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MISSILE DEFENSE

Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency

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GAO Highlights

Highlights of GAO-12-486, a report to congressional committees

Why GAO Did This Study

MDA has spent more than $80 billion since its initiation in 2002 and plans to spend $44 billion more by 2016 to develop, produce, and field a complex integrated system of land-, sea-, and space-based sensors, interceptors, and battle management, known as the BMDS.

Since 2002, National Defense Authorization Acts have mandated that GAO prepare annual assessments of MDA's ongoing cost, schedule, testing, and performance progress. This report assesses that progress in fiscal year 2011. To do this, GAO examined the accomplishments of the BMDS elements and supporting efforts and reviewed individual element responses to GAO data collection instruments. GAO also reviewed pertinent Department of Defense (DOD) policies and reports, and interviewed a wide range of DOD, MDA, and BMDS officials.

What GAO Recommends

GAO makes seven recommendations to the Secretary of Defense to reduce concurrency and strengthen MDA's near- and long-term acquisition prospects. DOD concurred with six recommendations and partially concurred with one related to reporting on the cause of the Aegis BMD Standard Missile-3 Block IB test failure before committing to additional purchases. DOD did not agree to tie additional purchases to reporting the cause of the failure. DOD's stated actions were generally responsive to problems already at hand, but did not consistently address implications for concurrency in the future, as discussed more fully in the report.

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April 2012

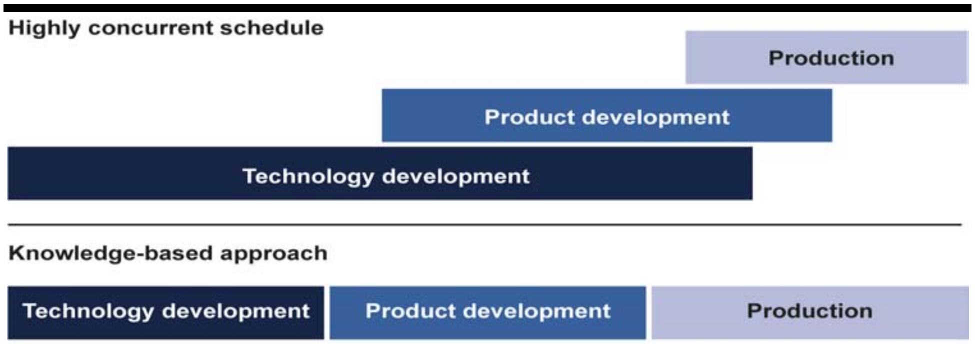
MISSILE DEFENSE

Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency

What GAO Found

In fiscal year 2011, the Missile Defense Agency (MDA) experienced mixed results in executing its development goals and Ballistic Missile Defense System (BMDS) tests. For the first time in 5 years, GAO found that all of the targets used in this year's tests were delivered and performed as expected. None of the programs GAO assessed were able to fully accomplish their asset delivery and capability goals for the year. Flight test failures, an anomaly, and delays disrupted the development of several components and models and simulations challenges remain. Flight test failures forced MDA to suspend or slow production of three out of four interceptors currently being manufactured while failure review boards investigated their test problems.

To meet the presidential 2002 direction to initially rapidly field and update missile defense capabilities as well as the 2009 announcement to deploy missile defenses in Europe, MDA has undertaken and continues to undertake highly concurrent acquisitions. Concurrency is broadly defined as the overlap between technology development and product development or between product development and production. While some concurrency is understandable, committing to product development before requirements are understood and technologies mature or 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. It can also create pressure to keep producing to avoid work stoppages. In contrast, as shown in the notional graphic below, successful programs that deliver promised capabilities for the estimated cost and schedule use a disciplined knowledge-based approach.



Source: GAO analysis.

High levels of concurrency were present in MDA's initial efforts and are present in current efforts, though the agency has begun emphasizing the need to follow knowledge-based development practices. During 2011, the Ground-based Midcourse Defense, the Aegis Standard Missile 3 Block IB, and the Terminal High Altitude Area Defense experienced significant ill effects from concurrency. For example, MDA's discovery of a design problem in a new variant of the Ground-based Midcourse Defense program's interceptors while production was underway increased costs, may require retrofit of fielded equipment, and delayed delivery. Flight test cost to confirm its capability has increased from $236 million to about $1 billion. Because MDA continues to employ concurrent strategies, it is likely that it will continue to experience these kinds of acquisition problems.

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Abbreviations

Aegis BMD	Aegis Ballistic Missile Defense
APL	Applied Physics Laboratory
APUC	average procurement unit cost
BAR	BMDS Accountability Report
BMDS	Ballistic Missile Defense System
CDR	critical design review
CE-I	Capability Enhancement-I
CE-II	Capability Enhancement -II
DACS	divert and attitude control system
DOD	Department of Defense
EKV	exoatmospheric kill vehicle
eMRBM	Extended Medium-Range Ballistic Missile
FTG	Flight Test GMD
FTM	Flight Test Missile of Aegis
FTT	THAAD Flight Test
FTX	Flight Test “Other”
GBI	ground-based Interceptor
GMD	Ground-based Midcourse Defense
ICBM	intercontinental ballistic missile
IMTP	Integrated Master Test Plan
IRBM	intermediate-range ballistic missile
LV	launch vehicle
MDA	Missile Defense Agency
MRBM	medium-range ballistic missile
OSF	Objective Simulation Framework
OTA	Operational Test Agency
PAA	Phased Adaptive Approach
PDR	preliminary design review
PTSS	Precision Tracking Space System
SM-3	Standard Missile-3
SPY-1	Army/Navy Water (Shipboard) Radar Surveillance
STSS	Space Tracking and Surveillance System
TDACS	throttleable divert and attitude control system
THAAD	Terminal High Altitude Area Defense
TSRM	third-stage rocket motor
VLS	vertical launching system

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United States Government Accountability Office
Washington, DC 20548

April 20, 2012

Congressional Committees

The Missile Defense Agency (MDA) has developed and deployed an initial integrated and layered Ballistic Missile Defense System (BMDS) to defend the United States, our deployed forces, allies, and friends, and is continuing development and production of additional capabilities. Since 2002, MDA has spent more than $80 billion and plans to spend an additional $44 billion through 2016 to develop a highly complex system of systems—land-, sea-, and space-based sensors, interceptors and battle management. To rapidly field missile defense capabilities, MDA has concurrently developed, produced, and fielded a variety of systems. While this approach has helped MDA to rapidly deploy initial capabilities, it also has meant that it has fielded some assets whose capabilities are uncertain or impaired. In addition, there has been limited transparency and accountability for the acquisitions, particularly limited understanding of the costs, schedules, requirements, and system effectiveness. As the United States government seeks to address growing fiscal pressures, investments in new weapon systems, like the BMDS, will face increasing scrutiny to ensure that they are providing the best value for the increasingly limited resources available.

Since 2002, National Defense Authorization Acts have mandated that we prepare annual assessments of MDA's ongoing cost, schedule, testing, and performance progress.[1] To date, we have delivered assessments of MDA's progress covering fiscal years 2003 through 2010 and are currently mandated to continue delivering assessments through fiscal

[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. See also National Defense Authorization Act for Fiscal Year 2012, Pub. L. No. 112-81, § 232 (2011).

year 2016.[2] This report provides our assessment of MDA's progress in fiscal year 2011. Specifically, it highlights (1) progress and challenges in delivery of assets for key programs, or elements; (2) progress in developing models and simulations needed to assess BMDS performance; and (3) challenges related to MDA's use of highly concurrent acquisition strategies. In terms of costs, we report on the cost effects MDA experienced or is likely to experience for individual systems as a result of its past, ongoing, and planned acquisition practices. We will not be able to assess aggregate cost reporting until corrective actions we recommended are implemented and substantial improvements are made to MDA's cost estimates. According to MDA senior-level officials, the agency has taken several actions in response to our recommendations. Finally, we will be issuing a separate report assessing MDA's progress in adopting best practices for developing project schedules as well as broader progress in enhancing and enabling Department of Defense (DOD) and congressional oversight for MDA.

To assess MDA's progress, we examined the accomplishments of eight BMDS elements and supporting efforts that MDA is currently developing and fielding: the Aegis Ballistic Missile Defense (Aegis BMD) with Standard Missile-3 Block IA and Block IB; Aegis Ashore; Aegis BMD Standard Missile-3 Block IIA, Aegis BMD Standard Missile-3 Block IIB; Ground-based Midcourse Defense (GMD); Precision Tracking and Space System (PTSS); Targets and Countermeasures; and Terminal High

[2] GAO, *Missile Defense: Actions Needed to Improve Transparency and Accountability*, GAO-11-372 (Washington, D.C.: Mar. 24, 2011); *Defense Acquisitions: Missile Defense Transition Provides Opportunity to Strengthen Acquisition Approach,* GAO-10-311 (Washington, D.C.: Feb. 25, 2010); *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); *Defense Acquisitions: Progress Made in Fielding Missile Defense, but Program Is Short of Meeting Goals*, GAO-08-448 (Washington, D.C.: Mar. 14, 2008); *Defense Acquisitions: Missile Defense Acquisition Strategy Generates Results but Delivers Less at a Higher Cost*, GAO-07-387 (Washington, D.C.: Mar. 15, 2007); *Defense Acquisitions: Missile Defense Agency Fields Initial Capability but Falls Short of Original Goals*, GAO-06-327 (Washington, D.C.: Mar. 15, 2006); *Defense Acquisitions: Status of Ballistic Missile Defense Program in 2004*, GAO-05-243 (Washington, D.C.: Mar. 31, 2005); and *Missile Defense: Actions Are Needed to Enhance Testing and Accountability,* GAO-04-409 (Washington, D.C.: Apr. 23, 2004).

Altitude Area Defense (THAAD).[3] We reviewed individual element responses to GAO data collection instruments, which detailed key accomplishments for fiscal year 2011. The results of these reviews are presented in detail in appendixes to this report and are also integrated as appropriate in our findings related to progress in delivering assets and capabilities. For more details on our scope and methodology, see appendix I.

We conducted this performance audit from April 2011 to April 2012 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

MDA's BMDS is being designed to counter ballistic missiles of all ranges—short, medium, intermediate, and intercontinental.[4] Since ballistic missiles have different ranges, speeds, sizes, and performance characteristics, MDA is developing multiple systems that when integrated, provide multiple opportunities to destroy ballistic missiles before they can reach their targets. The system includes space-based sensors as well as ground- and sea-based radars, ground- and sea-based interceptor missiles, and a command and control, battle management, and communications system providing the warfighter with the necessary communication links to the sensors and interceptor missiles. A typical engagement scenario to defend against an intercontinental ballistic missile would occur as follows:

[3] The BMDS also includes other elements and supporting efforts such as the Command, Control, Battle Management, and Communications and BMDS Sensors which are not covered in this report. For this report, we selected and focused our efforts on eight of the BMDS elements based on Congressional interest, known acquisition challenges and successes, and the current status of these efforts.

[4] Ballistic missiles are classified by range: short-range ballistic missiles have a range of less than 1,000 kilometers (621 miles); medium-range ballistic missiles have a range from 1,000 to 3,000 kilometers (621 to1,864 miles); intermediate-range ballistic missiles have a range from 3,000 to 5,500 kilometers (1,864 to 3,418 miles); and intercontinental ballistic missiles have a range greater than 5,500 kilometers (3,418 miles).

- Infrared sensors aboard early-warning satellites detect the hot plume of a missile launch and alert the command authority of a possible attack.
- Upon receiving the cue, land- or sea-based radars are directed to track the various objects released from the missile and, if so designed, to identify the warhead from among spent rocket motors, decoys, and debris.
- When the trajectory of the missile's warhead has been adequately established, an interceptor—consisting of a kill vehicle mounted atop a booster—is launched to engage the threat. The interceptor boosts itself toward a predicted intercept point and releases the kill vehicle.
- The kill vehicle uses its onboard sensors and divert thrusters to detect, identify, and steer itself into the warhead. With a combined closing speed of up to 10 kilometers per second (22,000 miles per hour), the warhead is destroyed above the atmosphere through a "hit to kill" collision with the kill vehicle.
- Inside the atmosphere, interceptors kill the ballistic missile using a range of mechanisms such as direct collision between the interceptor missile and the inbound ballistic missile or killing it with the combined effects of a blast fragmentation warhead (heat, pressure, and grains/shrapnel) in cases where a direct hit does not occur.

Table 1 provides a brief description of eight BMDS elements and supporting efforts currently under development by MDA.

Table 1: Description of MDA's BMDS Elements

BMDS element/supporting effort[a]	Description
Aegis Ballistic Missile Defense (Aegis BMD) with Standard Missile-3 (SM-3) Block IA and Block IB	Aegis BMD is a sea-based missile defense system being developed in incremental, capability-based blocks to defend against ballistic missiles of all ranges. Key components include the shipboard SPY-1 radar, SM-3 missiles, and command and control systems. It also is used as a forward-deployed sensor for surveillance and tracking of ballistic missiles. The SM-3 missile has multiple versions in development or production. The first two variants are referred to as the SM-3 Block IA and SM-3 Block IB.[b]
Aegis Ashore	Aegis Ashore is a future land-based variant of the ship-based Aegis BMD. It is expected to track and intercept ballistic missiles in their midcourse phase of flight using SM-3 interceptor variants as they become available. Key components include a vertical launch system and a reconstitutable enclosure that houses the SPY-1 radar and command and control system. DOD plans to deploy the first Aegis Ashore with SM-3 Block IB in the 2015 time frame as part of the missile defense of Europe called the European Phased Adaptive Approach (PAA).

BMDS element/supporting effort[a]	Description
Aegis BMD SM-3 Block IIA	The SM-3 Block IIA is the third SM-3 variant to be developed for use with the sea-based and future land-based Aegis Ballistic BMD. This program began in 2006 as a joint development with Japan, and it was added to the European PAA when that approach was announced in 2009. As part of European PAA Phase III, the SM-3 Block IIA is planned to be fielded with Aegis Weapons System version 5.1 by the 2018 time frame.
Aegis BMD SM-3 Block IIB	The SM-3 IIB is the fourth SM-3 variant planned. It is intended to defend against medium- and intermediate-range ballistic missiles and provide early intercept capabilities against some intercontinental ballistic missiles. The SM-3 Block IIB program began in June 2010 and is planned to be fielded by the 2020 time frame as part of the European PAA Phase IV. Given its early stage of development, program management officials stated that the SM-3 Block IIB is not managed within the Aegis BMD Program Office and has not been baselined.
Ground-based Midcourse Defense (GMD)	GMD is a ground-based missile defense system designed to destroy intermediate and intercontinental ballistic missiles during the midcourse phase of their flight. Its mission is to protect the U.S. homeland against ballistic missile attacks from North Korea and the Middle East. GMD has two ground-based interceptor variants—the Capability Enhancement I and the Capability Enhancement II. MDA has emplaced its total planned inventory of 30 interceptors at two missile field sites—Fort Greely, Alaska and Vandenberg, California.
Precision Tracking and Space System (PTSS)	PTSS is being developed as an operational component of the BMDS designed to support intercept of regional medium and intermediate range ballistic missile threats to U.S. forces and allies and long-range threats to the United States. PTSS will track large missile raid sizes after booster burn-out, which could enable earlier intercepts.
Targets and Countermeasures	MDA develops and manufactures highly complex targets for short, medium, intermediate and eventually intercontinental ranges used in BMDS flight tests to present realistic threat scenarios. The targets are designed to encompass the full spectrum of threat missile ranges and capabilities.
Terminal High Altitude Area Defense (THAAD)	THAAD is a ground-based missile defense system designed to destroy short- and medium-range ballistic missiles during the late-midcourse and terminal phases of flight. Its mission is to defend deployed U.S. forces and friendly foreign population centers.

Source: MDA data.

[a]The BMDS also includes other elements and supporting efforts such as the Command, Control, Battle Management, and Communications and BMDS Sensors efforts, which are not covered in this report.

[b]MDA is currently developing or producing four versions of the SM-3 interceptor—IA, IB, IIA, and IIB. The SM-3 Block IA and SM-3 Block IB are the earlier variants of the missile. The SM-3 Block IIA and SM-3 Block IIB are planned to provide successively greater range and velocity to intercept medium to long-range ballistic missiles. The latter two versions are reported on separately, in appendices V and VI, respectively.

European Missile Defense Acquisition Approach

In 2009, DOD altered its approach to European defense, which originally focused on ground-based interceptors from the GMD element and a large fixed radar as well as transportable X-Band radars, in order to provide defenses against long-range threats to the United States and short-, medium-, and intermediate-range Iranian threats to Europe. This new approach, referred to as the European Phased Adaptive Approach (PAA), consists primarily of Aegis BMD sea-based and land-based systems and interceptors, as well as various sensors to be deployed over time as the various capabilities are matured.

The European PAA policy announced by the President articulates a schedule for delivering four phases of capability to defend Europe and augment current protection of the U.S. homeland in the following time frames: Phase 1 in 2011, Phase 2 in 2015, Phase 3 in 2018, and Phase 4 in 2020. DOD's schedule for the European PAA comprises multiple elements and interceptors to provide an increasingly integrated ballistic missile defense capability. It is projected that each successive phase will deliver additional capability with respect to both threat missile range and raid size.

Table 2 outlines the plans and estimated delivery time frames associated with each European PAA phase.

Table 2: European Phased Adaptive Approach Plans and Delivery Time Frames as of 2009

Phase	Plans	Delivery time frame
Phase I	Deploy current and proven missile defense systems, including the sea-based Aegis Weapon System, the SM-3 interceptor (Block IA) and sensors such as the Army/Navy Transportable Radar Surveillance system to address regional ballistic missile threats to Europe and deployed U.S. personnel and their families.	2011
Phase II	After appropriate testing, deploy a more capable version of the SM-3 interceptor (Block IB) both at sea on Aegis ships and on land in the Aegis Ashore, as well as more advanced sensors, to expand the defended area against short- and medium-range missile threats.	2015
Phase III	After development and testing are complete, deploy the more advanced SM-3 Block IIA variant currently under development at sea and on land to counter short-, medium-, and intermediate-range threats.	2018
Phase IV	After development and testing are complete, deploy the SM-3 Block IIB at sea and on land to help better cope with medium- and intermediate-range missiles and the potential future intercontinental range ballistic missile threat to the United States.	2020

Sources: President's September 17, 2009, policy announcement and MDA data.

Mixed Progress in Development and Delivery Efforts

MDA experienced mixed results in executing its fiscal year 2011 development goals and BMDS tests. For the first time in 5 years, we are able to report that all of the targets used in fiscal year 2011 test events were delivered as planned and performed as expected. Moreover, the Aegis BMD program demonstrated the capability to intercept an intermediate-range target for the first time. Also, the THAAD program successfully conducted its first operational flight test in October 2011.

However, none of the programs we assessed were able to fully accomplish their asset delivery and capability goals for the year. At the same time, several critical test failures as well as a test anomaly and delays disrupted MDA's flight test plan and the acquisition strategies of several components. Overall, flight test failures and an anomaly forced MDA to suspend or slow production of three out of four interceptors currently being manufactured. The GMD program, in particular, has been disrupted by two recent failures, which forced MDA to halt flight testing and restructure its multi-year flight test program, halt production of the interceptors, and redirect resources to return-to-flight activities. Production issues forced MDA to slow production of the THAAD interceptors, the fourth missile being manufactured.

Table 3 presents a summary of selected MDA goals for fiscal year 2011 that details how well these goals were accomplished. Appendixes IV through XI further detail MDA's progress in each of the major programs.

Table 3: BMDS Fiscal Year 2011 Selected Accomplishments

Element	Fully accomplished goals	Partially or not accomplished goals
Aegis BMD SM-3 Block IA	Flight test FTM-15 demonstrated capability required for European Phased Adaptive Approach (PAA) Phase I. Deployed first ship in support of European PAA Phase I.	Delivered 6 out of 19 planned missiles by the end of fiscal year 2011; delivery of 12 missiles is on hold pending the results of the failure investigation of the anomaly in FTM-15. Depending on the results, delivered missiles may have to be retrofitted.
Aegis BMD SM-3 Block IB	Delivered first SM-3 Block IB developmental interceptor and fired it in the first flight test, FTM-16 E2.	The SM-3 Block IB failed to intercept the target during its first flight test, resulting in a failure review board investigating the cause of the failure. The flight test is scheduled to be re-conducted in 2012, delaying the certification of the Aegis BMD 4.0.1 weapon system.
Aegis BMD SM-3 Block IIA	None	Subsystem preliminary design review problems led to a program replan that adjusted the preliminary design review date to fiscal year 2012 and included new subsystem reviews for several components. The new subsystem reviews were completed in fiscal year 2011 and early fiscal year 2012.
Aegis BMD SM-3 Block IIB	Awarded three concept definition and program planning contracts in April 2011 and approved to begin technology development in July 2011.	Demonstration of low-cost divert and attitude control system components was delayed until the first quarter of fiscal year 2012.
Aegis Ashore	Completed preliminary design review in August 2011.	A new deckhouse fabrication plan delayed the award of the deckhouse fabrication contract, procurement of deckhouse fabrication materials, and the start of construction.
GMD	Completed three of the five limited interceptor upgrades, partially to resolve component issues identified in developmental testing and manufacturing.	Flight test, FTG-06a, failure in the first quarter of fiscal year 2011 resulted in interceptor production suspension pending the completion of an investigation and a successful nonintercept flight test.

Element	Fully accomplished goals	Partially or not accomplished goals
PTSS	Completed system requirements and system design reviews in the second quarter of fiscal year 2011.	Approval to begin technology development was delayed to the fourth quarter of fiscal year 2012.
Targets	Launched all 11 targets as planned.	Delivered 11 out of 14 targets it had planned.
THAAD	Successfully conducted first operational flight test, FTT-12, in October 2011. Delivered 11 missiles.	Materiel release to Army delayed to the second quarter of fiscal year 2012. THAAD delayed plans to deliver first battery to fiscal year 2012 because of production issues with the interceptor.

Source: GAO analysis of MDA data.

Note: BMDS fiscal year 2011 asset and capability deliveries for Airborne Infrared; Command, Control, Battle Management, and Communications; joint U.S.-Israel BMDS; Sea-based X-band radar; and Space Tracking and Surveillance System elements were not reviewed.

Highlights of progress and challenges this year include the following:

- *Targets*: In prior years, we reported that problems with availability and reliability of targets had caused delays in MDA's test program; however, in fiscal year 2011, MDA delivered 11 short- or intermediate-range targets, and all performed successfully. The targets launched during the year supported tests of several different BMDS elements, including Aegis BMD, GMD, and Patriot systems without causing major delays or failures in flight tests.[5] Among these successful flights was FTX-17, the return-to-flight of MDA's short-range air-launched target in July 2011. This was the target's first launch since an essential mechanism that releases it from the aircraft failed in a December 2009 THAAD flight test. After the failure, the agency identified shortcomings in the contractor's internal processes that had to be fixed before air-launched targets could be used again in BMDS flight tests. Nineteen months later, these deficiencies appeared to be overcome when the target missile was successfully air-launched in FTX-17. To reduce risk, the flight was not planned as an intercept mission but as a target of opportunity for several emerging missile defense technologies including the Space Tracking Surveillance System.

- *Aegis BMD*: In April 2011, the Aegis BMD program demonstrated capability for the first time to intercept an intermediate-range target,

[5] This report does not contain an assessment of the Patriot Advanced Capability-3 because its initial development is complete and it has been transferred to the Army for production, operation, and sustainment.

used remote tracking data provided by an Army/Navy Transportable Radar Surveillance – Model- 2 radar, and demonstrated support for European PAA Phase I. While the Aegis BMD program successfully conducted this test, there was an anomaly in a critical component of the SM-3 Block IA interceptor. Despite the anomaly, the interceptor was able to successfully intercept the target. In September 2011, the Aegis BMD program failed in its first attempted intercept of its SM-3 Block IB missile. During this test—named FTM-16 Event 2—a problem occurred in the interceptor and it failed to intercept the target. The Aegis program has had to add an additional flight test and delay multiple additional flight tests. Program management officials stated the SM-3 Block IA deliveries were suspended and the SM-3 Block IB production was slowed while the failure reviews are conducted.

- *THAAD*: The THAAD program also had some noteworthy testing accomplishments in 2011, successfully conducting its first operational flight test in October 2011.[6] This test was a significant event for the program as it was designed to be representative of the fielded system with soldiers conducting the engagement. During the test, the THAAD system engaged and nearly simultaneously intercepted two short-range ballistic missile targets. However, THAAD also experienced a delay in its planned flight test schedule for fiscal year 2011. A flight test originally scheduled for the second quarter of fiscal year 2011 was delayed until fiscal year 2012 due to the availability of air-launched targets and then subsequently was canceled altogether. This cancellation has delayed verification of THAAD's capability against a medium-range target.

- *GMD*: As has been the case since 2005, testing failures continue to affect the GMD program in fiscal year 2011. Specifically, as a result of the failed flight test in January 2010,[7] MDA added a retest designated as FTG-06a. However, this retest also failed in December 2010 due to a failure in a key component of the kill vehicle. The GMD program has added two additional flight tests in order to demonstrate the Capability Enhancement II (CE-II) interceptor. However, since fiscal year 2009 MDA has already manufactured and delivered 12 interceptors, 2 of

[6] An operational flight test is designed to test the components by having the warfighter utilize them in an operational environment.

[7] This test—FTG-06—was planned as the first test of GMD's enhanced version of the kill vehicle called the Capability Enhancement II.

which have been used in flight tests, prior to halting further deliveries. The manufacture of components related to the failure and delivery of interceptors has been halted while the failure review and resolution actions are ongoing. MDA conducted a failure review investigation throughout fiscal year 2011 and concluded that the CE-II interceptor design does not work as intended and therefore required redesign and additional development. MDA is currently undergoing an extensive effort to overcome the design problem and return to intercept flight tests.

According to a GMD program official, the program has already conducted over 50 component and subcomponent tests to develop a fix and verify the design. MDA also realigned resources from planned 2011 testing activities to fund the investigation and fund return-to-intercept activities including redesign efforts. For example, the program delayed funding the rotation of older fielded interceptors into flight test assets, delayed funding interceptor manufacturing, and delayed purchasing ground-based interceptor (GBI) upgrade kits. However, the agency did continue its efforts to increase reliability of the interceptors through upgrades and its repair of five interceptors to help mitigate the effects on the production line. MDA is planning on upgrading 15 interceptors between fiscal years 2013 to 2017. Additionally, MDA plans to refurbish five older interceptors between 2014 and 2017 to support flight tests.

- *SM-3 Block IIA*: MDA recognized that the program's schedule included elevated acquisition risks and, as such, took actions in fiscal year 2011 to reduce those risks as well as potential future cost growth. The program planned to hold its system preliminary design review (PDR)—at which it would demonstrate that the technologies and resources available for the SM-3 Block IIA would result in a product that matched its requirements—but subsystem review problems for key components meant the system review had to be adjusted by 1 year. The program appropriately added time and money to its program by revising its schedule to relieve schedule compression between its subsystem and system-level design reviews and incorporated lessons learned from other SM-3 variants into its development to further mitigate production unit costs. The program still expects to meet the 2018 time frame for European PAA Phase 3.

Limited Progress in Developing Models and Simulations; Much More Remains to Be Done

Models and simulations are critical to understanding BMDS capabilities. The complex nature of the BMDS, with its wide range of connected elements, requires integrated system-level models and simulations to assess its performance in a range of system configurations and engagement conditions. Assessing BMDS performance through flight tests alone is prohibitively expensive and faces safety and test range limitations that can best be dealt with through sound, realistic models and simulations.

Ensuring that the models and simulations are sound and realistic requires a rigorous process to accomplish two main tasks: (1) developing individual system models and realistically linking those models and simulations and (2) gathering data from MDA's ground and flight tests to feed into the models. MDA attempts to confirm that the models re-create the actual performance found in BMDS test events.[8] The Operational Test Agency (OTA) independently assesses how realistic the models are in a formal process called accreditation. When a model is accredited it means that it can be trusted to produce high-confidence results for its intended use, and the limitations of the model are known. The development of reliable MDA models depends upon the collection of test data upon which to anchor the models. Because MDA had made very limited progress in identifying and collecting needed data, MDA's test program was reoriented beginning in 2010 to enable the collection of data to support the development of BMDS models.

MDA has made some limited progress in developing the individual system models and linking those models. Originally, MDA's models had been developed for use only by each element, not for integrated assessments. MDA is still developing these individual element models, while at the same time linking the models to show BMDS-level performance. Since fiscal year 2010, MDA has made progress in creating a common framework, whereby the various BMDS element-level hardware-in-the-loop[9] models are subjected to a common and consistent scene and environment during test events. MDA is now using this framework, known as the Single Stimulation Framework, in assessing BMDS performance.

[8] This process is called anchoring.

[9] With hardware-in-the-loop models, simulations are conducted with actual mission components/hardware in a laboratory environment, and the physical environment/conditions are simulated, under the control of computer equipment.

MDA officials highlight that the framework is being used to evaluate BMDS performance in increasingly complex and realistic scenarios, employing greater numbers of BMDS assets.

The process of developing and linking these models is extremely complex and difficult and will take many years to accomplish. In August 2009, the U.S. Strategic Command and OTA jointly informed MDA of 39 system-level limitations in MDA's models and simulations program that adversely affect their ability to assess BMDS performance. Resolution of these 39 limitations, OTA maintains, would permit MDA's models and simulations to provide more realistic representations of BMDS performance using the full complement of fielded BMDS assets. OTA officials have noted that since August 2009, MDA has partially or fully resolved 7 of these issues and identified technical solutions for 15 more. According to OTA officials, most of the resolved limitations are issues that are more easily addressed, such as the installation of improved communications systems and the provision of separate workstations for simulation controllers. No technical solutions have yet been identified for the remaining 17 of the 39 issues and OTA officials maintain that they are still awaiting an MDA timeline for the complete resolution of these remaining limitations.

We reported, in 2009, problems with MDA's model development and the lack of flight test data. In 2009, MDA undertook a new approach to test planning to focus the test program on gathering critical test data needed for modeling and simulation. Since 2009, MDA has bolstered efforts to collect test data for the BMDS model and simulation program; however, considerable effort and time are required to address all known shortfalls. Through its ongoing test data collection activities, MDA has collected 309 critical variables since 2009; however, those represent only 15 percent of the total needed. Flight test failures, anomalies and delays have reduced the amount of real-world data MDA expected. Additionally, some required data are difficult to collect, posing challenges even when a flight test is properly executed. When tests are carried out, considerable post-test data analysis is required for model development. Under the current plan, MDA does not foresee complete collection of data on these critical variables until sometime between 2017 and 2022.

MDA has also made some limited progress in achieving partial accreditation for some BMDS models—ensuring that they are realistic and can be trusted and that their limitations are known. MDA models are accredited for specific functions for which they are to be employed. Over the past few years, OTA officials have performed assessments of MDA's models and simulations and have noted that, amongst the element-level models, those for THAAD and Aegis BMD are farthest along. While MDA has made some progress toward accreditation of element models for specific functional areas, MDA has not yet achieved OTA accreditation in other key areas, such as any of the 18 environmental models. See appendix III for further details on MDA's modeling and simulation efforts.

MDA's Highly Concurrent Acquisition Strategy Magnifies the Effects of Tests and Other Problems

To meet the 2002 presidential direction to initially rapidly field and update missile defense capabilities as well as the 2009 presidential announcement to deploy missile defenses in Europe, MDA has undertaken and continues to undertake highly concurrent acquisitions. For example, large-scale acquisition efforts were initiated before critical technologies were fully understood and programs were allowed to move forward into production without having tests completed to verify performance. Such practices enabled MDA to quickly ramp up efforts in order to meet tight presidential deadlines, but they were high risk and resulted in problems that required extensive retrofits, redesigns, delays, and cost increases. A program with high levels of concurrency (1) proceeds into product development before technologies are mature or appropriate system engineering has been completed or (2) proceeds into production before a significant amount of independent testing is conducted to confirm that the product works as intended. High levels of concurrency were present in MDA's initial efforts and are present in current efforts.

Recently, the agency has begun emphasizing the need to follow knowledge-based development practices, which encourage accumulating more technical knowledge before program commitments are made and conducting more testing before production is initiated. Developmental challenges and delays are to be expected in complex acquisitions, such as those for missile defense. However, when concurrency is built into acquisition plans, any developmental challenges or delays that do occur exacerbate the cost, schedule, and performance effects of those problems, particularly when production lines are disrupted or assets have already been manufactured and must be retrofitted. In 2009, we recommended that MDA synchronize the development, manufacturing, and fielding schedules of BMDS assets with the testing and validation schedules to ensure that items are not manufactured for fielding before their performance has been validated through testing. In response, DOD partially concurred with our recommendation, maintaining that MDA was pursuing synchronization of development, manufacturing, and fielding of BMDS assets with its established testing and validation requirements. However, because MDA continues to employ concurrent strategies, it is likely that it will continue to experience these types of acquisition problems.

Highly Concurrent Acquisition Strategies Often Lead to Cost, Schedule, and Performance Consequences

Concurrency is broadly defined as the overlap between technology development and product development or between product development and production of a system. The stated rationale for concurrency is to introduce systems in a timelier manner, to fulfill an urgent need, to avoid technology obsolescence and to maintain an efficient industrial development and production workforce. While some concurrency is understandable, committing to product development before requirements are understood and technologies 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.[10] At the very least, a highly concurrent strategy forces decision makers to make key decisions without adequate information about the weapon's demonstrated operational effectiveness, reliability, logistic supportability, and readiness for production. Also, starting production before critical tests have been successfully completed has resulted in the purchase of systems that do not perform as intended. These premature commitments mean that a substantial commitment to production has been made before the results of testing are available to decision makers. Accordingly, they create pressure to keep producing to avoid work stoppages even when problems are discovered in testing. These premature purchases have affected the operational readiness of our forces and quite often have led to expensive modifications.

In contrast, successful programs that deliver promised capabilities for the estimated cost and schedule follow a systematic and disciplined knowledge-based approach. This approach recognizes that development programs require an appropriate balance between schedule and risk and, in practice, programs can be executed successfully with some level of concurrency. For example, it is appropriate to order long-lead production material in advance of the production decision, with the pre-requisite that developmental testing is substantially accomplished and the design

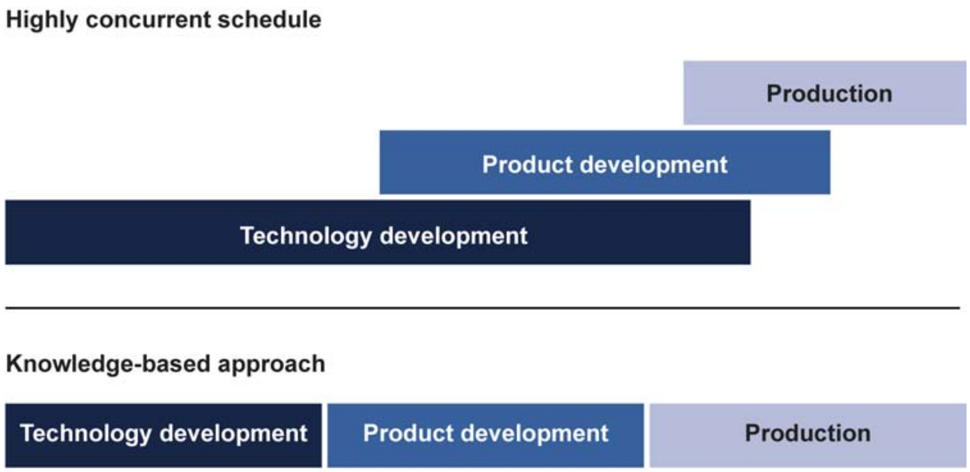
[10] GAO, *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, GAO-02-701 (Washington, D.C.: July 15, 2002), and *Defense Acquisitions: Production and Fielding of Missile Defense Components Continue with Less Testing and Validation Than Planned*, GAO-09-338 (Washington, D.C.: Mar. 13, 2009).

confirmed to work as intended. We have found that, in this approach, high levels of product knowledge are demonstrated at critical points in development.[11] This approach is not unduly concurrent because programs take steps to gather knowledge that demonstrates that their technologies are mature, their designs are stable, and their production processes are in control before transitioning between acquisition phases. This knowledge helps programs identify risks early and address them before they become problems. It is a process in which technology development and product development are treated differently and managed separately. The process of technology development culminates in discovery—the gathering of knowledge—and must, by its very nature, allow room for unexpected results and delays. The process of developing a product culminates in delivery and therefore gives great weight to design and production. If a program is falling short in technology maturity, it is harder to achieve design stability and almost impossible to achieve production maturity. It is therefore key to separate technology from product development and product development from production—in other words, it is key to avoid concurrency when these transitions are made. The result of a knowledge-based approach is a product delivered on time, within budget, and with the promised capabilities.

See figure 1 for depictions of a concurrent schedule and a schedule that uses a knowledge-based approach.

[11] GAO, *Defense Acquisitions: Assessments of Selected Major Weapon Programs*, GAO-06-391 (Washington, D.C.: Mar. 31, 2006).

Figure 1: Concurrency Compared to the Knowledge-Based Approach



Source: GAO analysis.

Programs That Undertook Highly Concurrent Strategies and Consequences

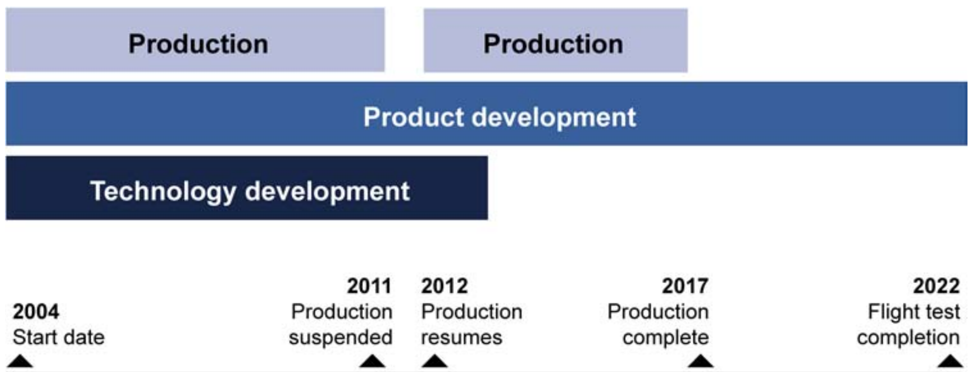
In fiscal year 2011, due to flight test failures and a flight test anomaly, MDA suspended production of two interceptors—one in the GMD program and one in the Aegis BMD program—and slowed production of a third—in the Aegis BMD program. In addition, development problems with a key THAAD component disrupted that program's interceptor production.

Ground-based Midcourse Defense

MDA undertook a highly concurrent acquisition strategy to meet the President's 2002 directive to deploy an initial set of missile defense capabilities by 2004. To do so, the GMD element concurrently matured technology, designed the system, tested the design, and produced and fielded a system. While this approach allowed GMD to rapidly field a limited defense that consisted of five CE-I interceptors and a fire control system, the concurrency resulted in unexpected cost increases, schedule delays, test problems, and performance shortfalls. Since then, MDA has produced and emplaced all of its planned CE-I interceptors. To address issues with the CE-I interceptors, MDA has undertaken an extensive retrofit and refurbishment program.

Prior to MDA fully completing development and demonstrating the capability of the initial interceptor, MDA committed in 2004 to another highly concurrent development, production, and fielding strategy for an enhanced version of the interceptor—CE-II—as shown in figure 2.[12]

Figure 2: GMD Concurrent Schedule



Source: GAO analysis of MDA data.

Note: CE-I development began in 1996—the first interceptor was delivered in 2004, the first intercept was completed in 2006, delivery was completed in first quarter of 2009.Testing continues.

MDA proceeded to concurrently develop, manufacture, and deliver 12 of these interceptors before halting manufacture of components and delivery of interceptors in 2011 due to the failure in FTG-06a.[13] Although MDA had not successfully tested this interceptor, failing in both its attempts, it manufactured and delivered 12 of these interceptors.

The discovery of the design problem while production is under way has increased MDA costs, led to a production break, may require retrofit of fielded equipment, delayed delivery of capability to the war-fighter, and altered the flight test plan. For example, the flight testing cost to confirm the CE-II capability has increased from $236 million to about $1 billion.[14]

[12] An interceptor is composed of two main components: the booster and an exoatmospheric kill vehicle. The CE-II upgrade was intended to update certain components, some of which were becoming obsolete. However, updating those components changed the performance of the interceptor and remains a substantial developmental challenge.

[13] MDA officials stated that the agency is allowing the contractor to continue work on those components of the EKV that would not be factors in the FTG-06a flight test failure in order to keep the production line moving.

[14] These costs include the target, mission planning, range support, and post-test analysis.

In addition, the program will have to undertake another retrofit program, for the 10 CE-II interceptors that have already been manufactured.[15] According to a GMD program official, although the full cost is currently unknown, he expects the cost to retrofit the CE-II interceptors to be around $18 million each or about $180 million for all 10. Intended to be ready for operational use in fiscal year 2009, it will now be at least fiscal year 2013 before the warfighter will have the information needed to determine whether to declare the variant operational.

The GMD flight test program has been disrupted by the two back to back failures. For example, MDA has restructured the planned multiyear flight test program in order to test the new design prior to an intercept attempt. MDA currently plans to test the new design in a nonintercept test in fiscal year 2012.

Because MDA prematurely committed to production before the results of testing were available, it has had to take steps to mitigate the resulting production break, such as accelerating retrofits to 5 of the CE-I interceptors. Program officials have stated that if the test confirms that the cause of the failure has been resolved, the program will restart the manufacturing and integration of the CE-II interceptors. According to MDA, because of the steps taken to develop and confirm the design change, a restart of the CE-II production line at that time will be low risk. However, while MDA has established a rigorous test plan to confirm that the design problem has been overcome, the confirmation that the design works as intended through all phases of flight, including the actual intercept, will not occur until an intercept test—FTG-06b—currently scheduled for the end of fiscal year 2012 or the beginning of fiscal year 2013.

High levels of concurrency will continue for the GMD program even if the next two flight tests are successful. GMD will continue its developmental flight testing until at least 2022, well after production of the interceptors are scheduled to be completed. MDA is accepting the risk that these developmental flight tests may discover issues that require costly design changes and retrofit programs to resolve. As we previously reported, to date all GMD flight tests have revealed issues that led to either a

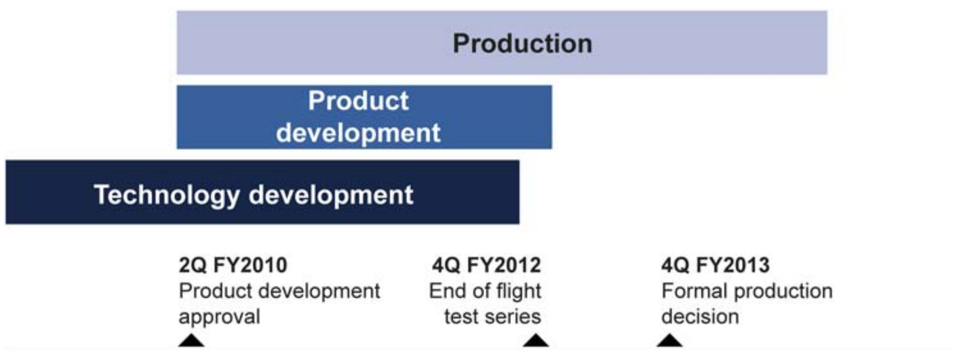
[15] Since fiscal year 2009 MDA has manufactured and delivered 12 interceptors, 2 of which have been used in flight tests.

hardware or software change to the ground-based interceptors.[16] See appendix VIII for more details on the GMD program.

Aegis BMD SM-3 Block IB

The SM-3 Block IB program, the second version of the SM-3 interceptor, is facing both developmental and production challenges that are exacerbated by its concurrent schedule, as shown in figure 3. This interceptor shares many components with the SM-3 Block IA, but the kinetic warhead is new technology that is being developed. The need to meet the presidential directive to field the Aegis BMD 4.0.1/SM-3 Block IB by the 2015 time frame for European missile defense is a key driver for the high levels of concurrency.

Figure 3: SM-3 Block IB Concurrent Schedule



Source: GAO analysis of MDA data.

In response to previous developmental problems and to prevent a production break, MDA has twice had to purchase additional SM-3 Block IA interceptors and faces a similar decision in fiscal year 2012. According to MDA, the additional SM-3 Block IA missiles were purchased to avoid a production gap as well as to keep suppliers active, and to meet combatant command SM-3 missile quantity requirements. The program, according to program management officials, was scheduled to purchase the last SM-3 Block IA in fiscal year 2010 and transition to procurement production of the SM-3 Block IB missiles in fiscal year 2011.

MDA began purchasing the SM-3 Block IB in 2009 beyond the numbers needed for flight testing while a critical maneuvering technology was

[16] GAO-11-372.

immature and prior to a successful flight test. According to the Director, MDA these missiles support development and operational testing; prove out manufacturing processes; provide information on reliability, maintainability and supportability; verify and refine cost estimates; and ensure that the missile will meet its performance requirements on a repeatable basis. MDA has determined that 18 of the 25 SM-3 Block IB missiles ordered are to be used for developmental testing; the remaining 7 interceptors are currently unassigned for tests and may be available for operational use.[17] According to program management officials, these unassigned rounds represent a small portion of the total planned purchases.

MDA is also planning to purchase 46 additional SM-3 Block IB missiles in fiscal year 2012. Meanwhile, testing has yet to validate the missile's performance, the cause of the test failures is not yet determined, and remaining tests may not be completed until 2013. Consequently, purchasing additional interceptors beyond those needed for development remains premature. The first SM-3 Block IB developmental flight test failed in September 2011, and an anomaly occurred in an April 2011 flight test of the SM-3 Block IA. The flight test failure and the test anomaly occurred in components that are shared between the SM-3 Block IA and IB. Program officials are still investigating the reason for these failures. The program was unable to validate initial SM-3 Block IB capability during the failed September test, and program officials hope to conduct a series of three intercept tests in fiscal year 2012 needed to validate SM-3 Block IB capability. Depending on the timing and content of the failure review board results, this schedule could change further.

Any SM-3 Block IB missiles ordered in fiscal year 2012 before mitigations for the anomaly and the failure, if needed, are determined and before the three flight tests confirm the design works as intended would be at higher risk of cost growth and schedule delays. In addition, SM-3 Block IB missiles already manufactured but not delivered also are at higher risk of requiring a redesign depending on the results of the failure review. Program management officials stated MDA has slowed SM-3 Block IB manufacturing until the outcome of the failure review board is known. It

[17] Six of the 18 missiles will not be needed for developmental tests until fiscal year 2015 or later. SM-3 Block IB missiles are used for developmental tests of the SM-3 Block IB and Aegis Weapons System 4.0.1 program and are planned for use in developmental tests for Aegis Ashore and Aegis Weapons System 5.0.

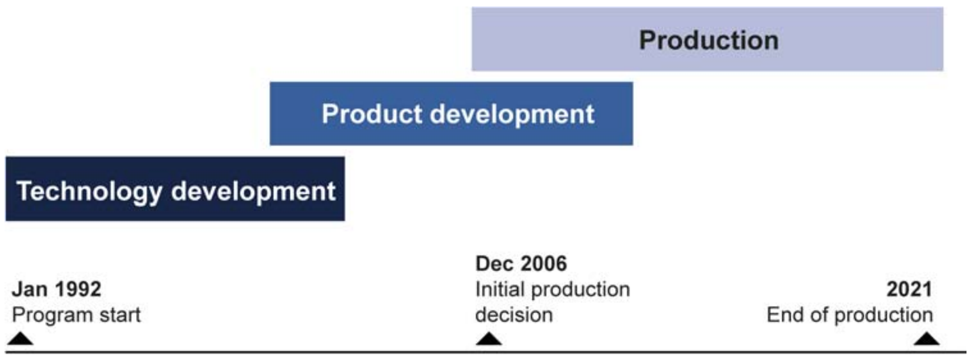
remains unclear whether the additional 46 missiles will be ordered before the failure reviews are complete and the interceptor is able to demonstrate that it works as intended. Recognizing the critical importance of the completing the planned fiscal year 2012 intercept tests, the operational need for SM-3 missiles, the relative success of the SM-3 Block IA, as well as the potential for a production break, the Senate Committee on Appropriations directed MDA to use the fiscal year 2012 SM-3 Block IB funds for additional Block IA missiles should the test and acquisition schedule require any adjustments during fiscal year 2012. However, a decision to purchase additional SM-3 Block IA missiles in fiscal year 2012 to help avoid a production break may be affected by the SM-3 Block IA failure investigation that has not yet been completed. Program management officials stated most deliveries of the SM-3 Block IA have been suspended pending the results of the failure review.

See appendix IV for more details on the Aegis BMD SM-3 Block IB program.

Terminal High Altitude Area Defense

MDA awarded a contract to produce THAAD's first two operational batteries in December 2006 before its design was stable and developmental testing of all critical components was complete. As a result, the THAAD program has experienced unexpected cost increases, schedule delays, test problems, and performance shortfalls. At that time, MDA's first THAAD battery, consisting of 24 interceptors, 3 launchers, and other associated assets, was to be delivered to the Army as early as 2009. In response to pressure to accelerate fielding the capability, THAAD adopted a highly concurrent development, testing, and production effort that has increased program costs and delayed fielding of the first THAAD battery until early fiscal year 2012. (See fig. 4.)

Figure 4: THAAD Concurrent Schedule



Source: GAO analysis of MDA data.

Problems encountered while THAAD was concurrently designing and producing assets increased costs by $40 million and caused slower delivery rates of both the first and second THAAD batteries. These batteries are not projected to be complete before July 2012—16 months after the original estimate of March 2011. While all assets except the interceptors were complete in 2010, the first operational interceptor for the first THAAD battery was not produced until the second quarter of fiscal year 2011. At the same time, MDA committed to purchasing more assets by signing a production contract for two additional THAAD batteries, despite incomplete testing and qualification of a safety device on the interceptor. During fiscal year 2011, after several production start-up issues, 11 of the expected 50 operational interceptors were delivered.[18] Consequently, the first battery of 24 interceptors was not complete and available for fielding until the first quarter of fiscal year 2012—more than 2 years later than originally planned. The same issues have delayed the second battery as well. Although the launchers and other components for the second battery were completed in 2010, the full 50 interceptors necessary for both batteries are not expected to be delivered until July 2012.

Newer Programs Continue High Levels of Concurrency

MDA has taken steps to incorporate some acquisition best practices in its newer programs, such as increasing competition and partnering with laboratories to build prototypes. However, the SM-3 Block IIB, Aegis Ashore, and the PTSS program acquisition strategies still include high or elevated levels of concurrency that set the programs up for increased acquisition risk, including cost growth, schedule delays, and performance shortfalls.

- *SM-3 Block IIB*: The program has high levels of concurrency because it plans to commit to product development prior to holding a PDR, as depicted in figure 5.

[18] Twelve total interceptors were delivered by the end of fiscal year 2011, but the first, produced in fiscal year 2010, was used in a flight test.

Figure 5: SM-3 Block IIB Concurrent Schedule

Source: GAO analysis of MDA data.

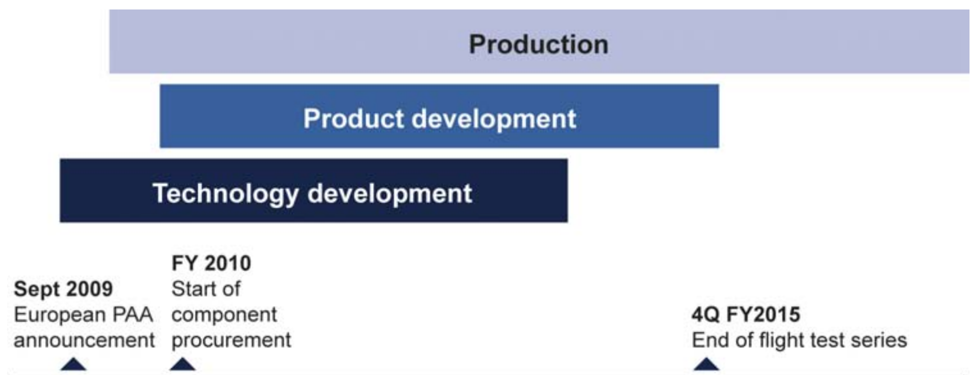
Note: Given the early stage of the program, which does not yet have a baselined schedule, we are not able to depict the production plans or the end of the product development phase for the SM-3 Block IIB.

The need to meet the 2020 time frame announced by the President to field the SM-3 Block IIB for European PAA Phase IV is a key driver for the high levels of concurrency. The program is following some sound acquisition practices by awarding competitive contracts to multiple contractors to develop options for missile configurations and mature key technologies as well as planning to compete the product development contract. However, while the program is holding a series of reviews that will provide engineering insight into the SM-3 Block IIB design, we have previously reported that before starting development, programs should hold key system engineering events, culminating in the PDR, to ensure that requirements are defined and feasible and that the proposed design can meet those requirements within cost, schedule, and other system constraints.[19] In addition, based on the initial schedule developed by the program and prior history of SM-3 interceptor development, the SM-3 Block IIB program will need to commit to building the first flight test vehicle prior to holding the PDR in order to remain on the planned test schedule. According to MDA, this approach is a low risk development if the program is funded at requested levels. The agency stated that the achievement of an initial operating capability will be based on technical progress and execution of a "fly before buy" approach.

[19] GAO, *Defense Acquisitions: Assessments of Selected Weapons Programs*, GAO-11-233SP (Washington, D.C.: Mar. 29, 2011).

- *Aegis Ashore*: The program initiated product development and established a cost, schedule, and performance baseline early; included high levels of concurrency in its construction and procurement plan; and has not aligned its flight testing schedule with construction and component procurement decisions. The need to meet the 2015 time frame announced by the President to field the Aegis Ashore for European PAA Phase II is a key driver for the high levels of concurrency. The high levels of concurrency are depicted in figure 6.

Figure 6: Aegis Ashore Concurrent Schedule



Source: GAO analysis of MDA data.

Aegis Ashore began product development and set the acquisition baseline before completing the PDR. This sequencing increased technical risks and the possibility of cost growth by committing to product development with less technical knowledge than recommended by acquisition best practices and without ensuring that requirements were defined, feasible, and achievable within cost and schedule constraints.

The program has initiated procurement of components for the installation and plans to start fabricating two enclosures called deckhouses—one for operational use at the Romanian Aegis Ashore installation and one for testing at the Pacific Missile Range Facility—in fiscal year 2012, but does not plan to conduct the first intercept test of an integrated Aegis Ashore installation until fiscal year 2014. Further, the program plans to build the operational deckhouse first, meaning any design modification identified through system testing in the test deckhouse or the intercept test will need to be made on an existing deckhouse and equipment. As we have previously reported, such modifications on an existing fabrication may be costly.

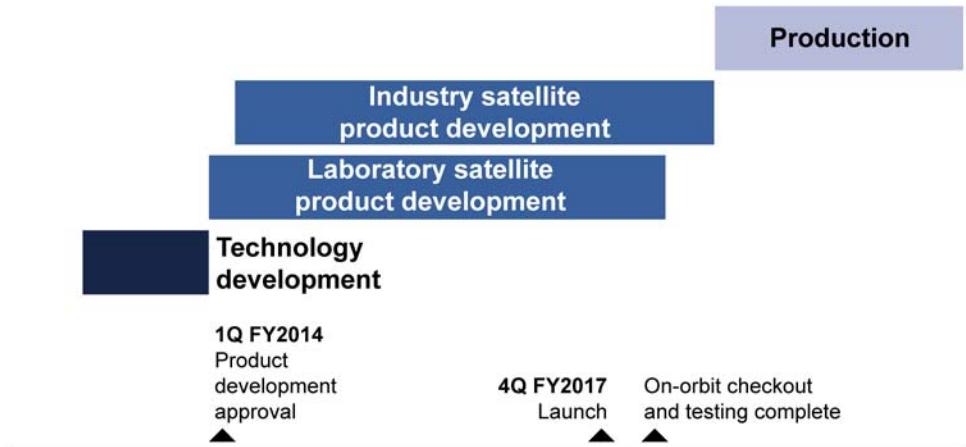
According to the Director of MDA, Aegis Ashore is a land adaptation of the Aegis weapons system sharing identical components. However, we previously have reported on the modifications to existing Aegis BMD technology that must be made to operate in a new land environment.[20] In addition, some of the planned components for Aegis Ashore are being developed for future Aegis weapon system upgrades and are still undergoing development. Aegis BMD program management officials stated that the risks of concurrency in the program schedule are low due to the program's reliance on existing technology and the ground testing that will be completed prior to the first intercept test. Nevertheless, the program has a limited ability to accommodate delays in construction or testing.

- *PTSS:* MDA approved a new acquisition strategy for PTSS in January 2012 that acknowledges some concurrency, but program officials stated that they have taken steps to mitigate the acquisitions risks and have worked to incorporate several aspects of acquisition best practices into the strategy. MDA plans to develop and acquire the satellites in three phases. First, a laboratory-led contractor team will build two lab development satellites. Second, an industry team, selected through open competition while the laboratory team is still in a development phase, will develop and produce two engineering and manufacturing development satellites. The two laboratory-built and the two industry-built development satellites are planned to be operational. Third, there will be a follow-on decision for the industry team to produce additional satellites in a production phase.

  While the strategy incorporates several important aspects of sound acquisition practices, such as competition and short development time frames, there remains elevated acquisition risks tied to the concurrency between the lab- and industry-built developmental satellites, as shown in figure 7.

[20] GAO-11-372.

Figure 7: PTSS Concurrent Schedule



Source: GAO analysis of MDA data.

Because the industry-built developmental satellites will be under contract and under construction before on-orbit testing of the lab-built satellites, the strategy may not enable decision makers to fully benefit from the knowledge about the design to be gained from that on-orbit testing before making major commitments.

See appendixes for more details on each program.

Conclusions

MDA has a long history of pursuing highly concurrent acquisitions in order to meet challenging deadlines set by the administration. Concurrency can enable rapid acquisition of critical capabilities but at a high risk, particularly if technologies are not well understood at the outset of a program, requirements are not firm, and decisions are made to keep moving a program forward without sufficient knowledge about issues, such as design, performance, and producibility. In MDA's case, many of its highly concurrent acquisition programs began with many critical unknowns. While the developmental problems that have been discovered in these acquisitions are inherent in complex and highly technical efforts, the effects were considerably magnified due to the high levels of concurrency, including questions about the performance of fielded assets, significant disruptions to production, and expensive retrofits. While MDA has embraced the value of reducing unknowns before making key decisions in some of its newer programs, such as the SM-3 Block IIA, and adopted good practices, such as awarding competitive contracts to multiple contractors in the SM-3 Block IIB program, it has continued to plan and implement highly concurrent approaches in others. In fact, today, MDA is still operating at a fast pace, as production and fielding of assets remains, in many cases, ahead of the ability to test and validate them.

As we recommended in 2009, these disruptions can only be avoided when the development, manufacture, and fielding schedules of BMDS assets are synchronized with the testing and validation schedules to ensure that items are not approved to be manufactured for fielding before their performance has been validated through testing. Moreover, as we have concluded for several years, while concurrency was likely the only option to meet the tight deadlines MDA has been directed to work under, having an initial capability in place should now allow the agency to construct acquisition approaches that are less risky from a cost, schedule and performance perspective. Near-term steps MDA can take to reduce cost, schedule, and performance risks include actions such as demonstrating the second GMD interceptor can work as intended before resuming production and verifying that the SM-3 Block IB completes developmental flight tests before committing to additional production. Longer-term solutions require the Office of the Secretary of Defense to assess the level of concurrency that currently exists within MDA programs and where that concurrency can be reduced. Moreover, while missile defense capabilities play a vital role in the United States' national security and international relationships, decisions about deadlines for delivering capabilities need to be weighed against the costs and risks of highly concurrent approaches.

Recommendations for Executive Action

We recommend that the Secretary of Defense take the following seven actions to reduce concurrency and strengthen MDA's near- and long-term acquisition prospects. To strengthen MDA's near-term acquisition prospects, we recommend that the Secretary of Defense:

For the GMD program, direct MDA to

1) demonstrate that the new CE-II interceptor design works as intended through a successful intercept flight test in the operational environment—FTG-06b—prior to making the commitment to restart integration and production efforts and

2) take appropriate steps to mitigate the effect of delaying the CE-II production restart until a successful intercept occurs. Specific consideration should be given by MDA to accelerating additional needed CE-I refurbishments.

For the Aegis BMD program, direct MDA to

3) verify the SM-3 Block IB engagement capability through the planned three developmental flight tests before committing to additional production beyond those needed for developmental testing and

4) report to the Office of the Secretary of Defense and to Congress the root cause of the SM-3 Block IB developmental flight test failure, path forward for future development, and the plans to bridge production from the SM-3 Block IA to the SM-3 Block IB before committing to additional purchases of the SM-3 Block IB.

For the SM-3 Block IIB program, direct MDA to

5) ensure that the SM-3 Block IIB requirements are defined and feasible and that the proposed design can meet those requirements within cost, schedule, and other system constraints by delaying the commitment to product development until the program completes a successful preliminary design review.

To strengthen MDA's longer-term acquisition prospects, we recommend that the Secretary of Defense:

6) Direct the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics to review all MDA acquisitions for concurrency, and determine whether the proper balance has been struck between the planned deployment dates and the concurrency risks taken to achieve those dates.

7) Direct the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics to review and report to the Secretary of Defense the extent to which the capability delivery dates announced by the President in 2009 are contributing to concurrency in missile defense acquisitions and recommend schedule adjustments where significant benefits can be obtained by reducing concurrency.

Agency Comments and Our Evaluation

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

In responding to a draft of this report, DOD concurred with six of our seven recommendations and commented on actions in process or planned in response. In some cases, these actions are responsive to immediate problems, but do not appear to consistently address the implications for concurrency in the future.

DOD concurred with our recommendation for the GMD program to demonstrate that the new CE-II interceptor design works as intended through a successful intercept flight test in the operational environment—FTG-06b—prior to making the commitment to restart integration and production efforts. In response to this recommendation, DOD stated that the program plans to restart the CE-II manufacturing upon successful completion of the FTG-06b flight test. This decision will reduce the risk of prematurely restarting CE-II production.

DOD also concurred with our recommendation for the Aegis BMD program to verify the SM-3 Block IB engagement capability through the planned three developmental flight tests before committing to additional production, stating that the final decision to purchase SM-3 Block IB missiles with DOD-wide procurement funding will be made after the next three planned flight tests. We remain concerned that MDA is planning to purchase 46 additional SM-3 Block IB missiles prematurely using research, development, test, and evaluation funds in fiscal year 2012 before validating the performance of the missile and before determining the root cause of test failures—risking disrupting the supply chain if testing reveals the need to make design changes. We continue to believe that the program should not purchase any additional missiles, regardless of the type of funding used to purchase them, until the SM-3 Block IB's engagement capability has been verified through the three developmental flight tests currently planned for the program. We have modified the recommendation to focus on verifying the capability before committing to additional production beyond the missiles needed for developmental testing.

DOD concurred with our recommendation to direct the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics to review all MDA acquisitions for concurrency, and determine whether the proper balance has been struck between the planned deployment dates and the concurrency risks taken to achieve those dates. In its response, DOD stated that it will wait until fielding dates are established to undertake concurrency assessments, and in the interim it will ensure that knowledge is gained to support capability deliveries. However, we remain concerned that DOD continues to focus on gaining key acquisition knowledge much later than needed. DOD's approach is to understand the extent to which the design works as intended after committing to production—a high-risk strategy—rather than before committing to production. The assessment of concurrency should precede and should inform the setting of fielding dates. If the department waits until fielding dates are set to assess concurrency in the BMDS, it will miss the opportunity and accept the performance, cost, and schedule consequences. Our position is not unique in this regard. In recent testimony, the Acting Under Secretary of Defense for Acquisition, Technology and Logistics confirmed that excessive concurrency can drive cost growth and result in major schedule disruptions that produce further inefficiency. Noting that the acceptable degree of concurrency between development and production depends on a range of factors, including the risk associated with the development phase, the urgency of the need, and the likely impact on cost and schedule of realizing that risk, he stated that the Office of the Secretary of Defense intends to assess the levels of concurrency within programs, as our report recommends should be done for missile defense elements.

DOD also concurred with our recommendation to direct the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics to review and report to Secretary of Defense the extent to which the presidentially announced capability delivery dates are contributing to concurrency in missile defense acquisitions and recommend schedule adjustments where significant benefits can be obtained by reducing concurrency. DOD stated that the current missile defense program is structured to develop and field capabilities at the earliest opportunity while taking into account prudent risk management practices and executing a thorough test and evaluation program. The department further noted that when fielding dates are established, the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics will review and report to the Secretary of Defense the extent to which presidentially announced capability dates may be contributing to concurrency in missile defense acquisitions and recommend schedule adjustments if significant benefits can be obtained by reducing concurrency. Given the amount of concurrency we have found in our reviews of the BMDS, we believe that significant benefits can be reaped if concurrency is assessed sooner rather than later.

DOD partially concurred with our recommendation to report to the Office of the Secretary of Defense and to Congress the root cause of the SM-3 Block IB developmental flight test failure, path forward for future development, and the plans to bridge production from the SM-3 Block IA to the SM-3 Block IB before committing to additional purchases of the SM-3 Block IB. DOD commented that MDA will report the root cause of the SM-3 Block IB test failure and the path forward for future development to the Office of the Secretary of Defense and to Congress upon completion of the failure review in the third quarter of fiscal year 2012. However, DOD makes no reference to delaying additional purchases until the recommended actions are completed, instead stating that MDA is balancing the need to demonstrate technical achievement and also ensure that the system is thoroughly tested before fielding with the need to keep the industrial base and supply chain healthy to ensure that production transitions as quickly as possible. We believe that an appropriate balance between schedule and risk is necessary for development programs. However, our analysis has shown that MDA undertakes acquisition strategies of accelerated development and production that have led to disruptions in the supply chain and have increased costs to develop some BMDS assets. We maintain our position that MDA should take the recommended actions before committing to additional purchases of the SM-3 Block IB.

We are sending copies of this report to the Secretary of Defense and to the Director of 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 XII.

Cristina Chaplain
Director
Acquisition and Sourcing Management

List of Committees

The Honorable Carl Levin
Chairman
The Honorable John McCain
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Daniel K. Inouye
Chairman
The Honorable Thad Cochran
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Howard P. McKeon
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable C.W. Bill Young
Chairman
The Honorable Norman D. Dicks
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Scope and Methodology

To assess the Missile Defense Agency's (MDA) cost, schedule, testing and performance progress, we reviewed the accomplishments of eight Ballistic Missile Defense System (BMDS) elements that MDA is currently developing and fielding: the Aegis Ballistic Missile Defense (Aegis BMD) with Standard Missile-3 Block IA and Block IB; Aegis Ashore; Aegis BMD Standard Missile-3 Block IIA; Aegis BMD Standard Missile-3 Block IIB; Ground-based Midcourse Defense (GMD); Precision Tracking and Space System (PTSS); Targets and Countermeasures; and Terminal High Altitude Area Defense (THAAD).[1] We developed data collection instruments (DCI) that were completed by the elements' program offices and reviewed the individual element responses. These instruments collected detailed information on schedule, cost and budget, contracts, testing and performance, and noteworthy progress during the fiscal year. We also examined the cost and resource, schedule, and test baselines as presented in the BMDS Accountability Report (BAR),[2] Baseline and Program Execution Reviews, test schedules and reports, and production plans. The results of these reviews are presented in detail in the element appendixes of this report and are also integrated as appropriate in our findings. We also interviewed officials within program offices and within MDA functional directorates, such as the Directorates for Engineering and Testing. We discussed the elements' test programs and test results with the BMDS Operational Test Agency and the Department of Defense's Office of the Director, Operational Test and Evaluation.

To assess whether MDA elements delivered assets and achieved self-identified capability goals as planned in fiscal year 2011, we examined the 2011 BAR, and compared it to the 2010 and 2009 versions, looking for similarities and differences between the three. We also reviewed MDA briefings to congressional staffers from March 2011 and responses to our DCIs, which detailed key accomplishments and asset deliveries for fiscal year 2011. To assess progress on MDA's development of models and simulations, we held discussions with officials at the Missile Defense

[1] The BMDS also includes other elements and supporting efforts such as the Command, Control, Battle Management, and Communications and BMDS Sensors which are not covered in this report. For this report, we selected and focused our efforts on eight of the BMDS elements based on Congressional interest, known acquisition challenges and successes, and the current status of these efforts.

[2] MDA issued an updated test baseline in March 2012, but we did not include it as part of this review because we received it at the end of our audit and did not have time to assess it. Our next assessment will include this updated test baseline.

Integration and Operations Center, and the Operational Test Agency, and reviewed budget documents and MDA's directive on modeling and simulation verification, validation, and accreditation.

Our work was performed at MDA headquarters in Fort Belvoir, Virginia, and in Dahlgren, Virginia; Alexandria, Virginia; Falls Church, Virginia; Annapolis, Maryland; Colorado Springs, Colorado; Arlington, Virginia; and at various program offices and contractor facilities located in Huntsville, Alabama, and Tucson, Arizona. In Fort Belvoir, we met with officials from the GMD program office and the Advanced Technology Directorate who manage the Aegis BMD Standard-Missile 3 Block IIB program. In Dahlgren, we met with officials from the Aegis BMD program office, the Aegis Ashore program office, and the Aegis Standard-Missile 3 Block IIA program office. In Alexandria, we met with the Director, Operational Test and Evaluation, and officials from the Institute for Defense Analysis. In Falls Church, we met with officials from the PTSS program office. In Arlington, we met with the Director, Developmental Test and Evaluation, the Missile Defense Executive Board, officials in the Pentagon Office of Strategic Warfare, and the Cost Analysis and Program Evaluation group. In Annapolis, we met with officials from the Defense Spectrum Organization/Joint Spectrum Center.

In Huntsville, we interviewed officials from the Airborne Infrared program office; the Terminal High Altitude Area Defense project office; the Targets and Countermeasures program office; and MDA's Acquisitions Directorate, Programs and Integration Directorate, Engineering Directorate, Test Directorate, Cost Directorate, and Advanced Technologies Directorate. We also met with Boeing officials in Huntsville to discuss the failure review investigation for the FTG-06a failure, and their plan to resolve the resulting manufacturing stop. In addition, we met with officials from the Operation Test Agency in Huntsville to discuss MDA's performance assessment, as well as models and simulations.

In Colorado Springs, we met with officials from U.S. Northern Command, the Joint Functional Component Command for Integrated Missile Defense, and the Missile Defense Integration and Operations Center. We met with Raytheon and Defense Contract Management Agency officials in Tucson to discuss the manufacturing of the exoatmospheric kill vehicle and schedule issues for GMD, respectively.

We conducted this performance audit from April 2011 to April 2012 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.

Appendix II: Comments from the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE
3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

APR 12 2012

Ms. Cristina 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-12-486, "MISSILE DEFENSE: Opportunity Exists to Strengthen Acquisitions by Reducing Concurrency," dated March 12, 2012 (GAO Code 120996).

The DoD concurs with six of the draft report's recommendations and partially-concurs with one. The rationale for our position is included in the enclosure. I submitted separately a list of technical and factual errors for your consideration.

We appreciate the opportunity to comment on the draft report. My point of contact for this effort is Lt Col Peter Jackson, 703-695-7328, Peter.Jackson@osd.mil.

Sincerely,

David G. Ahern
Deputy Assistant Secretary of Defense
Strategic and Tactical Systems

Enclosure:
As stated

GAO Draft Report Dated MARCH 12, 2012
GAO-12-486 (GAO CODE 120996)

"MISSILE DEFENSE: OPPORTUNITY EXISTS TO STRENGTHEN ACQUISITIONS BY REDUCING CONCURRENCY"

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATIONS

RECOMMENDATION 1: To strengthen the Missile Defense Agency (MDA's) near-term acquisition prospects for the Ground-based Midcourse Defense (GMD) program, the GAO recommends that the Secretary of Defense direct MDA to demonstrate that the new Capability Enhancement-II (CE-II) interceptor design works as intended through a successful intercept flight test in the operational environment- Flight Test GMD-06B- prior to making the commitment to restart integration and production efforts.

DoD RESPONSE: Concur. Flight Test GMD-06B is currently scheduled for 2nd Qtr FY13. After successful completion of this test, GMD plans to restart the CE-II manufacturing line.

RECOMMENDATION 2: To strengthen the MDA's near-term acquisition prospects for the GMD program, the GAO recommends that the Secretary of Defense direct MDA to take appropriate steps to mitigate the effect of delaying the CE-II production restart until a successful intercept occurs. Specific consideration should be given by MDA to accelerating additional CE-I refurbishments.

DoD RESPONSE: Concur. Since CE-II manufacturing was stopped (2^{nd} quarter FY 2011), GMD completed five CE-I upgrades (three in FY 2011 and two in FY 2012). Current schedule is to complete three more CE-I upgrades in CY 2012.

RECOMMENDATION 3: To strengthen the MDA's near-term acquisition prospects for the Aegis Ballistic Missile Defense (Aegis BMD) program, the GAO recommends that the Secretary of Defense direct MDA to verify the Standard Missile-3 (SM-3) Block IB engagement capability through the planned three developmental flight tests before committing to additional production.

DoD RESPONSE: Concur. The final decision to purchase SM-3 Block IB missiles with Defense Wide Procurement funding will be made after the next three planned flight tests. Missiles being manufactured today are part of the development program. Such action is in accordance with last year's GAO recommendation (GAO-11-372) to stabilize MDA's Test Plan to have sufficient spare test assets to absorb test failures and delays.

RECOMMENDATION 4: To strengthen the MDA's near-term acquisition prospects for the Aegis BMD program, the GAO recommends that the Secretary of Defense direct MDA to report to OSD and to Congress the root cause of the SM-3 Block IB developmental flight test failure, path forward for future development and the plans to bridge production from the SM-3 Block 1A to the SM-3 1B before committing to additional purchases of the SB-3 Block 1B.

DoD RESPONSE: Partially Concur. The MDA will report root cause of SM-3 Block IB test failure and the path forward for future development to OSD and Congress upon completion of the failure review in the third quarter of FY 2012. As a matter of frequent command interface, MDA has briefed OSD and all Congressional Defense Committees on the initial SM-3 Block IB failure analysis and path forward, and provided situational updates. As part of the path forward and plans to fulfill the COCOMs' demand for more sea-based BMD missiles, the missile buy and deliver strategy will address plans to bridge production from the SM-3 Block IA to the SM-3 Block IB that includes a purchase of SM-3 Block IB missiles in FY 2013. MDA is balancing the need to demonstrate technical achievement and ensuring the system is thoroughly tested before fielding with the need to keep the industrial base and supply chain healthy to ensure production transition as quickly as possible. (Reference: Director's testimony to Senate Appropriations Defense Subcommittee on May 25, 2011.)

RECOMMENDATION 5: To strengthen the MDA's near-term acquisition prospects for the SM-3 Block IIB program, the GAO recommends that the Secretary of Defense direct MDA to ensure that the SM-3 Block IIB requirements are defined and feasible and that the proposed design can meet those requirements within cost, schedule, and other system constraints by delaying the commitment to product development until the program completes a successful preliminary design review.

DoD RESPONSE: Concur. The Aegis BMD program office is planning for the SM-3 Block IIB Product Development acquisition. The Agency currently plans to competitively select one contractor to complete design of the interceptor through a disciplined series of Preliminary Design Reviews at the interceptor and interceptor subsystem level that will confirm the IIB is ready for Product Development.

RECOMMENDATION 6: To strengthen the MDA's longer term acquisition prospects, the GAO recommends that the Secretary of Defense direct the Office of Acquisition Technology and Logistics to review all MDA acquisitions for concurrency, and determine whether the proper balance has been struck between the planned deployment dates and the concurrency risks taken to achieve those dates.

DoD RESPONSE: Concur. The Deputy Secretary of Defense signed a memorandum in June 2011 that provided guidance to the Missile Defense Agency (MDA) and the Military Departments (MilDeps) for management and funding responsibilities for the Ballistic Missile Defense System (BMDS) elements as they progress through their life cycles. The memo also provided a process for the MDA and MilDeps to establish fielding dates for the BMDS elements. The MDA and the MilDeps are working to establish fielding dates for the BMDS elements. When the fielding dates are established, concurrency assessments will be possible. In the interim, the Missile Defense Agency, working closely with the Director, Operational Test and Evaluation (DOT&E) and the Deputy Assistant Secretary of Defense, Developmental Test and Evaluation (DASD (DT&E)) are working to ensure: alignment of BMDS T&E events and capability delivery; element readiness for system-level T&E; and updates to the BMDS Integrated Master Test Plan. When a full rate production decision is required, DOT&E will provide an assessment of operational effectiveness, suitability, and survivability in accordance with Title 10, United States Code.

RECOMMENDATION 7: To strengthen the MDA's longer term acquisition prospects, the GAO recommends that the Secretary of Defense direct the Office of Acquisition Technology and Logistics to review and report to Secretary of Defense the extent to which the Presidentially directed capability delivery dates are contributing to concurrency in missile defense acquisitions and recommend schedule adjustments where significant benefits can be obtained by reducing concurrency.

DoD RESPONSE: Concur. The current program is structured to develop and field capabilities at the earliest opportunity while taking into account prudent risk management practices and executing a thorough test and evaluation program. MDA is working closely with the DOT&E and DASD (DT&E) to ensure: alignment of BMDS T&E events and capability delivery; element readiness for system-level T&E; and updates to the BMDS Integrated Master Test Plan. When a full rate production decision is required, DOT&E will provide an assessment of operational effectiveness, suitability, and survivability in accordance with Title 10, United States Code. When fielding dates are established per the response to recommendation 6, the Office of Acquisition Technology and Logistics will review and report to Secretary of Defense the extent to which the Presidentially directed capability delivery dates may be contributing to concurrency in missile defense acquisitions and recommend schedule adjustments if significant benefits can be obtained by reducing concurrency.

Appendix III: BMDS Models and Simulations Progress

Fiscal year 2011 events	Overview
• The Missile Defense Agency (MDA) carried out a highly complex integrated digital simulated assessment involving six Ballistic Missile Defense System (BMDS) elements. • MDA awarded a major contract to build a unified models and simulations architecture for the BMDS.	➢ MDA has made progress in creating a strategic framework for developing its models and simulations. ➢ Model and simulation development is challenging, and much remains to be done. ➢ Test delays and an anomaly have limited progress in gathering needed data. ➢ Limited progress made in accrediting element models.

Background and Overview

Models and simulations are critical to understanding how capable the Ballistic Missile Defense System (BMDS) is and how well it can function. The complex nature of the BMDS, with its wide range of connected elements, requires integrated system-level models and simulations to assess its performance. Assessing BMDS performance through flight tests alone cannot be done, for it is prohibitively expensive and faces safety and test range limitations that can best be dealt with through sound, realistic models and simulations.

Ensuring models and simulations that are sound and realistic requires a rigorous process to accomplish two main tasks—(1) developing individual element models and realistically linking those models and simulations and (2) gathering data from the Missile Defense Agency's (MDA) ground and flight tests to feed into the models. The BMDS Operational Test Agency (OTA), an independent multi-service organization, then assesses how realistic the BMDS models are in order to accredit the models for use in simulating various levels of system performance.[1] When a model is accredited it means that it can be reliably trusted to produce high-confidence results for its intended use and the limitations of the model are known. Since developing reliable MDA models depends upon the

[1] As per MDA's Integrated Master Test Plan, or IMTP, OTA's accreditation recommendation, when signed by the Accreditation Authority (the Commanding General of the Army Test and Evaluation Center, the lead service test agency for the BMDS), is the official certification that models and simulations' products are acceptable for their intended use. While OTA is responsible for carrying out accreditation for this certification process, MDA also carries out internal model accreditation assessments.

collection of test data upon which to anchor them, MDA's test program[2] plays a crucial role in model development and BMDS performance assessments.

MDA Has Made Progress in Developing a Strategic Framework for Improving the Models and Simulations Program

MDA's models and simulations development effort is making progress in developing top-level planning documents, but two are not yet final. Two MDA planning documents, the Integrated Master Assessment Plan and the Integrated Models and Simulations Master Plan, are being developed to better focus and link the testing and assessment efforts. According to OTA officials, the Integrated Master Assessment Plan is based on sound methodology, which should improve MDA's models and simulations program, in part by elevating BMDS evaluation and assessment requirements as the key driver of test design. OTA officials noted that the Integrated Models and Simulations Master Plan should also lead to a greater emphasis on model development needs in driving the design of MDA's test events.

Model and Simulation Development Is Challenging, and Much Remains to Be Done

The task of developing and linking the element-level models and simulations together into an integrated BMDS model is extremely complex and difficult and will take years to accomplish. Last year, we reported that the overall performance of the BMDS could not be assessed because MDA models and simulations had not matured sufficiently and may not be fully mature until 2017. Since that time, there has been limited progress in resolving model issues that would provide more realistic representations of BMDS performance.

In August 2009, U.S. Strategic Command and OTA jointly informed MDA of 39 system-level limitations in MDA's models and simulations program that adversely affect their ability to assess BMDS performance. Resolving these limitations, OTA maintains, would permit MDA's models and simulations to provide more realistic representations of BMDS performance using the full complement of fielded BMDS assets. MDA officials have noted that since August 2009, MDA has fully resolved or is in the process of resolving 7 of these issues and has identified technical solutions for 15 more. According to OTA officials, most of the limitations resolved are issues that are more easily addressed, such as installing

[2] As laid out in MDA's IMTP.

improved communications systems and providing separate workstations for simulation controllers. No technical solutions have yet been identified for the remaining 17 issues, and OTA officials maintain that they are still awaiting an MDA timeline for the complete resolution of these remaining limitations. Among the remainder are some critical model deficiency issues, which result in modeled performance that does not reflect realistic operation and conditions. For instance, models for certain radars have artificial limitations constraining data processing, so that a simulation involving high debris levels would effectively shut down the model. Another model limitation is the need for accurate interceptor modeling for all BMDS weapon systems in system-level assessments, the absence of which prevents a determination of engagement success in such simulations.[3]

MDA has made some progress in developing a single, integrated model and simulation approach for the BMDS. Originally, MDA's models were developed for use by each element and not for integrated assessments. Since fiscal year 2010, MDA has made progress in creating a common framework, whereby the various BMDS element-level hardware-in-the-loop (HWIL)[4] models are subjected to a common and consistent scene and environment during test events. MDA is now using this framework, known as the Single Stimulation Framework, in assessing BMDS performance, and MDA officials maintain that progress achieved in developing it has facilitated MDA's efforts to resolve some of the 39 limitations. MDA officials further highlight that the framework is being used to evaluate BMDS performance in increasingly complex and realistic scenarios, employing greater numbers of BMDS assets.

MDA officials have also claimed some success in creating and integrating a purely digital model and simulation framework for the BMDS. In fiscal year 2011, MDA officials stated that they have achieved some measure of success in using the digital model in a key assessment of six key BMDS elements. According to MDA officials, in this assessment, the simulation tool was more successful than the previous major digital simulation event,

[3] MDA does, however, employ modeling tools external to the system-level simulations, in order to model interceptor performance and thereby assess end-game performance and probability of success.

[4] With HWIL models, closed loop simulations are conducted with actual mission components/hardware in a laboratory environment, and the physical environment/conditions are simulated, under the control of computer equipment.

which was carried out in 2009. MDA officials have noted a downward trend in simulation trouble or incident reports for both the Single Stimulation Framework and the digital model.

MDA plans to integrate these two efforts into a single Objective Simulation Framework (OSF). OSF is planned as an end-to-end representation of the BMDS in support of testing, training, exercises, and system development. OSF is scheduled to go online in the second quarter of fiscal year 2014, with the current digital simulation architecture phased out by fiscal year 2016. According to OTA officials, the common BMDS-level test framework that OSF is intended to provide has multiple advantages, such as the provision of a single tool with which to conduct data verification cross-checks. Additionally, this tool could serve to fill gaps that currently exist in the hardware-based models.

Test Delays and an Anomaly Have Limited Progress in Gathering Needed Data

MDA's difficulty in executing the test plan has limited the progress of modeling and simulations. The agency has refocused the design of its test program on collection of test data to strengthen the development of the models. As we reported in 2010, MDA revised its testing approach in response to GAO and Department of Defense concerns and began to base test scenarios on identified modeling and simulation data needs. In order to collect data required to fill certain model data gaps, MDA had increased planned testing in certain areas, such as ground testing. However, according to OTA officials, MDA has had difficulty conducting its test plan, since actual test events are not always carried out in accordance with the schedule. We have also reported consistent problems in conducting tests over the past few years. Test schedule disruptions delay not only the MDA test schedule, but also the models and simulations' efforts that depend on the test data.

Despite MDA's increased efforts to collect test data for the BMDS model and simulation program, it will take considerable effort and time to fill all knowledge gaps. MDA has succeeded in collecting some 309 critical variables since 2009; but, by the end of fiscal year 2011, those represented only 15 percent of the required total identified by MDA. Under the current plan, MDA does not foresee complete collection of these data until sometime between 2017 and 2022.

Limited test data is a significant challenge MDA faces in developing accredited models. Flight test failures, an anomaly, and delays in fiscal year 2011 have reduced the amount of data MDA expected to have available to support the anchoring of its models and simulations. MDA officials also maintain that some required data are difficult to collect and are challenging to obtain even when a flight test is properly executed. When tests are carried out, considerable post-test data analysis is required for model development, MDA officials maintain. However, MDA officials indicated that MDA must often limit the scope of its analysis to discrete model development objectives. Because of the challenges in carrying out the full range of testing required to collect the anchoring data to develop models, MDA is concurrently exploring alternative methods for model development, such as greater use of subject matter experts. According to OTA officials, the subject matter experts focus MDA's efforts toward scenario factors that are most important for actual and likely BMDS operation, thereby reducing the amount of testing data required.

Limited Progress Made in Accrediting Element Models

MDA has also made some limited progress in achieving partial accreditation for some BMDS models. MDA models may be partially accredited for some, but not all, intended functions due to limitations in the models or gaps in the data. Over the past few years, BMDS OTA officials have assessed MDA's models and simulations in an effort to fully understand the performance of the current BMDS configuration, and have noted that among the element-level BMDS models, those for Terminal High Altitude Area Defense (THAAD) and Aegis Ballistic Missile Defense (Aegis BMD) are farthest along developmentally. In an April 2011 accreditation report, independent assessors from the Johns Hopkins University Applied Physics Laboratory found improvements in five of six functional areas for a key THAAD modeling tool, noting that available data permitted accreditation for three areas. The report also noted progress with two key Aegis BMD models, each of which was assessed for limited accreditation in two of four BMDS target negation areas. MDA officials have also noted significant progress in the development of a key model for the Command, Control, Battle Management, and Communications element of the BMDS. MDA has made some progress toward accreditation of BMDS element models for specific functional areas, but MDA officials acknowledged that the agency has not yet achieved OTA accreditation in other key areas, such as any of the 18 environmental models.

While MDA has progressed in its use of simulated BMDS assessments, there are risks inherent in collecting information from unaccredited sources. Currently, both of the BMDS modeling and simulation frameworks rely on currently unaccredited models, despite the improvements that MDA has noted in the results of such assessments. OTA officials expressed lowered confidence in the data collected from such simulated assessments. The reliance on unaccredited models could result in poorly crafted tactics, techniques, and procedures and in the production and fielding of a system that is not able to actually counter real-world threats. As the BMDS matures and the number of fielded assets increases, modeling and simulation capabilities and laboratory representations of BMDS assets must keep pace to maintain operational realism.

Appendix IV: Aegis Ballistic Missile Defense (Aegis BMD) with Standard Missile-3 (SM-3) Block IA and Block IB

Fiscal year 2011 events	Overview
• In September 2011, the SM-3 Block IB failed during its first developmental flight test. • The planned 2011 SM-3 Block IB production decision was delayed to fiscal year 2013. • In April 2011, the SM-3 Block IA successfully intercepted an intermediate-range missile. During the test, the missile experienced an anomaly. The anomaly occurred in a component also used in the SM-3 IB. • Deliveries of both the SM-3 Block IA and the SM-3 Block IB are on hold until separate failure review boards are completed. • The program supported the deployment of the first ship for the European Phased Adaptive Approach Phase I.	➢ Aegis BMD achieved some significant accomplishments in fiscal year 2011. ➢ SM-3 Block IB's concurrent schedule overlaps development and production. ➢ Failure in SM-3 Block IB's first flight test led to cost growth and schedule delays. ➢ The production transition to the SM-3 Block IB from the SM-3 Block IA has been repeatedly disrupted. ➢ SM-3 Block IA production and deliveries are on hold while the April 2011 flight test anomaly is being investigated.

Background and Overview

Aegis BMD with the SM-3 Blocks IA and IB is a ship-based missile defense system designed to intercept short- to intermediate-range ballistic missiles during the midcourse phase of their flight. Key components include the Aegis Weapons System, shipboard SPY-1 radar, battle management and command and control systems, and SM-3 missiles. Missile Defense Agency (MDA) continues to develop Aegis BMD in spirals for the weapon system and successive capability-based variants of the SM-3 interceptor to improve defense against increased threat missile range, type, and raid size. The SM-3 missile has multiple versions in development or production: the SM-3 Blocks IA, IB, IIA, and IIB. The currently deployed system is Aegis BMD 3.6.1 with SM-3 Block IA, which is designed to hit short- to medium-range threat missiles. This system is included in Phase I of the European Phased Adaptive Approach (PAA). The next generation version is Aegis BMD 4.0.1 with SM-3 Block IB, which has greater capabilities. The SM-3 Block IB uses many of the same components as the SM-3 Block IA, but features an improved two-color target seeker capability for increased onboard discrimination, an advanced signal processor for engagement coordination, an improved throttleable divert and attitude control system (TDACS) for adjusting its course, and increased range and raid capabilities. The SM-3 Block IB with Aegis BMD 4.0.1 is planned to be deployed as part of European PAA Phase II in the 2015 time frame. The SM-3 Blocks IIA and IIB interceptors are discussed in appendixes V and VI.

Aegis BMD Achieved Some Significant Accomplishments in Fiscal Year 2011

Aegis BMD made several significant accomplishments in fiscal year 2011. The Aegis BMD 4.0.1/SM-3 Block IB program successfully conducted simulated flight test FTM-16 E1 in March 2011, delivered the SM-3 Block IB pathfinder round to hold FTM-16 E2, and gained sufficient data in FTM-16 E2 in September 2011 to support certification of the Aegis BMD 4.0.1 weapon system, planned in the second quarter of fiscal year 2012.

As for the Block IA interceptor, DOD fielded the Aegis BMD 3.6.1/SM-3 Block IA-equipped ship, U.S.S. *Monterey*, for Phase I of the European PAA in April 2011, meeting the 2011 time frame for deployment. During the fiscal year, MDA also installed one Aegis BMD 3.6.1 weapon system on a ship. In addition, the Aegis BMD program conducted a successful flight test of the Aegis BMD SM-3 Block IA, referred to as FTM-15, despite experiencing an anomaly during the test. The Aegis BMD SM-3 Block IA was also used in a Japanese flight test—JFTM-4—in which two U.S. Aegis BMD ships cooperated to detect, track, and conduct a simulated intercept engagement against the same target.

Overall, the Aegis BMD 3.6.1/SM-3 Block IA program has had eight out of nine successful flight tests. In addition, Japanese Aegis BMD has conducted three out of four successful intercepts using SM-3 Block IA interceptors.[1] The Aegis BMD 3.6.1 weapon system was the first MDA element to be assessed as operationally effective and suitable for combat by independent test officials, with limitations.

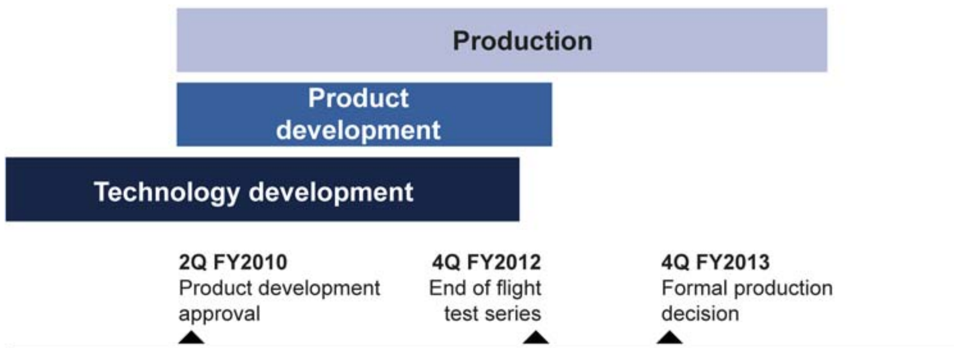
SM-3 Block IB's Concurrent Schedule Overlaps Development and Production

Problems with concurrency are affecting the production of SM-3 Block IB interceptors and delaying the phaseout of the SM-3 Block IA production. The acquisition plan for the SM-3 Block IB interceptor includes high levels of concurrency—buying weapon systems before they demonstrate, through testing, that they perform as required—between development and production. Specifically, the program purchased interceptors before confirming that the design works as intended by completing developmental tests and prior to ensuring that a key subcomponent has overcome prior developmental problems. The need to field the Aegis BMD 4.0.1/SM-3 Block IB by the 2015 time frame for European PAA Phase II announced by the President is a key driver for the high levels of

[1] Japanese flight tests help MDA officials understand performance, but because they are not U.S. assets, they are not considered developmental flight tests from a programmatic perspective.

concurrency. According to MDA, the program is purchasing interceptors for a variety of reasons, including in support of developmental and operational testing, proving the manufacturing process, and ensuring the missile will meet its performance requirements on a repeatable basis. See figure 8 for a depiction of the SM-3 Block IB's concurrent schedule.

Figure 8: SM-3 Block IB Schedule



Source: GAO analysis of MDA data.

The SM-3 Block IB's acquisition plan includes high levels of concurrency. We reported in February 2010 that planned interceptor production would precede knowledge of interceptor performance, and recommended that MDA delay a decision to produce interceptors to follow successful completion of developmental testing, a flight test, and manufacturing readiness review.[2] In March 2010, we reported that the Aegis BMD program is putting the SM-3 Block IB at risk for cost growth and schedule delays by planning to begin manufacturing in 2010 before its critical technologies have been demonstrated in a realistic environment.[3] We also reported in December 2010 that the SM-3 Block IB test schedule was not synchronized with planned production and financial commitments.[4] Finally, in March 2011, we reported that the schedule had become even more compressed due to the redesign and requalification of

[2] GAO-10-311.

[3] GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-10-388SP (Washington, D.C.: Mar. 30, 2010).

[4] GAO, *Missile Defense: European Phased Adaptive Approach Acquisitions Face Synchronization, Transparency, and Accountability Challenges*, GAO-11-179R (Washington, D.C.: Dec. 21, 2010).

a missile component, and in response, MDA deferred key program milestones so that it would have better informed production decisions.[5]

The program began production of SM-3 IB interceptors before resolving development issues with the TDACS, a key interceptor component that maneuvers the kill vehicle during the later stages of flight. The TDACS failed qualification testing in early 2010 and required a redesigned propellant moisture protection system. In order to hold the first SM-3 Block IB developmental flight test, FTM-16 Event 2, in September 2011 as scheduled, MDA only partially completed TDACS qualification testing and the version used in the failed flight test was not identical with the approved production design. The TDACS is expected to complete qualification testing in 2012; however, any additional issues discovered during qualification testing or developmental flight testing may require additional redesigns.

The commitment to produce SM-3 Block IB interceptors beyond those needed for developmental testing was made before the program had a sufficient level of knowledge about the missile's technology maturity and performance. MDA has determined that 18 of the 25 SM-3 Block IB missiles ordered are to be used for developmental testing. The remaining 7 interceptors are currently unassigned for tests and may be available for operational use.[6]

According to MDA, these interceptors will be used to support developmental and operational testing; to prove out the manufacturing processes; to provide information about reliability, maintainability, and supportability; to verify and refine cost estimates; and to ensure that the missile meets performance requirements. MDA officials acknowledged that missiles not consumed by testing could be used operationally. Program management officials stated that the unassigned missiles represent a very small portion of the total number of interceptors they

[5] GAO-11-372.

[6] Six of the 18 missiles will not be needed for developmental tests until fiscal year 2015 or later. SM-3 Block IB missiles are used for developmental tests of the SM-3 Block IB and Aegis Weapons System 4.0.1 program and are planned for use in developmental tests for Aegis Ashore and Aegis Weapons System 5.0. MDA originally planned to purchase 34 SM-3 Block IB interceptors; however, to address developmental issues with the TDACS in the SM-3 Block IB, in 2011, MDA reduced the planned quantity on order to 25 SM-3 Block IB interceptors. One interceptor was used in FTM-16 E2, leaving 24 interceptors.

plan to purchase, representing less than 5 percent of the total 472 interceptors that the program plans to purchase through fiscal year 2020. MDA decided that the risk was low given that many of the SM-3 Block IB critical technologies were based on critical technologies that were tested and used successfully by the SM-3 Block IA.

MDA is also planning to purchase 46 additional SM-3 Block IB missiles in fiscal year 2012. However, there are two failure investigations ongoing that affect SM-3 Block IB production that could delay three planned developmental flight tests that need to occur to validate SM-3 Block IB capability. It therefore remains unclear whether the additional 46 missiles will be ordered before the failure reviews are complete and the interceptor is able to demonstrate that it works as intended through these flight tests.

The program’s highly concurrent schedule is shaped primarily by the need to achieve initial capability for the fielding of Phase II of the European PAA by the 2015 time frame announced by the President. In addition, the program must be ready to participate in the second BMDS operational test in 2015. Program officials report that they are on track to achieve these time frames. However, until development is complete, any additional issues could lead to additional cost growth or schedule delays.

Failure in SM-3 Block IB’s First Flight Test Led to Cost Growth and Schedule Delays

The SM-3 Block IB failed its first developmental flight test, FTM-16 E2, leading to cost growth and schedule delays compounded by the disruption to ongoing production, the full extent of which has yet to be determined. During the flight test, the SM-3 Block IB experienced an unexpected energetic event in the third-stage rocket motor and failed to intercept a short-range ballistic missile target. Following the flight test, the program convened a failure review board to determine the root cause of the failure, modified the missile production contract, restructured the flight test program, and delayed key production decisions. While the failure review board is still investigating the flight test, MDA slowed production of SM-3 Block IB interceptors. The program had planned to deliver an additional three SM-3 Block IB missiles for flight testing in fiscal year 2011. However, the delivery of the remaining three has been delayed until spring 2012.

Program officials estimate that the flight test failure—including the failure investigation, design modifications, testing, and requalification for return to flight—may cost approximately $187 million in fiscal year 2012. In addition, because officials are still investigating the cause of the flight test failure and how many already-produced missiles may have to be retrofitted, they do not yet know how much the retrofits, if required, will cost. At this point, the program does not have an approved plan to avoid an SM-3 production gap.

The flight test failure also had several other consequences. The SM-3 Block IB manufacturing readiness review has been delayed from the second quarter of fiscal year 2011 to the third quarter of fiscal year 2012, and the procurement production decision for additional SM-3 Block IB missiles was moved from fourth quarter of fiscal year 2011 to the fourth quarter of fiscal year 2013. The failed flight test will be re-conducted in mid-2012, which may delay additional developmental flight testing.

The Transition to the SM-3 Block IB from the SM-3 Block IA Has Been Repeatedly Disrupted

Aegis BMD's transition to the SM-3 Block IB has been repeatedly disrupted because the transition was risky given the technology maturity of components developed for the SM-3 Block IB and the program's concurrent schedule. Originally, MDA planned that production of SM-3 Block IA interceptors would end in fiscal year 2009 as production of SM-3 Block IB interceptors began. However, due to developmental issues with the SM-3 Block IB, MDA twice had to extend SM-3 Block IA production—in 2010 and 2011—to cover emerging production gaps with the SM-3 Block IB. To date, MDA has contracted for 41 more SM-3 Block IA missiles than originally planned in order to bridge the production gaps. Now, following the September 2011 flight test failure, MDA is facing another production gap. It is extending production once again—it purchased 23 SM-3 Block IA missiles in fiscal year 2011 and is considering whether to purchase additional SM-3 Block IA missiles in fiscal year 2012.

In addition, the program has twice had to adjust the procurement of SM-3 Block IB missiles. Instead of purchasing 24 SM-3 Block IB missiles as planned in 2010, it purchased 18 SM-3 Block IA missiles and it did not procure 8 SM-3 Block IB missiles in 2011 as planned. To free up funding needed to improve TDACS operational suitability, MDA reduced the planned SM-3 Block IB missiles from 34 to 25 in fiscal year 2011. Thus far, the program has purchased 41 fewer missiles than previously planned. Due to the FTM-16 E2 developmental flight test failure, delivery of these SM-3 Block IB missiles is now being slowed until the failure review board completes its investigation and any possible retrofits are made. Despite the test failure and delivery hold, MDA is considering purchasing 46 SM-3 Block IB interceptors in fiscal year 2012 and 29 SM-3 Block IB interceptors in fiscal year 2013. Recognizing the critical importance of the completing the planned fiscal year 2012 intercept tests, the operational need for SM-3 missiles, the relative success of the SM-3 Block IA, as well as the potential for a production break, the Senate Committee on Appropriations directed MDA to use the fiscal year 2012 SM-3 Block IB funds for additional Block IA missiles should the test and acquisition schedule require any adjustments during fiscal year 2012.

SM-3 Block IA Deliveries Are on Hold While the April 2011 Flight Test Anomaly Is Being Investigated

As a result of an anomaly in the latest SM-3 Block IA flight test—FTM-15 in April 2011—MDA halted acceptance of SM-3 Block IA deliveries. During the April 2011 flight test, MDA demonstrated the Aegis BMD 3.6.1 weapon system's ability to launch the SM-3 Block IA interceptor using data from a remote sensor against a separating intermediate-range ballistic missile target and the capability of the interceptor to engage threat missiles in the range expected for Phase I of the European PAA. However, although the SM-3 Block IA interceptor intercepted the target, it experienced an anomaly. The anomaly occurred in a component also used in the SM-3 Block IB.

At the time of our review, the program had not completed its investigation into the cause of the anomaly or decided how it will address the issue. The program convened a failure review board, which has not yet completed its investigation of the root cause of the anomaly. Twelve assembled SM-3 Block IA missiles are not being accepted for delivery and are being held at the production factory until the investigation of the anomaly is complete and any possible refurbishments are made. This represents about 10 percent of the population of SM-3 Block IA missiles. Program management officials report that thus far seven missiles will need to be refurbished. Because the failure review board has not yet completed its investigation, an unknown quantity of additional SM-3 Block IA missiles may need to be refurbished due to the anomaly. At the time of our review, the program did not have an approved plan for how it will refurbish the affected missiles. Despite these issues, MDA purchased 23 SM-3 Block IA missiles in September 2011 and is considering whether to purchase additional missiles in 2012 to avoid production gaps and to keep SM-3 suppliers active.

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

Fiscal year 2011 events	Overview
• The program discovered problems with four key components during subsystem preliminary design reviews (PDR) and held reviews to resolve the issues with two components in fiscal year 2011. • The program was restructured in response to subsystem PDR problems, adjusting planned flight tests. • Preliminary testing of some U.S. and Japanese components began.	➢ The SM-3 Block IIA program began in 2006 as a cooperative development with Japan. It is required to be fielded by 2018 as part of the European Phased Adaptive Approach Phase III. ➢ Design review problems in fiscal year 2011 led to a program restructure and likely increased current costs. ➢ Program actions in fiscal year 2011 reduced acquisition risk and potential future cost growth. ➢ Despite positive changes in program schedule, technology development concerns remain.

Background and Overview

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 BMD. This interceptor is planned to have increased velocity and range compared to earlier SM-3s due to a larger 21-inch diameter, more sensitive seeker technology, and an advanced kinetic warhead.[1] Most of the SM-3 Block IIA components will differ from the versions used in the SM-3 Block IB, so technology has to be developed for the majority of the SM-3 IIA components. The SM-3 Block IIA is expected to defend against short-, medium-, and intermediate-range ballistic missiles.

Initiated in 2006 as a cooperative development program with Japan, the SM-3 Block IIA program was added to the European Phased Adaptive Approach (PAA) in 2009. As part of European PAA Phase III, the SM-3 Block IIA is planned to be fielded with Aegis Weapons System 5.1 by the 2018 time frame and is expected to provide engage on remote capability, in which data from off-board sensors is used to engage a target, and expand the range available to intercept a ballistic missile. The program is managing both the development of the SM-3 Block IIA and its integration with Aegis Weapons System 5.1, which also is still under development. In this appendix, we evaluate only the SM-3 Block IIA.

[1] A kinetic warhead is a “hit-to-kill” warhead that collides with a ballistic missile’s warhead to destroy it.

Design Review Problems in Fiscal Year 2011 Led to a Program Restructuring and Likely Increased Current Costs

The program planned to hold its system preliminary design review (PDR)—at which it would demonstrate that the technologies and resources available for the SM-3 Block IIA would result in a product that matched its requirements—but problems with the reviews of key components meant the system review had to be adjusted by 1 year. To prepare for the system review, the program held 60 subsystem reviews, for its components to ensure that they were feasible given the technology and resources available. Two components—divert and attitude control system (DACS) and DACS propellant—failed their subsystem reviews and two components—nosecone and third stage rocket motor (TSRM)—had their reviews suspended, indicating that the technological capability of these critical components and SM-3 Block IIA requirements were mismatched. The program took steps to resolve each of the four subsystem review problems, including restructuring the program to reduce future acquisition risk.

The DACS, used to adjust the course of the kinetic warhead, failed its subsystem review because it was not meeting weight and divert acceleration requirements, which the program resolved by reviewing and rebalancing subsystem requirements. The system-level DACS requirements did not change. The DACS propellant that failed the subsystem review was susceptible to a moisture problem, and the program selected a different propellant.[2] The nosecone, which encloses the kinetic warhead, was overweight and could become more so, and the mitigation plan for the weight issue was insufficient. To resolve these issues, the program evaluated weight reduction opportunities and risks. The TSRM, used to lift the missile out of the atmosphere and direct the kinetic warhead to the target, was also not meeting weight requirements, and one of its components, the attitude control system, was not meeting thrust accuracy and alignment requirements. To resolve this issue, the program rebalanced subsystem requirements, but did not change system-level TSRM requirements.[3]

[2] The SM-3 Block IB propellant was affected by the moisture issue, which was caused by a component shared with the initial SM-3 Block IIA propellant.

[3] The reviews to close out the nosecone and TSRM subsystem PDRs failures occurred in fiscal year 2011. The closeout review for the DACS and DACS propellant occurred early in fiscal year 2012.

The subsystem review issues also required program schedule changes, which included the following:

- Adjusting the system PDR from January 2011 to March 2012.
- Splitting in two the critical design review (CDR), at which the program will determine that the product's design matches the SM-3 Block IIA requirements and cost, schedule, and reliability goals. This led to schedule adjustments of 13 and 19 months, respectively, for each of the CDRs.
- Adjusting the interceptor flight test schedule. The program previously planned to hold its first intercept tests in fiscal years 2014 and 2015 as part of the co-development with Japan, but with the schedule adjustment, it will now have these tests in calendar year 2016.The United States and Japan finalized the development program restructuring on September 30, 2011. Despite this adjustment, the interceptor remains aligned with European PAA Phase III in the 2018 time frame.

Aegis BMD program management officials stated that the subsystem PDR problems and subsequent program restructure may increase current program costs, but they are not certain how much because the completion contract, which will run through fiscal year 2017, was still being negotiated as of December 2011.

Program Actions in Fiscal Year 2011 Reduced Acquisition Risk and Potential Future Cost Growth

The SM-3 Block IIA program took actions in 2011 that could reduce acquisition risk and mitigate future cost growth. Its previous schedule was compressed, which raised acquisition risk. For example, there was limited recovery time to investigate and resolve potential problems between program reviews as well as flight tests. The new schedule, made final in September 2011, relieves some compression concerns and adjusts to the subsystem review issues by adding time between the subsystem reviews and the system review to ensure that the technology issues are resolved. We have previously reported that reconciling gaps between requirements and resources before product development begins makes it more likely that a program will meet cost, scheduling, and performance targets, and programs that commit to product development with less technical knowledge and without ensuring that requirements are defined, feasible, and achievable within cost, schedule, and other system constraints face increased technical risks and possibility of cost growth.[4] The new SM-3 Block IIA schedule allows the program to have more knowledge before committing to product development in the second quarter of fiscal year 2014, a strategy that may reduce future cost growth and development risks. The new schedule also adds flexibility in the test schedule by adding an option for a third controlled test vehicle flight if needed. If the first two test vehicles prove to be successful and a third is not needed, this test can be converted into the first intercept test of the SM-3 Block IIA.

In addition to the schedule change, in fiscal year 2011 the program identified some steps to avoid the difficulties that affected SM-3 Block IB component production. For example, it found that using proven materials, standardizing inspections with vendors, and ensuring that designs included reasonable tolerances were practices to follow based on lessons learned from the SM-3 Block IB experience.

Finally, the SM-3 Block IIA program identified alternatives to one advanced seeker component that it had identified, based on the experience of the SM-3 Block IB, as potentially increasing production unit costs by 5 percent. Program management officials stated that they identified a viable alternative for this component and worked with the SM-3 Block IIB program to further develop manufacturing improvements for this technology.

Despite Positive Changes in Overall Program Schedule, Technology Development Concerns Remain

The program still faces significant technology development challenges. While the SM-3 Block IIA is a variant of the SM-3 missile, the majority of its components will change from their SM-3 Block IB configuration. The program must develop these components, some of which have consistently been technologically challenging for SM-3 development. In addition, two technology maturity challenges have emerged. Two critical technologies, the second and third stage rocket motors, experienced problems during testing that may require redesign and a potential CDR rescheduling. The program was investigating the problems and potential effects at the end of fiscal year 2011. In addition, following the subsystem

[4] GAO, *Best Practices: Using a Knowledge-Based Approach to Improve Weapon Acquisition*, GAO-04-386SP (Washington, D.C.: January 2004), and *Defense Acquisitions: Assessments of Selected Weapons Programs*, GAO-11-233SP (Washington, D.C.: Mar. 29, 2011).

review failure and selection of an alternate propellant, analysis of the DACS propellant performance showed that there may be a shortfall in divert performance for some missions. As of the end of fiscal year 2011, the program was still determining the extent of this issue.

Appendix VI: Aegis Ballistic Missile Defense (Aegis BMD) Standard Missile-3 (SM-3) Block IIB

Fiscal year 2011 events	Overview
• The program entered the technology development phase and awarded initial contracts for concept definition and technology risk reduction. • Inclusion of additional technology development efforts to support European Phased Adaptive Approach (PAA) Phase IV led to realignment of the resource plan. • The program continued development of technologies that may contribute to SM-3 interceptor variants. • The program prepared for transfer of SM-3 Block IIB development to Aegis BMD program office in 2013.	➢ SM-3 Block IIB program began in June 2010 and is planned to be fielded by the 2020 time frame as part of European PAA Phase IV. ➢ The program awarded three concept definition and program planning contracts to develop schedule and design options. ➢ The current program plan includes high levels of concurrency and acquisition risk. ➢ Full program acquisition costs have not been developed given the early stage of the program. ➢ The benefits of early intercept capability are unclear and the lack of analysis of alternatives may result in warfighter needs not being met within resource constraints.

Background and Overview

The SM-3 Block IIB is a planned interceptor for the Aegis BMD program that is intended to contribute to U.S. homeland defense by providing early intercept capabilities against some intercontinental ballistic missiles and regional defense against medium- and intermediate-range ballistic missiles. This interceptor has been described by the Missile Defense Agency (MDA) as critical to the Ballistic Missile Defense System (BMDS) and developing solutions to future BMDS capability shortfalls. The SM-3 Block IIB program began in June 2010 and entered the technology development phase in July 2011. Given its early stage of development, the SM-3 Block IIB does not have cost, schedule or performance baselines and is not managed within the Aegis BMD program office. Instead, this program has a tentative schedule and is being managed within MDA's Advanced Technology office until a planned 2013 transition to the Aegis BMD program office. The SM-3 Block IIB is planned to be fielded by the 2020 time frame as part of the European Phased Adaptive Approach Phase IV.

The program received a significant funding reduction in the fiscal year 2012 budget and, as of January 2012, was determining how to adjust its tentative schedule and future program plans. The program's fiscal year 2012 budget request was reduced by $110 million to $13 million.

Program Awarded Initial Contracts to Develop Schedule, Design Options, and Crosscutting Technology

The SM-3 Block IIB program is following a two-pronged development strategy. First, program officials have awarded competitive contracts to generate options for missile configurations and development plans. Second, in a separate effort, they are using multiple contractors to reduce risks by developing technologies that may be used in the SM-3 Block IIB and other SM-3 variants. The program awarded three concept definition and program planning contracts to define and assess viable missile configurations, conduct trade studies, and define a development plan. The contractors will develop alternative missile concepts, technologies and schedule for interceptor development beyond 2013. According to the program, the purpose of this competition is to minimize cost, schedule, and technical risks. There will be another competition to select one contractor for the product development phase in 2013. We have reported previously that competition among contractors can result in increased technological innovation that leads to better and more reliable products.[1]

The program is using technology risk reduction contracts to develop technologies that may cut across versions of the SM-3, such as the focal plane array,[2] and to invest in materials or technology that will increase missile velocity and containment of threat missiles. For example, this effort produced a major technical first when a contractor working on focal plane array issues changed the process for creating a component of the focal plane array in a way that may reduce the number of defects in the production of that component.

Current Program Plan Includes High Levels of Concurrency and Acquisition Risk

Program management officials have issued a tentative schedule beyond the technology development phase, but this plan, if implemented, includes high levels of concurrency and acquisition risk. We have previously reported the following:

- Concurrency leads to major problems being discovered in production, when it is either too late or very costly to correct them.[3]

[1] GAO, *Joint Strike Fighter: Assessment of DOD's Funding Projection for the F136 Alternate Engine*, GAO-10-1020R (Washington, D.C.: Sept. 15, 2010).

[2] The focal plane array is a component of the seeker.

[3] GAO, *High-Risk Series: Defense Weapons Systems Acquisition*, GAO/HR-93-7 (Washington, D.C.: December 1992).

- Before starting product development, programs should hold key engineering reviews, culminating in the preliminary design review (PDR), to ensure that the proposed design can meet defined, feasible requirements within cost, schedule, and other system constraints.[4]

- Committing to production and fielding before development is complete is a high-risk strategy that often results in unexpected cost increases, schedule delays, test problems, and performance shortfalls.[5]

Successful defense programs ensure that their acquisitions begin with realistic plans and baselines before the start of their development.[6] According to the tentative SM-3 Block IIB schedule, the product development decision will occur before the March 2015 PDR. As a result, MDA is planning to commit to developing a product with less technical knowledge than our prior work has shown is needed and without fully ensuring that requirements are defined, feasible, and achievable within cost, schedule, and other system constraints. This sequencing increases both technical risks and the possibility of cost growth.[7] In addition, the program will not have a stable design when it must commit to building flight test vehicles. According to acquisition best practices, a design is considered stable when the technologies are mature and the critical design review (CDR) confirms that at least 90 percent of the drawings are releasable for manufacturing. Based on the experience of other SM-3 interceptors, the program must commit to produce flight test interceptors 2 years before the March 2016 first flight. However, this timeline means the commitment to a flight test vehicle would occur a year before the SM-3 Block IIB PDR has confirmed that the design is feasible and more than a year and a half before CDR has confirmed that the design is stable. See figure 9 for a depiction of the tentative SM-3 Block IIB schedule.

[4] GAO, *Defense Acquisitions: Assessments of Selected Weapons Programs*, GAO-11-233SP (Washington, D.C.: Mar. 29, 2011).

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

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

[7] Given the funding reduction in fiscal year 2012, the program plans to delay the product development decision by several months but was still determining in January 2012 what other modifications to the tentative schedule would take place. We reviewed the tentative schedule issued prior to the funding reduction.

Figure 9: SM-3 Block IIB Schedule

Source: GAO analysis of MDA data.

Note: Given the early stage of the program, we are not able to depict the production plans or the end of the product development phase for the SM-3 Block IIB.

Program management officials stated that they have taken steps in the tentative schedule that reduce acquisition risk. According to SM-3 Block IIB program information, the tentative schedule is based on the experience of programs with similar magnitude and complexity, and the concept definition and program planning contractors will develop detailed product development schedules that will help refine the program schedule. Further, activities during the technology development phase, such as evaluating the performance of multiple contractor concepts, simulations conducted by the contractors, and affordability assessments, are designed to reduce risk in SM-3 Block IIB development. In addition, while the program plans to hold its production development decision prior to the PDR, it will hold a series of reviews with the concept definition contractors to receive engineering insight into each contractor's plans. Program management officials told us they also plan to hold a government-only system requirements review prior to the initiating the product development contract competition. This review is planned to confirm that SM-3 Block IIB has specific technical requirements that the developer can use to establish a product baseline as well as conduct a risk and technology readiness assessment.

Another key step for successful programs is ensuring that only mature technologies are brought into product development. MDA has identified technologies that are important for SM-3 variants and is investing in these technologies, particularly the less mature technologies, to facilitate SM-3 Block IIB development. However, as of October 2011, the program had not named specific critical technologies for the SM-3 Block IIB. Program officials stated that they do not plan to do so until the product development decision. The concept definition contractors are required to identify technology investments to increase the maturity of the technologies by demonstrating them in a relevant environment by the end of fiscal year 2013, which coincides with the product development decision. MDA, however, does not require that a program mature technologies to this level by this decision. Without knowing the specific critical technologies, it is not possible to identify the risk of including them in the product development phase. As we have previously reported, including immature technologies in product development can lead to delays and contribute to cost increases.[8]

Full Program Acquisition Costs Not Developed Given Early Stage of the Program

While the program has proposed that $1.673 billion in research and development funding is needed from fiscal years 2012 to 2016, a full program acquisition cost has not yet been developed. Given the early stage of the program, and that key decisions about requirements and the missile configuration have not been made, a full acquisition cost estimate is not currently feasible. According to MDA, the program plans to complete a detailed cost estimate prior to entering product development.

A cost estimate cannot be developed until key acquisition decisions are made. Program management officials stated that warfighter and system requirements for the SM-3 Block IIB have not been set, and discussions about the delivery schedule beyond the initial capability are ongoing. Further, whether the propellant will be liquid or solid, the SM-3 Block IIB's diameter, and whether modifications must be made to a vertical launch system are not yet known given the early stage of the program. In addition, as there is not yet a final schedule, the currently proposed funding is not informed by a complete post-product development decision schedule. Program management officials note that these key decisions are being informed by activities occurring during the technology development phase, such as trade studies involving the propulsion and missile diameter, and they are updating current cost estimates as they receive information from contractors as well as working on developing detailed cost estimates.

[8] GAO, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999).

Benefits of Early Intercept Capability Are Unclear and the Lack of Analysis of Alternatives May Result in Warfighter Needs Not Being Met within Resource Constraints

MDA determined that a key goal for the SM-3 Block IIB is to provide an early intercept capability. However, a recent Defense Science Board study suggested that other capabilities are more important than early intercept. The study concluded that early intercept capability is not useful for regional missile defense. Further, while early intercept with shoot-look-shoot capability could be part of a cost-effective defense of the U.S. homeland if a sufficiently fast missile was available, the size of the battlespace and not early intercept capability is the key driver of cost-effectiveness.[9] In addition, it is unclear if early intercept is possible for defense of the U.S. homeland due to the velocity required for an early intercept of an intercontinental ballistic missile aimed at the United States and the state of current missile technology. Finally, the value of a shoot-look-shoot capability relies on a robust ability to determine if the first missile was successful, often called kill assessment, but this ability has not been established.[10] In response, MDA stated that the Defense Science Board study had used a limited definition of early intercept and ignored significant benefits of the strategy that stem from decreasing the time available to the adversary to deploy countermeasures. Such benefits include providing a longer viewing time of deployment maneuvers for forward-based sensors, reducing the flight time of the interceptor, and increasing the complexity to the attacker of deploying countermeasures.

The program office did not conduct a formal analysis of alternatives to compare the operational effectiveness, cost, and risks of a number of alternative potential solutions to address valid needs and shortfalls in operational capability prior to embarking on the technology development phase. The program did assess some missile concepts for early intercept capability in a review that was not a formal analysis of alternatives. The program currently plans to conduct engineering and trade studies—including cost trades—that will be completed in the fourth quarter of fiscal year 2012 and review additional alternative concepts as part of the concept definition process. While MDA programs are not required to conduct an analysis of alternatives, we have previously reported that it is key to planning and establishing a sound business case. Specifically, an analysis of alternatives provides a foundation for developing and refining

[9] Shoot-look-shoot, also known as shoot-assess-shoot, means firing one interceptor, observing the results of the initial shot, and then launching the subsequent missile(s).

[10] The Aegis BMD weapons system includes an integrated kill assessment system. We did not evaluate the capabilities of this system.

the operational requirements for a weapons system program and provides insight into the technical feasibility and costs of alternatives. Further, without a full exploration of alternatives, the program may not achieve an optimal concept that satisfies the warfighter’s needs within available resource constraints.[11] Without this sound basis for program initiation, the SM-3 Block IIB is at risk for cost and schedule growth as well as not meeting the warfighter’s needs with the resources available.

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

Appendix VII: Aegis Ashore

Fiscal year 2011 events	Overview
• Initiated manufacturing of Aegis Ashore test site at Pacific Missile Range Facility in preparation for testing in fiscal year 2014. • Successfully completed system design review and preliminary design review. • Signed agreement with Romania to host Aegis Ashore site as part of European Phased Adaptive Approach Phase II. • Restructured acquisition strategy for deckhouse twice.	➢ Concurrent development and production schedule increase potential for cost growth and schedule delays. ➢ Various Aegis Ashore components require modification for a land-based configuration and development uncertainties remain. ➢ Unstable Aegis Ashore program content, affecting both the resource baseline and cost estimates, reduces transparency and impedes oversight and accountability.

Background and Overview

Aegis Ashore is the Missile Defense Agency's (MDA) planned land-based version of the ship-based Aegis Ballistic Missile Defense (Aegis BMD), which will track and intercept ballistic missiles in their midcourse phase of flight using Standard Missile-3 (SM-3) interceptors. Key components include a vertical launching system (VLS) with SM-3 missiles and a reconstitutable 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 next generation versions of the Aegis weapons systems—Aegis 4.0.1 and Aegis 5.0—that are still under development. In accordance with the September 2009 European Phased Adaptive Approach (PAA) announcement, the Department of Defense (DOD) plans to deploy the first Aegis Ashore installation with the SM-3 Block IB in the 2015 time frame and the second installation in the 2018 time frame.

Concurrent Development and Production Schedule Increase Potential for Cost Growth and Schedule Delays

Given the commitment to field Aegis Ashore by the 2015 time frame, the program's schedule contains a high level of concurrency—buying weapon systems before they demonstrate, through testing, that they perform as required—between development and production. The program began product development early, included high levels of concurrency in its construction and procurement plan, and has not aligned its testing schedule with component procurement and construction. As we have reported previously, an acquisition strategy for accelerated fielding, such as that of Aegis Ashore, will likely accept higher risk primarily through concurrent development and production.[1] Under such a strategy, major problems are more likely to be discovered in production, when it is either too late or very costly to correct them.

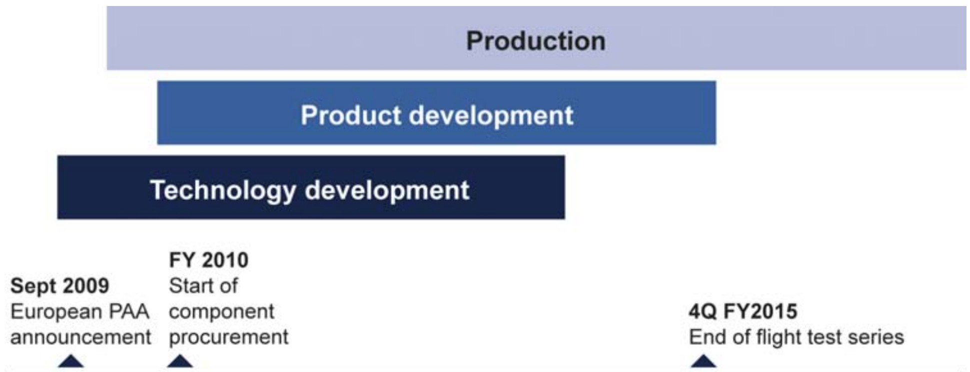
The program began product development and established the Aegis Ashore cost, schedule, and performance baseline in June 2010, which was 14 months before completing its preliminary design review. This concurrent sequencing can increase technical risks and the possibility of cost growth by committing to product development with less technical knowledge than needed by acquisition best practices and without ensuring that requirements are defined, feasible, and achievable within cost and schedule constraints. In addition, the program has a concurrent schedule for constructing deckhouses and procuring Aegis Ashore components. Since committing to product development and establishing the product development baseline, the acquisition strategy for deckhouse construction has been revised twice. The current plan, called the dual deckhouse plan, is to construct two deckhouses—first, an operational deckhouse planned for installation in Romania and a second for developmental testing in Hawaii. The test deckhouse will begin construction a quarter later than the operational deckhouse and will be installed for testing at the Pacific Missile Range Facility in Hawaii. Aegis BMD program management officials stated that a third deckhouse, for the Aegis Ashore installation in Poland, will be constructed at a later date to be set based on funding availability. The program also has initiated procurement of equipment, such as the VLS and SPY-1 radar that are needed for the Aegis Ashore installations.

This plan means that knowledge gained from testing the Hawaiian installation cannot be used to guide the construction of the Romanian deckhouse or procurement of components for operational use. Any design changes that arise from testing in Hawaii will have to occur on a complete deckhouse and on already procured components intended for operational use. As we have previously reported, rework on an existing fabrication is costly. Aegis Ashore is currently scheduled to participate in four flight tests, three of which are intercepts, with the first intercept flight test scheduled for the second half of fiscal year 2014, at which point two of the three deckhouses will be completed and Aegis Ashore site

[1] GAO, *High-Risk Series: Defense Weapons System Acquisition*, GAO/HR-93-7 (Washington, D.C.: December 1992).

construction and interceptor production will be well under way. The final flight test is planned for the fourth quarter of fiscal year 2015. See figure 10 for a depiction of Aegis Ashore's concurrent schedule.

Figure 10: Aegis Ashore Schedule



Source: GAO analysis of MDA data.

However, Aegis BMD program management officials state that Aegis Ashore has taken steps to lower the acquisition risks. First, the officials note that the program is using components already in use aboard Aegis BMD ships, reducing the technical risk of the program. The Director of MDA has stated that the sea-based system and Aegis Ashore will share identical components. According to program documentation, the dual deckhouse plan reduces risk and creates fabrication and construction efficiencies. Aegis BMD program management officials noted that the dual deckhouse plan has significant advantages over prior plans, all of which had the operational deckhouse built before the test deckhouse. For example, they noted that prior Aegis Ashore deckhouse construction plans required testing a different deckhouse design in Hawaii than the one that would be used at the operational sites. Constructing two deckhouses concurrently provides for greater efficiency in purchasing material and equipment and allows for one contractor to build both deckhouses. The Director of MDA stated that the deckhouse construction methodology is the most cost effective and efficient under the program's time constraints. In addition, the program expects to be able to modify the operational deckhouse prior to its installation in Romania if flight tests reveal that a modification is needed. The program management officials also stated that the dual deckhouse plan provides more time for testing the equipment that goes in the deckhouse. Aegis BMD program management officials stated that this plan allows them to test the electrical system in the Romanian deckhouse and to complete these tests more than 1 year earlier than previously scheduled. Finally, they noted that constructing two deckhouses also facilitates testing, including conducting Aegis Light Off events that consist of preflight test verification of the integration of Aegis Ashore components.

Aegis BMD program management officials told us that the schedule does contain more risk before the first controlled test vehicle flight test, which is the first time all of the Aegis Ashore components will be integrated, and less risk between that test and the fielding in Romania. They stated that they decided to increase the risk at the start of the schedule in order to meet the presidentially announced date of 2015 for the first Aegis Ashore installation.

While Aegis BMD program management officials are confident that the risks of a concurrent schedule are low given the nature of the Aegis Ashore program, the short time frame for integrating and fielding Aegis Ashore could magnify the effects of any problems that may arise. Program documentation states that there is limited to no margin in the schedule to deal with possible delays in fabrication or system testing, and as this effort is the first time a land-based deckhouse has been constructed, there is no prior experience on which to draw to alleviate any schedule delays.

Various Aegis Ashore Components Require Modification for a Land-Based Configuration, and Development Uncertainties Remain

While Aegis Ashore will use components already developed and used operationally in the sea-based Aegis BMD, key components—the VLS and radar—will be modified for use on land. In addition, the multimission signal processor, a key component for both the sea-based and land-based system that processes radar inputs from ballistic and cruise missile targets, is still under development and behind schedule. The first time all of the Aegis Ashore components are expected to be integrated and flight tested will be in fiscal year 2014. Given the concurrent schedule for the program, any difficulties with the modified components or partly developed components may affect the overall schedule, potentially leading to cost growth or an installation not meeting expectations because a needed modification was discovered too late.

The Aegis Ashore installations will include a VLS currently used on Aegis BMD ships, but it is planned to be located at a greater distance from the deckhouse. The communications system between the deckhouse and the VLS will require modification because of this increased distance. In addition, the VLS is planned to be surrounded by an environmental enclosure at Aegis Ashore installations. Aegis BMD program management officials stated that this enclosure will include the heating and cooling system and provide power to the launcher. Testing of this modification is planned for fiscal year 2014.

Aegis Ashore's SPY-1 radar likely will face challenges related to the radio-frequency spectrum, which is used to provide an array of wireless communications services, such as mobile voice and data services, radio and television broadcasting, radar, and satellite-based services. The radar might need to be modified if the performance of wireless devices in Romania is degraded by the SPY-1. Furthermore, Romania's future use of the radio-frequency spectrum is unknown but could allow more domestic wireless communications services to operate in or near the radar's operating frequency. Consequently, the Aegis Ashore site may need modifications to resolve this potential issue, or alternatively, Romanian wireless broadband devices may need to be modified. An initial analysis of radio-frequency spectrum use in Romania by the Defense Spectrum Organization, DOD's organization that provides information and assistance on radio frequency analysis, planning, and support, recommended to MDA that additional study of Romanian radio-frequency spectrum use occur. Aegis BMD management officials told us that they recognize the risks associated with operating the SPY-1 radar on land and that MDA plans additional study in fiscal year 2012 to better understand Romanian spectrum use and the potential effect of the SPY-1 radar on land, including study of existing land-based SPY-1 radars. There may be modifications to the SPY-1 radar to mitigate this potential issue, but the officials told us they do not currently know what modifications could be required to mitigate any frequency issues because of this need for further study. Depending on spectrum policy and usage in the host nation, this issue may be a long-term challenge over the life of the Aegis Ashore installations regardless of where they are fielded.

In addition, urban clutter—which could affect the ability to acquire, maintain track, and perform imaging on long-range targets—could affect the SPY-1 radar. Program documentation states that both the Romanian and Polish Aegis Ashore sites have clutter from urban structures and wind farms. Urban clutter may require modifications of the radar, such as software modifications, or may require additional testing or affect operations of the Aegis Ashore installation.

In addition to the aforementioned VLS and radar issues, developmental uncertainties also exist for the multimission signal processor. We have previously reported that it is behind schedule, with a significant percentage of its software increments still needing to be integrated.[2] This component of Aegis Ashore was unable to demonstrate planned functionality for a radar test event in December 2010, and the Defense Contract Management Agency has identified the multimission signal processor schedule as high risk.

As we have reported previously, Aegis Ashore is dependent upon next generation versions of Aegis systems—Aegis 4.0.1 and Aegis 5.0—as well as the SM-3 Block IB interceptor, all of which are still under development.[3]

Unstable Aegis Ashore Program Content, Affecting Both the Resource Baseline and Cost Estimates, Reduces Transparency and Impedes Oversight and Accountability

Aegis Ashore's requirements, acquisition strategy and overall program content were not stable when the resource baseline—the expected investment in the development and delivery of a product—was established, and subsequent program changes obscure the assessment of program progress. MDA's acquisition directive states that baselines are used to assess programs and program maturity. We have previously reported that baselines provide the best basis for transparency over actual program performance, giving decision makers key information about program progress and cost.[4] Baseline variances give management information about where corrective action may be needed to bring the program back on track. Variation from the baseline can provide valuable insight into program risk and its causes and can empower management to make decisions about how to best handle risks. However, this transparency is limited if the initial baseline is not sound or if the reporting of progress against the baseline obscures actual program cost or performance.

[2] GAO, *Arleigh Burke Destroyers: Additional Analysis and Oversight Required to Support the Navy's Future Surface Combatant Plans*, GAO-12-113 (Washington, D.C.: Jan. 24, 2012).

[3] GAO 11-372.

[4] GAO, *Defense Acquisitions: Missile Defense Acquisition Strategy Generates Results but Delivers Less at a Higher Cost*, GAO-07-387 (Washington D.C.: Mar. 15, 2007).

Aegis Ashore's resource baseline, established at the developmental baseline review on June 22, 2010, was initially $813 million. The initial resource baseline established the resources needed to develop and build two Aegis Ashore systems—one test and one operational— and deploy them in the 2015 time frame. In the June 25, 2010 BMDS Accountability Report (BAR) submitted to Congress 3 days after the review, MDA reported a revised resource baseline of $966 million, an increase of $153 million or 19 percent. According to information provided by the program, the reason for the increase was a refinement of the program requirements and a review of resource estimates provided earlier in fiscal year 2010.

Beyond this resource baseline adjustment, the anticipated cost of the program has grown as program plans have developed. By February 2012, program management officials provided information that the program was reporting a cost growth of $622 million over the 2010 baseline for a total cost estimate of $1.6 billion.[5] Aegis BMD management officials provided information attributing the cost growth to changes in the deckhouse fabrication plans, an increase in the cost of the Aegis Weapons system, and a refinement of equipment needs. In addition, the program has adjusted the calculations for the average procurement unit cost (APUC), or the ratio of procurement costs to the number of operational units, across the life of the program. At the developmental baseline review in June 2010, the APUC was based on the test installation in Hawaii. By June 2011, the program included two installations—for Romania and Poland—in the APUC. However, at the end of fiscal year 2011, the program changed the quantity to one Aegis Ashore installation. Information provided by the program office states that the increase to two installations occurred due to the addition of all European PAA phases to the program during the year and that the fiscal year 2012 BAR will include only one installation to be consistent with the 2011 BAR. The current estimate for the APUC also has changed. The baseline for the average procurement cost is $272 million for each Aegis Ashore system. Program management officials reported that by February

[5] According to information provided by the program, the $1.6 billion includes costs for development, military construction, operations and support and disposal. It excludes Navy military construction, manning and fleet operations costs as well as costs for MDA's command, control, battle management, and communications system. It also does not include any procurement funding.

2012, the estimate for the APUC was $380 million, a 40 percent increase over the baseline unit cost.

Appendix VIII: Ground-based Midcourse Defense (GMD)

Fiscal year 2011 events	Overview
• In December 2010, the program failed to successfully intercept a target during a retest of the unsuccessful January 2010 intercept attempt. The tests were designed to verify the capability of the enhanced version of the kill vehicle called the Capability Enhancement II (CE-II EKV). • Due to the failed intercept test, the Director, MDA halted final integration of the remaining CE-II EKVs. • At the request of the U.S. Northern Command, delivered a second fire control system to Fort Greely Alaska so that testing can occur while the system is also operational. • GMD participated in a BMDS ground test during which operational personnel executed tactics, techniques and procedures for the defense of the United States.	➢ GMD has not been able to verify the capability of the CE-II interceptor. ➢ MDA's cost to demonstrate the CE-II through flight testing has grown significantly. ➢ MDA has pursued a highly concurrent acquisition strategy for the GMD program that allowed for rapid fielding, but with increased risks. ➢ Consequences of MDA's highly concurrent acquisition strategy include schedule delays, cost growth and reduced understanding of system performance.

Background and Overview

The GMD element enables combatant commanders from the U.S. Space and Missile Defense Command[1] to defend the United States against a limited attack from intermediate- and intercontinental-range ballistic missiles from nations such as North Korea and the Middle East during the midcourse phase of flight. GMD consists of a ground-based interceptor (GBI)—a booster with an exoatmospheric kill vehicle (EKV) on top—and a fire control system that receives target information from Ballistic Missile Defense System sensors in order to formulate a battle plan. The GMD program has emplaced two EKV versions. The first, fielded since 2004, is known as the Capability Enhancement I (CE-I)[2] and the second, the current version in production, is called the Capability Enhancement II (CE-II). GMD has fielded its entire planned inventory of 30 GBIs.[3] According to the Director, Missile Defense Agency (MDA), GMD is expected to remain in service until at least 2032.

[1] This command is the Army service component to U.S. Strategic Command.

[2] The original EKV's delivered were called Test Bed kill vehicles, however, they have since been renamed Capability Enhancement I.

[3] In 2009, the Secretary of Defense reduced the number of planned emplaced GBIs from 44 to 30, reducing the number of GBIs needed. The reduced inventory includes 30 operational interceptors and an additional 22 for testing and spares.

In fiscal year 2011, MDA continued to provide U.S. Northern Command a capability to defend the nation against a limited ballistic missile attack and delivered a second fire control system to Fort Greely, Alaska, to provide flexibility to operate while also testing the system.

GMD Has Not Been Able to Verify the Capability of the CE-II EKV Interceptor

MDA has not successfully demonstrated the ability of the CE-II to intercept a target. The first two attempts failed—the first in January 2010 due to a quality control issue and the second in December 2010 due to a design issue.[4] During this second attempted test, MDA launched an intermediate-range target with a simulated reentry vehicle and associated objects. A forward-based radar provided acquisition and track data to the GMD system. In addition, the Sea-based X-band radar provided discrimination data to the GMD system. The GMD interceptor was launched from a silo at Vandenberg Air Force Base, flew as expected to its designated point, and deployed the CE-II EKV, which reached the target and identified the most lethal object but failed to intercept it.

After this failure, the Director, MDA, testified that the agency's top priority was to confirm the root cause, fix it, and successfully repeat the previous flight test.[5] Accordingly, MDA undertook an extensive and rigorous effort to determine the root cause of the failure and develop design solutions to resolve the failure. The investigation concluded the following: (1) ground testing cannot replicate the environment in which the kill vehicle operates and (2) the CE-II EKV, specifically the inertial measurement unit, requires redesign and additional development, which MDA has undertaken. For example, according to a GMD program official, the program has conducted over 50 component and subcomponent failure investigation and resolution tests. Additionally, the program has developed new testing techniques and special instrumentation to provide additional data in future flight tests.

[4] The failure review investigation concluded that FTG-06 failed due to a quality control escape where a lockwire was not inserted during the EKV manufacturing process. The contractor has altered its processes now to ensure that all steps are properly followed.

[5] According to GMD and contractor officials, they understood that they could not replicate the failure during ground testing and have since developed new technology to measure the frequencies that they might experience in space. Although the frequency ranges are not fully compatible, they are making progress.

MDA realigned resources from planned 2011 activities to fund the investigation and fund return-to-intercept activities including redesign efforts. For example, the program delayed funding the rotation of older fielded interceptors into flight test assets, delayed funding interceptor manufacturing, and delayed purchasing GBI upgrade kits. However, the agency did continue its efforts to increase reliability of the interceptors through upgrades and repair of five interceptors although the refurbishments conducted to date do not fix all known issues or provide a guarantee of reliability.

MDA's Cost to Demonstrate the CE-II Initial Capability through Flight Testing Has Grown Significantly

The cost to confirm the CE-II capability through flight testing has increased from $236 million to about $1 billion dollars due to the flight test failures as noted in table 4. In addition to the costs of the actual flight tests, the total cost for determining the root cause and developing the design changes has not been fully developed.

Table 4: Flight Test and Failure Review Cost to Assess CE-II Capability[a]

Dollars in millions

Activity	Cost
FTG-06	$236
FTG-06a	240
CTV-01 Costs as of February 2012	141
FTG-06b Costs as of February 2012	269
Failure review costs as of February 2012	91
Total	**$976**

Source: MDA.

[a] Flight test costs include the target, mission planning, range support, and post-test analysis.

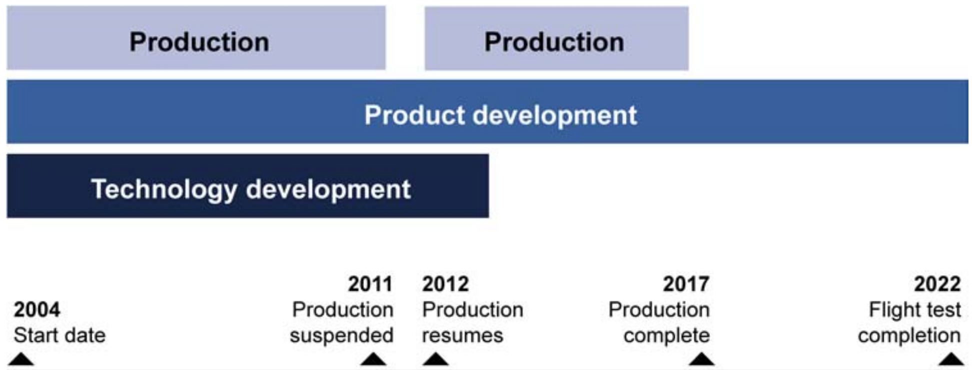
While the cost incurred by MDA to verify the CE-II variant through flight testing, as noted above, is about $1 billion, it does not reflect the costs already expended during development of the interceptor and target. For example, the cost of the flight test excludes nonrecurring development costs, such as the development costs for the interceptor or target and its support as well as those for systems engineering and test and evaluation, among others. Often these are costs that were incurred many years before the flight test was conducted. MDA has not separately reported the nonrecurring development costs for the CE-II interceptor, but instead reports the program acquisition unit costs (which are the development, production, deployment, and military construction costs divided by the total number of operationally configured units) for the combined CE-I and

CE-II interceptor effort. For these interceptors, the program acquisition unit costs are reported to be $421 million as of February 2011 and are likely increasing to address the flight test failure. MDA reports the nonrecurring costs for the targets used in these flight test as $141 million each. Consequently, including nonrecurring development costs for both the CE-II and the targets would substantially increase the costs for each flight test and the overall costs outlined in table 4.

MDA Has Pursued a Highly Concurrent Acquisition Strategy for GMD That Allowed for Rapid Fielding, but with Increased Risks

To meet a 2002 presidential directive to deploy an initial missile defense capability by 2004, MDA concurrently matured technology, designed the element, tested the design and produced and fielded an initial capability. A 2008 MDA briefing acknowledged that fielding while still in the development and test phase led to very risky decisions regarding schedule, product quality, and program cost. For example, the EKV team focused on technical aspects of design instead of also ensuring that the design could be produced, which led to a lack of production control and near continuous engineering changes. While this approach did lead to the rapid fielding of a limited defense, it also resulted in schedule delays, unexpected cost increases, a refurbishment program, and a reduced knowledge of system reliability necessary for program sustainment, as well as variations between delivered CE-I EKVs. (See fig. 11.)

Figure 11: GMD Concurrent Schedule



Source: GAO analysis of MDA data.

MDA emplaced its first GBI in 2004, although it had little of the data, such as interceptor reliability, that it would normally have had before fielding a system. Accordingly, the Director, MDA, testified on March 2011 that GMD put interceptors “that are more akin to prototypes than production representative missiles in the field.” Additionally, interceptors were emplaced in silos before successfully conducting a flight test of this configuration.

In 2004, MDA committed to another highly concurrent development, production, and fielding strategy for the new CE-II interceptor, approving the production before completing development of the prior version or flight testing the new components.[6] MDA proceeded to concurrently develop, manufacture, and deliver 12 of these interceptors even though MDA has not yet successfully tested this new version.

[6] The CE-II EKV was not originally a reliability upgrade or a performance upgrade program. Its initial priority was replacing obsolete components. However, updating certain components is expected to result in increased performance.

Consequences of MDA's Highly Concurrent Acquisition Strategy Include Schedule Delays, Cost Growth, and Reduced Understanding of System Performance

MDA's concurrent approach to developing and fielding assets has disrupted its acquisition efforts, resulted in cost growth and expensive retrofits, and reduced the planned knowledge of the system's capabilities and limitations. In response to the failure of FTG-06a in December 2010, MDA restructured its fiscal year 2011 manufacturing plan by halting deliveries of remaining CE-II EKVs until the completion of the failure review and a nonintercept attempt in fiscal year 2012.[7]

To help mitigate the affect of the production halt, the GMD program planned to perform five limited upgrades to previously manufactured CE-I interceptors. According to contractor officials, in order to keep the production line viable, they were directed to complete five limited interceptor upgrades; however, the program was only able to complete three and expects to complete the other two in fiscal year 2012. As we previously reported, in 2007 MDA began a refurbishment and retrofit program of the CE-I interceptors to replace questionable parts identified in developmental testing and manufacturing.[8] This program was to develop an overall plan to address known hardware upgrades and service life limitations, issues discovered since the interceptors were emplaced. However, MDA has yet to complete all planned refurbishments of CE-I EKVs, and program officials discovered additional problems during early refurbishments causing MDA to expand this effort. Consequently, refurbishments are planned to continue for many more years and the cost to refurbish each CE-I interceptor could range from $14 million to $24 million.

Additionally, MDA will have to undertake a major retrofit program for the CE-II EKVs that have already been manufactured and delivered in addition to the retrofit program for the CE-I GBIs that is already underway. According to GMD program management officials, the final cost for this effort has not been determined, but they expect the effort to cost about $18 million per EKV, resulting in an additional cost of about $180 million for 10 interceptors.[9]

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[7] A GMD program official stated that the agency is allowing the contractor to continue work on those components of the EKV that would not be factors in the FTG-06a flight test failure in order to keep the production line moving.

[8] GAO-09-338 and GAO-10-311.

[9] Although the program has delivered 12 EKVs, 2 have already been expended during flight testing.

The agency has also had to restructure its flight test program, adding two tests that were not previously planned before the failure. To verify the new design of the kill vehicle, MDA inserted a nonintercept test scheduled for the third quarter of fiscal year 2012. This test is designed to exercise as many CE-II EKV functions as possible that have not been demonstrated in either FTG-06 or FTG-06a. Performing the nonintercept mission, using an upgraded inertial measurement unit, provides the benefit of scripting the test in order to best stress the EKV design and to fully demonstrate the resolution of the failure in FTG-06a. MDA officials have stated that if the test confirms that the cause of the failure has been resolved, the program will restart the manufacturing and integration of the CE-II EKVs.

However, successfully completing an intercept that demonstrates the full functionality of the kill vehicle is necessary to validate that the new design works as intended. MDA added a new intercept flight test (FTG-06b) in the fourth quarter of fiscal year 2012, however due to further developmental challenges with the EKV, it has been delayed until at least the second quarter fiscal year 2013 to demonstrate CE-II intercept capability and achieve the unmet objectives of the two previous tests (FTG-06 and FTG-06a).[10] As a result, confirmation that the design works as intended will take place more than 9 years after the decision to begin production and more than 4 years after the first planned test.[11]

Lastly, MDA's continued inability to conduct the GMD developmental flight testing has resulted in less knowledge of the fielded systems capabilities and limitations than planned. For example, GMD has been only able to successfully conduct two intercept tests since 2006—the last successful intercept being conducted December 2008.[12] Additionally, GMD has yet to conduct a salvo test. As we reported in our last assessment, GMD cancelled its planned 2011 salvo test due to the failure in the January 2010 flight test and scheduled a salvo test for fiscal year 2015.

[10] This schedule to return to flight may also be at risk because a key component redesigned due to the earlier failure has experienced more problems in production.

[11] As we reported in 2009, MDA had originally planned to assess CE-II capability in fiscal year 2008. However, early ground test failures in the inertial measurement unit caused delivery delays and resulted in a redesign of the component. Consequently, the program had to delay the test. See GAO-09-338.

[12] GMD conducted FTG-03a in September 2007 and FTG-05 in December 2008.

Consequently, neither the CE-I nor CE-II variant capability is fully understood and according to the Director, Operational Test and Evaluation's fiscal year 2010 assessment, the continuing evolution of the interceptor design has resulted in multiple interceptor configurations among the fielded interceptors and test assets. These configuration differences complicate assessment of operational capability.

GMD's acquisition strategy will continue its high levels of concurrency. Developmental flight testing will continue through 2022, well after the currently planned completion of production. In following this concurrent acquisition strategy, the Department of Defense is accepting the risk that these later flight tests may discover issues that require costly design changes and retrofit programs to resolve.

Appendix IX: Precision Tracking Space System (PTSS)

Fiscal year 2011 events	Overview
• PTSS was initiated in the second quarter of fiscal year 2011. • Johns Hopkins University's Applied Physics Laboratory, under contract with the Missile Defense Agency, awarded subcontracts to industry partners, to bring them into the development process. • The PTSS program completed its System Requirements Review in March 2011.	➢ PTSS is just beginning the early acquisition phases. ➢ PTSS revised its acquisition strategy in January 2012, includes some acquisition best practices, but also elevated levels of concurrency. ➢ Projected size and cost of the entire PTSS constellation is unknown. ➢ While many technologies are well developed, technology maturation of key components still needed. ➢ PTSS concept development benefits from STSS testing.

Background and Overview

The Missile Defense Agency's (MDA) PTSS is being developed as a space-based infrared sensor system to provide persistent overhead tracking of ballistic missiles after boost and through the midcourse phase of flight. Being a space-based sensor system, PTSS is not constrained by geographical considerations that affect the placement of ground-, air-, and sea-based radar systems. While the number of PTSS satellites to make up the constellation has not yet been determined, the system is expected to expand the Ballistic Missile Defense System's (BMDS) ability to track ballistic missiles in the post-boost phase and plans to fill coverage gaps existing within the current BMDS radar configuration. According to PTSS officials, the constellation will provide coverage of some 70 percent of the earth's surface with a minimum of six satellites. Furthermore, the enhanced coverage planned for PTSS would help increase the size of the missile raids that the BMDS can track and respond to. The PTSS program plans to launch its first two development satellites in the fourth quarter of fiscal year 2017 and to increase the constellation to nine satellites by 2022.

The PTSS program plans to create a satellite constellation that can accommodate subsequent configuration adjustments. The program intends to create a flexible on-orbit and ground architecture that could accommodate such changes as an increase to the constellation size or changes to the communications infrastructure. This flexibility would permit the system to evolve in response to changes in the threat environment.

PTSS Is Just Beginning the Early Acquisition Phases

The PTSS program officially began as a new program in the second quarter of fiscal year 2011. Johns Hopkins University's Applied Physics

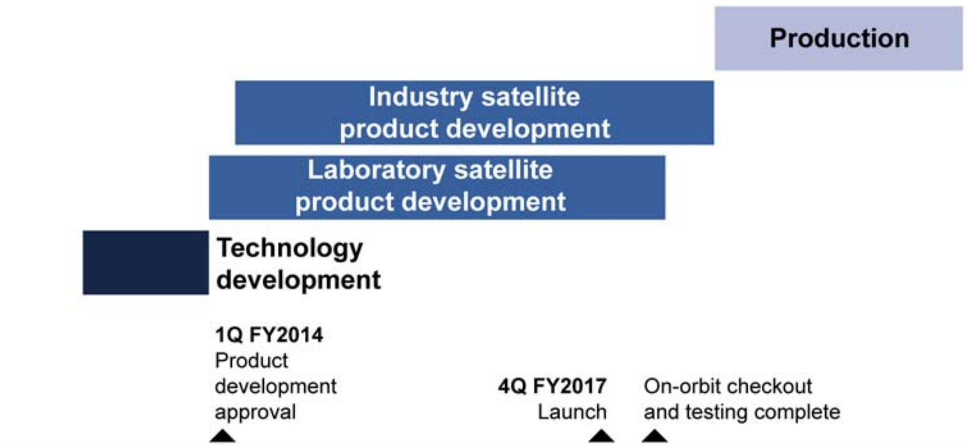
Laboratory (APL) is the lead system developer for PTSS. In this capacity, APL advises the PTSS program office on systems engineering and integration issues, while leading the other laboratories involved in the development effort. In early 2011, APL awarded six integrated system engineering team subcontracts to industry partners to provide manufacturing and producibility recommendations for the development of the PTSS initial article satellites: Raytheon, Northrop Grumman, Lockheed Martin, Ball Aerospace, Orbital Science, and Boeing. MDA's decision to involve the laboratories in initial development work is an action that we have previously recommended for other space acquisition programs.

During the course of 2011, the PTSS program made several schedule changes, in part due to budgetary issues. PTSS was scheduled to begin the Technology Development Phase in the fourth quarter of fiscal year 2011, but delayed it until the fourth quarter of fiscal year 2012. One of the key early analytical knowledge points, the establishment of mass raid engagement time windows, was also delayed from the fourth quarter of fiscal year 2011 to the first quarter of fiscal year 2012. Finally, the planned launch date for the first two initial satellites was delayed from the fourth quarter of fiscal year 2015 and is now planned for the fourth quarter of fiscal year 2017. The PTSS program also delayed the projected launch dates of production satellites for the PTSS constellation.

PTSS Revised Its Acquisition Strategy in February 2012; It Includes Some Acquisition Best Practices but Also Elevated Levels of Concurrency

According to the acquisition strategy report signed in January 2012, MDA plans to develop and acquire the satellites in three phases. First, the APL-led laboratory team will produce two lab-built development satellites. Second, an industry team, selected through open competition while the APL-led laboratory team is still in a development phase, will develop and produce two industry-built engineering and manufacturing development satellites. Third, there will be a follow-on decision for the industry team to produce additional satellites in a production phase. (See fig. 12.)

Figure 12: PTSS Concurrent Schedule



Source: GAO analysis of MDA data.

The strategy acknowledges some concurrency but maintains that there are benefits to this approach. Under the plan, the industry team will be approved for production of long-lead items for the two development satellites, while the laboratory team is still working to complete the first two development satellites. The program intends that by engaging industry concurrently at this development stage, industry can influence the selection of parts and subsystems in a manner that will minimize the need for system design changes between the two laboratory development satellites and the two initial industry satellites. The program intends to conduct on-orbit checkout and testing of the two laboratory-produced development satellites prior to the decision to complete the assembly of the two industry-built development satellites.

According to MDA, the approach aligns with several aspects of GAO's acquisition best practices. The program will establish firm requirements before committing to production, it will ensure full and open competition, the development cycle will be less than 5 years, it has a simple payload design and can deploy larger numbers in the constellation and it is deferring advanced capabilities until a second spiral thereby limiting the technological development challenge for the initial satellites.

According to program management officials, they have taken steps intended to mitigate cost, schedule, and performance risks. PTSS is being designed strictly for BMDS use, so the satellite payload is geared toward the BMDS missile tracking mission, with the objective of keeping the design as simple and stable as possible. Additionally, the acquisition strategy stipulates that PTSS will not duplicate functions found elsewhere in the BMDS, but instead will remain focused on the specific function for which it is being designed. The program aims to shorten its development schedule through the use of proven technologies with high technology readiness levels. According to PTSS program management officials, the use of currently available technologies helps to keep the PTSS design cost-effective. In addition, according to those officials, the government intends to acquire unlimited data rights, government purpose data rights, or both for the duration of the program, so that the government is not locked in with any particular contractor.

Because the PTSS acquisition strategy was only recently developed, we had limited time to assess the strategy for this review. We intend to review this new strategy next year. Building developmental and engineering and manufacturing development satellites is a positive step. However, the strategy may enable decision makers to fully benefit from the knowledge to be gained and the risk reduction opportunity afforded through on-orbit testing of the lab-built satellites before committing to the industry-built developmental satellites. The industry-built development satellites will be under contract and under construction before on-orbit testing of the first two lab-built satellites can confirm that the design works as intended.

Projected Size and Cost of the Entire PTSS Constellation Are Unknown

Currently, the PTSS program office has not determined how many satellites will make up the PTSS constellation, though the program is progressing with a flexible approach toward the number of satellites in the constellation. The size of a full PTSS constellation would depend on factors that have yet to be determined, most specifically, the size of missile raid that the system would be expected to track. In fiscal year 2011, the program conducted physics-based analysis to demonstrate the system's performance within the BMDS in handling a range of raid scenarios. The satellites for the PTSS constellation are expected to have a 5-year design life, though officials stated that they expect the operational life will exceed the 5 years. Relative to other military space programs, the PTSS satellite is intended to be a low-cost unit, which can be readily replaced as on-orbit units degrade over time. However, the full cost of development has not yet been determined, and it is currently unclear how many satellites will need to be replaced annually, as this will be determined by such factors as design life and the total number on orbit. The cost to launch a satellite into orbit can be very expensive, sometime exceeding $100 million or more. Because the full size of the constellation has also not yet been determined, the PTSS program is unable to estimate the anticipated full costs of the acquisition and operation of the system.

While Many Technologies Are Well Developed, Technology Maturation of Key Components Is Still Needed

In leveraging proven technologies with high technology readiness, many of the system's technologies are in relatively high states of maturity for a program in this early stage of development. The program office has identified two PTSS critical technologies: the optical payload and the communications payload. Many of the underlying components for the optical and communications payloads have been demonstrated in an environment relevant to the conditions under which they will be employed in the PTSS satellites. However, certain key components of these critical technologies require further development to reach maturity, and until these key components mature, they reduce the overall technological maturity of the payloads. Program management officials stated that they plan to have both critical technologies in functional form by the time of the preliminary design review, which is scheduled for the end of fiscal year 2013.

The high radiation environment in which the PTSS satellites will operate creates technical challenges for the development effort. The PTSS program has instituted risk reduction measures to address radiation risks pertinent to two technologies. For risk issues pertaining to the focal plane array, the PTSS's risk mitigation efforts are on schedule, with two contracts having been awarded to explore manufacturing processes to address radiation hardness requirements for the satellites' anticipated on-orbit environment. Radiation mitigation efforts are also required for the satellite's star tracker, a component of the system's guidance and control subsystem. The PTSS program plans to award contracts to several vendors in 2012 to evaluate options to address this concern.

PTSS Concept Development Benefits from STSS Testing

The PTSS development effort is benefiting from MDA's two operational Space Tracking and Surveillance System (STSS) satellites, which were launched into orbit in 2009. BMDS test events involving STSS have been useful in providing key information to the PTSS program. According to PTSS officials, the success of STSS in the FTM-15 flight test conducted in 2011 served as a "proof of principle" for PTSS, as the event demonstrated multiple aspects of the PTSS concept of operations, such as the ability to provide data from which interceptor missiles could be remotely launched and directed toward a missile threat. The FTM-12 flight test in late 2011 repeated the positive results noted in FTM-15, with tracking sensors locking onto targets and successfully providing direction for the fired interceptors. The STSS tests are assisting the PTSS program office as it develops the system's concept of operations.

Appendix X: Targets and Countermeasures

Fiscal year 2011 events	Overview
• Eleven targets were delivered and successfully launched. • Successful “return-to-flight” of short range air-launched target. • Intermediate-range ballistic missile (IRBM) target contract signed in March 2011. • Undefinitized contract action for eight reentry vehicles issued. • Intercontinental ballistic missile (ICBM) target contract solicitation canceled February 16, 2011.	➢ Targets were not a source of testing problems in 2011. ➢ Availability of targets increasing risk for first Ballistic Missile Defense System operational flight test and affecting other planned tests. ➢ Missile Defense Agency slowly building inventory of targets and implementing backup strategy. ➢ Significant decisions consolidate new work with the prime contractor.

Background and Overview

The Missile Defense Agency's (MDA) Targets and Countermeasures program designs, develops, produces and procures missiles serving as targets for testing missile defense systems. The targets program involves multiple acquisitions covering the full spectrum of threat missile capabilities (separating and nonseparating reentry vehicles, varying radar cross sections, countermeasures, etc.) and ranges.[1] Some target types have been used by MDA's test program for years while others have been recently or are now being developed and can represent more complex threats.

As MDA's test program has matured, its Targets and Countermeasures program has worked toward developing, in parallel, more complex targets that can more closely represent modern-day threats. Since the program was initiated in 2001, it has done this using several different acquisition strategies—the third was issued in 2011. Initially, MDA used many contractors to design and build the targets, but in 2003, it chose a single prime contractor, Lockheed Martin to lead the acquisition. Shortly after, MDA decided to pursue what it called the Flexible Target Family approach to acquiring targets, which used common components and shared inventory and promised reduced cycle time, cost savings, and

[1] Ballistic missiles are classified by range: short-range ballistic missiles have a range of less than 1,000 kilometers (621 miles); medium-range ballistic missiles have a range from 1,000 to 3,000 kilometers (621 to1,864 miles); intermediate-range ballistic missiles have a range from 3,000 to 5,500 kilometers (1,864 to 3,418 miles); and intercontinental ballistic missiles have a range greater than 5,500 kilometers (3,418 miles).

increased capability. At that time, MDA began work on the 72-inch diameter launch vehicle (LV)-2 target and the 52-inch diameter targets. When this approach proved more costly and less timely than expected, MDA suspended the 52-inch effort, focusing on the LV-2. Responding to congressional concern[2] about these problems and our 2008 recommendations, MDA revised its acquisition approach in 2009, seeking to increase competition by returning to a multiple contract strategy with four separate target classes and a potential of four prime contractors. MDA completed the intermediate-range target contract award, which reduced target costs. However, as proposals for the new medium-range ballistic missile (MRBM) contract were submitted, the program determined that costs associated with this approach were higher than anticipated. Solicitations for the medium-range and the intercontinental classes of targets were then canceled, and MDA began the process of revising its acquisition strategy for the third time.

Targets Were Not a Source of Testing Problems in Fiscal Year 2011

In the past, we have reported that availability and reliability of targets caused delays in MDA's testing of Ballistic Missile Defense System (BMDS) elements. However, in fiscal year 2011, MDA delivered 11 targets, all of which were successfully launched and did not negatively affect the test program. The targets launched during the year supported tests of several different BMDS elements, including Ground-based Midcourse Defense (GMD), Aegis Ballistic Missile Defense, and Patriot systems.[3]

All targets that were delivered or launched within the fiscal year were either short- or intermediate-range targets and performed as expected. Most notably, in July 2011 MDA successfully accomplished the return-to-flight of MDA's short-range air-launched target. This was the target's first launch since an essential mechanism that releases it from the aircraft failed in a December 2009 Terminal High Altitude Area Defense (THAAD) flight test. After the failure, the agency identified shortcomings in the contractor's internal processes that had to be fixed before air-launched targets could be used again in BMDS flight tests. Nineteen months later,

[2] H.R Rep No. 110-477 at 824 (2007) (Conf. Rep.) (accompanying the National Defense Authorization Act of 2008. Pub. L. No. 110-181).

[3] This report does not contain an assessment of the Patriot Advanced Capability-3, which has been transferred to the Army for production, operation, and sustainment.

these deficiencies were satisfactorily addressed when the target missile was successfully extracted from the rear of the C-17 aircraft in FTX-17. To reduce risk, the flight was not planned as an intercept mission but as a target of opportunity for several emerging missile defense technologies, including Space Tracking Surveillance System.

Availability of Targets Increasing Risk for First BMDS Operational Flight Test and Affecting Other Planned Tests

According to MDA and Director, Operational Test & Evaluation test officials, the availability of targets has affected planned future flight tests. MDA has scheduled the first two extended medium-range ballistic missiles (eMRBM) to launch in a crucial operational flight test (FTO-01) by the end of 2012, which is the first system-level test of the BMDS. On a tight schedule to meet this deadline, MDA is accepting higher risk that target issues could affect this test by launching the first two of the new targets in this operational test, rather than conducting a risk reduction flight first. Risk reduction flight tests are conducted the first time a system is tested in order to confirm that it works before adding other test objectives. The lack of such a test was one factor that delayed a previous GMD flight test (FTG-06) in 2010. While the target, the LV-2, was successfully flown in that flight test, aspects of its performance were not properly understood and lack of modeling data prior to the test contributed to significant delays in the test program.

In addition, the next air-launched target test was scheduled to use the new medium-range extended air launched target in 2012, but the flight test—FTT-13—was cancelled because of budgetary concerns and test efficiency. As a result, the first flight test using this target is not planned until the third quarter of fiscal year 2014, though it may be available for use as early as the fourth quarter of fiscal year 2012. Since the short-range air-launched target was successfully launched in July 2011, MDA now plans to continue acquisition of the one short-range and the two extended air-launched targets that are currently under contract through fiscal year 2014.

MDA Slowly Building Inventory of Targets and Implementing Backup Strategy

As development and production processes mature, the targets program is slowly developing an inventory of targets for use in BMDS testing. In previous years, failures of target missiles have caused major disruptions to MDA's flight test program, in part because no spare targets were available to retest once the cause of any failure was determined. In response, MDA has slowly begun working toward developing an inventory of both backup and spare missiles to support the test plan. The targets program currently has a limited backup strategy in place. In the event of a target failure, backup missiles assigned to a future mission could be taken from inventory and used for an earlier test and be replaced by newer missiles.

Significant Decisions Cancel or Defer Competition and Consolidate New Work with the Prime Contractor

The Targets and Countermeasures program made several key decisions in fiscal year 2011 that will shape future target acquisition. Two key contracts were definitized in 2011; the eMRBM contract in October 2011, and an intermediate-range ballistic missile (IRBM) target contract in March 2011. MDA realigned funding planned for the medium-range competition, which was canceled in 2010, to manufacture additional IRBM targets. MDA canceled the planned intercontinental ballistic missile (ICBM) competition because the new test plan delays the need for the first ICBM target by several years. Finally, MDA issued an undefinitized contract action to the prime contractor for reentry vehicles. One overall consequence of these decisions has been a consolidation of work with the prime contractor. (See table 5.)

Table 5: Fiscal Year 2011 Acquisition Events by Target Class

Target class	Fiscal year 2011 acquisition events
Short-range ballistic missile targets	• Air-launched target return-to-flight in July 2011 • Undefinitized contract action[a] issued for acquisition of one foreign military target
MRBM targets	• eMRBM production contract definitized in October 2011 for five targets • Undefinitized contract action issued in July 2011 for seven specialized MRBM targets • Extended-range air-launched target qualification process resumed
IRBM targets	• IRBM contract awarded in March 2011 for eight targets
ICBM targets	• Specialized ICBM contract solicitation canceled in February 2011—acquisition delayed to align with first ICBM test in 2020
Reentry vehicle	• Undefinitized contract action for eight common reentry vehicles issued to prime contractor

Source: GAO Analysis of MDA data.

[a]To meet urgent needs, DOD can issue undefinitized contract actions, which authorize contractors to begin work before reaching a final agreement on contract terms. Undefinitized contract action means any contract action for which the contract terms, specifications, or price are not agreed upon before performance is begun under the action. Defense Federal Acquisition Regulation Supplement 217.7401(d).

An agreement on price was reached for the production of five eMRBM targets in September 2011. MDA began developing the eMRBM for operational use in 2003 as part of the Flexible Target Family when it was referred to as the 52-inch target. Though development and production had been on hold since 2008 because of continuing cost and schedule problems, MDA resumed acquisition of eMRBMs through the existing prime contractor due to a target failure. The production contract was definitized in October 2011 after being undefinitized for about 540 days.[4] The Defense Federal Acquisition Regulation states that undefinitized contract actions shall provide for definitization by the earlier of either, 180 days after issuance of the action or the date on which more than 50 percent of the not-to-exceed price has been obligated. The 180-day threshold may be extended but may not exceed the date that is 180 days after the contractor submits a qualifying proposal. MDA program officials stated that because MDA continued to change the requirements on the undefinitized contract action, the contractor did not submit a qualifying proposal until March 2011. MDA definitized the contract approximately 194 days after receiving the proposal. During the 18-month delay, while the contract was being negotiated and requirements continued to change, the contractor spent over $82 million,[5] the quantity of targets under contract increased, and some capability was deferred to later years. The final negotiated price at completion was $321 million, $175 million less than the previously expected price ceiling. MDA contracting officials acknowledged that undefinitized contract actions can lead to undefined costs, but believe they are a good tool to use to meet urgent requirements.

MDA initiated three new undefinitized target contract actions in fiscal year 2011.

- First, an action for seven “T3” medium-range ballistic missile targets was initiated in July 2011. A requirement for this target type was

[4] Defense Federal Acquisition Regulations 217.7404-3 If a contractor submits a qualifying proposal before the 50 percent threshold has been reached, then the limitation on obligations may be increased to no more than 75 percent.

[5] The extended use of undefinitized contract actions has previously been identified by GAO and others as risky for the government. Because, under undefinitized contract actions, contracting officers normally reimburse contractors for all reasonable, allocable, and allowable costs they incur before definitization, contractors bear less risk and have little incentive to control costs during this period.

accelerated in the test plan to the first quarter of fiscal year 2014. T3s are unique targets designed for more specialized maneuvers in their respective ranges.

- Second, an action for a foreign military asset target to meet a fourth quarter of fiscal year 2012 requirement.
- Third, an action for eight common reentry vehicles, which will replace earlier ones.

MDA set up a common components project office to manage the acquisition strategy for the reentry vehicles, which are intended for flight tests in mid-2014. They have the potential to fly on any target launch vehicle, but the program is still developing more specific acquisition plans.

In 2011, MDA began implementing its third acquisition strategy for targets by acquiring common reentry vehicles from a single source, a significant change in the acquisition strategy for the program office. Reentry vehicles for targets were previously acquired separately, were more specifically tailored to the target launch vehicle, and were procured from more than one contractor. The single-source strategy implemented with the 2011 undefinitized contract action is intended to maximize commonality and could reduce costs through purchasing larger numbers. Through 2013, the single source will be the targets prime contractor. MDA plans to decide in the second quarter of fiscal year 2012 whether to issue a competitive solicitation for a new provider.

Appendix XI: Terminal High Altitude Area Defense (THAAD)

Fiscal year 2011 events	Overview
• The first production interceptor was delivered in March 2011. • Eleven of 50 THAAD operational interceptors were delivered in fiscal year 2011. • The production decision was made and the contract was issued for additional THAAD batteries. • Qualification problems with the ignition safety system and production start-up issues caused interceptor production rates to be slower than planned. • Two Missile Defense Agency knowledge points, once planned for fiscal year 2011, have not yet been achieved due to target availability issues.	➢ Army and Department of Defense test organizations successfully conducted the first THAAD operational flight test. ➢ THAAD's highly concurrent acquisition strategy led to delayed delivery of THAAD batteries. ➢ Requirements and design were not stable before THAAD interceptor production began. ➢ THAAD interceptor production issues delay deliveries and increase program costs. ➢ THAAD achieved conditional materiel release to the Army in 2012; full materiel release date not yet known ➢ Ongoing concurrency increases acquisition risks until developmental testing is complete.

Background and Overview

THAAD is a rapidly deployable ground-based system designed to defend against short- and medium-range ballistic missile attacks during their late midcourse and terminal stages. A THAAD battery consists of interceptor missiles, six launchers, a radar, a fire control and communications system, and other support equipment. The program is producing batteries for initial operational use for conditional materiel release to the Army. For this to occur, the Army must certify that the batteries are safe, suitable, and logistically supported. The date for full materiel release has not yet been determined because the program is still conducting flight tests to prove out the system, and production rates have been slower than planned.

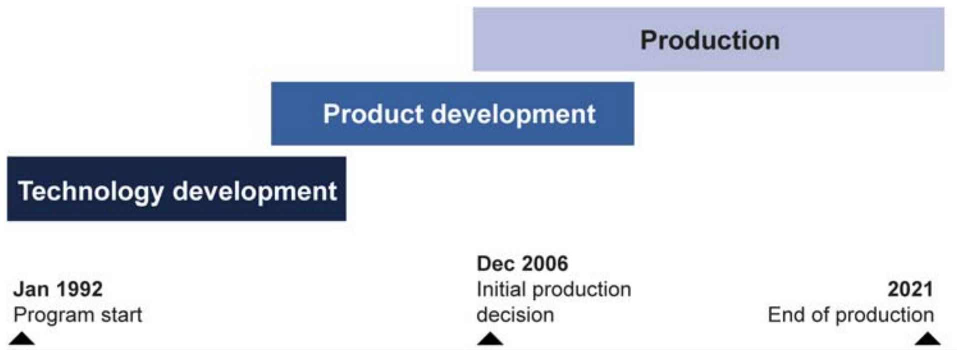
Army and Department of Defense Test Organizations Successfully Conducted the First THAAD Operational Flight Test

THAAD successfully conducted its first operational flight test in October 2011, a major accomplishment because this was its first operational test with the Army and Department of Defense test and evaluation organizations fully engaged to ensure that the execution and test results were representative of the fielded system. During the test, the THAAD system engaged and nearly simultaneously intercepted two short-range, threat-representative, ballistic missile targets. The test demonstrated the ability to perform in the full battle sequence, from planning through live operations, under operationally realistic conditions (within the constraints of test range safety). The U.S. Army Test and Evaluation Command and the Ballistic Missile Defense System (BMDS) Operational Test Agency will review data collected from this event to make an operational assessment of the THAAD system. In addition, the Director, Operational Test and Evaluation, will also independently evaluate the operational effectiveness of the system. The assessment of this event will support upcoming production and fielding decisions.

THAAD's Highly Concurrent Acquisition Strategy Led to Delayed Delivery of THAAD Batteries

The Missile Defense Agency (MDA) awarded a contract for THAAD's first two operational batteries in December 2006, before its design was mature and developmental testing of all critical components was complete. At that time, MDA's first THAAD battery, consisting of 24 interceptors, 3 launchers, and other associated assets, was to be delivered to the Army as early as 2009. While some assets were delivered by this time, the interceptors were delayed because of issues with components that had not passed all required testing. In response to pressure to accelerate fielding the capability, THAAD adopted a highly concurrent development, testing, and production effort, as shown in figure 13, that has increased program costs and delayed fielding of the first THAAD battery until early fiscal year 2012.

Figure 13: THAAD Concurrent Schedule



Source: GAO analysis of MDA data.

Problems encountered while THAAD was concurrently designing and producing assets caused slower delivery rates of both the first and second THAAD batteries, which are not currently projected to be complete before July 2012—16 months after the original estimate of March 2011. While all assets, except the interceptors, were complete in 2010, the first production interceptor for the first THAAD battery was not produced until the second quarter of fiscal year 2011. In the same quarter, MDA committed to purchasing additional assets by signing a production contract for two additional THAAD batteries, despite incomplete testing of a safety device on the interceptor. During fiscal year 2011, after several production start-up issues, 11 of the expected 50 operational interceptors were delivered.[1] Consequently, the first battery of 24 interceptors was not complete and available for fielding until the first quarter of fiscal year 2012—more than 2 years later than originally planned. The same issues have delayed the second battery as well. Although the launchers and other components for the second battery 2 were completed in 2010, the full 50 interceptors necessary for both batteries are not expected to be delivered until July 2012.

[1] Twelve total interceptors were delivered by the end of fiscal year 2011, but the first, produced in fiscal year 2010, was used in a flight test.

Requirements and Design Were Not Stable before THAAD Interceptor Production Began

A production contract was signed in 2006 before the requirements or design for a required safety device called an optical block was complete. Housed in the flight sequencing assembly, an optical block is an ignition safety device designed to prevent inadvertent launches of the missile. The program experienced design and qualification issues with this component until testing was complete in the fourth quarter of fiscal year 2011. Incorporating an optical block device into the THAAD interceptor has been a primary driver of design, qualification, and production delays for the program since as early as 2003, shortly after the Army issued a standard requirement for this type of safety device on munitions ignition systems. The original THAAD design did not have an optical block device, and MDA did not modify the development contract to include this requirement until 2006. Program management officials explained that the military standard is primarily written for smaller, more typical, munitions' fuses, not systems as technically complex as THAAD.

According to program management officials, THAAD has worked with the Army to tailor requirements and associated testing required of the optical block device during the past few years. The part failed initial qualification testing in early fiscal year 2010 and was not fully qualified until that September. Also, in May 2010, the Army added requirements to test the flight sequencing assembly during exposure to electrical stress and other environments, such as extreme temperature, shock, humidity, and vibration. Testing failures led THAAD to make minor design changes and extensive manufacturing process changes, which required requalification of the optical block and delayed production of the interceptors. Environmental testing was complete in March 2011, but the stress test was not completed until September 2011—after the first interceptor was produced.

As recently as fiscal year 2011, the program was considering further design changes to the optical block to make it more producible; however, the program estimated that the cost to make the needed design changes would be $150 million, an investment that could not be easily recouped in production savings in the near future. Program mangers decided not to make those changes because of improved flight sequencing assembly and optical block manufacturing performance, and program funding constraints. The current design was also successfully demonstrated in the recent flight test and in the other testing in support of conditional materiel release. Therefore, the program determined that the benefits of continuing the redesign no longer justified the cost.

THAAD Interceptor Production Issues Delay Deliveries and Increase Program Costs

Production issues have collectively delayed interceptor delivery by 18 months and are projected to cost the program almost $40 million. While issues with the flight sequencing assembly have been the most costly, three production start-up issues emerged in fiscal year 2011 that also caused delays. First, the program encountered problems with the availability of a solution containing nitrogen needed for production. Program management officials explained that since all of the liquid could not be extracted out of a newly designed bottle, due to unanticipated design changes in the delivery mechanism, more had to be ordered before production could continue, which caused the delay. Another production delay of over a month took place because of debris found in a transistor on the interceptor. Program management officials explained that a root cause analysis determined that the part had not undergone proper testing, which would have detected such debris. The transistors had to be replaced with properly tested parts. A third delay occurred because ragged, raised edges were discovered inside several of the fuel tanks. According to program management officials, in the unlikely event that a small metal edge broke off during pressurization of the fuel tank, it could cause an interceptor failure. They said that after conducting a risk analysis, the program decided to remove the rough edges on future procurements, but not on the first 50 interceptors, since the possibility of such risk was low.

The interceptor's flight sequencing assembly is currently being produced at or above the expected rate of about four per month. Due to start-up issues, which are common to new production lines, interceptor production rates have fluctuated, ranging anywhere from 0 to 5 in recent months. Also, some recent production rates could be artificially high as delays with some components have allowed others more time than usual to stockpile for future production. These stockpiles are projected to help with production through the second battery. The program needs to achieve a steady production rate in order to deliver the second THAAD battery by July 2012. After this date, the contractor is scheduled to return to a rate of 3 interceptors per month.

THAAD Achieved Conditional Materiel Release in 2012; Full Materiel Release Date Not Yet Known

THAAD achieved conditional materiel release to the Army in February 2012, though at one time, it had been expected as early as September 2010. It was delayed over a year due to ongoing safety issues with the interceptor and, most recently, to incorporate data from the October 2011 operational flight test. Conditional materiel release is an interim step to the Army's full materiel release decision. For example, for conditional materiel release, the Army Ignition System Safety Review Board requires that three flight sequencing assembly units complete a series of tests to evaluate the interceptor in various electrical and other stressing environments. By the end of fiscal year 2011, all these tests had been successfully completed. While THAAD has performed all test events required for conditional materiel release, including its most recent flight test (FTT-12), analysis of data is ongoing and the Army is still refining its requirements for full materiel release. Program management officials expect the gap in knowledge between conditional materiel release and full materiel release to be defined in second quarter of fiscal year 2012 as well. At that time, they explained, the Army will have developed a list of the remaining conditions that the program must address in order to receive full materiel release.

One of the conditions that must be met to achieve full materiel release of THAAD to the Army is the incorporation of the required Thermally Initiated Venting System, a safety feature of the interceptor that prevents the boost motor from becoming propulsive or throwing debris beyond a set distance in the event that the canister holding the interceptor heats up to a certain temperature. Development and testing of this system has been done concurrently with production of fielded interceptors. Even if the latest design and near-term testing is successful, the system will be approved too late to be incorporated in the first 50 interceptors. Although the system is not required for conditional materiel release, the program expects it to be required for full materiel release, unless the Army grants a waiver. Since the last two developmental tests of this safety feature have failed, THAAD is at risk of not complying with the requirement. The next test is scheduled for the second quarter of fiscal year 2012. According to program management officials, if it fails, the program will be forced to seek a waiver for the current design and accept the risk of not having the design on the interceptors. Program management officials explained that the requirement for a Thermally Initiated Venting System is primarily written for smaller-scale systems, not for a system as large as THAAD. Although officials said they are working to comply with the requirement, the technology may not be available to make it work. At best, the program could not incorporate the safety system into the interceptor until production of the third battery. The Army has approved fielding the first 48 interceptors configured without the safety system based on available testing and it has chosen to accept the associated risk.

Ongoing Concurrency Increases Acquisition Risks until Developmental Testing Is Complete

While MDA is committed to producing four THAAD batteries, more flight tests are needed to achieve two remaining MDA developmental knowledge points set for the program. Both are tied to flight tests that were, at one time, planned for fiscal year 2011 but were delayed into later fiscal years. MDA's knowledge points identify information required to make key decisions throughout the program and are typically defined early in the acquisition phase to manage program risks. Although success of the first operational test increases confidence in THAAD, we have reported that good acquisition outcomes require high levels of knowledge before significant decisions are made. The building of knowledge consists of information that should be gathered at critical points over the course of a program before committing to production.

To achieve the first remaining MDA knowledge point, THAAD must conduct an integrated flight test against a medium-range ballistic missile target. This test was originally scheduled for the second quarter of fiscal year 2011, but after an air-launched target failure in December 2009 and subsequent target availability issues, the agency moved the test to the third quarter of fiscal year 2012. Later in fiscal year 2011, the test was cancelled altogether because of budgetary concerns and test efficiency. The agency now plans to test the objective in the first BMDS operational test (FTO-01) in late fiscal year 2012. This test is not only planned as the first against a medium-range target for THAAD, but it will also be the first flight of the newly developed extended medium-range ballistic missile target. Assuming several new "firsts" during this high-level operational test poses significant additional risk for the agency and for achieving the knowledge point.

The second knowledge point is to demonstrate THAAD's Army Navy /Transportable Radar Surveillance - Model-2 radar advanced discrimination in terminal mode. This knowledge point was delayed from the first quarter of fiscal year 2010 into the fourth quarter of fiscal year 2011 because of the same 2009 target issue. However, this knowledge point was not accomplished in 2011 either. Additional changes to the flight test plan in 2011 moved this objective to a flight test scheduled for the third quarter of fiscal year 2013. As THAAD continues to gather data from these developmental flight tests, the program continues to concurrently produce interceptors, launchers, and associated equipment for operational use. As a result, the program is at risk for discovering new information that could lead to costly design changes and a need to retrofit missiles either already in the production process or in inventory.

Appendix XII: GAO Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

In addition to the contact named above, David B. Best, Assistant Director; Letisha J. Antone; Ivy Hübler; LaTonya Miller; Jonathan A. Mulcare; Kenneth E. Patton; John H. Pendleton; Karen Richey; Ann Rivlin; Luis E. Rodriguez; Steven Stern; Robert Swierczek; Hai V. Tran; and Alyssa Weir made key contributions to this report.

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