserted that the flight test schedule is doable, if everything goes according to plan, and that the biggest risk is fatigue among the personnel supporting the tests. While THAAD has a generally successful record for conducting flight tests, its current flight test schedule

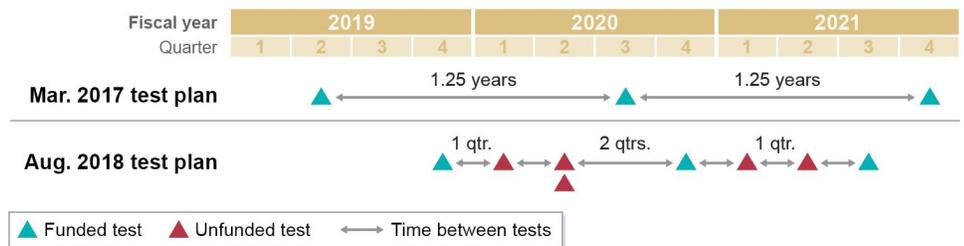
⁴National Defense Authorization Act for Fiscal Year 2016, Pub. L. No. 114-92, § 1675 (b).

⁵GAO, *Schedule Assessment Guide Best Practices for Project Schedules*, [GAO-16-89G](#), (Washington, D.C: Dec. 22, 2015).

⁶ [GAO-11-372](#) , [GAO-16-339R](#), and [GAO-17-381](#).

includes almost as many flight tests in 3 fiscal years as it did for the prior 9 fiscal years. Figure 10 below details the changes in THAAD’s flight testing from its previous plan to its current plan.

Figure 10: Missile Defense Agency’s Increase in Flight Testing for the Terminal High Altitude Area (THAAD) Program through Fiscal Year 2021



Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Data for Figure 10: Missile Defense Agency’s Increase in Flight Testing for the Terminal High Altitude Area (THAAD) Program through Fiscal Year 2021

March 2017 test plan

- 2nd quarter FY2019: Funded test
- 3rd quarter FY2020: Funded test (1.25 years from last test)
- 4th quarter FY2021: Funded test (1.25 years from last test)

Aug. 2018 test plan

- 4th quarter FY2019: Funded test
- 1st quarter FY2020: Unfunded test (1 quarter from last test)
- 2nd quarter FY2020: 2 unfunded tests (1 quarter from last test)
- 4th quarter FY2020: Funded test (2 quarters from last test)
- 1st quarter FY2021: Unfunded test (1 quarter from last test)
- 2nd quarter FY2021: Unfunded test (1 quarter from last test)
- 3rd quarter FY2021: Funded test (1 quarter from last test)

In addition to the increase in testing and lack of margin between tests, another risk to THAAD’s flight test schedule is that some tests have not yet been funded, as shown in figure 10 above. Funding is essential to enable the planning and execution of each flight test. While THAAD is tracking the lack of funding for these tests as a risk, there is no mitigation strategy if all testing to support USFK JEON remains unfunded. If a single

test is not funded or executed, the Army will perform a risk-based assessment using the available data to decide whether or not to deploy the capability for use by the warfighter. If THAAD does not conduct the testing as planned, it will forego the demonstration and confirmation of capability performance which leaves the warfighter with the decision to either not use the capability or use it with an increased risk that it may not perform as intended. THAAD officials noted, however, that the Army's decision to deploy a capability is based on multiple sources of data such as laboratory and ground testing, not just flight testing.

MDA and Army closer to resolving the impasse regarding the transfer of THAAD and the Army Navy/Transportable Radar Surveillance and Control Model-2 (AN/TPY-2)

MDA and the Army are nearing a resolution regarding the transfer of the THAAD and AN/TPY-2 programs to the Army; however, the resolution will likely resemble the current arrangement wherein MDA maintains primary responsibility through production and the Army operates and sustains them. We previously reported that MDA and the Army were at an impasse over the transfer of the THAAD and AN/TPY-2 programs because MDA was willing to transfer them as-is, but the program cannot meet the Army's mission requirements and it would take an estimated \$10.1 billion to do so.⁷ Table 16 lists the differences between the programs of record and the Army's requirements.

Table 16: Terminal High Altitude Area Defense (THAAD) and Army Navy/Transportable Radar Surveillance and Control Model-2 (AN/TPY-2) Program of Record Versus Army Requirements

THAAD and AN/TPY-2 Program of Record	Army Requirements	Difference	Estimated Cost
7 THAAD batteries of ground equipment	9 THAAD batteries of ground equipment	2 THAAD batteries of ground equipment	\$52.7 million
12 AN/TPY-2 radars	14 AN/TPY-2 radars	2 AN/TPY-2 radars	\$476.3 million
42 operational launchers	81 operational launchers	39 operational launchers	\$348 million
660 interceptors	1,002 interceptors	342 interceptors	\$6.5 billion
Replace Gallium Arsenide (GaAs) to Gallium Nitride (GaN) technology on the AN/TPY-2 radar through attrition	Tech refresh from GaAs to GaN technology for AN/TPY-2 radar. Update minimum of 1 radar/year for about 12 years	Attrition versus tech refresh	\$884.3 million

⁷GAO-18-324

Appendix VIII: Terminal High Altitude Area Defense (THAAD)

THAAD and AN/TPY-2 Program of Record	Army Requirements	Difference	Estimated Cost
MDA has no plan to conduct High Altitude Electromagnetic Pulse Hardening for AN/TPY-2 Forward Based sites	High Altitude Electromagnetic Pulse Hardening for 5 AN/TPY-2 Forward Based sites	MDA is not addressing	\$100 million

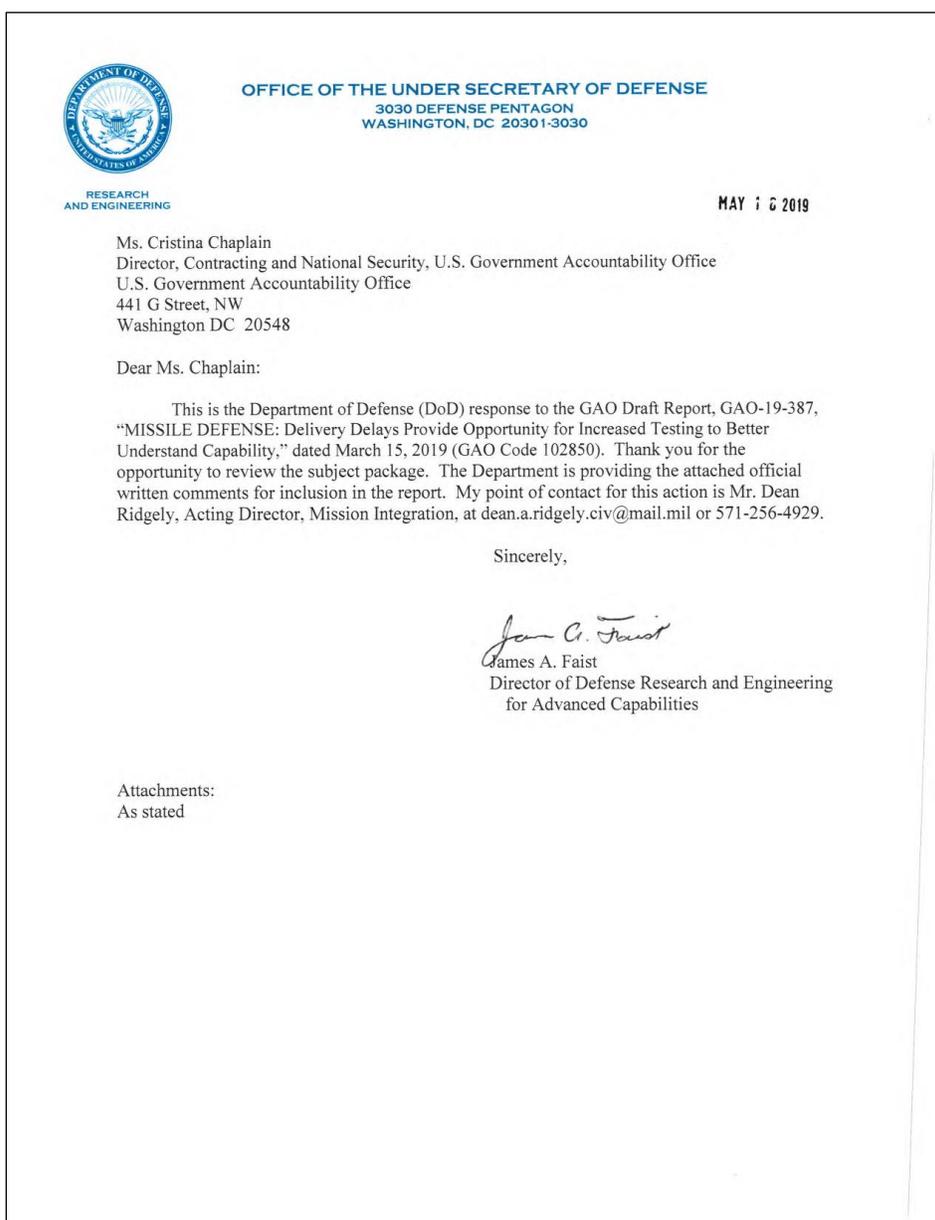
Source: GAO analysis of Missile Defense Agency data. | GAO-19-387

Note: According to MDA officials, the values reported were based on 2016 estimates. In addition, certain parts are out of production and the costs might not be representative of the current cost to procure the required equipment for two additional THAAD batteries.

When MDA was established in 2002, it was tasked with using existing and new technologies to rapidly develop weapon systems for the warfighter, and once mature, the weapon systems were to be handed over to a military service for production, operation, and sustainment. At this point, MDA has some weapon systems where production is either nearing completion or is complete. Consequently, Congress set forth a requirement in the National Defense Authorization Act for 2018 that MDA transfer all programs in production to the military services by 2021, which includes THAAD and AN/TPY-2.⁸ As part of this requirement, Congress requested a status report on MDA’s transfer of programs in production to military services not later than December 12, 2018. MDA prepared a report for the Under Secretary of Defense Acquisition and Sustainment who then requested the deadline be extended to June 2019 to enable further analysis and development of a viable option. However, according to program officials, at a March 2018 meeting between MDA and the Army, the Army stated that it prefers that THAAD and AN/TPY-2 remain with MDA. According to officials, they discussed transferring the sustainment only because MDA is best suited to maintain primary responsibility through production in order to integrate the BMDS and keep pace with the threat, as well as protect resources through the budgetary process.

⁸Pub. L. No. 115-91, § 1676(b) (2017)

Appendix IX: Comments from the Department of Defense



GAO DRAFT REPORT DATED MARCH 15, 2019
GAO-19-387 (GAO CODE 102850)

“MISSILE DEFENSE: Delivery Delays Provide Opportunity for Increased Testing to
Better Understand Capability”

DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATION

RECOMMENDATION 1: The GAO recommends that the Director, Missile Defense Agency (MDA), should utilize additional schedule margin afforded by the European Phased Adaptive Approach (EPAA) Phase 3 delay to conduct additional testing necessary to thoroughly assess the capabilities and limitations of Phase 3 against Intermediate Range Ballistic Missiles (IRBM) and a raid scenario prior to delivery. (Recommendation 1)

DoD RESPONSE: The Department partially concurs with the recommendation. MDA has addressed the intent of the GAO recommendation by adding integrated ground tests. MDA’s original plan for EPAA Phase 3 data collects included a robust series of hardware-in-the loop (HWIL) tests with operational raid scenarios with Warfighters on console. These HWIL tests were conducted with MDA accredited models anchored by the flight test data from SFTM-01, SFTM-02, FTM-29, FTM-45, and FTI-03. All EPAA Phase 3 BMDS functions requiring a flight test environment were successfully demonstrated in 2018 to include a successful flight intercept in December 2018 against IRBMs (FTI-03, see Figure 3, pg. 25). Additionally, MDA funded two new ground tests in FY20, including both a HWIL and a distributed event using Operational Assets and communication equipment, to further characterize system capabilities and limitations. Testing supporting EPAA Phase 3 is part of a larger test program documented in the MDA Integrated Master Test Plan. EPAA Phase 3 testing includes flight and ground tests designed and executed in tandem to deliver the required body of evidence to support associated decisions. Flight tests focus on data collections that require physical world interactions (e.g., radar emissions, missile in flight, etc.). Ground testing, where processor-in-the-loop is supported by simulation of the real world, enables many test cases and a fuller examination of BMDS capabilities and limitations, which provides the developer and operational test community the data necessary to explore the bounds of weapon system battlespace; tests operational plans and concept plans under wartime conditions; and validates tactics, techniques and procedures. The demands on the test program due to the evolutionary nature of BMDS acquisition leave no margin (cost or schedule) for adding additional flight tests to an already full test schedule, especially when that testing is not required to support delivery decisions.

Text of Appendix IX: Comments from the Department of Defense

Page 1

Ms. Cristina Chaplain

Director, Contracting and National Security , U.S. Government Accountability Office

U.S. Government Accountability Office 441 G Street, NW

Washington DC 20548 Dear Ms. Chaplain:

This is the Department of Defense (DoD) response to the GAO Draft Report , GAO-19-387,

"MISSILE DEFENSE: Delivery Delays Provide Opportunity for Increased Testing to Better Understand Capability," dated March 15 , 2019 (GAO Code 102850). Thank you for the

opportunity to review the subject package. The Department is providing the attached official written comments for inclusion in the report. My point of contact for this action is Mr. Dean Ridgely, Acting Director , Mission Integration, at dean.a.ridgely.civ@mail.mil or 571-256-4929.

Sincerely,

James Faist

Director of Defense Research and Engineering for Advanced Capabilities

Attachments:

As stated

Page 2

GAO DRAFT REPORT DATED MARCH 15, 2019 GAO-19-387 (GAO CODE 102850)

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Appendix X: GAO Contact and Staff Acknowledgments

GAO Contact

Cristina Chaplain (202) 512-4841 or chaplainc@gao.gov

Staff Acknowledgments

In addition to the contact named above, LaTonya Miller, Assistant Director; Matthew Ambrose; Pete Anderson; James Bennett; Jon Felbinger; Kurt Gurka; Helena Johnson; Joe Kirschbaum; Wiktor Niewiadomski; Steven Stern; Brian Tittle; Hai V. Tran; and Alyssa Weir made key contributions to this report.

Related GAO Products

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 2017.

Missile Defense: Opportunities Exist to Reduce Acquisition Risk and Improve Reporting on System Capabilities. [GAO-15-345](#). Washington, D.C.: May 2015.

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

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

Missile Defense: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency. [GAO-12-486](#). Washington, D.C.: Apr. 2012.

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

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

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Defense Acquisitions: Missile Defense Agency Fields Initial Capability but Falls Short of Original Goals. [GAO-06-327](#). Washington, D.C.: Mar. 2006.

Defense Acquisitions: Status of Ballistic Missile Defense Program in 2004. [GAO-05-243](#). Washington, D.C.: Mar. 2005.

Missile Defense: Actions Are Needed to Enhance Testing and Accountability. [GAO-04-409](#). Washington, D.C.: Apr. 2004.

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