Missile Defense

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Ballistic Missile Defense System (BMDS) Testing Delays Affect Delivery of Capabilities

GAO

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Introduction

Since 2002, the Department of Defense's (DOD) Missile Defense Agency (MDA) has been developing an integrated and layered Ballistic Missile Defense System (BMDS) of highly complex land-, sea-, and space-based sensors, interceptors, and battle management to detect, track, and defend the homeland (United States) and regional allies, including Europe, against enemy missiles.[1] Since 2002, MDA has received approximately $123 billion to develop and deploy the BMDS and plans to spend an additional $38 billion from fiscal year 2016 through 2020. As such, the BMDS represents a significant investment for the United States.

In 2002, to enable the rapid delivery of the BMDS, the Secretary of Defense authorized MDA to develop and field it outside of the traditional acquisition policies until a mature capability is ready to be handed over to a military service for production and operation. Because the BMDS program has not yet formally entered the DOD acquisition cycle, application of laws and policies that are designed to facilitate oversight and accountability of major defense acquisition programs and that are triggered by phases of this cycle have also effectively been deferred. Since 2002, various National Defense Authorization Acts (NDAA) included provisions for GAO to prepare annual assessments of MDA's progress toward meeting its acquisition goals.[2] In 2010, as required by Congress, MDA established detailed acquisition baselines for the BMDS, and GAO was subsequently mandated to annually report on MDA's progress against these acquisition baselines, including any other observations as appropriate.[3]

To date, we have provided 12 reports covering MDA's annual progress and made recommendations to address challenges in developing and fielding BMDS capabilities, as well as other transparency, accountability, and oversight issues. This year, to fulfill our responsibilities under the mandate, we have prepared detailed briefing slides accompanied by a correspondence.

[1] Battle management is the process of determining the best system or systems to fire interceptors to ensure the highest probability of a successful intercept.
[2] National Defense Authorization Act for Fiscal Year 2002, Pub. L. No. 107-107, § 232(g) (2001); Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005, Pub. L. No. 108-375, § 233 (2004); National Defense Authorization Act for Fiscal Year 2006. Pub. L. No. 109-163, § 232; John Warner National Defense Authorization Act for Fiscal Year 2007, Pub. L. No. 109-364, § 224 (2006); and National Defense Authorization Act for Fiscal Year 2008, Pub. L. No. 110-181, § 225 and National Defense Authorization Act for Fiscal Year 2012, Pub. L. No. 112-81, § 232 (2011).
[3] National Defense Authorization Act for Fiscal Year 2012, Pub. L. No. 112-81, § 232 (2011).

Objectives, Scope, and Methodology

For this briefing, we focused our assessment on MDA's testing and asset delivery goals.

Objective 1: To what extent has MDA, and its missile defense elements, progressed in achieving its fiscal year 2015 testing goals?

To assess MDA's progress against its fiscal year testing 2015 goals, we examined and analyzed the testing goals detailed in the March 2014 BMDS Accountability Report (BAR) for selected elements. We compared the information against the goals and accomplishments as baselined in the February 2015 BAR that supports its budget request for fiscal year 2016. We also interviewed element officials, reviewed relevant policies, testing plans and reports, and available management documents, and provided questions to gather documented responses.

Objective 2: What progress, if any, has MDA achieved in developing and delivering capabilities and assets for the BMDS?

To assess MDA's progress in developing and delivering capabilities and assets to support an integrated BMDS, we reviewed the goals to deliver capability outlined in the prior year's Master Integration Plans (MIP), which includes the descriptions, risks, and schedules for integrated capability deliveries, and the asset delivery goals baselined in the March 2014 BAR. We compared this information against the most recent MIP and the March 2015 BAR. Additionally, we analyzed relevant policies, available system-engineering and integration planning documents, and MDA's responses to GAO data collection instruments. We also met with agency officials and independent assessors to discuss the progress of integrating capability necessary for Regional and Homeland Defense missions. The results are presented in our findings and detailed further in the element appendixes.[4]

We shared a draft of this briefing with the agency. The agency provided technical comments, which were incorporated as appropriate.

[4] We did not assess the acquisition progress of some MDA elements because they fall outside the scope of the BAR.

Background: BMDS Elements

MDA is developing a variety of systems, known as elements, which includes sensors, interceptors, command and control, battle management, and communications system to enable the warfighter to destroy enemy missiles before they can reach their targets. The ultimate goal is to integrate these various elements to function as a single system, the BMDS (for more detailed information on the elements see appendixes I-VIII).

Ballistic Missile Defense System (BMDS) Elements[5] and Description	
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.
• Aegis BMD Standard Missile-3 (SM-3) Block IB	The Aegis BMD SM-3 Block IB interceptor features capabilities to identify, discriminate, and track objects during flight to defend against short- and medium-range ballistic missiles threats.
• Aegis BMD SM-3 Block IIA	The Aegis BMD SM-3 Block IIA interceptor, the newest variant, has increased range, more sensitive seeker technology, and an advanced kill vehicle to defend against medium- and intermediate-range ballistic missiles.
• Aegis Ashore	Aegis Ashore is 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 and two operational sites.
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.
Ground-based Midcourse Defense (GMD)	GMD defends against intermediate and intercontinental ballistic missiles by using ground-based interceptors that consist of a booster, and kill vehicle, plus a ground system that includes launch, communications, and fire control capabilities. There are two versions of the kill vehicle: the initial version—Capability Enhancement-I (CE-I)—and the upgraded version—Capability Enhancement-II (CE-II).
Targets and Counter-measures[6]	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.

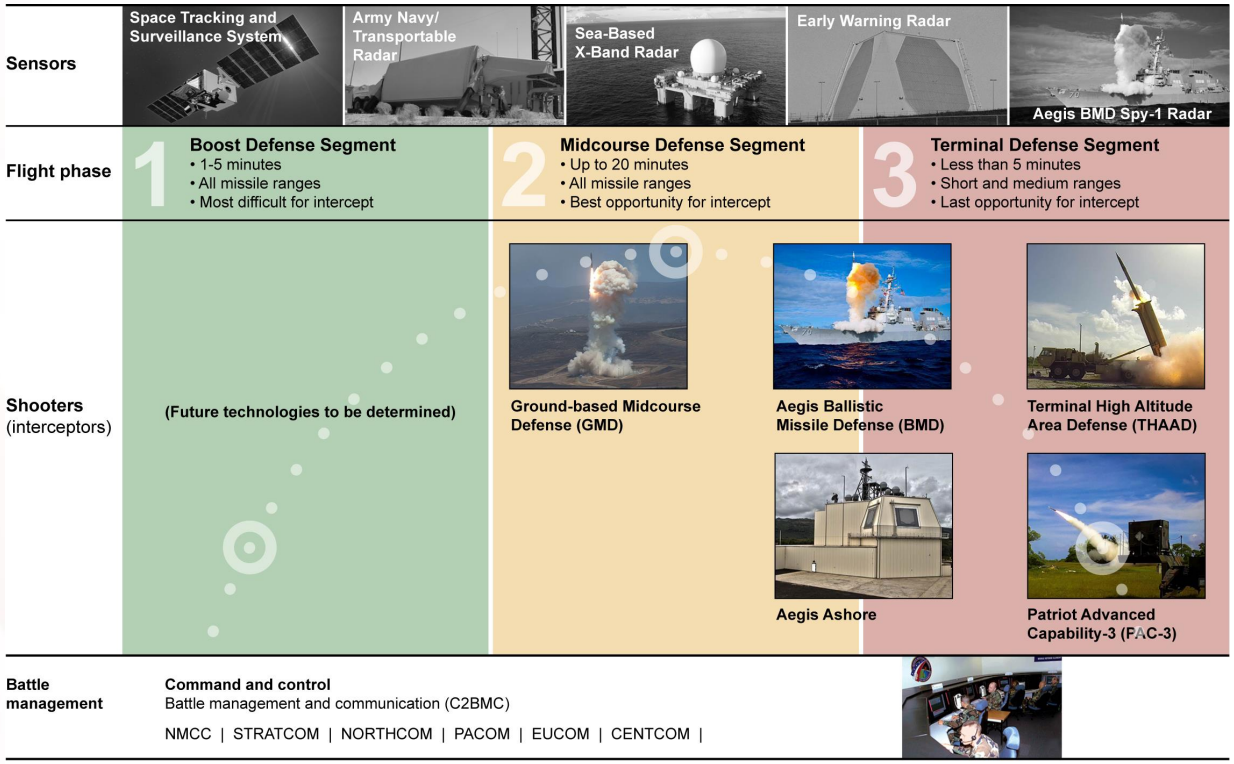
Source: GAO Analysis of MDA data. | GAO-16-339R

[5] This table details the elements included in this review, but MDA is developing additional elements for the BMDS that are not included in this review.
[6] Targets and Countermeasures provides assets to test the performance and capabilities of the BMDS elements, but these testing assets are not operationally fielded.

Background: BMDS Overview

The BMDS elements, when integrated, are designed to destroy enemy missiles of various ranges, speeds, sizes, and performance characteristics in their different phases of flight (see figure 1).[7] Once an enemy missile has been launched, sensors and interceptors are coordinated via the command and control, battle management, and communications system to enable the warfighter to track or engage it.

Figure 1: Ballistic Missile Defense System Architecture Overview



Source: GAO analysis of Missile Defense Agency (MDA) data (data and images). | GAO-16-339R

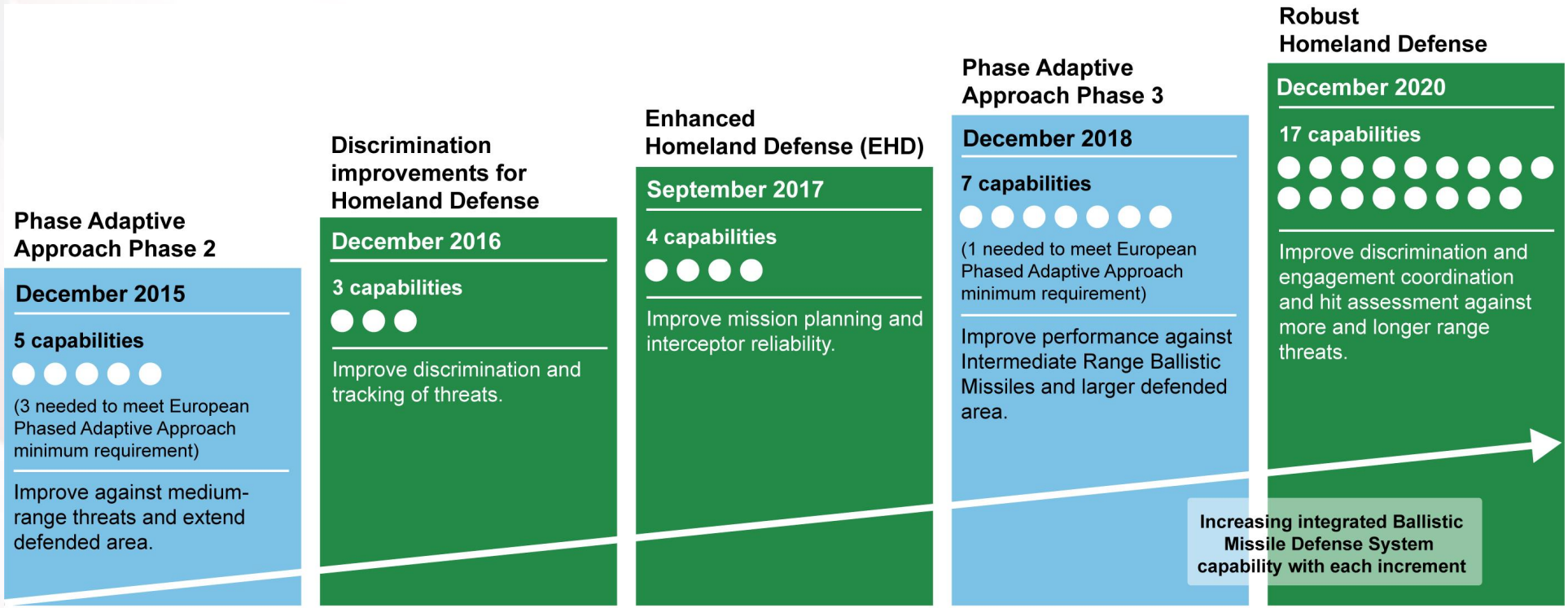
[7] Short-range is less than 621 miles, medium-range is 621 to 1,864 miles, intermediate-range is 1,864 to 3,418 miles, and intercontinental range is greater than 3,418 miles.

Background: Incremental Approach for Delivering BMDS Capabilities

- **MDA is using an incremental approach to deliver BMDS capabilities.** Integrated elements achieve BMDS capabilities that cannot be realized by an element working independently. As an example, Engage on Remote (EOR) is a BMDS capability that integrates Aegis BMD with forward-based radars and C2BMC to allow the warfighter to acquire and intercept an enemy missile sooner and, consequently, defend a larger area. Individual capabilities, such as EOR, are grouped together and delivered in increments to meet specific missile defense goals.
- **MDA is planning to deliver five increments of BMDS capabilities annually or bi-annually in support of its Agency or Presidentially-directed goals for Regional and Homeland defense (see figure 2).**
  - Phase Adaptive Approach (PAA) or Regional defense: provides defense of regional allies and U.S. forces deployed to Asia-Pacific, the Middle East, and Europe against short-, medium-, and intermediate-range enemy missiles by integrating Aegis BMD, THAAD, C2BMC, and various space- and land-based sensors. European PAA (EPAA), announced by the President in 2009 with policy commitments to deliver specific BMDS capabilities for defense of European countries that are members of the North Atlantic Treaty Organization (NATO), is a part of MDA's PAA. However, only a subset of the PAA capabilities is required for EPAA. For example, only one of the seven capabilities to be delivered in the December 2018 PAA Phase 3 increment is required for EPAA.
  - Homeland defense: provides defense of the United States against intermediate- and intercontinental-range enemy missiles by integrating GMD, C2BMC, and various space- and land-based sensors.
- **Each increment delivery includes 3 to 17 BMDS capabilities that are either new or improvements to existing capabilities.** Upcoming increment deliveries (years 2015 to 2018) include 3 to 7 BMDS capabilities and the last increment (in year 2020) includes 17 (for more information on the BMDS capability increments, see figures 2 and 4).

Background: Increments of BMDS Capabilities

Figure 2: Increments of Ballistic Missile Defense System Capabilities Planned for Delivery through 2020, as of October 2015



Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-16-339R

Background: BMDS Testing Approach

- **Knowledge gathered or performance demonstrated during testing provides confidence in the delivery of element (independent) and BMDS (integrated) capabilities.** Completing planned testing is a key step to enable the delivery of capabilities and assets, in line with GAO best practices. Also, military services generally require items be fully tested prior to being delivered to the warfighter for operational use, but there are some exceptions to this requirement, such as urgent warfighter needs.
- **MDA uses flight and ground tests to assess, gather knowledge on, and demonstrate the operational effectiveness, suitability, and survivability of element and BMDS capabilities.**
  - **Flight tests**: use actual elements to assess and demonstrate performance either through non-intercepts which evaluate specific aspects of an element or scenarios and potentially reduce risks for future tests or intercepts, which include active engagement of one or more targets.
  - **Ground tests:** use a combination of actual elements and models of elements, support infrastructure, and threats to simulate integrated performance in order to repeatedly conduct scenarios that may be too costly or subject to constraints if flight tested.
    - The BMDS Operational Test Agency conducts and independent assessment of the BMDS and accredits models for ground testing by verifying and validating that they represent realistic operational performance.
- **Each year, MDA specifies its test plan for the upcoming and future fiscal years in its BAR and associated Integrated Master Test Plan (IMTP), which supports its funding request**. Later in the year, MDA updates its test plan in a memo that is approved by DOD testing officials, but this memo does not detail any changes to funding needs and is not provided to Congress, according to MDA officials.
- **MDA has multiple lines of funding to pay for any costs associated with testing.** The Directorate of Testing (DT) manages and executes testing using its funding lines. In addition, the Targets and Countermeasure program provides targets that are test assets and each element has a line of funding for testing.

Objective 1: To What Extent Has MDA and Its Missile Defense Elements Progressed in Achieving Its Fiscal Year 2015 Testing Goals?

Key Findings:

- MDA Conducted 11 of 20 Flight Tests in Fiscal Year 2015 to Increase Its Knowledge of BMDS Capabilities
- For EPAA, MDA Made Trade-offs to Conduct Flight and Ground Tests for Phase 2 Delivery in December 2015
- Flight Tests Were Successful in Other Areas
- Several Factors Have Contributed to Delays in BMDS Flight Testing Between Fiscal Year 2010 and 2015
- From Fiscal Year 2010 to 2015 MDA Has Delayed or Removed About 40 Percent of its Flight Tests; a Trend That May Continue
- Test Execution and the Reliability of Results Are at Risk Moving Forward
- Reconciling BMDS Test Changes Is Challenging and Diminishes Traceability of Progress and Costs

MDA Conducted 11 of 20 Flight Tests in Fiscal Year 2015 to Increase Its Knowledge of BMDS Capabilities

	No.	Tests Name	Conducted in Fiscal Year 2015	Status
Delayed from prior fiscal years	1	FTG-09	No	Delayed to and conducted in fiscal year 2016 with a shift in mission and renamed to GMD Controlled Test Vehicle (GM CTV)-02+. Originally planned to be conducted in fiscal year 2014.
	2	FTM-24	No	Delayed to fiscal year 2017. Originally planned to be conducted in fiscal year 2014.
	3	FTM-26	No	Removed. Originally planned to be conducted in fiscal year 2014.
	4	FTX-19	Yes	Conducted. Originally planned to be conducted in fiscal year 2013.
	5	FTX-20	Yes	Conducted. Originally planned to be conducted in fiscal year 2014.
Planned for fiscal year 2015	6	AST-15	Yes	Target failed. Retest was conducted in December 2015 (fiscal year 2016).
	7	FTM-25	Yes	Conducted.
	8	FTO-02 E1	Yes	Target failed. The new target—IRBM T1—failed due to a malfunction with a safety switch that indicates it has cleared the aircraft. A retest was conducted in December 2015 (fiscal year 2016).
	9	FTO-02 E2	No	Delayed to and conducted in fiscal year 2016.
	10	FTP-09	No	Delayed to fiscal year 2016.
	11	FTP-10	No	Delayed to and conducted in fiscal year 2016.
	12	FTT-18	No	Delayed to fiscal year 2017.
	13	FTX-21	No	Delayed to fiscal year 2016.
	14	SCD CTV-01	Yes	Conducted.
	15	SCD CTV-02	No	Delayed to and conducted in fiscal year 2016.
Added to fiscal year 2015	16	MMW E1	Yes	Conducted.
	17	MMW E2	Yes	Conducted.
	18	MMW E3	Yes	Conducted.
	19	MMW E4	Yes	Conducted.
	20	DST-3	Yes	Conducted.

Source: GAO analysis of Missile Defense Agency data.

For EPAA, MDA Made Trade-offs to Conduct Flight and Ground Tests for Phase 2 Delivery in December 2015

- **To meet the EPAA Phase 2 delivery goal, MDA accepted the risk of using a new target in an operational flight test which failed**.

  MDA conducted two BMDS operational flight tests in support of EPAA Phase 2. MDA used a new target—the IRBM T1—during the initial attempt of one of the BMDS operational flight tests—FTO-02 Event 1. The target failed due to a malfunction with a safety switch that indicates it has cleared the aircraft which prevented it from executing further steps and it descended into the ocean. An IRBM T1 target was reallocated for the retest that was successfully executed in December 2015, just prior to the EPAA Phase 2 delivery deadline. The second BMDS operational flight test—FTO-02 Event 2—was conducted in October 2015.

- **The testing delays compressed the time available to analyze tests results to inform the EPAA Phase 2 delivery**.
  - As the BMDS operational flight tests were originally scheduled, MDA and relevant test officials had up to approximately six months to analyze the test results; whereas the retests left only 9 to 48 days.
  - MDA conducted two ground tests in support of the delivery of EPAA Phase 2 and was able to use the initial results from these tests to inform the delivery of capabilities. However, it concluded these tests just prior to the delivery, which reduced the time available to assess the results. Additionally, the flight test delays may have precluded the validation of the Aegis Ashore model, used in these ground tests, which could lower confidence in the interpretation of the test data.

- **Other flight tests, while important, were considered lower priority and thus were delayed or removed.** THAAD's flight test to demonstrate its capability against an intermediate-range threat—FTT-18—has been delayed almost two years from fiscal year 2015 to 2017. However, the Army deployed a THAAD battery to Guam in 2013 to defend against this threat range and, as a result, will have a battery deployed for at least four years with undemonstrated capability.

Flight Tests Were Successful in Other Areas

- **MDA conducted nine flight tests to demonstrate upgrades to Aegis BMD (see appendix IX)**.
  - A BMDS operational flight test called FTO-02 Event 1 to test Aegis Ashore's interoperability with other BMDS elements, in support of EPAA Phase 2 delivery, was initially conducted in June 2015, but the new target failed. The retest, called FTO-02 Event 1a, was successfully executed in December 2015.
  - Three non-intercept tests to assess tracking, coordination between multiple Aegis BMD ships, and new interceptor performance.
  - Five intercept tests to evaluate new capabilities for intercepting short-range ballistic missiles, as well as cruise missiles, in their middle and terminal phases of flight.

- **MDA participated in a flight test with international allies**.
  - A cooperative test with Israel—DST-3—included the intercept of threat missiles to improve Israel's defense capabilities against ballistic missile threats.

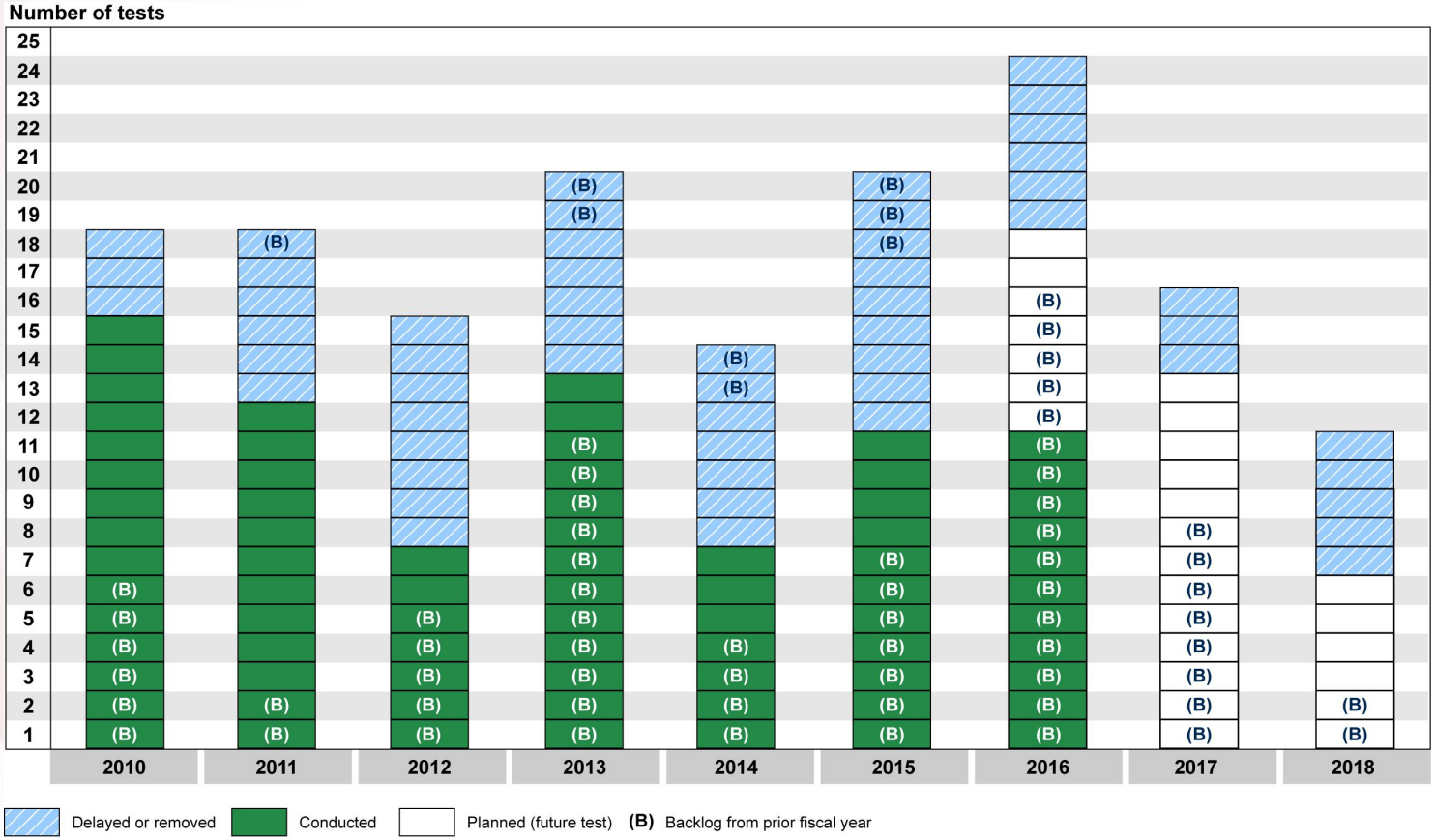
Several Factors Have Contributed to Delays in MDA's Flight Testing From Fiscal Year 2010 to 2015

- **Since at least fiscal year 2010, MDA has experienced testing delays**. From fiscal year 2010 to 2015, MDA has delayed multiple tests each year (see figure 3). MDA then reprioritizes the testing plan to accommodate the backlog of delayed tests and any changes in requirements. Inclement weather, test equipment malfunctions, and test range availability, which are external to MDA's control, contribute to delays, but there are a number of internal contributing factors as well:
  - **MDA's continued use of highly concurrent acquisition strategies—overlap between development and production**.[8] MDA has acquisition flexibilities that allow it to move forward with production without completing testing to verify performance to enable the rapid delivery of capabilities, albeit at increased risks. We previously recommended that MDA sync its schedules to ensure testing verifies performance before production, and although it has taken some actions, it has not fully implemented it.[9] Consequently, when tests are delayed or fail, MDA must adjust production or continue with less knowledge. For instance, MDA continued to produce GMD CE-I and CE-II interceptors despite their performance not being demonstrated through testing. After a series of test failures, it finally halted production (see slide 24 for more details).
  - **MDA's use of new targets during intercept flight tests**. We previously reported that, new, untested targets introduce higher risk for failure that can mean costly and time-consuming retests.[10] 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 tests. MDA has not implemented this recommendation and used a new target during a BMDS operational flight test called FTO-02 Event 1, which failed. A retest was necessary and successive tests reliant on this target had to be delayed.
  - **MDA's test schedule has left little to no margin to ensure executability**. Since fiscal year 2010, testing delays have led to up to 24 flight tests scheduled in a fiscal year; however, on average, MDA conducts 11 each fiscal year. Consequently, MDA must deconflict the test schedule, and in most instances, it has left little to no schedule margin which has compounded delays and led to removals. For example, MDA was unable to conduct an Aegis BMD test—FTM-26—due to weather, among other reasons. The test schedule could not accommodate a retest, consequently it was removed from the test plan.[11]

[8] GAO, *Missile Defense: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency,* GAO-12-486 (Washington, D.C.: Apr. 20, 2012).
[9] GAO, *Defense Acquisitions: Production and Fielding of Missile Defense Components Continues with Less Testing and Validation Than Planned*, GAO-09-338 (Washington, D.C.: Mar. 13, 2009).
[10] GAO, *Missile Defense: Opportunity to Refocus on Strengthening Acquisition Management,* GAO-13-432 (Washington, D.C.: Apr. 26, 2013).
[11] MDA officials assert that removing tests is necessary at times, but that the test's objectives are not removed and are captured through a compilation of prior tests or future tests.

From Fiscal Year 2010 to 2015 MDA Has Delayed or Removed About 40 Percent of its Flight Tests; a Trend That May Continue

Figure 3: Missile Defense Agency's Flight Tests for Fiscal Years 2010 to 2018[a]



Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-16-339R

[a] The number of tests in each fiscal year include: (1) tests that were originally planned for a prior fiscal year but were delayed into that fiscal year (i.e. backlogged tests), (2) tests planned for that fiscal year per the Integrated Master Test Plan (IMTP), and (3) any new tests added to that fiscal year after the IMTP was published to meet emerging test requirements. Some tests included are not solely led by the Missile Defense Agency (MDA), such as Patriot tests—which are controlled by the Army—or international tests which involve a coordinated effort among multiple entities from different nations. However, MDA includes these test events in its IMTP because they are a part of the Department of Defense's overarching Ballistic Missile Defense System (BMDS) program and, as the BMDS systems integrator, it can leverage opportunities to gather knowledge and increase collaboration.

Test Execution and the Reliability of Results Are at Risk Moving Forward

- **MDA is increasing the complexity and pace of flight testing for fiscal years 2016 to 2018**. MDA has increased the complexity of flight tests for fiscal years 2016 to 2018, as 82 percent will be intercept tests, compared to 63 percent in the past. Also, MDA's third and largest BMDS operational flight test—FTO-03—is scheduled for fiscal year 2018 just prior to the delivery deadline for the the EPAA Phase 3 increment. To execute all of these tests, MDA must increase its pace by conducting more tests than it has averaged in the past. If MDA is unable to achieve this increased pace, it may need to make trade-offs among priorities and delay or remove tests.

- **MDA is continuing to use new targets during intercept flight tests**. Despite the challenges MDA has experienced from using new targets during intercept flight tests, it plans to use a new target during a GMD intercept test—FTG-15—in fiscal year 2017. This test is needed to meet the Secretary of Defense's direction to field 44 GMD interceptors by the end of 2017, but with a new target there are increased risks to the execution. The schedule margin between this test and the delivery deadline is limited and if this test is delayed or fails due to the new target, MDA may deliver GMD interceptors with less knowledge than planned.

- **MDA uses element models during ground tests that have not been fully accredited**. Without accreditation, the reliability of the test results, in some instances, may be questionable. For example, six out of eight element models MDA used during ground tests to support the delivery of EPAA Phase 2 were not accredited; due, in part, to flight test delays. Furthermore, the models for the key EPAA Phase 2 elements—Aegis Ashore and the ship-based Aegis BMD Weapon System—were not accredited.

Reconciling BMDS Test Changes Is Challenging and Diminishes Traceability of Progress and Costs

- **Individual element and BMDS developmental progress is difficult to determine due to constant test changes**.

  MDA's flight test changes, such as delays, renaming and combining, and removal, while necessary to some degree, make it difficult to determine what objectives have been met, when, and with what test (i.e., progress). For example, THAAD conducted a test—FTT-11—in 2009 to demonstrate the advanced algorithm to meet the Army's acceptance requirements, but the target failed. The retest was conducted in October 2015, six years later, as a part of the BMDS operational flight test called FTO-02 Event 2. During that time, THAAD made hardware and software changes, which has led to multiple configurations. As such, it is unclear when or which of the five THAAD battery equipment sets and over 100 interceptors delivered before this test, if any, have met the Army's initial acceptance requirements.

- **MDA does not track or report the actual costs of tests or the impact of testing changes on its funding needs**.

  MDA officials explained that they do not track the actual amounts spent per flight test, however they have confidence in their cost estimates for each flight test in the IMTP to support the funding request for testing each year. Actual amounts spent are the foundation of credible cost estimates and can facilitate internal and external oversight and accountability.[12] MDA officials stated that it would be a significant undertaking to compile this information, but they have recently initiated an effort to do so. Further, since 2010 MDA has conducted less than half of the total tests planned in its IMTPs and it has made multiple changes to the tests in that timeframe. We previously recommended that MDA track test changes, their rationale, and cost effects in the BAR or budget documentation submitted to Congress.[13] While MDA reports changes in tests in the IMTP, such as delays, and to a limited extent, their rationale, it does not report the impacts to its funding needs. Consequently, there is limited traceability of the costs associated with each test—how much funding has been requested, received, and spent on a test—within a fiscal year and from year to year.

[12] GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: Mar. 2, 2009).
[13] GAO, *Missile Defense: Actions Needed to Improve Transparency and Accountability*, GAO-11-372 (Washington, D.C.: Mar. 24, 2011).

Objective 2: What Progress, If Any, Has MDA Achieved in Developing and Delivering Capabilities and Assets for the BMDS?

Key Findings:

- In Fiscal Year 2015, MDA Made Progress Developing Integrated BMDS Capabilities, but Delayed Some Future Capabilities
- MDA Has Added Some BMDS Capabilities—Mostly to Its Last Planned Increment Delivery—and Delayed Others
- Since 2010, MDA Has Scaled Back Key BMDS Capabilities Due to Challenges with Its Integrating Element—C2BMC
- Future Capabilities Are at Risk Due to C2BMC Funding and Technical Challenges
- Some but Not All Individual Elements' Assets Were Delivered in Fiscal Year 2015
- MDA Took Actions to Mitigate Some Acquisition Risks for Aegis BMD and GMD in Fiscal Year 2015
- MDA Continues to Use Acquisition Practices That Put BMDS Elements at Risk For Cost Growth and Performance Shortfalls

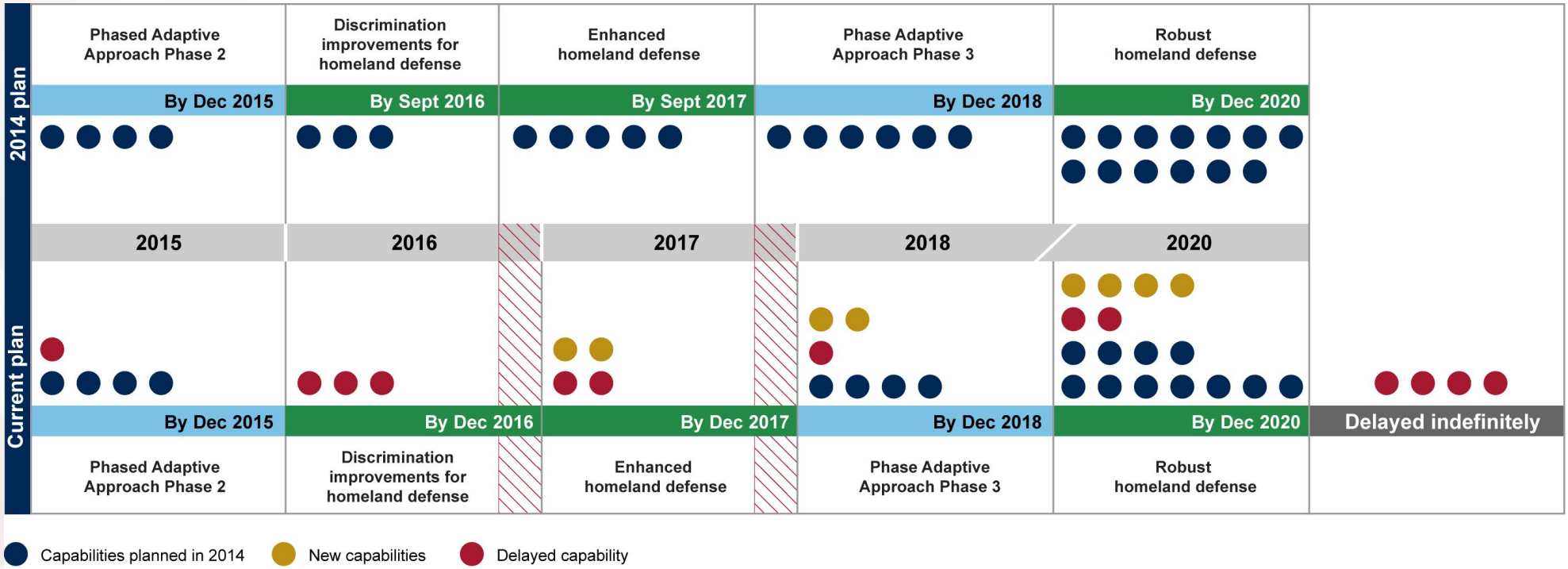
In Fiscal Year 2015, MDA Made Progress Developing Integrated BMDS Capabilities, but Delayed Some Future Capabilities

- **MDA continued the development of integrated capabilities to support the delivery of the EPAA Phase 2 and made progress on capabilities for future homeland and regional defense increments**.
  - MDA integrated and assessed three capabilities—integration of Aegis Ashore to the EPAA architecture, its ability to launch interceptors on cues from a forward-based radar, and upgrades to C2BMC for processing ballistic missile tracks—and delivered EPAA Phase 2 in December 2015. MDA also began assessing some capabilities for the next increment delivery in December 2016.
  - MDA added new capabilities to improve future regional and homeland defense increments (see figure 4). For example, it added a new capability for delivery in December 2017 to enable a ground-based sensor to track various space objects. It added a capability to improve THAAD's performance against longer range threats, as well as integration with the Army's Integrated Air and Missile Defense for the PAA Phase 3 delivery in December 2018. It also added capabilities to assess success of intercepts using space-based assets and improve discrimination for the Robust Homeland Defense increment delivery in December 2020.
  - MDA took steps to mitigate risks for planned capabilities, including those for EPAA Phase 3 to enable Aegis BMD to use cues from forward-based radars to intercept threats earlier.
- **Amid progress, MDA delayed some capabilities due to technical, funding, and testing challenges**. MDA delayed 12 of the 27 capabilities planned for delivery between 2016 and 2020 between 3 months to two years, or indefinitely (see figure 4 and table below). For example, discrimination improvements to defend against threats to the homeland were delayed three months due to disruptions in ground testing. Although new capabilities have been added, in terms of BMDS integration, they are smaller in scope than those that have been delayed. The following table lists several capabilities that have been delayed a year or more.

Examples of Capabilities Delayed in Fiscal Year 2015	Delayed from	Delayed to
Improvements to integration with NATO	Sep. 2017	Dec. 2018
Two capabilities designed to improve discrimination for GMD engagements	Sep. 2017	Indefinitely
Improvements to engagement coordination and target deconfliction between regional shooters	Dec. 2018	Dec. 2020
Two capabilities to improve automated BMDS engagement planning and asset network management	Dec. 2020	Indefinitely

MDA Has Added Some Capabilities—Mostly to Its Last Planned Increment Delivery—and Delayed Others

Figure 4: Comparison of MDA's Ballistic Missile Defense System Capability Delivery Plans for 2014 and 2015



Source: GAO analysis of Missile Defense Agency (MDA) data. | GAO-16-339R

Since 2010, MDA Has Delayed Key BMDS Capabilities Due to Challenges with Its Integrating Element—C2BMC

- **Since 2010, MDA has delayed some capabilities that integrate and automate the BMDS, largely due to C2BMC schedule slips caused in part, according to MDA, by funding reductions and changes in priorities.** C2BMC is being designed to integrate all of the BMDS elements, in order to create a system that is more effective and efficient than individual elements working independently. However, C2BMC has experienced delays with capabilities that centralize and automate threat response options, leaving human operators to coordinate these tasks during BMDS operations.

Delayed BMDS Capabilities for Integration and Automation	Planned delivery	Current status
Automated coordination and threat engagement deconfliction between some BMDS shooters	Dec. 2015	Dec. 2020
Automated engagement command and management at the BMDS-level	Dec. 2015	Dec. 2020

- **MDA has also scaled back the number of EPAA capabilities required for each increment delivery, in part, due to C2BMC delays**. While MDA's initial delivery plans did not distinguish between EPAA and PAA, currently only a subset of the capabilities in the PAA increments are needed to meet the presidentially mandated commitments for EPAA. MDA adjusted its internal delivery plans by reducing the number of required EPAA capabilities in each increment, after delays.

Capabilities Associated with EPAA	Planned delivery	Current status
Integration of additional space-based sensors to improve threat acquisition and tracking	Dec. 2015 (Phase 2)	Dec. 2017
Processing of threat tracking from various types of sensors into a single track picture, in part, to support the capability to launch interceptors on data from forward-based sensors	Dec. 2015 (Phase 2)	Dec. 2017
Improved integration with European NATO allies	Dec. 2015 (Phase 2)	Dec. 2018 (Phase 3)
THAAD capability to launch interceptors on tracks from forward-based sensors	Dec. 2015 (Phase 2)	Dec. 2020
Aegis BMD engage on remote capability that allows SM-3 Block IIA to intercept threats based entirely on tracks from forward-based sensors—the only capability needed for EPAA Phase 3 declaration	Dec. 2018 (Phase 3) – full delivery	Dec. 2018 (Phase 3) – partial delivery
		Dec. 2020 – partial delivery

Future BMDS Capabilities Are at Risk Due to C2BMC Funding and Technical Challenges

- **Recent funding and technical challenges for C2BMC could further delay a number of capabilities planned for delivery between 2018 and 2020.** While MDA plans to deliver a number of key BMDS capabilities in increments scheduled for 2018 and 2020, recent technical and funding challenges affecting C2BMC's version that is planned for integration in 2018 (Spiral 8.2-3) may require the deferral of these capabilities to the last increment in 2020, and those planned for the 2020 increment, even later.
  - C2BMC Spiral 8.2-3 has increased schedule risk due to funding challenges. This spiral, planned for delivery in the December 2018 increment, provides a number of improvements to integrated BMDS performance to meet the PAA Phase 3 commitments. According to program documentation, funding shortfalls could delay the completion of the spiral development beyond the beginning of the integration and testing events needed to deliver the increment. While the full extent of potential capability shortfalls is currently unclear, our initial assessment indicates that Aegis BMD's engage on remote capability could be affected, as well as some other capabilities planned for delivery in 2020.
  - Delivery of Aegis BMD's engage on remote capability is at risk due to technical challenges. According to program documentation, C2BMC has identified challenges with integration and the processing and quality of data from the various sensors that the Aegis BMD weapon system will be reliant on for receiving and directing its SM-3 Block IIA interceptors to engage threat missiles remotely. While the discrimination capabilities of the Aegis BMD SM-3 Block IIA interceptors are expected to mitigate some of these shortfalls, the probability of successful engagements could be reduced.

Some but Not All Individual Elements' Assets Were Delivered in Fiscal Year 2015

- **MDA's Aegis BMD and GMD elements nearly met their fiscal year 2015 asset delivery goals, but THAAD experienced setbacks**.
  - Aegis BMD delivered the Aegis Ashore installation in Romania, after some construction delays. It also delivered 20 out of 21 Aegis SM-3 Block IB interceptors. According MDA officials, the delivery of one was deferred to fiscal year 2016 due to delays in the BMDS operational flight tests, FTO-02 Event 1 and FTO-02 Event 2. Aegis BMD provided a new weapon system version for ships and Aegis Ashore, but with certain limitations.
  - After falling several years behind delivering CE-II interceptors due to test failures, GMD restarted interceptor production and delivered 8 out of 8 new CE-II interceptors as scheduled.
  - THAAD delivered 3 out of 44 Lot 4 interceptors—upgraded to address obsolescence—and the remaining interceptors were delayed to address mission computer failures and shelf-life concerns with some components. Once corrections were made and testing was completed, deliveries resumed.

Element	Planned asset delivery	Status
Aegis Ashore	Romania Installation	Delivered
Aegis BMD SM-3 Bock IB	21 interceptors	20 delivered
Aegis BMD Weapon System	Aegis BMD 5.0 CU for ships and Aegis Ashore	Delivered with limitations
GMD	8 CE-II Ground Based Interceptors (GBIs)	Delivered
THAAD	44 interceptors	3 delivered

MDA Took Actions to Mitigate Some Acquisition Risks for Aegis BMD and GMD in Fiscal Year 2015

- **MDA delayed the production decision for the Aegis BMD SM-3 Block IB interceptor to conduct testing for a redesigned component**. MDA plans to conduct two non-intercept flight tests for the Aegis BMD SM-3 Block IB interceptor in fiscal year 2016 to demonstrate the redesigned third-stage rocket motor nozzle prior to incorporating it into production. Further, it delayed the full-rate production decision until after these tests. According to MDA officials, MDA took these actions in response to our prior recommendation, which we made to strengthen and improve its SM-3 acquisitions and outcomes.[15]

- **MDA restarted GMD's CE-II interceptor production after successfully conducting an intercept flight test, potentially saving the agency costly and time-consuming rework**. GMD failed two consecutive CE-II flight tests in 2010. MDA subsequently suspended production of the CE-II interceptors pending a successful intercept flight test, as we previously recommended.[16] In June 2014, after working to resolve the issues, MDA successfully conducted its first intercept test with the CE-II interceptor and it resumed production in early fiscal year 2015. Delaying production of the CE-II interceptors until after a successful intercept test was a positive step because it minimized the risk of having to recall interceptors to fix any issues identified during testing.

[15] GAO, *Missile Defense: Mixed Progress in Achieving Acquisition Goals and Improving Accountability,* GAO-14-351 (Washington, D.C.: Apr. 1, 2014).
[16] GAO-12-486

MDA Continues to Use Acquisition Practices That Put BMDS Elements at Risk For Cost Growth and Performance Shortfalls

- **MDA awarded a production contract for the Aegis BMD SM-3 Block IB interceptors prior to finalizing costs for a redesigned component and testing software and hardware upgrades.**
  - MDA awarded a production contract in May 2015 for 44 Aegis BMD SM-3 Block IB interceptors which includes the estimated cost for a redesigned component. However, the cost for the actual redesigned component has not been finalized. Further, the retrofit costs to incorporate the redesigned component into the interceptors have not been finalized. Consequently, costs could increase if additional design changes are needed after flight testing the redesigned component as planned in fiscal year 2016.
  - MDA added software and associated hardware upgrades to the Aegis BMD SM-3 Block IB interceptor production prior to flight testing them. The upgraded interceptor was used during a test in October 2015, but it failed. MDA officials indicated that the failure was related to a legacy SM-3 component and not the new upgrades. The interceptor was flown successfully in December 2015.

- **MDA's fielding schedule to meet the directive of 44 GMD interceptors by 2017 could put it at risk for reliability issues.**
  - MDA performed a limited redesign of the current kill vehicle—a new interceptor version called the CE-II Block I—and an extensive upgrade to the boost vehicle as part of an effort to address concerns with the current interceptor fleet and to meet a Secretary of Defense directive to field 44 interceptors by the end of 2017. To meet this goal, MDA adopted an optimistic and aggressive schedule that: (1) includes a high level of concurrency; (2) could further compromise reliability; and (3) extends risk to the warfighter. For example, the new thrusters for the kill vehicles will not be available at the start of new CE-II Block I production because the program is concurrently developing and producing the interceptor. To stay on track with its fielding goal, MDA will integrate the component later in the production process. As a result, it will not undergo some factory testing that could increase confidence in its performance and workmanship prior to being delivered to the warfighter.

Prior GAO Recommendations Remain Valid and Should Be Implemented

GAO is not making any new recommendations, but believes prior recommendations remain valid:

- **Increasing transparency:**
  - In 2011, we recommended that MDA report changes in testing, such as test delays or removals, and include the rationale and cost effects in its IMTP or budget documentation submitted to Congress.[17] MDA concurred and it does report changes in testing in its IMTP, and to a limited extent the rationale, but it does not track the actual costs of each test or report the impacts of changes to its funding needs. Given the potential impact to funding needs associated with some test changes, we believe these recommendations are important for traceability and oversight, both internally and externally.
- **Improving acquisition outcomes and minimizing risk**:
  - In our prior work, we have recommended that MDA implement a knowledge-based acquisition approach, include sufficient schedule and resource margin in it its test plan, and align production decisions with flight testing.[18] MDA concurred with many of our recommendations and has taken some actions to address them but several of them have not been fully implemented. We believe these recommendations are valid and instrumental to ensuring that MDA executes sound, knowledge-based acquisitions.
- **Improving management of EPAA**:
  - In 2012, we recommended that DOD assess the extent to which the dates announced by the President in 2009 for EPAA are contributing to concurrency and propose schedule adjustments where significant benefits could be obtained.[19] Based on DOD's response to this recommendation and subsequent follow-up, we do not expect it to be fully implemented. However, we continue to believe that implementing it is important to improve acquisitions for EPAA, especially given the policy commitments to deploy capabilities that are proven and cost-effective, and fiscally sustainable over the long term.[20]

[17] GAO-11-372.
[18] GAO-11-372 and GAO-14-351.
[19] GAO-12-486.
[20] Ballistic Missile Defense Review Report, February 2010.

Appendixes

Appendix I: Aegis Ballistic Missile Defense (BMD) Weapon System (AWS)

Overview

The Aegis BMD is the Navy's component of the Missile Defense Agency's (MDA) Ballistic Missile Defense System (BMDS). It consists of the Aegis BMD Weapon System (AWS), a radar, and Standard Missile-3 (SM-3) interceptors.

MDA develops the AWS in versions called spirals that expand on preceding capabilities. Deliveries are planned to support MDA's Phased Adaptive Approach (PAA) for Regional defense, including European PAA (EPAA), in the 2015 and 2018 timeframes, as well as improvements to discrimination and tracking of threats in support for Homeland Defense missions.

Major Deliveries

Spiral	Capabilities	Status
AWS 4.0.2	Improves discrimination and ability to launch interceptors on cues from forward-based sensors.	Delivered
AWS 4.0.3	Improves discrimination and tracking of long ranger threats.	Delivered
AWS 5.0CU	Improves performance against more complex threats in middle to late phases of flight; Allows simultaneous engagement of threat missiles and larger raids (Integrated Air and Missile Defense-IAMD).	Delivered with limitations
AWS 4.1	Similar capabilities as AWS 5.0CU, without the IAMD.	Delayed
AWS 5.1	Improves AWS 5.0CU capabilities against longer range and more complex threats in middle and terminal phases of flight; Extends defended areas by engaging threats based on tracks from forward-based sensors; Increases raid size handling.	In progress

Appendix I: Aegis Ballistic Missile Defense (BMD) Weapon System (AWS)

Fiscal Year 2015 Key Findings

- AWS 4.1 will not be available to support the European PAA Phase 2 delivery, as previously planned, which reduces ship based capabilties for Regional defense against certain Phase 2 threats.
- AWS 5.0 Capability Upgrade for ships and the land-based Aegis Ashore was delivered in December 2015. The delivery decision was made after less robust testing than initially planned and significant capability limitations, which increases performance risks for EPAA Phase 2.
- AWS 5.1 and Aegis BMD SM-3 Block IIA interceptor integration testing is at risk due to delays in the interceptor's development, which may require additional work just prior to testing and may delay assessment of some capabilties such as kill assessment. Additionally, C2BMC delays could defer Aegis BMD's capability to intercept threats based entirely on tracks from forward-based sensors until fiscal year 2021.

Fiscal Year 2015 Scorecard - Flight Tests

Test name	Conducted	Status
FTO-02 E1	Yes[a]	Target failed
FTO-02 E2	No[b]	Delayed
FTX-19	Yes	-
FTX-20	Yes	-
MMW Event 1	Yes	-
MMW Event 2	Yes	-
MMW Event 3	Yes	-
MMW Event 4	Yes	-

Fiscal Year 2015 Scorecard - Asset and Capability Deliveries

Delivery goal	Met	Status
AWS 4.0.3	Yes	-

[a] The new intermediate range target—the IRBM T1—failed during the initial attempt of FTO-02 E1. The retest, named FTO-02 E1a, was conducted in December 2015 (fiscal year 2016).
[b] The test was renamed FTO-02 E2a and was conducted in October 2015 (fiscal year 2016). AWS was assessed, but the interceptor failed early in flight, preventing collection of some performance data.

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

Overview

The Aegis BMD Standard Missile-3 (SM-3) Block IB interceptor is designed to defend against short- to intermediate-range threat missiles during the middle stage of their flight. It is an upgraded version of the earlier, SM-3 Block IA, and features an enhanced target seeker capability for increased discrimination, an improved throttleable divert and attitude control system for adjusting its course, an advanced signal processor for engagement coordination, and increased range. It is linked with Aegis BMD Weapon System (AWS) 4.0.2, AWS 5.0 Capability Upgrade (CU), and is the primary interceptor for European Phased Adaptive Approach (EPAA) Phase 2.

In September 2014, MDA began production of an upgraded version called the SM-3 Block IB Threat Upgrade (TU), which is designed to capitalize on improved AWS 5.0CU capabilities. It is primarily comprised of software upgrades with some associated hardware changes to enhance discrimination capability.

Major Deliveries

Asset	Delivered	Remaining	Total
SM-3 Block IB	41	0	41
SM-3 Block IB TU	17	359	376

Overall Progress and Challenges

- The program has made progress rectifying prior issues with a component of the Third Stage Rocket Motor (TSRM), by completing preliminary assessments of the resigned component. Additionally, it also took actions to strengthen its acquisition efforts by scheduling two flight tests to assess the redesign prior to beginning production and delayed the full-rate production decision until after these tests.

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

Key Fiscal Year 2015 Findings

- The upgraded variant of the Aegis BMD SM-3 Block IB interceptor called Threat Upgrade (TU) has been in production for over a year prior to a successful flight test. Assessment was delayed because the upgrade was not available for the first test (FTM-25), and subsequent tests were either removed or deferred, largely due to target failures. The Aegis BMD SM-3 Block IB TU interceptor failed during FTO-02 E2, but MDA traced the failure to a legacy component, and it was successfully tested in December 2015.
- MDA plans to conduct two non-intercept flight tests of the Third-stage Rocket Motor (TSRM) nozzle redesign prior to the full-rate production decision planned for March 2016. However, it awarded a production contract for the Aegis BMD SM-3 Block IB TU interceptors without incorporating the preliminary cost estimate for the redesigned TSRM. Thus, contract costs could increase if testing reveals the need for additional retrofits.

Fiscal Year 2015 Scorecard - Flight Tests

Test name	Conducted	Status
FTM-24	No	Delayed
FTM-25	Yes	-
FTM-26	No	Removed
FTO-02 E1	Yes[a]	Target Failed
FTO-02 E2	No[b]	Delayed

Fiscal Year 2015 Scorecard - Asset and Capability Deliveries

Delivery goal	Met	Status
21 Interceptors	Partially	20 delivered, 1 delayed

attempt of FTO-02 E1. The retest, named FTO-02 Event 1a, was conducted in December 2015 (fiscal year 2016).

[b] The test was renamed FTO-02 E2a and was conducted in October 2015 (fiscal year 2016). AWS was assessed, but the interceptor failed early in flight, preventing collection of some performance data.

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

Overview

The Aegis BMD SM-3 Block IIA interceptor is being developed to expand the capabilities provided by the Aegis BMD SM-3 Block IB interceptor. The Aegis BMD SM-3 Block IIA interceptor will have increased range and speed, more sensitive seeker technology, an advanced kinetic warhead, and the capability to engage threats based on cues from sensors off-board of the firing Aegis BMD ship. Most of the Aegis BMD SM-3 Block IIA interceptor's components will differ from other standard missile versions, requiring development of new technology.

Initiated in 2006 as a SM-3 Cooperative Development program with Japan, the Aegis BMD SM-3 Block IIA program was added to the European Phased Adaptive Approach (EPAA) to provide coverage needed for EPAA Phase 3. It is planned for deployment with the Aegis BMD Weapon System 5.1 in 2018.

Major Deliveries

Asset	Delivered	Remaining	Total
SM-3 Block IIA	0[a]	351	351

[a] Deliveries are planned to begin in fiscal year 2017.

Overall Progress and Challenges

- The program awarded the contract for Aegis BMD SM-3 Block IIA 's long lead material needed for integration and test missiles.
- The program addressed prior performance issues that stemmed from challenges with the divert attitude control system, demonstrating fixes during component testing.

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

Key Fiscal Year 2015 Findings

- Aegis BMD SM-3 Block IIA successfully conducted one of two non-intercept tests—SCD Controlled Test Vehicle (CTV)-01—in June 2015 after about a five month delay, which successfully demonstrated the interceptor launch through the third-stage of flight. However, it deferred the second test, SCD CTV-02, to fiscal year 2016 due to delays in hardware deliveries.
- The program is still experiencing cost growth due to technical challenges and schedule delays, some of which are expected to continue to impact development efforts through 2017. Delay of the non-intercept tests resulted in an estimated $30 million cost growth for the program.
- Challenges with the integration of the guidance system exceeded remaining cost margins and DCMA officials estimate that it will result in an approximately $200 million cost overrun by the end of the developmental contract.

Fiscal Year 2015 Scorecard - Flight Tests

Test Name	Conducted	Status
SCD CTV-01	Yes	-
SCD CTV-02	No[a]	Delayed

Fiscal Year 2015 Scorecard - Asset and Capability Deliveries

Delivery Goal	Met	Status
None	Not applicable[b]	-

[a] SCD CTV-02 was conducted in December 2015 (fiscal year 2016)
[b] Deliveries are planned to begin in fiscal year 2017.

Appendix IV: Aegis Ashore

Overview

Aegis Ashore is a land-based, or ashore, version of the ship-based Aegis BMD, to track and intercept threat missiles in the middle of their flight using Aegis BMD Standard Missile-3 (SM-3) interceptors. Key components include a vertical launching system with Aegis BMD SM-3 interceptors and an enclosure, referred to as a deckhouse, that contains the SPY-1 radar and command and control system. Missile Defense Agency (MDA) plans to equip Aegis Ashore with a modified version of the Aegis BMD weapon system software.

A total of three Aegis Ashore sites are planned: a test site in Hawaii and two operational sites, one in Romania and the other in Poland to support the European Phased Adaptive Approach (EPAA). DOD deployed the test facility in April 2014 and the Romania operational site in December 2015. DOD plans to deploy the Poland operational site in December 2018.

Major Deliveries

Asset	Delivered	Remaining	Total
Test site	1	0	1
Operational site	1	1	2

Overall Progress and Challenges

- **Meeting Site Installation Schedule Goals.** MDA completed construction of the deckhouse and supporting building, installed the Aegis BMD Weapon System at the site in Romania, and began some efforts for the site in Poland.
- **Coexistence Assessment For the Site in Poland.** MDA completed an assessment of Aegis Ashore's radiofrequency interference with Poland's telecommunication infrastructure at the Hawaii test site. This test indicated no noticeable interference during 98 percent of regular operations, but the full extent of impact at the operational site may not be fully understood until after the delivery.

Appendix IV: Aegis Ashore

Fiscal Year 2015 Key Findings

- Despite construction delays in fiscal year 2015, MDA delivered the Romanian site in December 2015, although it will not be completed until late fiscal year 2016, and a newly discovered operational vulnerability may not be fully addressed until 2018.
- Aegis Ashore's first intercept attempt—Flight Test Operational-02 Event 1 (FTO-02 E1)—experienced a target failure due to a malfunction with a safety switch that indicates it has cleared the aircraft. A retest was conducted in December 2015 (fiscal year 2016) which resulted in an intercept. The delay between the initial test and the retest reduced the time available to assess all aspects of performance prior to the Romania site delivery.
- The Poland site's schedule has been compressed due to construction schedule changes and the Navy's request for earlier transfer to ensure the site is ready for operations by December 2018.

Fiscal Year 2015 Scorecard - Flight Tests

Test name	Conducted	Status
FT0-02 E1	Yes[a]	Target failed

Fiscal Year 2015 Scorecard - Asset and Capability Deliveries

Delivery goal	Met	Status
Romania operational site	Yes	-

[a] The new intermediate range target—the IRBM T1—failed during the initial attempt of FTO-02 E1. The retest, named FTO-02 E1a, was conducted in December 2015 (fiscal year 2016).

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

Overview

C2BMC is a global system of hardware—workstations, servers, and network equipment—and software that link and integrate individual missile defense elements of the Ballistic Missile Defense System (BMDS). It allows users to plan operations, see the battle develop, and manage sensors. As the integrator, C2BMC allows the BMDS to defend a larger area than individual systems operating independently and against more missiles simultaneously, thereby conserving interceptor inventory.

C2BMC delivers capabilities via software spirals and hardware upgrades. The current spiral is Spiral 6.4, which became operational in 2011. Upgrades to this version improve threat acquisition and discrimination. Since its delivery MDA delivered a number of additional capabilties for this spiral, and plans additional upgrades in 2016. Spiral 8.2 is the next version and will be delivered in segments in 2017, 2018, and 2020.

Major Deliveries

Spiral	Capabilities	Status
Spiral 6.4	Multiple radars track reporting to elements; cueing between radars, improved identification of threat objects among debris, and discrimination of longer range threats.	Delivered; upgraded after delivery
Spiral 8.2-1	Integration of surface and space-based sensors, processing their tracks to produce a single track picture; space-based sensor cueing; optimized sensor tasking and infrastructure improvements for handling larger raids	In progress; Scaled back
Spiral 8.2-3	Improvements to threat track data processing and reporting to elements, including Aegis BMD's ability to intercept based entirely on forward-based sensors (Engage on Remote or EOR); integration with Army's IAMD.	In progress; Scaled back
Spiral 8.2-5	Planned to complete Spiral 8.2-3 capabilities, including EOR, and improve discrimination for GMD.	In progress

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

Key Findings for Fiscal Year 2015

- **Spiral 6.4** operational status has been extended to December 2018, to accommodate schedule slips for spiral 8.2-1, caused in part, according to MDA, by funding reductions and changes in priorities. This resulted in increased sustainment costs and raised some performance risks until the next spiral is fielded.
- **Spiral 8.2-1** delivery was delayed to December 2017. Additionally, it was scaled back to exclude two combatant commands—EUCOM and CENTCOM—which will receive the associated capabilities about a year later with a different spiral. However, ongoing testing risks may reduce the capabilities for other combatant commands—PACOM and NORTHCOM.
- **Spiral 8.2-3** delivery was split into two segments, with initial capabilities to be delivered in December 2018 and the remainder in December 2020 as part of a Spiral 8.2-5. Delivery of capabilities planned for December 2018, including engage on remote, are at risk due to ongoing technical and funding challenges.

Fiscal Year 2015 Scorecard Tests

Test name	Conducted	Status
GTD-04e Part 2	Yes	-
GTI-06 Part 1	Yes	-
GTI-06 Part 3	Yes	-
GTD-06 Part 1	Yes	-

Fiscal Year 2015 Asset and Capability Deliveries

Delivery goal	Met	Status
New maintenance upgrades	Yes	-

[a] As the integrator, C2BMC capabilities are primarily assessed during ground tests.

Appendix VI: Ground-based Midcourse Defense (GMD)

Overview

GMD is a ground-based defense system to defend the United States against limited intermediate and intercontinental threat missiles. The interceptor consists of a booster with a kill vehicle on top that uses on-board sensors and divert capabilities to steer it and destroy threat missiles. The ground system includes launch, communication, and fire control capabilities. There are currently two deployed versions of the kill vehicle: the initial design known as the Capability Enhancement (CE)-I and the upgraded known as the CE-II.

MDA has performed a limited redesign of the CE-II, called the CE-II Block I, to fix known issues with the CE-II, address obsolescence, and improve producibility and cost. MDA is also developing a new kill vehicle—called the Redesigned Kill Vehicle (RKV)—which MDA plans to be more reliable, producible, testable, and cost-effective than the CE-II Block I.

MDA has fielded over 30 interceptors and plans to increase the number of fielded interceptors to 44 by the end of 2017, as directed by the Secretary of Defense.

Major Deliveries

Asset	Delivered	Remaining	Total
CE-I interceptors	24	0	24
CE-II interceptors	22	0	22
CE-II Block I interceptors	0[a]	10	10

[a] Deliveries are scheduled to begin in fiscal year 2017.

Overall Progress and Challenges

- **High-risk acquisition practices.** MDA has not demonstrated several key Homeland Defense capabilities and is relying on high-risk acquisition practices to achieve its goal of fielding 44 interceptors by the end of 2017.
- **Optimistic long-term outlook.** MDA is taking steps to improve its investment decisions and acquisition outcomes by assessing options to identify the most promising solutions to pursue and implementing knowledge-based decision points for the RKV.

Appendix VI: Ground-based Midcourse Defense (GMD)

Fiscal Year 2015 Key Findings

- Balancing the need for flight testing and fielding new capabilities continues to be a challenge for MDA, and it may not execute the next GMD flight tests as currently scheduled, if risks associated with accelerating GMD's flight testing pace materialize.
- MDA continues to address quality and reliability concerns and accept risk in order to maintain its optimistic and aggressive schedule of fielding 44 interceptors by the end of 2017. For example, MDA was recently informed that the supplier for the CE-II Block I's communication encryptor used a memory device manufactured in China. MDA subsequently determined the security risk was low and approved the use of the encryptor.
- MDA's acquisition approach for the RKV has several potential benefits and aligns production decisions with flight testing. However, MDA does not plan to compete the RKV's development and, as such, may encounter challenges with meeting its cost, schedule, and performance commitments.

Fiscal Year 2015 Scorecard

Flight Tests

Test name	Conducted	Status
FTG-09	No[a]	Delayed

Asset and Capability Deliveries

Delivery goal	Met	Status
8 CE-II Interceptors	Yes[b]	-

[a] FTG-09 was delayed due to a shift in mission, renamed to GMD Controlled Test Vehicle-02+ (GM CTV-02+). GM CTV-02+ was conducted in January 2016 after experiencing further delays as a result of a failure of the air-launched IRBM target in FTO-02 Event 1.

[b] These 8 CE-II interceptors were originally planned to be delivered prior to fiscal year 2015.

Appendix VII: Targets and Countermeasures

Overview

MDA's Targets and Countermeasures (hereafter referred to as Targets) designs, develops, and procures missiles to serve as targets during the testing of independent or integrated ballistic missile defense elements. As such, targets are test assets and are not operationally fielded. A typical target consists of a launch vehicle with one or more boosters, a control module that steers the vehicle after the booster stage separates, a payload module that can deploy countermeasures, and a surrogate re-entry vehicle.

The Targets program acquires many types of targets covering the full spectrum of threat missile capabilities and ranges. While some targets have been used by MDA's test program for years, others have been recently or are now being developed to more closely represent current and future threats. The quality and availability of these targets are instrumental to the execution of MDA's flight test schedule.

Major Deliveries

The Targets program provides multiple short-, medium-, intermediate-, and intercontinental-range targets for testing the BMDS element. However, the number of each vary based on element requirements and testing schedules.

Overall Progress and Challenges

- **Cost insight and reduction efforts.** Targets has internally reorganized to reduce and better account for costs, according to program officials.
- **Contracting, target performance, and availability.** Targets has had challenges with its contracting approach, slow development, cost overruns, and target failures.

Appendix VII: Targets and Countermeasures

Key Fiscal Year 2015 Findings

- Two tests critical for delivering the European Phased Adaptive Approach (EPAA) Phase 2 by December 2015 were delayed due to target failures. FTO-02 E1's new IRBM T1 target failed due to a safety switch that indicates it has cleared the aircraft. Consequently, the next available IRBM T1 was reallocated for the retest, delaying successive tests reliant on this target. FTO-02 E2's SRALT target failed because its parachute deployed early, but the parachute was replaced and the retest was conducted later.
- The MRBM T1/T2 target's first fight has been delayed more than five years from its original date due to contractor performance issues, which Targets is working to resolve. After several changes to the test schedule, MDA was set to use this target for the first time during a major BMDS operational test called FTO-03 E2. However, developmental delays with the target and other factors, such as requirement changes, led to MDA's decision to use a proven target instead, which could reduce risk for this test.

Fiscal Year 2015 Scorecard – Asset and Capability Deliveries

Delivery goal	Met[a]	Status
5 ARAV-B	Yes	-
1 ARAV-TTO-E	Yes	-
1 eMRBM	Yes	-
1 FMA	Yes	-
4 IRBM T1	No	Delivered 3
3 MRBM T3	No	Delivered 1
1 SRALT	Yes	-

[a] The target deliveries included in this table—new and inventoried—are based on the planned testing for fiscal year 2015 as presented in the fiscal year 2014 Ballistic Missile Defense Accountability Report (BAR). New target deliveries include first time targets and existing targets scheduled for delivery in fiscal year 2015. Inventoried targets are those that were planned to be used in a prior fiscal year, but were not used, so they were placed in storage until allocated to another test. Inventoried targets must be redelivered and undergo necessary processing and delivery procedures to be used in a test. Also, delays in testing, test removals, changes in requirements, and other adjustments to the test plan affect target deliveries so a target not being delivered may not be directly attributable to the Targets and Countermeasures program. According to program officials, Targets and Countermeasures must remain flexible and responsive to testing needs.

Appendix VIII: Terminal High Altitude Area Defense (THAAD)

Overview

THAAD is a mobile, ground-based system to defend against short- and medium-range ballistic missiles in the middle, and end stages of their flight. THAAD is organized as a battery, which includes interceptors, launchers, a radar, a fire control and communications system, and other support equipment.

There are two THAAD acquisition efforts—1.0 and 2.0. THAAD 1.0 includes production of batteries, interceptors, and hardware. THAAD 2.0 is primarily software development to expand the defense range and capacity and increase integration with other BMDS elements and Integrated Air and Missile Defense (IAMD) systems.

The first five THAAD batteries have been made available to the Army for use. MDA plans to continue production through fiscal year 2025 for a total of seven batteries, seven radars, and 539 interceptors.

Major Deliveries

Asset	Delivered	Remaining	Total
Battery Equipment Sets[a]	5	2	7
Interceptors	101	438	539

[a] The first four batteries delivered for operational use have been accepted by the Army either conditionally or based on urgent warfighter needs, pending closure of issues for full material release. The fifth battery has been made available to the Army for new equipment training.

Progress and Challenges

- **Cost avoidance or reduction efforts.** THAAD combined interceptor production with foreign military sales to avoid costs associated with decreased production. THAAD also took actions that, according to program officials, could reduce costs, such as streamlining its battery configuration and implementing a new transport method for interceptors.
- **Interceptor production delays.** THAAD is delivering batteries of equipment, but there is about a 3 year delay between the delivery of the battery equipment and its interceptors. Consequently, the Army will have to determine how to allocate available interceptors between each battery.

Appendix VIII: Terminal High Altitude Area Defense (THAAD)

Fiscal Year 2015 Key Findings

- THAAD delivered 3 of 44 planned interceptors. THAAD's Lot 4 interceptors—upgraded to address obsolescence—were delayed to address memory and shelf-life issues. Once corrections were made and testing was completed, deliveries resumed.
- THAAD's flight test to demonstrate its capability against an intermediate-range threat—FTT-18— has been postponed almost two years due to testing prioritization. The Army deployed a THAAD battery to Guam in 2013 to defend against this threat range and will therefore have a battery deployed for at least four years to defend against a range that has not been demonstrated.
- Although conducted in fiscal year 2016, THAAD successfully intercepted two targets during FTO-02 E2 demonstrating integrated ballistic missile defense capabilities, confirming obsolescence upgrades to interceptors, and addressing outstanding conditions for the Army's full acceptance of THAAD equipment.

Fiscal Year 2015 Scorecard - Flight Tests

Test name	Conducted	Status
FTO-02 E2	No[a]	Delayed
FTT-18	No	Delayed

Asset and Capability Deliveries

Delivery goal	Met	Status
1 Battery of Equipment (Battery 5)	Yes	-
44 Interceptors	Partially	3 Delivered; 39 Delayed
B3.0.0 Software	No	Delayed

[a] The test was renamed FTO-02 E2a and was conducted in October 2015 (fiscal year 2016).

Appendix IX: Nine of Eleven Successful Flight Tests Conducted in Fiscal Year 2015 Provided Increased Knowledge

Flight Tests Conducted in Fiscal Year 2015				
No.	**Test name**	**Intercept or non-intercept**	**Date conducted**	**Status and description**
1	AST-15	Intercept	Dec. 2014	**Target failed**. Cooperative test with Israel for the first intercept of a target using the Arrow-3 interceptor. Retest was conducted in December 2015 (fiscal year 2016).
2	DST-3	Intercept	By Apr. 2015	**Successful**. Cooperative test with Israel to improve its architecture against threat missiles.
3	FTM-25	Intercept	Nov. 2014	**Successful**. An Aegis BMD 5.0 capability upgrade ship used an SM-3 IB interceptor to engage a short-range target and SM-2 Block IIIA guided interceptor s for two low-flying cruise missiles, near-simultaneously.
4	FTO-02 E1	Intercept	Jun. 2015	**Target failed**. An operational test of Aegis Ashore to demonstrate its interoperability with other BMDS elements and use the Standard Missile-3 (SM-3) Block IB Threat Upgrade (TU) interceptor. The target, which was new and flying for the first time, failed. Consequently, corrections were made to the target and a retest was conducted in December 2015 (fiscal year 2016).
5	FTX-19	Non-Intercept	Feb. 2015	**Successful**. First flight test of the Aegis BMD 4.0 Weapon System's capability against a raid (3) short-range targets and the Distributed Weighted Engagement Scheme (DWES)—automated engagement coordination between multiple Aegis BMD ships to determine which one is the preferred shooter, reducing duplication and missile expenditures while ensuring threat coverage.
6	FTX-20	Non-Intercept	Oct. 2014	**Successful**. An Aegis BMD 5.0 capability upgrade ship detected and tracked a target, exercising several fire control, discrimination, and engagement functions.
7	MMW E1	Intercept	Jul. 2015	**Successful**. An Aegis BMD 5.0 capability upgrade ship engaged a short-range target using SM-6 Dual I interceptor, the first live fire of this interceptor.
8	MMW E2	Intercept	Jul. 2015	**Successful**. An Aegis BMD 5.0 capability upgrade ship used a SM-2 Block IV interceptor to engage a short-range target.
9	MMW E3	Intercept	Jul. 2015	**Successful**. An Aegis BMD 5.0 capability upgrade ship used the SM-6 Dual I interceptor to engage a cruise missile.
10	MMW E4	Intercept	Aug. 2015	**Successful**. An Aegis BMD 5.0 capability upgrade ship used a SM-6 Dual I interceptor to engage a cruise missile, but it was programmed not to detonate within lethal range of the target.
11	SCD CTV-01	Non-Intercept	Jun. 2015	**Successful**. A developmental test of the SM-3 Block IIA to collect various performance data in support of production decision.

Appendix X: Prior GAO Annual Reports on Missile Defense

Report number	Report date	Report title
GAO-04-409	Apr. 2004	*Missile Defense: Actions Are Needed to Enhance Testing and Accountability*
GAO-05-243	Mar. 2005	*Defense Acquisitions: Status of Ballistic Missile Defense Program in 2004*
GAO-06-327	Mar. 2006	*Defense Acquisitions: Missile Defense Agency Fields Initial Capability but Falls Short of Original Goals*
GAO-07-387	Mar. 2007	*Defense Acquisitions: Missile Defense Acquisitions Strategy Generates Results but Delivers Less at a Higher Cost*
GAO-08-448	Mar. 2008	*Defense Acquisitions: Progress Made in Fielding Missile Defense, but Program is Short of Meeting Goals*
GAO-09-338	Mar. 2009	*Defense Acquisitions: Production and Fielding of Missile Defense Components Continue with Less Testing and Validation Than Planned*
GAO-10-311	Feb. 2010	*Defense Acquisitions: Missile Defense Transition Provides Opportunity to Strengthen Acquisition Approach*
GAO-11-372	Mar. 2011	*Missile Defense: Actions Needed to Improve Transparency and Accountability*
GAO-12-486	Apr. 2012	*Missile Defense: Opportunity Exists to Strengthen Acquisitions By Reducing Concurrency*
GAO-13-432	Apr. 2013	*Missile Defense: Opportunity to Refocus on Strengthening Acquisition Management*
GAO-14-351	Apr. 2014	*Missile Defense: Mixed Progress in Achieving Acquisition Goals and Improving Accountability*
GAO-15-345	Mar. 2015	*Missile Defense: Opportunities Exist to Reduce Acquisition Risk and Improve Reporting on System Capabilities*

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Congressional Relations

Katherine Siggerud, Managing Director, siggerudk@gao.gov
(202) 512-4400, U.S. Government Accountability Office
441 G Street, NW, Room 7125, Washington, DC 20548

Public Affairs

Chuck Young, Managing Director, youngc1@gao.gov
(202) 512-4800, U.S. Government Accountability Office
441 G Street, NW, Room 7149, Washington, DC 20548

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