United States Government Accountability Office

Report to Congressional Committees

May 2015

MISSILE DEFENSE

Opportunities Exist to Reduce Acquisition Risk and Improve Reporting on System Capabilities

GAO-15-345

May 2015

MISSILE DEFENSE

Opportunities Exist to Reduce Acquisition Risk and Improve Reporting on System Capabilities

GAO Highlights

Highlights of GAO-15-345, a report to congressional committees

Why GAO Did This Study

Since 2002, MDA has spent approximately $105 billion, and it plans to spend about $38 billion more by 2019, to defend against enemy ballistic missiles. MDA is developing a BMDS comprised of a command and control system, sensors that identify incoming threats, and intercepting missiles. For over a decade, GAO has reported on MDA's progress and challenges in developing and fielding the BMDS. GAO is mandated by law to assess the extent to which MDA has achieved its acquisition goals and objectives, as reported through its acquisition baselines, and to report on other acquisition issues as appropriate. This, GAO's 12th annual report, examines progress and challenges in fiscal year 2014 associated with MDA's: (1) individual element testing and asset delivery goals, (2) efforts to reduce acquisition risks, and (3) reporting on the BMDS integrated capability. GAO examined MDA's acquisition reports and assessed them against GAO's acquisition best practices, analyzed baselines reported to discern progress, and interviewed DOD and MDA contractor officials.

What GAO Recommends

GAO recommends that, in order to reduce acquisition risk, MDA align future efforts for Aegis BMD and GMD with GAO's knowledge-based acquisition practices. GAO also recommends that the Secretary of Defense direct MDA to report annually to Congress and DOD on the progress it has made in achieving an integrated capability. DOD concurred or partially concurred with all of our recommendations. GAO continues to believe the recommendations are valid as discussed in this report.

View GAO-15-345. For more information, contact Cristina Chaplain at (202) 512-4841 or chaplainc@gao.gov.

What GAO Found

In fiscal year 2014, the Missile Defense Agency (MDA) made some progress in achieving its testing and delivery goals for individual elements of the Ballistic Missile Defense System (BMDS), but was not able to complete its planned fiscal year goals for testing. MDA conducted two intercept tests demonstrating an increased capability. However, it did not complete six planned flight tests for a variety of reasons, including test delays and retests to address previous failures, which limit the knowledge gained in fiscal year 2014. Additionally, several BMDS elements delivered assets in fiscal year 2014 without completing planned testing, which increases cost and schedule risks for an individual system and the BMDS as a whole. In one instance, the Terminal High Altitude Area Defense element delivered assets although its capability has not been demonstrated through flight testing.

Potential also exists to reduce acquisition risks for several MDA efforts that are pursuing high-risk approaches that do not adhere to an approach which encourages accumulating more knowledge before program commitments are made and conducting testing before production is initiated. Specifically:

- Aegis Ballistic Missile Defense (BMD)—MDA demonstrated that it had matured the Aegis Standard Missile-3 (SM-3) Block IIA interceptor's design prior to starting production, a best practice. However, Aegis BMD is still addressing issues in the Aegis SM-3 Block IB interceptor revealed through prior test failures and is planning to award a multiyear procurement contract prior to flight testing the final design. If design changes are later needed, the cost, schedule, and performance impact could be significant.
- Ground-based Midcourse Defense (GMD) system—MDA reduced risk by adding a non-intercept flight test in fiscal year 2015 which allows the program to collect valuable data on redesigned components. However, GMD increased risk to the warfighter by prioritizing new interceptor production over fixing previously deployed interceptors and resolving known issues. In addition, MDA has decided to redesign the GMD kill vehicle prior to determining whether the effort is the most cost-effective solution.

Unless MDA aligns its future efforts for Aegis and GMD with acquisition best practices, the agency's acquisition outcomes may be on a similar trajectory to that of prior years, incurring both cost growth and schedule delays.

MDA is working to increase the extent to which the various elements of the BMDS are capable of working as one integrated system, but the agency reports limited information to Congress regarding its integration goals and its progress against these goals. Integration of the BMDS is important because it improves the system performance beyond the abilities of individual elements. Although MDA is not required to provide this information in its reports and briefings to Congress, congressional decision makers have limited insight into the planned BMD system-level capabilities, the supporting element-level upgrades, and how element-level efforts are synchronized to ensure timely delivery.

Contents

Tables

Figures

Abbreviations

Aegis BMD	Aegis Ballistic Missile Defense
AN/TPY-2	Army Navy/Transportable Radar Surveillance and Control Model 2
BAR	BMDS Accountability Report
BMDS	Ballistic Missile Defense System
BMD	Ballistic Missile Defense
C2BMC	Command, Control, Battle Management, and Communications
CE-I	Capability Enhancement-I
CE-II	Capability Enhancement-II
DOD	Department of Defense
EPAA	European Phased Adaptive Approach
GMD	Ground-based Midcourse Defense
MDA	Missile Defense Agency
NDAA	National Defense Authorization Act
SM-3	Standard Missile-3
THAAD	Terminal High Altitude Area Defense

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
Washington, DC 20548

May 6, 2015

Congressional Committees

Since 2002, the Missile Defense Agency (MDA) has spent approximately $105 billion to provide protection from enemy ballistic missiles by developing a Ballistic Missile Defense System (BMDS) comprised of a command and control system, sensors that identify incoming threats, and missiles that can intercept enemy ballistic missiles. The agency plans to spend an additional $37.6 billion between 2015 and 2019 to continue to develop and field BMDS elements and supporting efforts, such as BMDS targets necessary for testing. For over a decade, we have reported on MDA's progress and made recommendations to address challenges in developing and fielding BMDS capabilities, as well as other transparency, accountability, and oversight issues. We have made recommendations to help address these challenges and MDA has made progress in implementing them. Moreover, as MDA continues to expand its efforts to increase the defense of the United States and protect our allies, understanding developmental progress can inform congressional decision makers.

Since the 2002 National Defense Authorization Act (NDAA), we have been mandated to prepare annual assessments of MDA's progress toward meeting its acquisition goals.[1] The fiscal year 2012 NDAA requires us to report on the extent to which MDA has achieved its stated acquisition goals and objectives, as reported through its acquisition baselines as stated in the BMDS Accountability Report (BAR), and also to include any other findings and recommendations on MDA acquisition programs and accountability as appropriate.[2] This report, including individual appendixes, provides our assessment of MDA's progress in fiscal year 2014. Specifically, it assesses MDA's: (1) fiscal year 2014

[1] 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).

[2] Pub. L. No. 112-81, § 232 (a) (2011).

progress and challenges associated with testing and asset delivery goals, (2) efforts to reduce acquisition risks, and (3) reporting on the overall BMDS integrated capability.

In addition, the fiscal year 2014 NDAA, and its related joint explanatory statement mandated GAO to provide separate assessments on several other missile defense related issues.[3] For example, GAO was required to provide its views on a DOD report on the status and progress of its regional BMD programs and efforts, including operational issues on regional BMD and progress made in developing and testing elements of systems intended for Europe. Additionally, GAO provided in December 2014 its views on MDA's report on plans to improve the quality of cost estimates, which included an assessment of the extent to which planned improvements for the quality of its cost estimates are in line with GAO guidelines and best practices.[4]

For this report, we focused our assessment on MDA's testing and asset delivery goals. To assess MDA's fiscal year 2014 progress towards meeting these goals, we reviewed the planned fiscal year 2014 testing and delivery baselines as stated in the BAR, approved May 2, 2013.[5] We compared these planned efforts to the annual progress as detailed in key management documents, including program and baseline reviews and flight test plans and reports. In addition, we met with MDA officials from the Testing and Engineering Directorates, as well as individual element program officials. We also met with officials from DOD's Office of the Director of Operational Test and Evaluation, and key contractors.

To assess MDA's efforts to reduce acquisition risks, we reviewed MDA's program decision documents, including baseline reviews, test and

[3] e.g., Pub. L. No. 113-66, § 231(c)(2)(F) (2013).

[4] For further details on each report see GAO, *Regional Missile Defense: DOD's 2014 Report Generally Addressed Required Reporting Elements, but Excluded Additional Key Details*, GAO-15-32 (Washington, D.C.: Dec. 1, 2014). Also, see GAO, *Missile Defense: Cost Estimating Practices Have Improved, and Continued Evaluation Will Determine the Effectiveness*, GAO-15-210R (Washington, D.C.: Dec. 12, 2014).

[5] MDA outlines its goals for the upcoming fiscal year in its BAR. For example, MDA's May 2013 BAR outlines its goals for fiscal year 2014. As such, we used the 2013 BAR as the baseline to assess MDA's goals for fiscal year 2014 and we used other agency documents and meetings with agency officials to determine the progress that MDA has made toward those goals.

systems engineering plans, budget justification material, and program management documents. We analyzed GAO's acquisition best practices developed in our prior assessments of major defense acquisition programs; DOD and MDA's acquisition policies; independent DOD assessments, such as those conducted by DOD's Office of the Director of Operational Test and Evaluation and the Defense Contract Management Agency; and prior GAO recommendations to identify areas of significant acquisition risk.[6] Additionally, we met with individual element officials to discuss their current program plans and their plans for future development.

To assess MDA's reporting of integration and the overall BMDS capability, we compared the information presented in its internal management documents against the information presented to Congress in the 2014 BMDS Accountability Report. For this comparison, we primarily relied on the 2014 Master Integration Plan, which presents the schedule for delivering BMD system-level capabilities, schedules for synchronized delivery of BMD elements, and potential risks to their delivery. We also reviewed integration plans from prior years, the 2014 master test plan, element-level baseline reviews, and similar program-level briefings. Additionally, we met with officials from MDA's Directorate for Engineering to discuss the integration process, external reporting of integration, and progress in integrating BMDS elements.

We conducted this performance audit from June 2014 to May 2015 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

The BMDS is designed to defend the United States homeland and our regional friends and allies against attacks from ballistic missiles of all

[6] For examples of previous GAO reports that include acquisition best practices, see GAO, *Missile Defense: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency*, GAO-12-486 (Washington, D.C.: Apr. 20, 2012) and *Defense Acquisitions: Assessment of Selected Weapon Programs*, GAO-14-340SP (Washington, D.C.: Mar. 31, 2014).

ranges—short, medium, intermediate, and intercontinental.[7] Since ballistic missiles have different ranges, speeds, sizes, and performance characteristics, MDA is developing a variety of systems, known as elements or programs, that, when integrated, provide multiple opportunities to destroy ballistic missiles in flight. The BMDS includes space-based sensors; ground- and sea-based radars; ground- and sea-based interceptor missiles; and a command and control system that provides communication links to the sensors and interceptor missiles.

Description of BMDS Elements

The BMDS is comprised of several systems, which MDA calls elements or programs. Table 1 provides a brief description and status of the BMDS elements assessed in this report. See appendixes II-IX for more detailed information.

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

BMDS element/ program	Description and key components	Status
Aegis BMD Weapon System	The Aegis Ballistic Missile Defense (BMD) weapon system is being developed to provide ship- and land-based BMD capabilities. It consists of a radar, command and control system and employs Standard Missile-3 (SM-3) interceptors to defend against ballistic missile threats. Upgrades are planned to improve its ability to locate, discriminate, and track more sophisticated threat objects at once, as well as uplink that data to the SM-3 in flight. The Aegis BMD Weapon System supports regional missile defense, including Europe, as the primary deployed BMDS weapon system, and homeland defense missions providing long range surveillance and track data to the Ground based Midcourse (GMD) system for intercontinental ballistic missile threats.	The Missile Defense Agency (MDA) certified version 4.0.2 for deployment in December 2012, with plans to certify several upgraded versions in fiscal years 2015 through fiscal year 2018.
Aegis BMD Standard Missile-3 (SM-3) Block IB	MDA is developing several versions of SM-3 interceptors.[a] The SM-3 Block IB, is the second version, which features additional capabilities over the previous SM-3 version to identify, discriminate, and track objects during flight. The SM-3 Block IB is expected to defend against short- and medium-range ballistic missiles.	MDA plans to move into full-rate production of the SM-3 Block IB interceptors in the second quarter of fiscal year 2015. MDA plans to procure 405 interceptors through 2019.

[7] Short-range ballistic missiles have a range of less than 621 miles; medium-range ballistic missiles have a range from 621 to 1,864 miles; intermediate-range ballistic missiles have a range from 1,864 to 3,418 miles; and intercontinental ballistic missiles have a range greater than 3,418 miles.

BMDS element/ program	Description and key components	Status
Aegis BMD SM-3 Block IIA	The SM-3 Block IIA is the third SM-3 version to be developed for use with the sea-based and future land-based Aegis system in cooperation with Japan. This interceptor is planned to have increased range compared to earlier SM-3 variants. The SM-3 Block IIA is also planned to have more sensitive seeker technology and an advanced kill vehicle compared to the SM-3 Block IB. The SM-3 Block IIA is expected to defend against medium- and intermediate-range ballistic missiles.	The SM-3 Block IIA completed its system-level review of the interceptor design in October 2013, with no major issues.
Aegis Ashore	A land-based, or ashore, version of Aegis BMD using SM-3 interceptors and Aegis BMD weapon system capabilities as they become available. MDA is currently planning to construct three Aegis Ashore sites: one test site and two operational sites for the defense of Europe.	MDA completed the installation of the Hawaii test site in April 2014 and completed its first non-intercept flight test in May 2014. One additional test is planned in the middle of 2015 for initial Aegis Ashore capability. MDA plans to deliver the first operational site in Romania by the end of 2015 and the second site in Poland by the end of 2018.
Army Navy/ Transportable Radar Surveillance and Control Model -2 (AN/TPY-2)[b]	The AN/TPY-2 is a transportable X-band high resolution radar that is capable of tracking ballistic missiles of all ranges. AN/TPY-2 can be used in two modes: in the forward-based mode for early detection or in the terminal mode used with Terminal High Altitude Area Defense.	MDA has delivered nine AN/TPY-2 radars worldwide to support regional defenses. Forward-based radars are conditionally accepted by the Army with full acceptance expected by June 2016. MDA officials told us they plan to procure and deliver four additional radars for use in terminal mode.
Command, Control, Battle Management, and Communications (C2BMC)	C2BMC is a globally deployed system that links and integrates individual missile defense elements. It also allows users to plan ballistic missile defense operations, see the battle develop, and manage networked sensors. MDA has released several versions of the software, known as spirals, which continue to improve on the C2BMC's ability to manage information among the BMDS elements. The system also includes hardware such as workstations, servers, and network equipment.	The latest version, known as Spiral 6.4, has been operational since 2011. MDA completed delivering some fixes and additional capabilities to this spiral in 2014 and plans additional enhancements through 2016. The next spiral, known as Spiral 8.2, is in development with plans to be installed in fiscal year 2017.
Ground-based Midcourse Defense (GMD) System	GMD is a ground-based defense system designed to defend the United States against a limited intermediate and intercontinental ballistic missile attack in the middle part of their flight. Key components include a ground-based interceptor consisting of a booster with a kill vehicle on top, as well as a communication system and a fire control capability. The kill vehicle uses on-board sensors and divert capabilities to steer itself into the threat missile to destroy it. There are currently two versions of the kill vehicle: the initial design known as the Capability Enhancement-I (CE-I) and the upgraded design known as the Capability Enhancement-II (CE-II).	MDA has completed fielding 24 of the CE-I interceptors, one of which was used in a flight test. MDA has also delivered 14 of the CE-II interceptors, ten of which were deployed and four of which were used in flight tests. These interceptors were deployed to missile fields located at Fort Greely, Alaska and Vandenberg Air Force Base, California. MDA plans to field 44 interceptors by the end of 2017, as directed by the Secretary of Defense in a September 2013 announcement.
Targets and Counter-measures	MDA develops and procures a variety of highly complex targets to represent realistic threats during BMDS flight testing. Targets include short-, medium-, intermediate-, and intercontinental ranges.	Because targets are developed to support the testing activities of other BMDS elements, they are not operationally fielded.

BMDS element/ program	Description and key components	Status
Terminal High Altitude Area Defense (THAAD)	THAAD is a mobile, ground-based missile defense system designed to defend against short- and medium-range ballistic missiles in the late-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 configurations—1.0 and 2.0. THAAD 1.0 is a production effort for the batteries, interceptors, and hardware. THAAD 2.0 is primarily software development intended to expand capability to defend against threats in multiple regions and at different ranges and increase integration with other BMDS elements.	The first four THAAD batteries have been made available for operational use. THAAD 2.0 is developing multiple software builds adding incremental capability with plans for full operational capability in fiscal year 2020. MDA plans to equip a total of seven batteries through fiscal year 2025.

Source: GAO analysis of MDA data. | GAO-15-345

[a] Another Aegis BMD SM-3 interceptor version includes the SM-3 Block IA. We did not assess the SM-3 Block IA because it has been in production since 2005 and is currently operational for regional defense in Europe as well as other regions.

[b] Details on the acquisition progress of other MDA programs are not included in the report as they fall outside the scope of the BAR. These include the Sea-based X-band radar, Cobra Dane radar and Long Range Discriminating Radar. We also did not provide a separate appendix on the AN/TPY-2 as most of the program's fiscal year 2014 efforts were focused on sustaining the previously delivered assets. Additionally, we also did not assess programs that have been transferred to a military service such as the Patriot Advanced Capability-3 program.

MDA's Acquisition Flexibilities and Steps Taken to Address Transparency

When MDA was established in 2002, it was granted exceptional flexibility in setting requirements and managing the acquisition. The BMDS was to be developed as a single program designed to quickly deliver a set of integrated defensive capabilities. This decision deferred application of DOD acquisition policy to the BMDS 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, such as the engineering and manufacturing development phase, have also effectively been deferred.[8] These laws and policies include such things as:

- Documenting program parameters in an acquisition program baseline that has been approved by a higher-level DOD official prior to the

[8] The BMDS program meets the definition of a major defense acquisition program, which is defined in 10 U.S.C. § 2430 and implemented by DOD in its acquisition regulations. DOD Instruction, 5000.02, Operation of the Defense Acquisition System, Jan. 7, 2015.

program's entry into the engineering and manufacturing development phase or program initiation, whichever occurs later.[9]

- Measuring the program against the approved baseline or obtaining the approval of a higher-level acquisition executive before making changes.
- Reporting certain increases in unit cost measured from the original or current program baseline.[10]
- Obtaining an independent life-cycle cost estimate prior to beginning engineering and manufacturing development, and/or production and deployment.[11]
- Regularly providing detailed program status information to Congress, including information on cost, in Selected Acquisition Reports.[12]

Congress and DOD have taken actions to address oversight of MDA. For example, in the NDAA for Fiscal Year 2008, Congress required MDA to establish acquisition cost, schedule, and performance baselines for each system element that has entered the equivalent of the engineering and manufacturing development phase of acquisition or is being produced or acquired for operational fielding.[13] MDA reported its newly-established resource, schedule, test, operational capacity, technical, and contract baselines for certain BMDS components for the first time in its June 2010 BMDS Accountability Report (BAR). Since that time, Congress has continued to alter MDA's baseline reporting requirements in the NDAA for

[9] 10 U.S.C. § 2435 requires an approved program baseline description for major defense acquisition programs before the program enters system development and demonstration (now known as engineering and manufacturing development), production and deployment, and full-rate production. As implemented by DOD, this is referred to as an acquisition program baseline.

[10] 10 U.S.C. § 2433.

[11] 10 U.S.C. § 2434.

[12] 10 U.S.C. § 2432. MDA does provide a limited Selected Acquisition Report for the BMDS as a whole.

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

Fiscal Years 2011[14] and 2012.[15] Additionally, to enhance oversight of the information provided in the BAR, MDA continues to incorporate suggestions and recommendations from GAO on the content and clarity of the information reported in the BAR to include: 1) the addition of information to explain the major changes experienced by each program over the past year; 2) the addition of buy/delivery information for each program that has advanced to Product Development, Initial Production, or Production; 3) a description of cost items not included in program Resource Baselines; and 4) a summary of critical schedule milestones with their respective initial baseline dates and dates from the previous BAR to facilitate tracking.

High-Risk Approach to Acquisitions Has Affected Certain Outcomes

Successful programs that deliver promised capabilities for the estimated cost and on schedule use a disciplined, knowledge-based approach where knowledge supplants risk over time. In our past work examining weapon system acquisition and best practices, we have found that successful commercial firms pursue an acquisition approach that is anchored in knowledge, whereby high levels of product knowledge are demonstrated at critical points in the acquisition process.[16] This approach recognizes that programs require an appropriate balance between schedule and risk, but does not include an undue amount of what is often referred to as acquisition concurrency, where overlap occurs between technology development and product development or between product development and production of a system. Instead, programs take steps to

[14] The Ike Skelton National Defense Authorization Act for Fiscal Year 2011, Pub. L. No. 111-383, § 225 required the Secretary of Defense to ensure that MDA establishes and maintains an acquisition baseline for each program element of the BMDS. This law detailed specific requirements for the contents of the acquisition baseline, including a comprehensive schedule, a detailed technical description, a cost estimate, and a test baseline.

[15] Pub. L. No. 112-81, § 231, codified at 10 U.S.C. § 225, supersedes the 2011 NDAA but similarly requires that the MDA Director 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 adds new requirements for the contents of the acquisition baseline in addition to what was described in the 2011 NDAA. Annually, MDA is to submit a report on the baselines. After the first report, subsequent reports mush identify any changes or variances made to the elements of the baseline compared to the initial acquisition baseline and the acquisition baseline submitted in the previous year.

[16] GAO-14-340SP.

gather knowledge prior to moving from one acquisition phase to another. These steps for a program include:

- Demonstrating its technologies are mature and that allotted resources match the program's requirements before deciding to invest in product development.
- Demonstrating its designs are stable and perform as expected before deciding to build and test production-representative prototypes.
- Demonstrating its production processes are in control and meet cost, schedule, and quality targets before deciding to produce first units.

Since 2002, MDA has developed, demonstrated, and fielded a limited homeland and regional ballistic missile defense capability, but has fallen short of its goals, in part, because of its acquisition practices. Some of these practices include initiating new programs without robustly assessing alternative solutions, incorporating high levels of concurrency, and fielding capabilities prior to completing flight testing. While some concurrency is understandable, committing to product development before requirements are understood and technologies are mature, as well as committing to production and fielding before development is complete is a high-risk strategy that often results in performance shortfalls, unexpected cost increases, schedule delays, and test problems.[17] We previously found that although these practices enabled MDA to quickly ramp up efforts in order to meet tight, presidentially-directed deadlines, they were also high risk and resulted in problems that caused some programs to be cancelled or significantly disrupted. For example:

- In July 2013, we found that the Secretary of Defense decided to cancel an MDA satellite system program, called the Precision Tracking Space System, based on the results of a departmental review of the program which determined that the program had significant technical, programmatic, and affordability risks.[18] We previously found that MDA did not consider a broad range of alternatives prior to its decision to start the program, was relying on a highly-concurrent acquisition approach despite significant technical

[17] GAO-12-486.

[18] GAO, *Missile Defense: Precision Tracking Space System Evaluation of Alternatives*, GAO-13-747R (Washington, D.C.: Jul. 25, 2013).

and operational challenges, and was projecting a lower total program cost by increasing risk to the warfighter.[19] Although MDA gained some technical knowledge from the effort, it also expended significant resources—approximately five years and $231 million. The sensor coverage gaps, such as persistent tracking from space, that the program was intended to address persist.

- In April 2014, we found that a series of GMD test failures in conjunction with a highly concurrent CE-II development, production, and fielding strategy caused major disruptions to the program.[20] Because the program moved forward with producing and fielding interceptors before completing its flight test program, test failures exacerbated the disruptions to the program, causing the program to fall several years behind on its flight test program and increasing the cost to demonstrate the CE-II from $236 million—the cost of GMD's first CE-II flight test—to $1.981 billion—the cost to resolve the test failures and implement a retrofit program. See appendix VII for more detailed information.

MDA Conducted Several Key Tests and Continued to Deliver Assets, but Did Not Achieve All Planned Goals for Fiscal Year 2014

MDA made progress, but did not achieve all of its planned test and asset delivery goals for fiscal year 2014, and has not fully met its test goals since first reporting baselines in its 2010 BAR. MDA utilizes ground, non-intercept, and intercept tests to provide it with knowledge on the operational effectiveness, suitability, and survivability of an asset or capability. Ground tests use simulations and scenarios when flight testing may be impractical or cost-prohibitive. Flight tests—intercept and non-intercept—evaluate an asset's ability to defend against a specific threat. Intercept tests include active engagement of one or more targets, while non-intercept tests do not include active engagement of a target. Moreover, non-intercept tests can assess specific aspects of an asset to potentially reduce risks for future intercept tests. Completing planned testing is a key step to enable the delivery of assets and capabilities, in line with GAO best practices. However, despite testing delays, shortfalls, and failures, MDA has continued to deliver assets. Without completing

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

[20] GAO, *Missile Defense: DOD's Report Provides Limited Insight on Testing Options for the Ground-based Midcourse Defense System*, GAO-14-350R (Washington, D.C.: Apr. 30, 2014) and *Missile Defense: Mixed Progress in Achieving Acquisition Goals and Improving Accountability*, GAO-14-351 (Washington, D.C.: Apr. 1, 2014).

planned testing, MDA is delaying or foregoing the full breadth and depth of knowledge it planned to have attained prior to the delivery of its assets.

MDA Conducted Some Tests in Fiscal Year 2014 as Planned

In fiscal year 2014, MDA conducted four out of ten planned flight tests (as shown below in table 2). It also conducted an additional flight test in June 2014 that was inserted into the schedule to retest and confirm a capability that failed during a prior test.

Table 2: Planned and Conducted Flight Tests in Fiscal Year 2014

Planned tests' names	Flight test type	Conducted (yes or no)	Date conducted	Change in test plan
Aegis Ashore CTV-01	Non-intercept	Yes	May 2014	-
Aegis FTM-22	Intercept	Yes	October 2013	-
Aegis FTM-23	Intercept	No	-	Cancelled due to sequestration.
Aegis FTM-24	Intercept	No	-	Delayed until first quarter of fiscal year 2016 due to ship, test range, and target availability.
Aegis FTX-18	Non-intercept	Yes	January 2014	-
Aegis FTX-19	Non-intercept	No	-	Delayed until second quarter of fiscal year 2015 due to sequestration.
Aegis FTX-20	Non-intercept	No	-	Delayed until first quarter of fiscal year 2015 due to target availability.
GMD CTV-02	Non-intercept	No	-	Cancelled because objectives were met during prior tests.
GMD FTG-09	Intercept	No	-	Delayed until first quarter of fiscal year 2016 with a shift in mission, renamed to GMD Controlled Test Vehicle (GM CTV)-02+.
SCD PTV-01	Non-intercept	Yes	October 2013	-
Other tests	**Flight test type**	**Conducted (yes or no)**	**Date conducted**	**Change in test plan**
GMD FTG-06b[a]	Intercept	Yes	June 2014	-

Source: GAO Analysis of Missile Defense Agency documentation. | GAO-15-345

[a] FTG-06b was not originally included in the test plan for fiscal year 2014—the May 2013 BAR—but was later included as a part of the test plan after the BAR was released.

MDA conducted two intercept and three non-intercept flight tests in fiscal year 2014 that demonstrated an increased capability for the Aegis BMD and the GMD programs. The three non-intercept tests evaluated Aegis Ashore's ability to launch and guide an SM-3 interceptor, as well as the SM-3 Block IIA interceptor booster performance and tracking capabilities for the Aegis BMD Weapon System. One intercept test supported the Aegis BMD program's full rate production decision for the SM-3 Block IB

interceptor by demonstrating the capability to intercept a medium- range ballistic missile target. The other intercept test—FTG-06b—was inserted into the test schedule to retest and demonstrate the performance of the CE-II interceptor, which failed its prior two attempts in 2010. MDA successfully executed FTG-06b in June 2014, which was a major accomplishment for the program as it was the first successful intercept attempt with the CE-II interceptor, ending a five-and-a-half year period without a successful intercept for the GMD program. For further details about the Aegis BMD and GMD programs, see appendixes II, III, IV, V, and VII.

MDA did not conduct six planned flight tests in fiscal year 2014, and it has been unable to conduct all of its planned tests since fiscal year 2010 because, as we previously reported, its test plan is ambitious and success-oriented, which makes it difficult to adjust the schedule if necessary and results in frequent changes and disruptions to its test plan.[21] MDA officials have told us that they do not plan for target failures, test failures, or potential retests when developing the test schedule, and that there is no flexibility to absorb these issues. We previously recommended that MDA include sufficient margin in its test schedule based on recent test outcomes and forecasted testing demands so it could better meet its testing goals.[22] However, MDA has not implemented this recommendation. Consequently, when MDA encounters challenges, it does not have the flexibility to accommodate changes and falls short of its testing goals and hinders oversight.

According to MDA officials, the reasons that the six flight tests in 2014 were not conducted as planned include: sequestration that limited the funds available for testing, target availability, and retests to address previous failures. To address these challenges, MDA made the decision to remove or delay some planned tests. For instance, of the four Aegis BMD program tests that were planned but not conducted, one was cancelled and one was delayed due to sequestration, and two were delayed due to lack of target availability. Some of these tests are designed to assess MDA's regional ballistic missile defense approach for

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

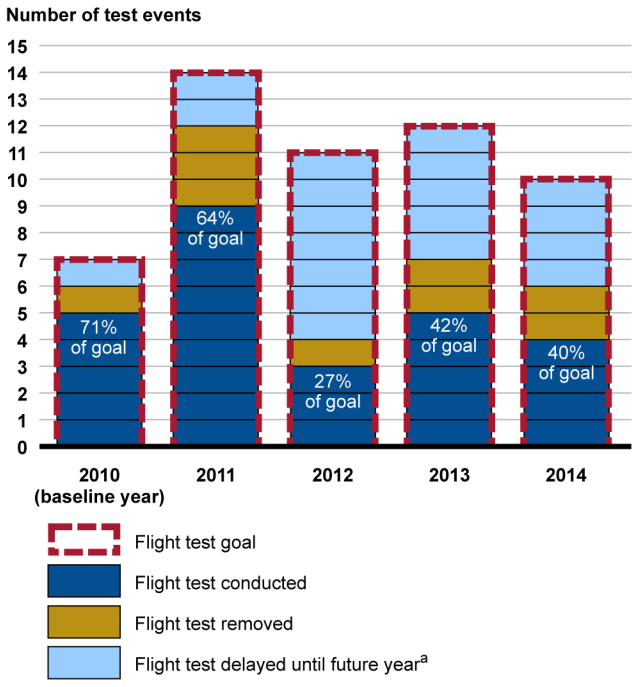
[22] GAO-11-372.

Europe, also called the European Phased Adaptive Approach (EPAA).[23] As a result, MDA risks discovering performance shortfalls with some of its assets after they are fielded and declaring future phases without all of the information it initially planned to have. Of the two GMD program flight tests that were planned but not conducted, the program cancelled one because the test objectives were met through prior tests, and the other test was significantly changed, including a new name and test objectives, after the successful FTG-06b test.

MDA came closest to achieving its testing goals in fiscal year 2010 when it conducted five out of seven, or 71 percent, of its planned tests (see figure 1).

[23] MDA manages capabilities that are intended for the defense of the United States under the Homeland Defense construct. On the other hand, capabilities that are intended to defend U.S. forces and allies abroad are managed under the Phased Adaptive Approach (PAA) for a Regional BMD construct. European PAA (EPAA) is DOD's plan to deploy regional BMD capabilities in Europe. EPAA is part of U.S. policy.

Figure 1: Flight Tests Conducted as Scheduled in Fiscal Years 2010-2014



Source: GAO analysis of Missile Defense Agency documentation. | GAO-15-345

[a] These tests reflect the planned tests events outlined in the prior fiscal year BARs, and may not include tests planned or conducted after it was released each year.

Each year as MDA falls short of its testing goals due to target failures, test failures, or retests, it takes steps to recoup by delaying and removing tests. As a result, MDA is delaying, and in some cases, not collecting knowledge about the asset's capabilities and limitations prior to delivery. For example, FTX-19—a significant flight test of Aegis BMD's ability to coordinate two ships to track and engage multiple threats—has been delayed twice from its original planned date in fiscal year 2013, once to fiscal year 2014 and then again to fiscal year 2015. Additionally, since 2010, Aegis Ashore has removed five of its seven flight tests designed to assess its capability for EPAA Phase 2. According to program officials, the program is leveraging data from sea-based Aegis BMD tests, but conditions at sea are different than on land, as are the system configurations (for more information see appendix III). Moreover, frequent changes to the test schedule make it difficult to track what MDA has and has not accomplished in terms of testing and system capability.

MDA Delivered Some Assets in Fiscal Year 2014 as Planned

In fiscal year 2014, MDA continued to deliver its BMDS assets (see table 3).

Table 3: Missile Defense Agency's (MDA) Planned and Delivered Assets for Fiscal Years 2014

Ballistic Missile Defense System element		Planned	Delivered
Aegis	Standard Missile-3 Block IB Interceptors	14	25
	Aegis Ashore test facility	1	1
	Ships	4	5[b]
Ground-based Midcourse Defense CE-II Interceptors		3	1
Terminal High Altitude Area Defense (THAAD) Interceptors		10[a]	10

Source: GAO analysis of MDA documentation. | GAO-15-345

[a] THAAD planned to deliver 12 interceptors in fiscal year 2014 to complete the production of its second lot of interceptors. However, it delivered two additional interceptors in fiscal year 2013 which only left 10 interceptors to complete the lot.

[b] Although the program delivered more ship upgrades than it planned for 2014, its expectation for total cumulative deliveries are lower than planned.

However, some of these assets were delivered without completing planned testing, which increases risks for an individual system and the BMDS as a whole. For example, Aegis BMD continued to deliver SM-3 Block IB interceptors—11 more than originally planned—although it is still working to address its past test failures, including redesigns to one of its components. Also, THAAD delivered assets to meet urgent warfighter needs although there were changes incorporated to address obsolescence issues, and these will not be tested until the fourth quarter of fiscal year 2015. We have previously recommended that MDA synchronize its testing and asset delivery schedules to ensure that assets are tested before they are delivered.[24] If assets are delivered without testing, it could lead to costly and time-consuming retrofits if the asset does not perform as intended. Also, all of MDA's programs have complex interactions and interdependencies, so delivering problematic or underperforming assets could not only affect the performance or

[24] GAO, *Defense Acquisitions: Production and Fielding of Missile Defense Components Continue with Less Testing and Validation than Planned,* GAO-09-338 (Washington, D.C.: Mar. 13, 2009).

capability of one system, but others as well, and could compromise the overall operational performance of the BMDS.

MDA Can Do More to Improve Its Acquisition Outcomes by Reducing Risk

In fiscal year 2014, MDA undertook several risk reduction efforts designed to achieve or improve its acquisition outcomes, such as being able to deliver assets on time and that perform as expected. However, uncertainty exists as to whether the agency will be able to achieve such outcomes because it continues to undertake other efforts that are either high risk or lack a sound acquisition basis. Even with the risk reduction efforts, the agency's acquisition outcomes may be on a similar trajectory to that of prior years because it missed some risk reduction opportunities in fiscal year 2014.

MDA Took Some Actions in Fiscal Year 2014 to Improve Acquisition Outcomes by Reducing Risk

Several BMDS programs took actions in fiscal year 2014 to reduce risks to help the agency achieve or improve its desired acquisition outcomes. In March 2014, we identified knowledge-based acquisition practices based on our prior work on best product-development practices and found that successful programs take steps to gather knowledge to confirm technology maturity and design stability.[25] Aegis BMD reduced testing and production risks for its SM-3 Block IIA by achieving full design maturity at its critical design review—a key knowledge point juncture for acquisition programs considering whether to start building and testing production-representative prototypes. As we previously reported, the Aegis BMD program has taken steps aligned with this best practice by revising its SM-3 Block IIA schedule to alleviate compressed events and include additional time for subsystem reviews before conducting the critical design review to resolve any issues. As such, the program conducted the critical design review in October 2013 with no major issues identified and 100 percent of its design drawings completed—a key indication that the interceptor's design is stable. This allows the program to move forward with flight testing and into initial production with assurance of design maturity.

Also in fiscal year 2014, GMD took additional actions to reduce development and testing risk by incorporating an additional non-intercept flight test in fiscal year 2015. After successfully conducting FTG-06b in June 2014, the GMD program planned to conduct its next flight test—an intercept test called FTG-09—in the third quarter of fiscal year 2015. This

[25] GAO-14-340SP.

test, in part, was designed to demonstrate two redesigned components intended to address prior issues discovered in flight test failures. However, the program subsequently encountered delays developing the redesigned components and could not support the planned test date for FTG-09. According to program officials, the Director, MDA decided to repurpose FTG-09 as a non-intercept flight test, called GMD Controlled Test Vehicle (GM CTV)-02+, to provide the program with additional time to complete development for the redesigned components and to test additional objectives, such as the capability to discriminate the target from other objects during an engagement. The program previously conducted a non-intercept flight test, GM CTV-01, prior to conducting FTG-06b, which significantly contributed to the intercept flight test's success. Adding the non-intercept flight test GM CTV-02+ is a positive step as it allows the program to collect valuable data on how the redesigned components operate in the in-flight environment, which reduces risk for the next intercept flight test.

The Targets and Countermeasures program reduced BMDS testing risks by using a non-intercept flight test for a new target prior to its use in more complex and costly intercept tests. New, untested targets introduce higher risks of failures and, if a target fails, it often means costly and time-consuming re-tests, which could further delay the delivery of the capability to the warfighter. In 2013, we recommended that MDA add risk reduction flight tests for each new target type.[26] Risk reduction flight tests are conducted to confirm that the target works as intended and to discover and resolve issues prior to its use in an intercept test. MDA has not fully implemented this recommendation. However, the Targets and Countermeasures program successfully conducted a non-intercept flight test in October 2014 using a new target called the Medium-Range Ballistic Missile Type 3 (MRBM T3) prior to its first planned intercept test in fiscal year 2016. This non-intercept flight test reduces testing risks, such as potential target failures, by giving the program insight into the target's performance, and provides about a year to address any issues that may emerge. If the program continues to integrate non-intercept flight tests into the test schedule prior to intercept tests when new target types are introduced, it may reduce the risks for failures in intercept test events. The Targets and Countermeasures program also adopted contracting types aimed at providing incentives for the successful performance of

[26] GAO-13-432.

targets. Such measures may help prevent cost growth and performance problems seen in the past and minimize risk to the government.

Potential Exists to Improve Acquisition Outcomes for Several MDA Efforts

While MDA took actions to reduce risk, some of its elements are still using fundamentally risky acquisition strategies. MDA missed opportunities in fiscal year 2014 to further reduce risk and is planning to undertake efforts in the future that are either high risk or lack a sound acquisition basis as a result of not following some knowledge-based acquisition practices. We have previously identified several of these knowledge-based practices in our assessment of major defense acquisition programs.[27] However, opportunities remain for MDA to reduce risk in these future planned efforts, which would help the agency achieve its acquisition goals.

Aegis BMD: Opportunity Exists to Insert an Additional Flight Test to Assess Redesigned Component for the SM-3 Block IB Prior to a Multiyear Procurement Decision

Aegis BMD is currently redesigning a key component of its SM-3 Block IB interceptor to address prior test failures, but has no plans to flight test it before incorporating it into the interceptor. An SM-3 Block IB interceptor failed during a flight test in September 2013, when two SM-3 Block IB interceptors were launched against a single target (the first of which successfully intercepted the target). Although a failure review investigation is ongoing to determine the root cause of the failure, preliminary findings indicate that the third-stage rocket motor—the component that controls the final maneuvers of the interceptor—experienced a failure similar to that which occurred in September 2011.[28] As a result of the interceptor failures during the two flight tests, Aegis BMD is redesigning components in the third-stage rocket motor and expects to complete and accept the final redesign specifications in the second quarter of fiscal year 2015.

The Aegis BMD program is currently not planning to flight test the SM-3 Block IB with the redesigned components of the third-stage rocket motor before it is incorporated into the production line and deployed, in part, to support the regional defense of Europe. According to program officials and contractor representatives that produce the SM-3 Block IB interceptors, the effort to redesign components in the rocket motor is considered to be relatively straightforward and low risk. They also

[27] GAO-14-340SP.

[28] A previous Aegis flight test, designated FTM-16 E2, experienced an unexpected energetic event that resulted in a failed target intercept.

indicated that they do not believe that a flight test to demonstrate the redesigned rocket motor components is necessary, as plans are in place to conduct ground tests. However, without flight testing the redesigned rocket motor components, MDA may not fully understand the interceptor's performance and capabilities and whether it works as intended. Additionally, Director, Operational Test and Evaluation officials stated that the environments for a flight and ground test are very different and that MDA has not been able to replicate the SM-3 Block IB interceptor failure through ground tests. As we have previously reported, both failures occurred during flight tests, not ground tests. Moreover, different issues with that same component have contributed to previous SM-3 Block IB program schedule delays and production disruptions which resulted in a delayed production decision.

The Aegis BMD program is also moving forward with plans to initiate SM-3 Block IB full rate production in fiscal year 2015 and plans to enter into a multiyear procurement contract in fiscal year 2016. Both the full-rate production decision and multiyear procurement contract represent major commitments by the program and carry significant cost and schedule risks as the SM-3 Block IB with the redesigned third-stage rocket motor components have not been demonstrated through flight testing. When used appropriately, multiyear contracting can save money compared to a series of annual contracts by allowing contractors to use their resources more efficiently. However, multiyear procurement can limit DOD's budget flexibility and also entails certain risks that must be balanced against potential benefits, such as the increased costs to the government should the multiyear contract be changed. As MDA progresses with the full rate production of the interceptors and upcoming interceptor acquisition decisions, Aegis BMD still has an opportunity to insert a flight test into its test plan prior to inserting the redesigned components of the third-stage rocket motor into its production line. Until a flight test confirms that the redesigned components work as intended, MDA does not know if or how the changes will affect the interceptor's performance or if other changes are needed. Since the redesign of the third-stage rocket motor components are not finalized, MDA has not accounted for the potential costs associated with it. Without knowing the extent of modifications needed to the SM-3 Block IB, the agency may not realize the full potential of benefits associated with the multiyear procurement strategy.

GMD: Opportunity Exists to Reduce Risk Caused by the Program's Use of a Concurrent Strategy to Meet Its Goal of Fielding 44 Interceptors by 2017

The GMD program currently has multiple variants of its interceptor at different stages of development and production as a result of its developmental challenges and flight test failures. The production and integration of the CE-II interceptor was previously suspended following a failure in its December 2010 flight test. As we have previously reported, this flight test failed because of excessive vibration in the inertial measurement unit (IMU)—a component of the kill vehicle's guidance system.[29] The program subsequently modified the IMU to mitigate the excessive vibration; demonstrated the modified IMU's effectiveness in the non-intercept flight test; and performed a successful intercept with a CE-II configured with the modified IMU during FTG-06b in June 2014. Following the successful flight test, the GMD program resumed integration and production of the CE-II interceptor. In addition to modifying the IMU, according to the Director, MDA, the program is also developing alternate divert thrusters (ADT)—a component that steers the kill vehicle in flight—to address the systemic problem of in-flight vibration. The program plans to implement this new component, along with changes to components in the booster, such as the flight computer, into new interceptor production in fiscal year 2017. In addition to changes to the kill vehicle, table 4 below describes the current fleet of fielded interceptor versions and the program's plans to upgrade, retrofit and redesign the CE-II interceptor.

[29] GAO-14-350R.

Table 4: Plans for Current and Future Fleet of Ground-based Midcourse Defense (GMD) Interceptor Configurations

Timeframe	Version	Configuration	Fielding dates	Fielding total
Current fleet	Capability Enhancement (CE)-I	Prototype-designed kill vehicle with heritage 3-stage (C1) boost vehicle (flight test failure mitigation software deployed in FY 2015)	Fiscal Year (FY) 2004-2007	24 (1 of which was used in a prior flight test)
	CE-II with heritage Inertial Measurement Unit (IMU)	Limited upgraded kill vehicle with heritage IMU and C1 boost vehicle	FY 2009-2010	14 (4 of which were used in prior flight tests)
FY 2015-2019	CE-II with modified IMU	CE-II kill vehicle with modified IMU and C1 boost vehicle	FY 2015-2016	8
	Upgraded CE-II	Currently deployed CE-IIs retrofitted with modified IMU	FY 2015-2016	8 (retrofitting previously fielded CE-IIs)
	CE-II Block I	CE-II kill vehicle with modified IMU, alternate divert thrusters, upgraded (C2) boost vehicle, and other reliability improvements	FY 2017-2018	10
	Upgraded CE-I	Currently deployed CE-Is retrofitted with design upgrades and flight test failure mitigations	FY 2018 and beyond	To Be Determined (TBD)
FY 2020 and beyond	Redesigned Kill Vehicle	Redesigned kill vehicle with evolved, 2-stage (C3) boost vehicle	FY 2020 and beyond	TBD
	Next Generation Exoatmospheric Kill Vehicle	Multiple kill vehicle interceptor	TBD	TBD

Source: GAO analysis of Missile Defense Agency data. | GAO-15-345

CE-II with Modified IMU: The GMD program experienced a number of setbacks in fiscal year 2014 that increased risk to the program's goal of fielding 44 interceptors by 2017. For example, the program experienced delays with restarting interceptor production for the current interceptor version—the CE-II with the modified IMU. Defective wiring harnesses were identified on all CE-II interceptors, including those previously fielded and those currently undergoing production. It was determined that an improper soldering application was used during wiring harness assembly that could later cause corrosion, which could have far reaching effects because of the component's power and data interfaces with the kill vehicle's IMU. The program previously experienced problems with the wiring harness and the issue was resolved, but the corrective actions were not passed along to other suppliers. MDA assessed the likelihood for the component's degradation in the operational environment as low and decided to accept the component as-is, which helped mitigate the schedule delay, but increased the risk for future reliability failures. An assessment conducted by the Defense Contract Management Agency found that any deviation from the program's kill vehicle delivery schedule

of one kill vehicle per month could jeopardize the program's chances of meeting its goal of fielding 44 interceptors by 2017.

CE-II Block I: The GMD program is following a high risk approach for acquiring the CE-II Block I, but an opportunity exists for the program to reduce risk by flight testing the CE-II Block I prior to starting the interceptor's production. In July 2014, we found that the program planned to start production of CE-II Block I interceptors for operational use almost two years before it conducts Flight Test GMD (FTG)-15—a demonstration flight test planned to occur in the fourth quarter of fiscal year 2016 to determine if the new interceptor components work as intended.[30] According to acquisition best practices reported in our July 2002 assessment of DOD's weapon system acquisition process, the demonstration flight test should be conducted before production for operational use.[31] As we testified last year, the GMD program has had many years of significant and costly disruptions caused by production getting well ahead of testing and then discovering issues during testing.[32] Even though assets have already been produced, MDA has had to add tests that were not previously planned and delay tests that are necessary to understand the system's capabilities and limitations. By continuing to follow a concurrent acquisition approach, it is likely that the GMD program will continue to experience delays, disruptions, and cost growth.

In addition, the GMD program has encountered issues with a number of the component modifications being developed for the CE-II Block I. The developmental issues have caused the program to delay necessary design reviews, generated significant schedule compression, and has pushed out the completion of CE-II Block I deliveries to the second quarter of fiscal year 2018. For example, in November 2013, the program experienced an ADT qualification test failure as a result of design changes that were not verified prior to qualification testing. By omitting steps in the design process, the program increased the risk for costly,

[30] GAO, *Missile Defense: DOD's Report Provides Limited Insight on Improvements to Homeland Missile Defense and Acquisition Plans*, GAO-14-626R (Washington, D.C.: July 17, 2014).

[31] GAO, *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes,* GAO-02-701 (Washington, D.C.: Jul. 15, 2002).

[32] GAO, *Missile Defense: Mixed Progress in Achieving Acquisition Goals and Improving Accountability*, GAO-14-481T (Washington, D.C.: Apr. 2, 2014).

time-consuming problems to occur later in development. These risks materialized when the program failed the qualification test, resulting in a one-year delay to the ADT development effort, which the Defense Contract Management Agency assessed as having left the program with no schedule margin for performing the next flight test, GM CTV-02+, according to the program's current schedule. Although the recent delays to the CE-II Block I design reviews put the program behind schedule, it also provides the program with additional decision time—should program officials choose to use it—to assess the merits of conducting FTG-15 prior to starting CE-II Block I production for operational use.

GMD: Opportunity Exists to Incorporate Results of Alternatives Assessment Which Provide Valuable Knowledge for Its Kill Vehicle Redesign Plans

MDA is moving forward with the Redesigned Kill Vehicle (RKV) program—a new effort intended to address concerns about GMD's interceptor fleet reliability—prior to considering the benefits and risks of a broad range of options. Both the Director, Operational Test and Evaluation and the Under Secretary of Defense for Acquisition, Technology, and Logistics have previously voiced concerns with the CE-II's reliability. MDA validated these concerns when it acknowledged that the current kill vehicle design is costly to produce and sustain and requires the warfighter to fire more interceptors to overcome anticipated in-flight reliability failures. In the fall of 2013, DOD's Office of Cost Assessment and Program Evaluation began conducting a study to assess options, called an analysis of alternatives (AOA), for improving, augmenting, or providing an alternative interceptor to improve homeland ballistic missile defense. The assessment continued through fiscal year 2014 and is expected to be completed in fiscal year 2015.

We previously reported that a key challenge facing MDA was improving investment decisions, and that an AOA can help establish a sound basis for new acquisition efforts.[33] Robust AOAs are a sound investment practice because they objectively compare the costs, performance, effectiveness, and risks of a broad range of alternatives, which aid congressional and DOD decision makers in making an impartial determination to identify the most promising and cost-effective approach to pursue. We also found that MDA did not conduct AOAs for its new programs, which placed its programs at risk for cost, schedule, and technical problems as a result of pursuing potentially less than optimal solutions.

[33] GAO-13-432.

MDA began the RKV program, complete with a five-year funding request and schedule goals, before the AOA for homeland missile defense was completed. MDA began the RKV program to replace currently fielded interceptors with ones that are more testable, reliable, producible, and cost effective. According to MDA, this effort began in July 2013 and options for the RKV program were based on interim results from an ongoing GMD fleet assessment and an interim analysis MDA produced in support of the homeland missile defense AOA. MDA defined the RKV design parameters and assessed design concepts provided by industry. MDA proceeded to incorporate the RKV effort into GMD's current program of record and increased GMD's budget request for fiscal years 2015 through 2019 by over $700 million to fund the RKV's development. In addition, MDA added two RKV flight tests to the GMD test plan and collaborated with industry to finalize the RKV concept. MDA developed plans to conduct the first RKV flight test in fiscal year 2018 and begin delivering interceptors in fiscal year 2020. Although several plans have been established, MDA has not finalized its acquisition strategy for the RKV and, as such, the agency's plans are subject to change.

While redesigning the GMD kill vehicle may be justifiable, MDA did not have the results of the AOA prior to making the determination to pursue the redesign effort. By not making the AOA a major part of the RKV effort, MDA runs the risk of starting the effort on an unsound acquisition footing and pursuing a kill vehicle that may not be the best solution to meet the warfighter's needs within cost, schedule, and technical constraints. In September 2009, we found that the effectiveness of AOAs for some major defense acquisition programs were limited because decision makers locked into a solution before an AOA was conducted and the results of AOAs came too late in the process.[34] However, in April 2014, the Director, MDA committed to following a knowledge-based approach to acquire the RKV, which is an encouraging sign that the agency intends to take actions to place this new investment on a sound acquisition footing.[35] Moreover, the agency has made several design decisions, but it has not

[34] GAO, *Defense Acquisitions: Many Analyses of Alternatives Have Not Provided a Robust Assessment of Weapon System Options,* GAO-09-665 (Washington, D.C.: Sep. 24, 2009).

[35] During an April 2014 Senate Armed Services Committee hearing, the Director, MDA, expressed that the agency was committed to implementing a rigorous acquisition process for the redesigned kill vehicle and would not circumvent sound acquisition practices for developing a weapon system.

yet finalized the RKV's requirements or begun development activities. Thus, a window of opportunity still exists for MDA to make the AOA a major part of the redesign effort.

MDA Provides Limited Insight Into the Overall BMDS Integrated Capability Goals

The NDAA for fiscal year 2012 requires MDA to report capability delivery goals and progress at the element level, which enables Congress to track acquisition plans and progress of individual BMDS elements, including those at high risk of cost and schedule growth. However, this law does not require MDA to externally report key aspects of integrating two or more elements and delivering integrated BMDS capabilities, which allow the BMDS to achieve performance levels not realized by individual elements working independently. For example, integrating Aegis BMD with forward-based radars through C2BMC allows it to launch the interceptor earlier, before its own radar can acquire the threat, thus defending larger areas. Table 5 includes additional examples of planned integrated capabilities. Because MDA does not systematically report this information, external decision makers have limited insight into the interdependencies between element-level development efforts and whether these efforts are on track to reach maturity needed for integration activities. Additionally, external decision makers may have limited insight as to whether MDA is on schedule to complete delivery of certain system-level capabilities or if they have been delayed.

Internally, MDA reports overall BMDS capability goals in its systems engineering documents, but according to MDA officials, these management documents are not provided to external decision makers. MDA uses these documents to describe how element upgrades are synchronized to support deliveries of system-level capabilities, including the timeframes by which they need to complete their own development in order to be available for integration and test events. MDA also uses these documents to identify when particular BMD system-level capabilities are expected to be integrated and delivered in order to improve architectures that defend the U.S. homeland and U.S. forces and allies abroad. Additionally, the system engineering documents identify test and assessment needs to confirm capability delivery goals, as well as potential challenges and risks to meeting the integrated capability delivery goals. While useful to MDA for management purposes, these documents in their entirety are too detailed for external oversight. Nonetheless, key sections of their systems engineering documents contain high-level information that would be useful to congressional decision makers, such as the schedule for delivery of BMD system-level capabilities and schedules for synchronized delivery of BMD elements to integration events that support these capabilities.

Table 5 below illustrates how reporting on MDA's progress in achieving capabilities that hinge on integration is fairly limited, particularly when compared to our analysis of MDA's systems engineering documents. While the BAR may identify a key capability as present or as part of an individual element, it does not describe when the capability will actually be achieved since that depends on a family of elements working together. The systems engineering documents also identify potential challenges to delivering system-level capabilities that the report to Congress does not. As a result, congressional decision makers do not receive key information that could aid them in oversight of MDA's development efforts.

Table 5: Comparison of Key Integration Information from Missile Defense Agency's (MDA) System Engineering and Other Internal Documents to Information Presented to Congress

Capability	Description of capability	Information presented to Congress	Key information from MDA's systems engineering and other internal documents
Aegis Ballistic Missile Defense (BMD) Launch on Remote	• This capability involves Command, Control, Battle Management and Communications (C2BMC) providing information about the paths (called tracks) of ballistic missile threats, to Aegis BMD from forward based radars. It expands the space where a system can intercept the threat and the defended area. • Involves C2BMC, Army Navy/ Transportable Radar Surveillance and Control Model - 2 (AN/TPY-2) and Aegis BMD	• Capability delivered.	• MDA is working on upgrades for 2015, in part to address issues associated with the accuracy and timeliness of data received by Aegis BMD.
Aegis BMD Engage on Remote	• This capability further expands the space where the Aegis BMD can intercept ballistic missile threats beyond Aegis BMD Launch on Remote. It allows the Aegis BMD to intercept threats that never come into the range of its own radar based on data provided by C2BMC from forward based radars. • Involves C2BMC, AN/TPY-2 and Aegis BMD	• Does not detail the versions of Aegis BMD and C2BMC necessary for this capability.	• Identifies dates when Aegis BMD and C2BMC upgrades are needed for integration in support of this capability. A recent schedule delay of C2BMC may affect its availability for these events as well as a key flight test.[a] As a result, MDA may have fewer opportunities to rectify integration and performance issues should these arise prior to the planned delivery date in 2018.

Capability	Description of capability	Information presented to Congress	Key information from MDA's systems engineering and other internal documents
Regional Debris Mitigation	• This capability allows the system to continue tracking and engage threats when they are surrounded by a large number of objects, or debris. • Involves C2BMC, AN/TPY-2, Aegis BMD and Terminal High Altitude Area Defense (THAAD)	• Capability is noted as part of Aegis BMD, THAAD and AN/TPY-2 programs, but not C2BMC. • Does not present the planned timeframes for delivery of integrated capability upgrades. • Does not present the extent to which development efforts at element level are synchronized to support the delivery.	• Includes C2BMC as part of system-level capability upgrades. • Upgrade initially planned for 2014 has been delayed to 2015 through 2017. • Provides delivery dates for element-level upgrades needed to complete the capability delivery.
Discrimination Improvements to Homeland Defense	• Discrimination Improvements to Homeland Defense (DIHD), is designed to improve discrimination, as well as the reliability and effectiveness of engaging threats across the entire Homeland Defense architecture, and as a result decrease the number of interceptors that the warfighter needs to fire at each threat. • Involves C2BMC, Ground-based Midcourse Defense (GMD), AN/TPY-2, and Sea-based X-band Radar (SBX).	• Capability noted for AN/TPY-2, but not GMD, C2BMC, and SBX. • Does not present the planned timeframes for delivery of integrated capability upgrades. • Extent of needed element synchronization not presented.	• Includes C2BMC, GMD, and SBX as part of system-level capability upgrades. • Includes initial system-level delivery planned for fiscal year 2016 with upgrades to follow in fiscal year 2019. • MDA's plans for delivering this capability may need to be changed to allow some of the constituent element-level capabilities to mature.[b]

Source: GAO analysis of MDA documentation. | GAO-15-345

[a] Aegis BMD Engage on Remote is still expected to support the declaration of EPAA Phase 3 in December 2018.

[b] While the MDA's internal management documentation indicates that there are challenges and potential risks to delivering some capabilities in the table, MDA officials told us that these capabilities are currently on time.

Conclusions

As with previous years, MDA had mixed progress in achieving its testing and delivery goals for 2014. MDA conducted two intercept and three non-intercept flight tests that demonstrated an increased capability for Aegis BMD and the GMD program. Moreover, several programs, such as the Aegis BMD SM-3 Block IIA and the Targets and Countermeasures program, took steps to reduce acquisition risk. At the same time, however, MDA is still allowing production to get ahead of testing (concurrency)—a practice which has consistently led to cost and schedule growth as well as performance problems in the past. For the Aegis BMD SM-3 Block IB, MDA will have a full rate production decision in fiscal year 2015 and plans to enter into a multiyear procurement

contract in the following year. If it does not conduct a flight test of the redesigned components of its third-stage rocket motor before entering into full production, the Aegis BMD program is at risk for potential cost growth and schedule delays, affecting its planned interceptor production. A flight test serves as an opportunity to increase the confidence that the redesigned component works as intended and determine if any additional changes are necessary. For GMD, the program planned to start production of CE-II Block I interceptors for operational use almost two years before it conducts an intercept flight test in the fourth quarter of fiscal year 2016. In this case, recent development challenges have delayed design reviews, providing the program with additional time to assess the merits of conducting the demonstration flight test ahead of starting CE-II Block I production.

In addition, because the agency started the RKV program in the fall of 2013 rather than await the results of an ongoing AOA for homeland missile defense, congressional and DOD decision makers may not have the insight necessary to discern whether MDA's approach is the most promising, cost-effective solution to pursue. Though design decisions have been made, development activities have yet to begin, so there is still an opportunity for the Director, MDA to follow through on his commitment to follow a rigorous systems engineering approach to conduct the redesign effort.

Lastly, although MDA has increased its focus on BMDS integration and delivering integrated system-level capabilities, it does not provide a systematic view of its plans and progress for delivering these capabilities to external decision makers. While the agency is currently not required to externally report key aspects of integration, insight into the interdependencies between element-level development efforts and whether these efforts are on track to reach maturity needed for integration activities is necessary to understand MDA's progress, as many of the capabilities envisioned for EPAA and other regional deployments hinge on successful integration.

Recommendations for Executive Action

We recommend that the Secretary of Defense take the following three actions to strengthen MDA's acquisition efforts and help support oversight.

1. To ensure that future efforts are aligned with a sound acquisition approach, which includes robust systems engineering and testing, we recommend that the Secretary of Defense direct the following two actions:

a) For Aegis BMD SM-3, DOD conduct a flight test to increase confidence that the redesigned SM-3 Block IB third-stage rocket motor component works as intended prior to inserting it into the SM-3 Block IB production line.
b) For GMD, delay production of CE-II Block I interceptors intended for operational use until the program has successfully conducted an intercept flight test with the CE-II Block I interceptor.

2. To ensure MDA makes sound investment decisions on improving homeland ballistic missile defense, the Secretary of Defense should direct MDA to make the department's analysis of alternatives an integral part of its planning effort and delay any decisions to begin development of the new GMD Redesigned Kill Vehicle until:

   a) the department's analysis of alternatives is completed and identifies the best solution to pursue; and
   b) Congressional and DOD decision makers have been provided the results of that analysis.

3. Drawing from information it already has, the Secretary of Defense should direct MDA to report annually to Congress its plans for, and achieved progress in developing and delivering integrated BMDS-level capabilities. This reporting should include:

   a) planned integrated BMDS-level capabilities, including dates for when capability is planned for delivery; and
   b) element-level upgrades needed for delivery of the integrated BMDS capability, including dates that these upgrades need to be available for integration into the BMDS capability.

Agency Comments and Our Evaluation

DOD provided written comments on a draft of this report. These comments are reprinted in Appendix I. DOD also provided technical comments, which were incorporated as appropriate.

In responding to a draft of this report, DOD partially concurred with our first two recommendations regarding Aegis SM-3 Block IB and GMD and concurred with our third recommendation to report to Congress its annual progress towards planned integrated BMDS-level capabilities.

DOD concurred with the first part of our recommendation to conduct an Aegis SM-3 Block IB flight test prior to inserting a redesigned third-stage rocket motor component into the interceptor's production line. However, the department partially concurred with the second part of this recommendation to delay production of the CE-II Block I interceptors until the program has conducted a successful intercept attempt with this new

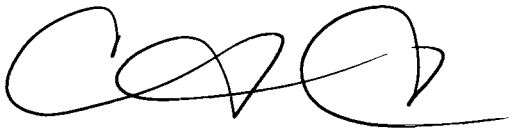
interceptor version. In its comments, DOD stated it will delay emplacement of CE-II Block I interceptors until the program has successfully conducted an intercept flight test with the CE-II Block I, but will continue production and final integration of interceptors. DOD also stated that delaying interceptor production and integration until the flight test is conducted would unacceptably increase the risk to reaching the Secretary of Defense mandate to achieve 44 emplaced interceptors by the end of 2017. Based on our past work examining weapon system acquisition and best practices, we found that successful programs follow a knowledge-based acquisition approach and achieve an appropriate balance between schedule and risk that does not include an undue amount of concurrency. However, MDA's current approach for acquiring the CE-II Block I embraces a proven risk of undue concurrency because any issues uncovered during the intercept test could significantly affect the program. As we found in this report, such an approach has proven very costly for MDA. Because the agency moved forward with CE-II production prior to completing flight testing, test failures exacerbated the disruptions to the program and increased the CE-II's cost by $1.745 billion. We maintain our position that MDA should take the recommended action to delay production of CE-II Block I interceptors intended for operational use until the program has conducted a successful intercept flight test with the CE-II Block I in an effort to align its efforts with a sound acquisition approach.

DOD partially concurred with our recommendation to delay any decision to begin development of the RKV until: 1) the department's AOA for improving homeland ballistic missile defense is completed and identifies the best solution to pursue; and 2) congressional and DOD decision makers have been provided the results of that analysis. In its response, DOD stated that interim results from the AOA have been used to inform planning decisions and that the results of the final analysis of alternatives will be provided to Congressional and DOD leadership. The department also noted that that an AOA does not make a "best solution" determination but rather provides an objective comparison of alternatives that allows the leadership to make the determination of what path the department should take. We agree that there is generally no requirement for an AOA to identify a single solution. However, the goal of an AOA is to identify the most promising options for decision makers to consider rather than simply providing a comparison of alternatives that does not clearly indicate the most promising solutions, whether it be one or multiple options. DOD declined to commit to delaying any decision to begin developing the RKV and stated its investment decisions will be sound because interim results from the ongoing AOA have been used to inform

early planning decisions, including an acquisition strategy framework for the RKV. While we recognize in this report that DOD's decision to redesign the GMD kill vehicle may be justifiable, by starting RKV development in advance of the AOA's completion, DOD runs the risk of locking into a solution that may not be the most promising and cost effective option to pursue. In addition, MDA has previously attempted to start new major efforts that were not informed by AOAs which DOD later cancelled because of the programs' high-risk acquisition strategies and technical challenges. As such, we maintain that MDA should delay any decision to begin RKV development until an AOA that identifies the most promising solution(s) to pursue to improve homeland ballistic missile defense is completed and the results of which have been provided to congressional and DOD decision makers.

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

If you or your staff have any questions about this report, please contact me at (202) 512-4841 or 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,
Acquisition and Sourcing Management

List of Committees

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

The Honorable Thad Cochran
Chairman
The Honorable Richard J. Durbin
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

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

The Honorable Rodney Frelinghuysen
Chairman
The Honorable Pete Visclosky
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Comments from the Department of Defense

ASSISTANT SECRETARY OF DEFENSE
3600 DEFENSE PENTAGON
WASHINGTON, DC 20301-3600

ACQUISITION

APR 22 2015

Ms. Christina Chaplain
Director, Acquisition and Sourcing Management
U.S. Government Accountability Office
441 G Street, N.W.
Washington, DC 20548

Dear Ms. Chaplain:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-15-345, "Missile Defense: Opportunities Exist to Reduce Acquisition Risk and Improve Reporting on System Capabilities," dated March 4, 2015 (GAO Code 121212). Detailed comments on the report recommendations are enclosed.

Sincerely,

Katharina McFarland

Enclosures:
As stated

DOD's enclosure to this letter is marked FOR OFFICIAL USE ONLY (FOUO) on the bottom of each page in reference to a table that contains Sensitive Information. GAO is not including this table as part of this appendix, but per DOD's explanatory note on the enclosure, is striking through the FOUO markings.

GAO DRAFT REPORT DATED MARCH 4, 2015
GAO-15-345 (GAO CODE 121212)

"MISSILE DEFENSE: OPPORTUNITIES EXIST TO REDUCE ACQUISITION RISK AND IMPROVE REPORTING ON SYSTEM CAPABILITIES"

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATIONS

Recommendation 1a:
To ensure that future efforts are aligned with a sound acquisition approach, which includes robust systems engineering and testing, the GAO recommends that the Secretary of Defense direct the following actions:

- For Aegis SM-3, DOD conduct a flight test to increase confidence that the redesigned SM-3 Block IB third-stage rocket motor component works as intended prior to inserting it into the SM-3 Block IB production line.

MDA Response to Recommendation 1a: CONCUR.
The DoD will conduct a ground testing qualification program across all operational environments including post-test hardware inspection for the third stage rocket motor nozzle design enhancement. To obtain additional confidence in the SM-3 BLK IB design update, the DoD will conduct a flight test prior to incorporating the design enhancement into the SM-3 Block IB production line.

Recommendation 1b:
To ensure that future efforts are aligned with a sound acquisition approach, which includes robust systems engineering and testing, the GAO recommends that the Secretary of Defense direct the following actions:

- For GMD, delay production of CE-II Block I interceptors intended for operational use until the program has successfully conducted an intercept flight test with the CE-II Block I interceptor.

**The attached table "Progress on Integrated System Capability" contains information that may be exempt from mandatory disclosure under the Freedom of Information Act. This MDA Response to GAO Recommendations document is Unclassified and should have the For Official Use Only page marking struck through when separated from the attachment.

~~**FOR OFFICIAL USE ONLY ATTACHMENT**~~

DOD's enclosure to this letter is marked FOR OFFICIAL USE ONLY (FOUO) on the bottom of each page in reference to a table that contains Sensitive Information. GAO is not including this table as part of this appendix, but per DOD's explanatory note on the enclosure, is striking through the FOUO markings.

MDA Response to Recommendation 1b: PARTIALLY CONCUR.
To ensure a sound acquisition approach, the DoD will delay emplacement of CE-II Block I interceptors intended for operational use until the program has successfully conducted an intercept flight test with the CE-II Block I interceptor. The intercept flight test for the CE-II Block I interceptor will be the third in a progressive series of flight tests. First, the CE-II Block I cradled inertial measurement unit (IMU) with version 10 firmware (CV10) was successfully tested during intercept flight test FTG-06b in June 2014. Second, a non-intercept flight test in early FY 2016, CTV-02+, will test the CV10 IMU and the new alternate divert thruster (ADT). And third, the intercept flight test in early FY 2017, FTG-15, will test the CE-II Block I kill vehicle (CV10 IMU, ADT, new Divert Attitude Control System tanks, and electrical improvements) and the upgraded Configuration 2 integrated boost vehicle with consolidated booster avionics upgrade. Allowing interceptor integration before flight test incurs a minimum amount of concurrency, with two inceptors scheduled to complete integration before completion of the intercept flight test. Delaying this integration would unacceptably increase the risk to reaching the Secretary of Defense mandate to achieve 44 emplaced interceptors by the end of CY 2017 to continue to defend the homeland against the threat of limited ballistic missile attack.

Recommendation 2a:
To ensure MDA makes sound investment decisions on improving homeland ballistic missile defense, the GAO recommends that MDA should make the department's analysis of alternatives an integral part of its planning effort and delay any decisions to begin development of the new GMD Redesigned Kill Vehicle until:

- The department's analysis of alternatives is completed and identifies the best solution to pursue; and

MDA Response to Recommendation 2a: PARTIALLY CONCUR.
Investment decisions will be sound. Interim results from the Homeland Defense Analysis of Alternatives (AoA) have been used to inform decisions regarding the early planning for the GMD Redesigned Kill Vehicle (RKV). The final results of the AoA are expected to be available in 3QFY15 and any changes from the interim results will be incorporated into the GMD (RKV) acquisition strategy prior to beginning development of the (RKV). The AoA does not make a "best solution" determination; it only provides an objective comparison of alternatives that allows the leadership to make the determination of what path the Department should take.

Recommendation 2b:
To ensure MDA makes sound investment decisions on improving homeland ballistic missile defense, the GAO recommends that MDA should make the department's analysis of alternatives an integral part of its planning effort and delay any decisions to begin development of the new GMD Redesigned Kill Vehicle until:

- Congressional and DOD decision makers have been provided the results of that analysis.

**The attached table "Progress on Integrated System Capability" contains information that may be exempt from mandatory disclosure under the Freedom of Information Act. This MDA Response to GAO Recommendations document is Unclassified and should have the For Official Use Only page marking struck through when separated from the attachment.

~~**FOR OFFICIAL USE ONLY ATTACHMENT**~~

DOD's enclosure to this letter is marked FOR OFFICIAL USE ONLY (FOUO) on the bottom of each page in reference to a table that contains Sensitive Information. GAO is not including this table as part of this appendix, but per DOD's explanatory note on the enclosure, is striking through the FOUO markings.

MDA Response to Recommendation 2b: PARTIALLY CONCUR.
The Department's Homeland Defense Analysis of Alternatives (AoA) will be an integral part of the planning effort; the results of the final analysis of alternatives will be provided to Congressional and DoD leadership. In the interim, MDA has kept DoD and Congressional decision makers informed of initial planning for the GMD Redesigned Kill Vehicle (RKV). Additionally, USD (AT&L) approved the acquisition strategy framework for the GMD RKV in December 2014.

Recommendation 3a: Drawing from information it already has, the GAO recommends the Secretary of Defense direct the MDA to report annually to Congress its plans for, and achieved progress, in developing and delivering integrated BMDS-level capabilities. This reporting should include:

- Planned integrated BMDS-level capabilities, including dates for when capability is planned for delivery; and

MDA Response to Recommendation 3a: CONCUR.
MDA will provide Congress a table summarizing the development and delivery of integrated BMDS capabilities annually, beginning in the 2016 BMDS Accountability Report (BAR). This information will include element-level program delivery dates. In the interim, MDA will provide this information as an addendum to the 2015 BAR. (See attachment)

Recommendation 3b:
Drawing from information it already has, the GAO recommends that the Secretary of Defense direct the MDA to report annually to Congress its plans for, and achieved progress, in developing and delivering integrated BMDS-level capabilities. This reporting should include:

- Element-level upgrades needed for delivery of the integrated BMDS capability, including dates that these upgrades need to be available for integration into the BMDS capability.

MDA Response to Recommendation 3b: CONCUR.
MDA will provide Congress a table summarizing the development and delivery of integrated BMDS capabilities, annually beginning in the 2016 BAR. This information will include element-level program delivery dates. In the interim, MDA will provide this information as an addendum to the 2015 BAR. (See attachment)

**The attached table "Progress on Integrated System Capability" contains information that may be exempt from mandatory disclosure under the Freedom of Information Act. This MDA Response to GAO Recommendations document is Unclassified and should have the For Official Use Only page marking struck through when separated from the attachment.

~~**FOR OFFICIAL USE ONLY ATTACHMENT**~~

Appendix II: Aegis Ballistic Missile Defense (BMD)

Key Findings for Fiscal Year 2014

- Some Aegis BMD Weapon System capabilities planned for the 2015 timeframe are at risk of delays and performance shortfalls due to technical challenges.
- Aegis BMD Weapon System planned for 2018 is on track but changes to the test program delay the assessment of key capability.
- MDA revised its Aegis BMD baselines, limiting transparency by reducing insight into developmental activities.

Program Overview

Aegis Ballistic Missile Defense (BMD) is the naval component of the Missile Defense Agency's (MDA) Ballistic Missile Defense System (BMDS). It consists of the Aegis BMD Weapon System (AWS), including 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) to regional BMD, including the PAA in Europe (EPAA), in 2015 and 2018 timeframes.[1] For specifics on the Aegis SM-3 interceptors, see appendixes IV and V.

MDA delivered the first AWS spiral for PAA Phase 2, called AWS 4.0.2 in December 2012. However, additional spirals are being developed to ensure that MDA can meet PAA and EPAA Phase 2 goals. One of the spirals, AWS 5.0 Capability Upgrade (CU), expands the battle-space and raid size capability and improves performance against medium and intermediate range threats.[2] It also expands capability to intercept threats in the terminal phase and allows for Integrated Air and Missile Defense (IAMD) where ballistic missiles and air threats (i.e. cruise missiles) can be engaged at the same time. Additionally, AWS version 4.1 is planned to provide similar BMD capabilities as Aegis BMD 5.0CU.

MDA is developing AWS 5.1 to support PAA, including EPAA, Phase 3 in 2018. It is planned to further expand performance of AWS 5.0CU against longer range threats and intercepts of threats in terminal phase. Its key

[1] MDA uses the construct of PAA to manage the development and delivery of regional BMD capabilities. European PAA (EPAA) is a subset of PAA capabilities which are specifically developed for use in Europe.

[2] According to MDA officials, battle-space comprises the area where the system can engage the interceptor, while raid size capability is the number of missiles the system can engage at once.

capability–Engage on Remote —also allows the system to execute intercepts based on tracking information about the location of threats from remote sensors without the need for the Aegis radar to ever acquire them. MDA is developing this spiral in two phases: 1) provides initial capabilities and integrates the weapon system with SM-3 Block IIA, and 2) delivers remaining capabilities including Engage On Remote needed for EPAA.

Table 6: Aegis Ballistic Missile Defense Weapon System (AWS) Facts

Key upcoming events		
Fiscal year 2015		
Fourth quarter	Flight Test Operational (FTO)-02 Event 2—assessment of Aegis Ballistic Missile Defense (BMD) to intercept a medium- range ballistic missile MRBM) in an operational scenario involving other interceptor systems	
	AWS 5.0 Capability Upgrade (CU) certification	
Fiscal year 2016		
Second quarter	AWS 4.1 certification	
Fiscal year 2018		
First quarter	Flight Test Standard Missile (FTM)-29—first intercept based on tracking by remote sensor	
Third quarter	FTO-03 Event 1—assessment of AWS 5.1 intercept of an intermediate-range ballistic missile (IRBM) in an operational scenario involving other interceptor systems	
Major assets delivered		
Three 4.0 ships for a total of eight		
Two 5.0/5.0CU ships		
Flight test performance		
Test name	**Test date**	**Test result**
FTM-15	Apr. 2011	Success
FTM-16 Event 2	Sep. 2011	Failed intercept
FTM-16 Event 2a	May 2012	Success
FTM-18	June 2012	Success
FTM-20	Feb. 2013	Success
FTM-19	May 2013	Success
FTM-21	Sep. 2013	Target intercepted, but had second interceptor failure
FTM-22	Oct. 2013	Success
FTM-25	Nov. 2014	Success

Source: GAO analysis of Missile Defense Agency data. | GAO-15-345

Some AWS capabilities planned for the 2015 timeframe are at risk of delays and performance shortfalls, due to technical challenges

MDA documents indicate that the AWS planned for deployment in support of Phase 2 of the PAA is at risk of schedule delays or performance shortfalls due to technical challenges. While MDA delivered initial Aegis BMD capabilities for PAA Phase 2 with AWS 4.0.2, its documents indicate that ship- based capabilities needed to meet certain PAA Phase 2 goals will not be available until the subsequent versions—AWS 4.1 and 5.0CU—are deployed.[3] However, the certification of AWS 4.1 has been delayed from the end of 2015 to the second quarter of fiscal year 2016, after EPAA Phase 2 is declared. Although MDA accelerated its AWS 4.1 schedule in 2014, including the certification date, by about three months, the new plan could present a challenge by compressing its test schedule. Additionally, both AWS 4.1 and 5.0CU may be certified for deployment before they complete planned development and testing. Specifically, both versions have technical challenges that may further delay the delivery of some capabilities or require fixes after delivery. Although AWS 5.0CU and 4.1 are planned to be certified in the fourth quarter of fiscal year 2015 and second quarter of fiscal year 2016 respectively, both may not complete development and be fully integrated into the BMDS architectures until 2017.

Technical challenges for AWS 4.1 may reduce their capability or further delay their delivery. For example, MDA's analysis indicates that AWS 4.1 raid size handling capabilities do not meet the planned requirement. To mitigate this issue, the program initially considered making modifications to the system. However, Aegis BMD program management officials told us that they rejected this option due to the expected cost and decided to instead lower the requirement. Additionally, capability for intercepting missiles in terminal phase of flight—designed to allow Aegis BMD ships to protect nearby ships from ballistic missiles—is also at risk because of technical challenges and may require an alternate design that could lead to cost growth and schedule delays. Moreover, flight testing of this capability is currently being considered to be conducted three months after AWS 4.1 certification for operations, placing the program at additional risk should issues be discovered during flight testing.

The delivery of AWS 5.0CU is expected to meet its 2015 delivery date, but current plans indicate that its enhanced capability to intercept ballistic

[3] MDA is developing AWS 4.1 specifically to meet coverage needs for European PAA Phase 2 because initial deployments of AWS 5.0CU are planned to support other regional BMD missions.

missiles in the terminal phase of flight will be flight tested after delivery. Currently, the flight test is planned for the first quarter of fiscal year 2017—more than one year after delivery—placing the program at additional risk should issues be discovered during flight testing. The program also continues to discover software defects faster than it can rectify them, while also working on mitigating performance limitations from previous versions that remain applicable. The program made progress in rectifying prior shortfalls and has identified high priority fixes that are still required. While the program plans to fix the key defects prior to delivery, some modifications will have to be made after it is deployed.

AWS planned for 2018 is on track but changes to the test program delay the assessment of key capability

In January 2014, the program reviewed the designs of both development phases for AWS 5.1. For the first phase, which is designed to integrate the SM-3 Block IIA with the weapon system and deliver other initial AWS 5.1 capabilities, the program demonstrated requisite maturity to proceed to the next stage of development. For the second phase, which builds on the first and is planned to complete AWS 5.1 capabilities, including Engage On Remote, the program met review goals by demonstrating that requirements needed to proceed with development have been well defined. Despite the progress, however, the assessment of the Engage On Remote capability has been delayed and may be at risk. This is a key capability for PAA Phase 3 (including for EPAA), which is designed to mitigate limitations posed by the range of the Aegis radar. The capability allows the ship to execute intercepts based on tracks from certain forward based radars before the threat comes close enough for the Aegis radar to track it. As a result, it expands the space in which the ship can intercept the threat and allows for greater defended area. The full delivery and integration of this capability into the BMDS depends on Aegis BMD, as well as C2BMC and certain sensors. While the required AWS is currently projected to meet the date for a flight test scheduled to assess this capability, C2BMC will not. Rather than delaying the test, MDA will assess only part of the capability in the first quarter of fiscal year 2018, by substituting key aspects with another Aegis ship to directly provide tracks to the shooter. It is currently unclear, whether MDA will introduce another test to assess the full remote engagement capability or add a requirement to two subsequent operational flight tests, which are designed to assess the BMD system-level performance of Phase 3 architectures. If MDA chooses the latter, it will take on additional risk by adding another system-level test objective to already complex flight test designs. For specifics on the C2BMC element, see appendix VI.

MDA Revised its Aegis BMD Baselines, Limiting Some Transparency by Reducing Insights into Developmental Activities

In fiscal year 2014, MDA changed its approach to managing the development of the AWS, combining all spirals into a single baseline, limiting some visibility into its progress for this year. MDA uses baselines to monitor the progress of its programs and report them to Congress annually in the BMDS Accountability Report. Previously, AWS spirals were included with associated interceptors, aligned to EPAA phases. In June 2014, MDA combined AWS 5.0CU, AWS 4.1 and AWS 5.1 into a single baseline, managed by a single program manager. According to Aegis BMD program management officials the reorganization was expected to allow the program to realize efficiencies in managing the development of the AWS spirals, because of the interdependency between the spiral development efforts.[4] However, officials also told us that there are no tangible savings that have been realized as a result of the reorganization. Moreover, in order for baselines to be useful for managing and overseeing a program, they need to be stable over time so progress can be measured and so that decision makers can determine how best to allocate limited resources.[5] In April 2013, we found that activities from one Aegis BMD baseline were reallocated and combined with activities in other baselines which limited our ability of assess them. [6] Similarly, the proposed baseline for fiscal year 2015 reconfigures the way some content is presented, making comparison with 2014 baselines difficult or impossible.

[4] For example, development of AWS 4.1 depends on AWS 5.0CU efforts. Specifically, software upgrades developed as part of the AWS 5.0CU are then incorporated onto ships with AWS 4.0.2 hardware, in order to meet the coverage needs for EPAA Phase 2. AWS 5.1 builds on capabilities of AWS 5.0CU.

[5] GAO, *GAO Cost Estimating and Assessment Guide*, GAO-09-3SP (Washington, D.C.: Mar. 2009).

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

Appendix III: Aegis Ashore

Key Findings for Fiscal Year 2014

- Aegis Ashore's first non-intercept flight test met its objectives.
- MDA plans one intercept flight test to assess the Romanian capability and one to assess the capability in Poland.
- Schedule delays and changed testing requirements compress the time for assessment of Aegis Ashore performance with other systems.
- Aegis Ashore made progress addressing challenges related to radio-frequency spectrum but some challenges remain.

Program Overview

Aegis Ashore is planned to be a land-based, or ashore, version of the ship-based Aegis BMD. Aegis Ashore is to track and intercept ballistic missiles in the middle of their flight using Standard Missile-3 (SM-3) interceptors. Key components include a vertical launching system with SM-3 interceptors and an enclosure, referred to as 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 BMD weapon system that are still in development. Missile Defense Agency (MDA) plans to equip Aegis Ashore with a modified version of the Aegis BMD weapon system software that will share many components with the sea-based Aegis BMD. A total of three Aegis Ashore facilities are planned: one test facility in Hawaii, an operational facility in Romania in 2015, and another operational facility in Poland in 2018 to support European Phased Adaptive Approach (EPAA).

DOD deployed the test facility in April 2014. It was used for the first Aegis Ashore flight test in May 2014, and will be used to flight test Aegis Ashore capabilities as upgrades become available.

DOD plans to deploy Aegis Ashore in Romania with the Aegis BMD Weapon System (AWS) 5.0CU and SM-3 Block IB in the 2015 time frame. The program received all fabricated components at the site and is currently installing the facility. It plans to complete testing of this facility by the end of 2015.

DOD plans to deploy the second operational facility in the 2018 time frame in Poland, equipping it and upgrading the facility in Romania with the AWS 5.1 and SM-3 Block IIA. It plans to begin site preparations in and begin fabrication in the middle of fiscal year 2016.

Table 7: Aegis Ashore Program Facts

Key upcoming events		
Fiscal year 2015		
Third quarter	Flight Test Operational (FTO)-02 Event 1 intercept of an intermediate-range ballistic missile (IRBM) by Aegis Ashore in Aegis BMD Weapon System (AWS) 5.0 Capability Upgrade (CU) configuration during a system-level operational flight test	
Fiscal year 2016		
First quarter	Delivery of Aegis Ashore capability in Romania	
Fiscal year 2018		
Third quarter	FTO-03 Event 1 intercept of IRBM by Aegis Ashore in AWS 5.1 configuration during a system- level operational flight test	
Fiscal year 2019		
First quarter	Delivery of Aegis Ashore capability in Poland	
Major assets delivered		
Test facility in Hawaii delivered in April 2014		
Flight test performance		
Test name	**Test date**	**Test result**
AACTV-01	May 2014	All test objectives achieved

Source: GAO analysis of Missile Defense Agency data. | GAO-15-345

Aegis Ashore's first non-intercept flight test met its objectives

MDA successfully conducted the first flight test involving components of the Aegis Ashore system at the Aegis Ashore Missile Defense Test Complex in May 2014. During the test, a simulated ballistic missile target was acquired, and tracked. This flight test supports development of the Aegis Ashore capability of Phase 2 of EPAA, planned to begin operations in Romania in 2015. During the test, the Aegis BMD Weapon System fired an SM-3 Block IB interceptor from the Vertical Launch System. Several functions were exercised during the test, but the primary purpose of the test, designated as Aegis Ashore Controlled Test Vehicle (AA CTV)-01, was to confirm the functionality of Aegis Ashore by launching a land-based SM-3. The test met its objectives but also revealed a problem. Specifically, there was an issue with how the system steered the interceptor, that potentially resulted from differences between the sea-based and ashore versions of the system. Program management officials said this problem has been corrected and the correction will be installed in the AWS software before the next flight test occurs.

MDA plans one intercept flight test to assess the Romanian capability and one to assess the capability in Poland

Aegis Ashore is scheduled to participate in only two intercept flight tests–one to assess its Romanian capability and the other to assess the capability for Poland. These capabilities will be delivered to the warfighter in 2015 and 2018 for EPAA Phase 2 and Phase 3, respectively. Since 2010, the program has reduced its test plan from seven flight tests to only three, two of which involve intercepts. Both of these intercept tests–FTO-02 E1 scheduled for the third quarter fiscal year 2015 and FTO-03 E1 scheduled for the third quarter of fiscal year 2018—are system-level operational flight tests designed to assess the integrated capability of BMD systems for the upcoming EPAA phase. According to program officials, the risk to understanding performance and limitations is small because the AWS slated for Aegis Ashore will be flight tested more extensively on ships. However, the conditions on land are different than at sea and require modifications to adapt the weapon system for operations on land. While leveraging ship-based flight tests to assess some Aegis Ashore capabilities saves testing costs, the non-intercept Aegis Ashore flight test held in May 2014 demonstrated that adaptations made for land-based operations may have unforeseen performance implications. Flight testing Aegis Ashore intercept capability just once prior to delivery may result in schedule delays, cost growth or performance shortfalls, should issues be discovered during flight testing.

Schedule delays and changed testing requirements compress the time for assessment of Aegis Ashore performance with other systems

Delays in construction at the Romanian operational site and changes to test requirements delay system-level simulated demonstration of new capabilities to just before Aegis Ashore delivery and limits time to rectify issues, should they be discovered during testing. This test is designed to assess the interoperability of the operational Aegis Ashore in Romania with other systems slated for Europe.[1] According to the program, the changes to test requirements were driven by independent testing officials. Previously, all Aegis Ashore tests were going to employ the test asset, which is deployed at the Pacific missile range site in Hawaii. However, MDA made the change to ensure that the operational Aegis Ashore is tested along with the other operational systems deployed in Europe. This test was delayed by about six months, and it is now scheduled to conclude just prior to the delivery of Aegis Ashore in 2015 which limits time for assessment and to rectify issues prior to delivery of the capability.

[1] In addition to flight tests, MDA also plans to assess Aegis Ashore in ground tests. These tests focus on assessing interoperability between a number of systems and simulate intercepts.

Aegis Ashore made progress addressing challenges related to radio-frequency spectrum but some challenges remain

The Aegis Ashore program identified potential workarounds to issues associated with operating the Aegis Ashore radar in the presence of European telecommunication infrastructure, but there could be additional challenges. Radio-frequency is a set of waves that is used to operate the SPY-1 radar used by Aegis BMD, as well as provide an array of wireless communication services to the civilian community, such as mobile voice and data services, radio and television broadcasting, and satellite-based services. While only a part of spectrum needed for radar operations is also used by Romanian telecommunications, the overlap presents challenges with the use of the radar. In March 2011, April 2012, and April 2013 we highlighted issues that Aegis Ashore faces related to radio-frequency spectrum, including: (1) the possibility that the SPY-1 radar might interfere with host nation wireless usage; and (2) the program and the relevant host nation authorities must work together to ensure that host nations approve use of the operating frequency needed for the SPY-1 radar.[2]

In March 2014, the Romanian National Allied Radio Frequency Agency granted DOD access to the entire spectrum needed for radar operations, but with limitations. These peacetime limitations include the direction the radar may be radiated as well as times of day. According to the program, MDA has means to coordinate for additional radar operations if required, but the current access should be sufficient to maintain radar reliability. However, there could still be risk to some of the communications infrastructure. The program completed a study that included recommendations that could mitigate some of these effects, by modifying Romanian civilian equipment that could be exposed to the periodic radar radiation.

Throughout fiscal year 2014 the program also began negotiations with Poland to secure the use of the Aegis Ashore radar across its entire operating spectrum at that site by 2018. If mitigating procedures work within Romania, DOD expects them to work in Poland. However, anticipated interference during operations is still unknown. Poland has a much more congested spectrum space than Romania, and according to officials from European Command, could experience greater

[2] GAO, *Missile Defense: Actions Needed to Improve Transparency and Accountability*, GAO-11-372 (Washington, DC.: Mar. 24, 2011); *Missile Defense: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency*, GAO-12-486 (Washington, DC.: Apr. 20, 2012); *Missile Defense: Opportunity to Refocus on Strengthening Acquisition Management*, GAO-13-432 (Washington, D.C.: Apr. 26, 2013).

unanticipated interference problems. Additionally, various objects that are found on land and not at sea could interfere with the radar. For example, wind farms, which are located near the proposed site, may interfere with radar operations in some instances. According to program management officials, this is not expected to be a significant issue because of where potential threats would be coming from and the reliance of Aegis Ashore on forward based radars for early acquisition of incoming threats.

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

Key Findings for Fiscal Year 2014

- The Aegis BMD program conducted a successful intercept test with the SM-3 Block IB interceptor— FTM-22— on October 4, 2013, which is a key test for a full rate production decision.
- The SM-3 Block IB interceptor may not be flight tested again with the third-stage rocket motor (TSRM) component redesign which increases production acquisition risk.
- The program plans for a multiyear procurement strategy in fiscal year 2016.

Program Overview

The Standard Missile-3 (SM-3) Block IB is a ship-and shore based missile defense system 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. The SM-3 Block IB features an enhanced target seeker capability for increased discrimination, an advanced signal processor for engagement coordination, 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) Weapon System 4.0.2, Aegis BMD 5.0 Capability Upgrade and Aegis Ashore. For additional information about the Aegis BMD Weapon Systems see appendix II and for Aegis Ashore, see appendix III.

The SM-3 Block IB program largely overcame previous development challenges and successfully intercepted all targets in three flight tests. We previously reported that its production line was repeatedly disrupted since 2011 due to flight test anomalies and that MDA had rectified many of those issues identified since then.

However, as we reported last year, the final report for the investigation regarding a second interceptor failure test that occurred in September 2013 was expected to be completed in December 2014, but according to officials, the report is further delayed.[1] MDA is also preparing to award a production contract in fiscal year 2015.

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

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

Key upcoming events		
Fiscal year 2015		
Second quarter	The program intends to enter into full rate production of the SM-3 Block IB interceptors	
	The program will select the final redesign plans for the third-stage rocket motor	
Second to fourth quarters	Two operational test events scheduled	
Third quarter	Planned production contract award	
Fiscal year 2016		
First quarter	One intercept flight test scheduled	
Major assets delivered		
Fiscal year 2014 deliveries		
Delivered 25 SM-3 IB interceptors		
Total delivered		
39 interceptors delivered to date		
Flight test performance		
Test name	**Test date**	**Test result**
FTM-16E2	Sep. 2011	Failed intercept
FTM-16E2a	May 2012	Target intercepted
FTM-18	June 2012	Target intercepted
FTM-19	May 2013	Target intercepted
FTM-21	Sep. 2013	Target intercepted, but had second interceptor failure
FTM-22	Oct. 2013	Target intercepted
FTM-16E2	Sep. 2011	Failed intercept
FTM-16E2a	May 2012	Target intercepted
FTM-18	June 2012	Target intercepted

Source: GAO analysis of Missile Defense Agency data. | GAO-15-345

The Aegis BMD program conducted a successful intercept test with the SM-3 Block IB interceptor—FTM-22—on October 4, 2013, which is a key test for full rate production decision

On October 4, 2013, MDA conducted a successful operational flight test of the Aegis BMD system. The test resulted in the lethal intercept of a medium-range ballistic missile target in an operationally representative threat environment. The test, designated FTM-22, met its primary objective, which was to intercept a medium- range ballistic missile target. This test exercised the latest version of the second-generation Aegis BMD Weapon System, capable of engaging longer range and more sophisticated ballistic missiles.

FTM-22 was the last required test conducted for a full production decision—the last key production authorization by the Under Secretary of Defense, Acquisition, Technology, and Logistics that would allow MDA to produce the remaining 366 of the 405 total interceptors. With the successful results of FTM-22, MDA anticipates receiving approval for full rate production of SM-3 Block IB from Under Secretary of Defense, Acquisitions, Technology, and Logistics in fiscal year 2015.

The SM-3 Block IB interceptor may not be flight tested again with the third-stage rocket motor (TSRM) component redesign which increases production acquisition risk

Concurrently with initiating full rate production, the Aegis program office, along with the contractor, is working on a redesign of the third-stage rocket motor (TSRM) components. The TSRM is used to lift the interceptor out of the atmosphere and direct the warhead to the target. This component contributed to test failures. Specifically, although the failure investigation is ongoing, preliminary results indicate that the second interceptor failure from flight test FTM-21 occurred in the TSRM. This failure is also related to the one that occurred in September 2011 flight test FTM-16E2. Consequently, although design changes are considered necessary, MDA does not plan to demonstrate the redesign works as intended via a flight test prior to production. According to program officials and contractor representatives that produce the SM-3 Block IB interceptors, the effort to redesign components in the rocket motor is considered to be relatively straightforward and low risk. Program officials are currently planning to retrofit the interceptors that have already been produced during the four year certification process. According to program officials, they had planned to select the final redesign in early first quarter of fiscal year 2015. However, because of developmental and test challenges with the redesigned component, the program office delayed the selection until later in the fiscal year.

Additionally, according to program officials, since the program has not selected the redesign, it is too early to determine the costs associated with inserting it into the interceptor and has not yet been accounted for. Consequently, until the program thoroughly understands the extent of

needed modifications, if any, and their effects on performance as demonstrated through testing, its production strategy is at risk of cost growth and schedule delays. Additionally, different issues with that same component have contributed to previous SM-3 Block IB schedule delays and production disruptions in the past.

In 2014, we made a recommendation to delay full rate production until such testing demonstrates that the redesigned interceptor is effective and suitable.[2] As it stands, MDA noted that any changes to the SM-3 Block IB would not be included in the full production contract, and that the retrofitting may lead to unanticipated cost increases. As we have previously reported, MDA had experienced these consequences in other elements when it pursued design changes concurrently with production.

The program plans for a multiyear procurement strategy in fiscal year 2016

After the program enters into full production, MDA has plans to enter into a multiyear procurement contract which is a special contracting method that allows the agency issue one contract for up to five years, which will allow the agency to procure interceptors for up to five years, even though funds for the entire five years may not be available at the time of award. DOD would need to certify to Congress that the conditions for a multiyear procurement are met. Congress will then have to specifically authorize the multiyear procurement in law before MDA may award the contract.

When used appropriately, multiyear contracting can save money compared to a series of annual contracts by allowing contractors to use their resources more efficiently. However, multiyear procurement also entails certain risks that must be balanced against potential benefits, such as the increased costs to the government should the multiyear contract be changed, and can limit DOD's budget flexibility.

MDA is currently redesigning components of the TSRM of the SM-3 Block IB interceptor and it is unclear whether or not it would need any additional changes. Once the redesigned interceptor's performance has been demonstrated through flight tests the program office may also better understand the costs needed to incorporate those changes into the ongoing production, in addition to if any other design changes are necessary. Consequently, the production strategy is at risk for cost growth and schedule delays. Until the program thoroughly understands

[2] GAO-14-351.

the extent of needed modifications, and their effects on performance, not only is the program at risk of additional cost growth and schedule delays—it may also affect any planned cost savings associated with the multiyear procurement.

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

Key Findings for Fiscal Year 2014

- The program completed its system-level review of the interceptor's design and is transitioning to product development to further refine and mature the design and manufacturing processes.
- The program faces several challenges, including technical issues with a key component—Throttleable Divert and Attitude Control System.
- The program has a number of flight tests and decisions to be made prior to Phase 3 declaration to the European Phased Adaptive Approach (EPAA).

Program Overview

The Standard Missile-3 (SM-3) interceptor has multiple versions in development or production: the SM-3 Blocks IA, IB, and IIA. The SM-3 Block IIA interceptor has a 21-inch body diameter which provides increased speed, more sensitive seeker technology, and an advanced kinetic warhead. The SM-3 Block IIA is expected to defend against short-, medium-, and intermediate-range ballistic missiles. Additionally, most of the SM-3 Block IIA components will differ from other standard missile versions requiring new technology being developed for the majority of the SM-3 Block IIA components. This interceptor is planned to have increased range compared to earlier SM-3s. For additional information on the SM-3 Block IB interceptor, see appendix IV.

Initiated in 2006 as a cooperative development program with Japan, the SM-3 Block IIA program was added to the European Phased Adaptive Approach (EPAA) in 2009 to defend against longer range threats.[1] The SM-3 Block IIA interceptor is planned to be fielded with Aegis Ballistic Missile Defense (BMD) Weapon System 5.1 by the 2018 time frame and is expected to provide engage on remote capability, in which data from other sensors is used to engage a target, and expand the range available to intercept a ballistic missile. For additional information on Aegis BMD Weapon Systems, see appendix II.

[1] GAO, *Regional Missile Defense: DOD's 2014 Report Generally Addressed Required Reporting Elements, but Excluded Additional Key Details*, GAO-15-32 (Washington, D.C.: Dec. 1, 2014).

Table 9: Aegis Ballistic Missile Defense Standard Missile-3 (SM-3) Block IIA Program Facts

Key upcoming events		
Fiscal year 2015		
Third quarter	Planned first flight test of SM-3 Block IIA interceptor	
Fiscal year 2016		
First through fourth quarters	Three planned flight tests, which include 2 intercept test events	
Fiscal year 2017		
First quarter	One planned intercept flight test	
Third quarter	Initial production decision	
Fiscal year 2018		
First through fourth quarters	Four planned flight tests, which include three operational test events	
Major assets delivered		
N/A		
Note: The program recently transitioned to product development and testing		
Flight test performance		
Test name	**Test date**	**Test result**
PTV-1	Oct. 2013	Successful booster test

Source: GAO analysis of Missile Defense Agency data. | GAO-15-345

The program completed its system-level review of the interceptor's design and is transitioning to product development to further refine and mature the design and manufacturing processes

The program held a system-level review of the interceptor's design in October 2013, and passed with no major action items and the design met all top level requirements. Completion of at least 90 percent of engineering drawings at this point provides tangible evidence that the product's design is stable, and a prototype demonstration shows that the design is capable of meeting performance requirements. At the critical design review, the SM-3 Block IIA program completed 100 percent of its drawings and used a prototype of key components to test its performance.

As a result of the critical design review, the SM-3 Block IIA design is complete and is proceeding to product development and testing. In June 2014, MDA approved the transition for the SM-3 Block IIA from the technology development phase to the production development phase in its acquisition process. This is where the program further refines and matures the design and manufacturing issues. Once into initial production, the program would provide an initial base for production and deliver assets for continued testing.

Additionally, in October 2013, the program completed a propulsion test vehicle test event called PTV-1. It demonstrated that the SM-3 Block IIA interceptor can launch from the vertical launch system.

The SM-3 Block IIA program and expected baselines will be included in the BMDS Accountability Report. These baselines—which include resource, schedule, and test, among others—are used to guide and track development of ballistic missile defense capabilities.

The program faces several challenges, including technical issues with a key component—Throttleable Divert and Attitude Control System

The program is facing some technical challenges with its Throttleable Divert and Attitude Control System (TDACS), which is a key interceptor component that maneuvers the kill vehicle during the later stages of flight. The program designated the issues involving the TDACS (and its associated hardware) as a "moderate risk" that is driving up related cost significantly and causing schedule delays. MDA noted that the problems reduce the TDACS' performance capabilities while still meeting MDA-set requirements.

Because the part has no substitute or alternate supplier, concerns were raised about the delays affecting the program schedule. However, the contractor and program are working to ensure the TDACS and its components do not affect the program schedule. With its current efforts, the program office expects a reduction of risk regarding the TDACS issue. Additionally, they are working with the contractor to stabilize costs and schedules. Until then, the TDACS production and delivery costs and schedule may continue to be at high risk. In the past, the program experienced some problems developing the TDACS, which has historically been a challenge for SM-3 development. Those challenges led to delays in the program's schedule in conducting the system-level review as well as delaying flight tests until fiscal year 2016.

The program has a number of flight tests and decisions to be made prior to Phase 3 declaration to the European Phased Adaptive Approach (EPAA)

The program has nine flight tests scheduled between fiscal years 2015 and 2018 and production decisions for the program prior to the Phase 3 declaration of EPAA in late 2018. The flight tests include four intercept tests and three operational tests. During that time period, the program is making its initial production decision in the middle of fiscal year 2017. Based on the program's test schedule that is laid out, the program does not have a lot of time to make adjustments or changes to the program if a problem emerges.

As we reported in the past, any decisions it makes will affect the overall program cost and timing. For example, program officials have stated that the program has not yet determined the number of development and production rounds to be produced. In addition, any decisions on future production plans will require negotiations with Japan since many key components on the interceptors are developed there.

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

Key Findings for Fiscal Year 2014

- MDA is developing new capabilities for delivery to the current spiral.
- Some planned modifications to the existing spiral, in part, mitigate earlier schedule delays and capability gaps.
- The program faces delays caused by added development scope and funding issues.
- Key improvements to battle management capability of interceptor systems are planned for delivery beyond 2020.

Program Overview

C2BMC is a global system that links and integrates individual missile defense elements. It allows users to plan ballistic missile defense operations, see the battle develop, and to manage designated sensors. As the integrator, C2BMC allows the Ballistic Missile Defense (BMD) system to defend against more missiles simultaneously, to conserve interceptor inventory, and to defend a larger area than individual systems operating independently. The program delivers the software capabilities in spirals.

The current spiral is Spiral 6.4, which became operational in 2011. It provides control of multiple radars. It also processes ballistic missile tracks, and reports these tracks to Ballistic Missile Defense System (BMDS) shooters, such as Ground-based Midcourse Defense (GMD), Aegis BMD, Terminal High-Altitude Area Defense (THAAD), and Patriot, which then use their own command and control, and mission planning tools for stand-alone engagements.[1] Upgrades to this version improve threat acquisition, raid handling and discrimination and are planned through 2016.

The next Spiral 8.2 is intended to improve and expand the Spiral 6.4 capabilities, further improving integrated sensor management. Initial version, called Spiral 8.2-1, is planned for delivery in 2017. It will integrate additional sensors and further improve track processing in support of Aegis BMD capability to launch an interceptor before its sensor can acquire the threat.

[1] Patriot is a land-based element that is now operational and fielded by the United States Army. We did not assess programs that have been transferred to a military service for production, operation or sustainment such as Patriot.

Spiral 8.2-3 is planned for initial delivery in 2018. It includes discrimination upgrades and supports capabilities of some systems to intercept a threat before their organic sensor can acquire that threat. Upgrades to Spiral 8.2-3 are planned past its initial delivery in 2018.

Table 10: Command, Control, Battle Management and Communications (C2BMC) Program Facts

Key upcoming events		
Fiscal year 2015		
Adjust program baseline to account for schedule and funding challenges in 2015		
Fiscal year 2015 through fiscal year 2016		
Demonstrate new capabilities and fixes for Spiral 6.4 in test campaigns		
Fiscal year 2017		
Third through fourth quarters	Deliver Spiral 8.2-1	
Fiscal year 2019		
First quarter	Deliver initial Spiral 8.2-3 capabilities with additional capabilities in 2020	
Major assets delivered		
Spiral 6.4 has been delivered at all five world-wide locations with some upgrades		
Flight test performance[a]		
Test name	**Test date**	**Test result**
FTM-15	Apr. 2011	Passed ballistic missile track onto a network in support of launching of SM-3 prior to Aegis Ballistic Missile Defense (BMD) acquiring threat with its own radar
FTI-01	Oct. 2012	Managed an Army Navy/ Transportable Radar Surveillance and Control Model -2 (AN/TPY-2) radar from which it forwarded acquisition cues to Aegis BMD and Terminal High-Altitude Area Defense (THAAD)
FTM-20	Feb. 2013	Provided tracks generated by the experimental space sensors to an Aegis BMD 4.0.2 ship to intercept a target with a Standard Missile-3 interceptor
FTG-07	July 2013	Forwarded tracks from Aegis BMD to Ground-based Midcourse Defense (GMD)
FTO-1	Sep. 2013	Managed AN/TPY-2 radar demonstrating upgrades to separate threats from debris and passed tracks to Aegis BMD and THAAD. It also received messages from THAAD and Aegis BMD
FTG-06b	June 2014	Forwarded Aegis BMD tracks to GMD

Source: GAO analysis of Missile Defense Agency data. | GAO-15-345

[a] C2BMC participates in numerous flight tests every year. This list represents a subset of these tests that includes key intercept tests.

MDA is developing new capabilities for delivery to the current spiral

The current spiral has been operational and in sustainment since 2011. The Missile Defense Agency (MDA) is developing and delivering capability upgrades before the next version is available in 2017. These upgrades are designed to mitigate existing capability gaps, some of which have been identified through testing. Key capability upgrades include:

- Regional Debris Mitigation, which allows the system to continue tracking and engage threats when they are surrounded by a large number of objects, or debris. C2BMC deployed the initial capability in May 2014 in support of regional BMD.
- Boost Phase Cueing between two AN/TPY-2 radars, which enables one radar that is better positioned to acquire a threat while it is boosting, to cue another radar that is better positioned for extended tracking, allowing for earlier tracking and tracking of larger raids. This capability was delivered in December 2014, in support of homeland defense.
- Discrimination Improvements for Homeland Defense–Near Term, where C2BMC will integrate a set of element capabilities to improve BMDS engagement reliability, lethality, and discrimination, and as a result improve the warfighter shot doctrine, preserving limited inventory. Planned for delivery in 2016, in support of homeland defense. Additional upgrades for this capability are planned to be included in future spirals.

Some planned modifications to the existing spiral, in part, mitigate earlier schedule delays and capability gaps

MDA is developing modifications to the fielded spiral of C2BMC that mitigate earlier delays of the next spiral. As we found in March 2014, the delivery of this new version, Spiral 8.2, has slipped from 2015 to 2017 having ripple effects on capabilities of other BMD systems.[2] For example, MDA delayed the delivery of a capability that improves the tracking of threats by reducing uncertainties about their location earlier in the engagement timeline, thus allowing Aegis BMD to launch its interceptors sooner, extending the area it can defend. This delay also created a misalignment between the schedules of C2BMC and two efforts that improve satellite capabilities, which are expected to complete development prior to 2015:

[2] See GAO, *Regional Missile Defense: DOD's Report Provided Limited Information; Assessment of Acquisition Risks is Optimistic,* GAO-14-248R (Washington, D.C.: Mar. 14, 2014).

1. Air Force's upgrades to satellites that provide early warning of missile launches for homeland defense, called Space-Based Infrared System (SBIRS) Increment 2.
2. MDA's program for existing satellites to provide boost phase cues to land based radars, in support of regional and homeland defense, called BMDS Overhead Persistent Infra Red Architecture (BOA).

In order to mitigate the misalignment with the Air Force's SBIRS Increment 2 program, MDA developed a retrofit to C2BMC that ensured continued interoperability between the satellites and the homeland defense architecture. Specifically, without the retrofit, C2BMC would have lost its ability to pass early warnings of missile launches to land based radars and GMD, delaying the ability to track threats and develop plans to intercept them. MDA began testing the retrofit in January 2014 and will continue to do so through 2016. According to program documentation, the cost of this effort was $8.9 million.

MDA delayed the delivery of boost phase cueing by BOA until Spiral 8.2 is available, but in 2014 it developed AN/TPY-2 to AN/TPY-2 cueing on boosting tracks. This capability is significantly more limited than the BOA cueing, since the satellite fields of view cover greater areas; however, it allows some of the same benefits, including earlier acquisition and tracking of larger raids by the radar receiving the cues. Furthermore, according to MDA officials, the capability was developed to capitalize on the delivery of the second AN/TPY-2 radar to Japan and will only be applicable to homeland defense, while the satellite capability, once delivered, will support all BMD missions. MDA delivered this capability in December 2014. According to program documentation, the cost to develop the capability was $3.7 million.

The program faces delays caused by added development scope and funding issues

Added development scope, furloughs and funding challenges could delay C2BMC milestones and the delivery of some capabilities. According to program documentation, some contract and program milestones were delayed, some up to over one year, in part to accommodate work needed to develop capabilities that were added over the last 2 years. Additionally, the program underestimated some of its costs in the last budget submission, which, in addition to the current and projected funding levels, require it to reassess its plans.

While the program does not plan to develop new baselines until the fiscal year 2015 budget is finalized, documentation indicates that completion of key activities for the current and following spirals will need to be delayed. For example the program plans to delay the assessment of C2BMC

capability that allows BMDS shooters to intercept threat missiles earlier, based on tracks provided by forwarded based radars, before their own radars can acquire the threat. Specifically, MDA plans to complete the initial assessment of the remote engagement capability at the beginning of fiscal year 2019, rather than the end of fiscal year 2017. The agency will also assess the second phase of this capability delivery in the beginning of fiscal year 2021, rather than in the beginning of the second quarter of fiscal year 2019, as previously planned. While these new schedules still support the system-level declarations planned for regional and homeland defense in December 2018 and 2020 respectively, they leave little time to rectify issues, should they be discovered during testing. The program is also considering delaying Spiral 6.4 and 8.2-1 milestones, but as of now, there are no plans to delay the assessments and declaration of their capabilities.

Key improvements to battle management capability of interceptor systems are planned for delivery beyond 2020

C2BMC has limited battle management capabilities which currently allows only for control of radars but does not provide a system-level capability to coordinate engagement decisions. According to the Director, Operational Test and Evaluation, effective “battle management” requires C2BMC to not only collect and process information from sensors and weapons, as it currently does, but to also determine which threats should be engaged by which interceptor system, to produce the highest probability of engagement success, and then to transmit this information back to the sensors and weapons. While initially planned for delivery in 2018, such a capability is currently planned for Spiral 8.4, which is scheduled for delivery sometime after Spiral 8.2-3.

Appendix VII: Ground-based Midcourse Defense (GMD)

Key Findings for Fiscal Year 2014

- Flight Test GMD (FTG)-06b was a milestone achievement towards demonstrating that the Capability Enhancement (CE)-II version works as intended.
- Flight testing is several years behind; CE-II demonstration cost increased to $1.98 billion.
- Delays in interceptor retrofits extend risk to warfighter.
- GMD's Redesigned Kill Vehicle (RKV) program has the potential to end two decades of multi-billion dollar efforts to fix and upgrade the kill vehicle.

Program Overview

The GMD program is a ground-based defense system designed to defend the United States against a limited intermediate and intercontinental ballistic missile attack in the middle part of their flight.

Key components include a ground-based interceptor consisting of a booster with an exoatmospheric kill vehicle (EKV) on top, as well as a communication system and a fire control capability. The kill vehicle uses on-board sensors and divert capabilities to steer itself into the threat missile to destroy it.

There are currently two versions of the kill vehicle that have been deployed: the initial design known as the Capability Enhancement (CE)-I and the follow-on design, known as the CE-II. In March 2013, the Secretary of Defense announced plans to increase the number of deployed GMD interceptors from 30 to 44 to add protection to the homeland and to stay ahead of long-range ballistic missile threats.

The Missile Defense Agency (MDA) conducted a successful CE-II intercept test, called Flight Test GMD (FTG)-06b, in June 2014. MDA has since resumed CE-II interceptor production with deliveries starting in the first quarter of fiscal year 2015.

In addition, MDA recently decided a redesign of the GMD kill vehicle is required to address ongoing CE-II reliability concerns and has begun a new effort, called the Redesigned Kill Vehicle (RKV). MDA worked with industry to finalize the RKV concept, which, according to MDA, informed its schedule goals to conduct the first flight test in fiscal year 2018 and new interceptor production beginning in fiscal year 2020.

Table 11: Ground-based Midcourse Defense (GMD) Program Facts

Key upcoming events		
Fiscal year 2015		
Third quarter	Missile Defense Agency (MDA) plans to declare initial homeland defense ready	
Fiscal year 2016		
First quarter	GMD's next flight test, a non-intercept test called GMD Controlled Test Vehicle (GM CTV)-02+	
Fourth quarter	First planned Capability Enhancement(CE)-II Block 1 flight test, an intercept test called Flight Test GMD (FTG)-15	
Fiscal year 2018		
First quarter	Deadline for deploying 44 interceptors	
Third quarter	First planned Redesigned Kill Vehicle (RKV) flight test, a non-intercept test called GM CTV-03	
Major assets delivered		
CE-I Interceptors	24 delivered and fielded, one of which has been used in a flight test	
CE-II Interceptors	14 delivered, 10 of which were fielded and 4 used in flight tests	
Flight test performance		
Test name	**Test date**	**Test result**
FTG-02	Sep. 2006	Success—CE-I met objectives[a]
FTG-03	May 2007	Failure—target failed
FTG-03a	Sep. 2007	Success—CE-I intercept
FTG-05	Dec. 2008	Success—CE-I intercept
FTG-06	Jan. 2010	Failure—CE-II kill vehicle failure
FTG-06a	Dec. 2010	Failure—CE-II kill vehicle failure
FTG-07	July 2013	Failure—CE-I kill vehicle failure
FTG-06b	June 2014	Success—CE-II intercept

Source: GAO analysis of MDA documentation. | GAO-15-345

[a] Although an intercept was not part of the test's primary objectives, the kill vehicle hit the target. However, the Director, Operational Test and Evaluation has reported that the hit would not have resulted in a kill.

FTG-06b was a milestone achievement towards demonstrating that the CE-II works as intended

FTG-06b was a milestone achievement for the GMD program and the first of several needed successful intercept tests to fully demonstrate the CE-II interceptor works as intended. While the successful execution of FTG-06b was a major accomplishment for the program, additional testing is necessary to demonstrate the CE-II design works as intended and for the warfighter to have a full understanding of the interceptor's capabilities and limitations. Some of the CE-II capabilities that both MDA and the warfighter have identified that need to be demonstrated include: intercepting a target representative of an intercontinental ballistic missile;

performing a salvo test where two interceptors are utilized against a single target; and performing a long time of flight intercept. MDA currently plans to complete these tests by fiscal year 2024.

Flight testing is several years behind; CE-II demonstration cost increased to $1.98 billion

The path to FTG-06b was a disruptive period for the GMD program. The program initially planned to conduct its first CE-II intercept test, FTG-06, in the first quarter of fiscal year 2008 prior to fielding the first CE-IIs later in fiscal year 2008. However, in March 2009, we found that CE-II fielding had outpaced flight testing, as the program began fielding CE-IIs in advance of conducting FTG-06.[1] The program subsequently experienced approximately six and a half years of delays, failing both of its CE-II intercept attempts and a CE-I intercept attempt. With the GMD program's successful execution of FTG-06b, the program demonstrated it had resolved some of the major technical problems discovered during the prior six-and-a-half year period of test failures and development challenges and successfully executed FTG-06b.

Although the program has resolved many of the technical challenges, it now faces the long term effects from the prior period, as flight tests were delayed by several years in order for the program to overcome the test failures. For example, the program initially planned to conduct a salvo intercept test in early fiscal year 2009 following a successful CE-II intercept test. However, because of the test failures and development delays, the salvo test is now planned to occur in late fiscal year 2017—almost nine years later than initially planned. The cumulative effect of these delays has extended the completion of planned CE-II flight tests to fiscal year 2023—approximately five and a half years after the program has completed fielding the CE-IIs.

Another long term effect from the prior period of CE-II test failures is that the cost to demonstrate, as well as fix, the currently deployed CE-IIs has increased from an initial $236 million—the cost of the first CE-II flight test—to currently $1.981 billion. The need for failure reviews, additional flight tests, mitigation development efforts, and a retrofit program have increased the CE-II's demonstration cost by $1.745 billion. Some of the mitigation development efforts are ongoing and, as such, the cost to demonstrate and fix the CE-IIs may continue to increase.

[1] See GAO, *Defense Acquisitions: Production and Fielding of Missile Defense Components Continue with Less Testing and Validation Than Planned*, GAO-09-338 (Washington, D.C.: Mar. 13, 2009).

Delays in interceptor retrofits extend risk to warfighter

MDA's fleet of currently deployed CE-I and CE-II interceptors are in need of upgrades and retrofits to address prior test failures. However, in order to meet the goal of fielding 44 interceptors by the end of 2017 and also offset the unplanned cost increase to demonstrate and fix the CE-II, MDA plans to delay fixing the fielded CE-IIs until fiscal year 2015 with fielding completed in fiscal year 2016. MDA also plans to delay fixing the fielded CE-Is until fiscal year 2018, which will continue beyond fiscal year 2020. In addition, according to program officials, the program does not plan to fix the currently deployed or newly produced CE-IIs' divert thrusters, a component with known performance issues that helps steer the interceptor in flight.

While MDA's plan to produce new interceptors ahead of fixing the fielded interceptors may enable the program to field additional interceptors sooner, it also increases risk for the warfighter because the deployed interceptors do not have the fixes needed to address known issues. As such, the fielded interceptors are susceptible to experiencing the same failure modes exhibited during prior test failures, leaving the warfighter with an interceptor fleet that may not work as intended. According to MDA, the warfighter can compensate for some of these anticipated in-flight reliability failures by launching a number of interceptors to defend against an enemy attack. However, such an approach is inventory-intensive and limits the system's raid handling capacity, reducing the system's overall effectiveness to defend the homeland against ballistic missile attacks. In addition, since MDA tentatively plans to begin replacing the fleet of currently fielded interceptors with RKV interceptors starting in fiscal year 2020, it is unclear why MDA would expend the resources to fix the CE-Is only to begin replacing them two years later.

GMD's RKV program has the potential to end two decades of multi-billion dollar efforts to fix and upgrade kill vehicle

MDA's decision to redesign the GMD kill vehicle will be DOD's seventh major attempt to fix and improve the current kill vehicle design. The current GMD kill vehicle was initially designed as a prototype in the early 1990's. Since then, MDA has spent tens of billions of dollars to correct issues with the original prototype design, improve the kill vehicle's performance, and increase the number of interceptors fielded to expand capabilities to defend the homeland from ballistic missile attacks. In the fall of 2013, MDA began a new effort to redesign the GMD kill vehicle, called the Redesigned Kill Vehicle (RKV), to address growing concerns within the department about the CE-II's reliability. The RKV is in addition to efforts currently underway to upgrade and redesign the CE-II, as seen in table 12 below:

Table 12: Current and Planned Efforts to Improve the Ground-based Midcourse Defense (GMD) Interceptor Design

Interceptor version	Purpose for upgrade/redesign	Development start
Capability Enhancement (CE)-0	Baseline exoatmospheric kill vehicle (EKV) design	Fiscal year (FY) 1991
Test Bed	Limited upgrade for laboratory-to-production design changes	FY 2000
CE-I	Prototype design with limited upgrade to address obsolescence	FY 2002
Upgraded CE-I	Design upgrade to address reliability and incorporate flight test failure mitigations	FY 2007
CE-II	Redesign to fix known issues, address obsolescence, and improve producibility	FY 2004
CE-II Block I	Redesign to fix known issues, upgrade boost vehicle, address obsolescence, and improve producibility and cost	FY 2010
Upgraded CE-II	Design upgrade to incorporate flight test failure mitigations	FY 2011
Redesigned Kill Vehicle (RKV)	Redesign to improve testing, reliability, producibility, and cost effectiveness	FY 2015[a]
Next Generation EKV	New design to evolve kill vehicle capabilities	To be determined

Source: GAO analysis of Missile Defense Agency data. | GAO-15-345

[a] According to current program plans.

MDA's prior performance in upgrading and redesigning the GMD kill vehicle has achieved mixed results. Over the past 15 years, MDA has, on average, initiated redesign or upgrade efforts for GMD approximately every two years. These efforts, while perhaps needed, have proven to be very expensive and, according to MDA, did not achieve the goal of providing the warfighter with a reliable, producible, and cost-effective interceptor.

A more recent example of updating the GMD kill vehicle is the CE-II Block I, which began in 2010 when MDA awarded a contract to Boeing to develop and sustain the GMD system. As part of that effort, Boeing was tasked with redesigning the CE-II EKV to address obsolescence and improve reliability, producibility, availability, and maintainability. MDA has since devised a new, multi-phased strategy to evolve the GMD system and the planned improvements for the CE-II Block I are now limited to component modifications and quality improvements that were identified during the FTG-06a failure resolution effort. Many of the initial goals and

objectives for the CE-II Block I appear to have been passed onto the RKV. According to MDA, it is pursuing the RKV to replace the current fleet of interceptors with new ones that are testable, reliable, more producible, and cost effective.

During an April 2014 Senate Armed Services Committee hearing, the Director, MDA, stated that the agency was committed to implementing a rigorous acquisition process for the redesign effort and would not circumvent sound acquisition practices. Also, in an April 2014 report submitted to Congress describing the RKV's plans and objectives, MDA described some initial steps the agency is taking to employ a rigorous systems engineering process, such as including manufacturability, reliability, and testability criteria as critical design conditions. The agency's recent commitment to follow a knowledge-based approach to acquire the RKV is a positive indication that the agency is seeking to improve its investment decisions and achieve better outcomes. Our prior work on best practices for acquisitions found that successful programs take steps to confirm their technologies are mature, their designs are stable, and their production processes are in control. These steps help ensure a high level of knowledge is achieved at key junctures in development.

Appendix VIII: Targets and Countermeasures (Targets)

Key Findings for Fiscal Year 2014

- The Targets program supported MDA's test schedule and improved reliability by reducing failures.
- The program's current contracting approach may result in better acquisition outcomes.
- The Targets program has flown targets in non-intercept tests that can reduce risks, but it continues to use new targets in more expensive and higher risk intercept tests.

Program Overview

The MDA's Targets and Countermeasures (hereafter referred to as Targets or Targets program) designs, develops, and procures missiles to serve as targets during the testing of missile defense systems. 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 the Missile Defense Agency's (MDA) 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. See table 13 for the quantities of targets planned for fiscal year 2014 through 2019 based on the range of the target.

Table 13: Targets and Countermeasures Program Facts

Key upcoming events	
Fiscal year 2015	
First quarter	Flight Test Other (FTX)-20- First flight test of the medium-range target named MRBM T3 during an Aegis Ballistic Missile Defense (BMD) test
Third quarter	Flight Test Operational (FTO)-02 Event 1- First flight of the new intermediate-range ballistic missile (IRBM) to demonstrate the Aegis Ashore European Adaptive Approach architecture
Fourth quarter	FTO-02 Event 2- Second high-level operational flight test of the Ballistic Missile Defense System for Aegis BMD and Terminal High Altitude Area Defense (THAAD) using multiple targets
Fiscal year 2016	
Fourth quarter	Flight Test GMD (FTG)-15- First flight of the new intercontinental ballistic missile (ICBM)during a Ground-based Midcourse Defense (GMD) test
Fiscal year 2017	
First quarter	First flight test, called SFTM-02, of the new medium-range target named MRBM T1/T2 during an Aegis BMD test
Planned procurement quantities	
Target range	**Quantity (fiscal years 2014-2019)**
Short-Range Ballistic Missile (SRBM)	16
Medium-Range Ballistic Missile (MRBM)	18
Intermediate-Range Ballistic Missile (IRBM)	10
Intercontinental Ballistic Missile (ICBM)	2
Total	**46**

Source: GAO analysis of Missile Defense Agency data. | GAO-15-345

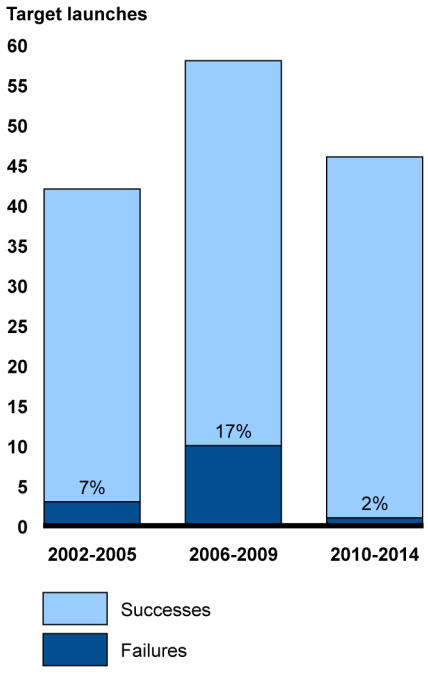
The Targets program supported MDA's test schedule and improved reliability by reducing failures

The Targets program successfully launched four targets in fiscal year 2014 to support MDA's test schedule, including the first flight of a new medium- range target called the ARAV-TTO-E—described as a simple low-cost target by program officials. Specifically, the Targets program provided three short-range targets and one medium-range target to support Aegis testing requirements, including the full-rate production decision for the SM-3 Block IB interceptor. The Targets program provided seven additional targets in fiscal year 2014, including an intermediate-

range target to support the retest of Ground-based Midcourse Defense's (GMD) Capability Enhancement (CE)-II interceptor that failed during FTG-06a in December 2010.

In the past we have reported that reliability and availability of targets has caused delays in MDA's testing schedule.[1] For example, target failures and anomalies have caused the Terminal High Altitude Area Defense (THAAD) program to change its flight test plan and decrease the amount of flight tests. However, while the program has improved its reliability by reducing the number of target failures (see figure 2), target availability remains a risk to MDA's test schedule.

Figure 2: Target Successes and Failures in Fiscal Years 2002-2014



Source: GAO analysis of Missile Defense Agency documentation. | GAO-15-345

[1] See GAO, *Defense Acquisitions: Sound Business Case Needed to Implement Missile Defense Agency's Targets Program*, GAO-08-113 (Washington, D.C.: Sep. 26, 2008); *Missile Defense: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency*, GAO-12-486 (Washington, D.C.: Apr. 20, 2012); and *Missile Defense: Opportunity to Refocus on Strengthening Acquisition Management*, GAO-13-432 (Washington, D.C.: Apr. 26, 2013)

From fiscal years 2010 through 2014, only one of the 46 targets launched failed. The Targets program may have reduced target failures during this timeframe, in part, by primarily using short-range targets that are less complex than medium-, intermediate-, and intercontinental-range targets. Moving forward, however, the majority of MDA's tests will use medium-, intermediate-, and intercontinental-range targets. Another contributing factor to the reduction in target failures may be the additional time available to further develop targets while programs have been resolving developmental issues. For example, the GMD program's CE-II interceptor failed during FTG-06a in December 2010 which resulted in the need for a retest. The GMD program's first retest failed in fiscal year 2011 and it successfully conducted a retest in fiscal year 2014. Consequently, this slowed the GMD program's test schedule and subsequently its target demands providing the Targets program with additional time to further develop or resolve issues with any of its targets. As GMD and other programs resolve their developmental issues, the test plan becomes more aggressive, and target demands increase, additional time to develop or address issues with targets may not be as readily available.

Target availability remains a risk to the MDA test plan. For example, two of the Targets program's medium-range targets—the MRBM T1/T2 and MRBM T3—have not been available as planned for some tests. Consequently, these tests either received substitute targets or were delayed. According to program officials, there was a delay in awarding the MRBM T1/T2 contract due to a procurement integrity allegation which was not substantiated, but affected its availability for testing. As a result, the first flight of this target was delayed two and half years from the third quarter of fiscal year 2014 to the first quarter of fiscal year 2017 and several substitute targets were needed for tests between that timeframe.[2] The MRBM T3 has had some development issues that had to be resolved which delayed its availability for tests, according to program officials. Subsequently, the first flight of this target was delayed approximately one year from the first quarter of fiscal year 2014 to the first quarter of fiscal year 2015.

[2] According to MDA officials, the first flight of the MRBM T1/T2 targets has been further delayed to the fourth quarter of fiscal year 2018 to support the use of lower cost targets, such as the ARAV-TTO-E, where possible in the test schedule.

The program's current contracting approach may result in better acquisition outcomes

The program's contracting approach for targets is potentially improving by moving from sole-source to competitive awards and restructuring contracts to better achieve desired outcomes. Past contracting decisions have had cost and schedule impacts. For example, the Targets program began work on a medium-range target—the eMRBM—in fiscal year 2010 under an existing contract. According to program officials, the eMRBM contract did not contain disincentives for poor performance or failures. Accordingly, when there were issues with the target during testing, the program stated they had to pay the contractor additional money to resolve the issues. Consequently, after developmental delays and spending $333 million for two of these targets—one successfully used in fiscal year 2013 and one planned to be used in fiscal year 2015—the remaining requirements were reduced due to affordability and the multiple tests that were scheduled to use this target either received substitute targets or were deleted. Conversely, in fiscal year 2014, the Targets program competitively awarded a contract for a new medium-range target—MRBM T1/T2—which, according to program officials, includes a range of incentives for successful execution during testing and a fixed price for the target to better control costs and achieve expected outcomes. As such, if the target performs poorly or fails during a test, then according to program officials, the contractor may receive less money.

Program officials explained that they have also adjusted the contracting approach to better control costs by only buying the number of targets needed and including options to buy additional targets at a pre-negotiated price if requirements change. For example, the MRBM T3 contract procures four targets, but it also has options for up to three additional targets. As structured, this gives the program some flexibility to adjust to changing requirements with less risk of impacts to cost and the test schedule.

The Targets program has flown targets in non-intercept tests that can reduce risks, but it continues to use new targets in more expensive and higher risk intercept tests

The Targets program successfully flew a new medium-range target during a non-intercept flight test in October 2014 that may enable the program to reduce risks associated with this target prior to its use in an intercept flight test in fiscal year 2015. Non-intercept flight tests can serve as risk reduction flights by confirming that the target works as intended and to discover and resolve issues prior to its use in a more costly and higher risk intercept flight test that is designed to test a system's performance. However, the Targets program plans to use new intermediate- and intercontinental-range targets for the first time in intercept flight tests in fiscal years 2015 and 2016, respectively. Program officials explained that many of the components in the intermediate- and intercontinental-range targets have already been flown and based on previous flight data and modeling and simulation they have a high level of confidence that the targets will work as intended. The Targets program is also taking other measures, such as component-level ground tests and pre-test trials, to identify and resolve any issues prior to the planned intercept tests. We have previously recommended that MDA conduct risk reduction flight tests—non-intercept tests—for each new target, but it has not fully implemented this recommendation and program officials maintain that the decision to use new targets in intercept flight tests will continue based on associated risks.[3]

[3] GAO-13-432.

Appendix IX: Terminal High Altitude Area Defense (THAAD)

Key Findings for Fiscal Year 2014

- THAAD delivered assets for operational use prior to demonstrating their capability in a flight test.
- THAAD delivered 10 interceptors to complete its second lot in fiscal year 2014.
- THAAD's streamlined battery configuration may enable cost savings and early delivery of the remaining batteries.
- A new transport method may double the number of THAAD interceptors that can be transported via C-17 aircraft in fiscal year 2015.

Program Overview

THAAD is a rapidly-deployable ground-based system able to defend against short- and medium-range ballistic missile attacks during the middle and end stages of a missile's flight. THAAD is organized as a battery that consists of interceptors, multiple launchers, a radar, a fire control and communications system, and other support equipment. The first two batteries have been conditionally accepted by the Army for operational use. In December 2014, THAAD received urgent materiel release approval from the Commanding General of the United States Army Aviation and Missile Command to enable an earlier delivery of equipment for the next two batteries for operational use to meet the Army's request to support urgent warfighter needs.[1] THAAD plans to continue production through fiscal year 2025, for a total of 7 batteries, 503 interceptors, and 7 radars.

THAAD has two development efforts—THAAD 1.0 and THAAD 2.0. THAAD 1.0 is for the production of the batteries, interceptors, and supporting hardware and provides the warfighter with initial integrated defense against short- and medium-range threats in one region. THAAD 2.0 is primarily software enhancements that expand THAAD's ability to

[1] The materiel release process ensures that a weapon system is safe, suitable, and supportable prior to placing it in the hands of the warfighter. Generally, all weapon systems used by the Army must go through the materiel release process. An urgent materiel release provides a limited certification of a weapon system's safety, suitability, and supportability and bypasses the standard materiel release process to meet pressing operational needs or demands. THAAD must complete a full materiel release process for this weapon system in the future. Army Regulation 700-142.

defend against threats in multiple regions and at different ranges, and adds debris mitigation and other upgrades.

THAAD currently has two hardware configurations—one for the first two batteries and another to address obsolescence issues for the remaining five batteries. However, the program plans to equip the first two batteries with the upgraded hardware by fiscal year 2018. THAAD is testing the new configuration that addresses obsolescence issues in two upcoming flight tests in fiscal year 2015.

Table 14: Terminal High Altitude Area Defense (THAAD) Program Facts

Key upcoming events		
Fiscal year 2015		
Fourth quarter	Flight Test THAAD (FTT-18)- The first test of the intermediate range ballistic missile capability and changes to address obsolescence	
	Flight Test Operational (FTO)-02 Event 2 (prior FTT-11a)- second test of changes to address obsolescence	
Fiscal year 2017		
Second quarter	FTT-15—debris mitigation capability	
Fiscal year 2018		
Fourth quarter	FTO-03 Event 3- Second test of intermediate-range ballistic missile capability	
Major assets delivered		
Batteries	4	
Interceptors	98	
Flight test performance		
Test name	**Test date**	**Test result**
FTT-11	Dec. 2009	No test—target failed
FTT-14	June 2010	Success
FTT-12	Oct. 2011	Success
FTI-01	Oct. 2012	Success
FTO-01	Sep. 2013	Success

Source: GAO analysis of Missile Defense Agency data. | GAO-15-345

THAAD delivered assets for operational use prior to demonstrating their capability in a flight test

THAAD delivered assets to defend against an intermediate-range threat, although this capability is not planned to be demonstrated in a flight test until the fourth quarter of fiscal year 2015.[2] As such, THAAD program officials currently have limited insight into if and how THAAD will perform against an intermediate-range threat. However, program officials expect THAAD to perform successfully based on modeling and simulations and analysis from a previous flight test that used a medium-range target with a velocity close to that of an intermediate-range target. If THAAD does not perform as expected during this test, the program may have to retrofit its currently deployed assets at an additional cost.

THAAD delivered equipment for its next two batteries for operational use, although it has not flight tested the changes made to this equipment to address obsolescence issues. THAAD planned to release these two batteries for operational use in the fourth quarter of fiscal year 2016, but the Army requested an urgent materiel release enabling operational use earlier to meet warfighter needs. However, these two batteries have new hardware and software to address obsolescence issues and the two flight tests to assess these changes are in the fourth quarter of fiscal year 2015. Without the flight tests to confirm that the obsolescence issues have been corrected, the program may have delivered assets to the Army that may not work as intended or that may require fixes.

THAAD delivered 10 interceptors to complete its second lot in fiscal year 2014

THAAD delivered the remaining 10 interceptors to complete its second lot in fiscal year 2014, which represents a 60 percent decrease in production from the prior fiscal year. Program officials attribute the decrease in production to funding challenges related to sequestration. Although the program only delivered 10 interceptors in fiscal year 2014, it was able to avoid costs associated with decreased production by combining the build of subassemblies for its next lot of interceptors with some foreign military sales. According to program officials, this allowed the program to avoid over a $100 million in costs because the production rate remained at a sufficient level to prevent any additional funding to accommodate decreases.

[2] Intermediate-range ballistic missiles have a range from 1,864 miles to 3,418 miles.

THAAD's streamlined battery configuration may enable cost savings and early delivery of the remaining batteries

The first two THAAD batteries conditionally accepted by the Army for operational use have a configuration that includes two tactical station groups—one for fire control and communications and another as backup—that are both fully interchangeable. According to program officials, the warfighter has been primarily using one tactical station group and using the other for training when needed. As such, the program streamlined the battery configuration to a single tactical station group and it is developing a table-top trainer and portable planner that program officials liken to the size and functionality of a computer to subsume the role of the second one being used for training. The remaining batteries will have the streamlined configuration and program officials noted that they will also update the first two batteries with the streamlined configuration when they are modernizing them with the changes to address obsolescence. Program officials believe that this streamlined battery configuration has reduced cost for the program which may allow the early delivery of the remaining batteries.

A new transport method may double the number of THAAD interceptors that can be transported via C-17 aircraft in fiscal year 2015

Program officials explained that currently four THAAD interceptors can be transported at one time in a C-17 aircraft, but the program has designed and tested a new missile transport method that may allow it to double the capacity per aircraft in fiscal year 2015. The program is spending approximately $59 million to achieve this doubled capacity and plans to have the ability to equip all of its batteries with this upgrade by fiscal year 2019. Program officials assert that this new missile transport method, if fully implemented, may provide efficiencies for the warfighter by reducing the number of C-17 aircraft flights to transport THAAD interceptors to needed locations.

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; David Best; Helena Brink; Joe Kirschbaum; Anh Nguyen; Wiktor Niewiadomski; Kenneth E. Patton; Karen Richey; Steven Stern; Robert Swierczek; Brian Tittle; Hai V. Tran; and Alyssa Weir.