United States Government Accountability Office

GAO

Report to Congressional Committees

March 2005

DEFENSE ACQUISITIONS

Status of Ballistic Missile Defense Program in 2004

GAO

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Highlights

Highlights of GAO-05-243, a report to Congressional Committees

Why GAO Did This Study

Since 1985, the Department of Defense (DOD) has invested $85 billion in ballistic missile defense programs, with $66.5 billion more anticipated over the next 7 years through 2011. As a major result of this investment, the Department is on the verge of activating our nation's first missile defense system for protecting the United States from intercontinental ballistic missile attacks out of Northeast Asia. This initial capability—referred to as Limited Defensive Operations (LDO)—is the first step of a national priority to develop, field, and evolve over time an overarching ballistic missile defense system (BMDS).

To fulfill a congressional mandate, GAO assessed how well the Missile Defense Agency (MDA) met its cost, schedule, testing, and performance goals during fiscal year 2004. GAO assessed the program last year and will continue to provide assessments of MDA progress through 2006.

What GAO Recommends

To help decision makers in Congress and DOD better understand the relationship between requested funding and delivered capabilities, GAO recommends that MDA clarify and modify, as needed, its block policy to ensure its cost and fielding goals are consistently aligned. DOD concurred with our recommendation.

www.gao.gov/cgi-bin/getrpt?GAO-05-243.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Robert E. Levin at (202) 512-4841 or levinr@gao.gov.

March 2005

DEFENSE ACQUISITIONS

Status of Ballistic Missile Defense Program in 2004

What GAO Found

By the end of fiscal year 2004, MDA carried out activities needed to field an initial missile defense capability, as planned. These included delivery and emplacement of Ground-based Midcourse Defense interceptors; upgrades of ground-based radars; enhancements to Aegis Navy ships for improved surveillance and tracking; development of command and control software for system operation; and tests to verify that components of this initial capability can communicate as part of an integrated whole. However, the performance of the system remains uncertain and unverified, because a number of flight tests slipped into fiscal year 2005 and MDA has not successfully conducted an end-to-end flight test using operationally-representative hardware and software. Additionally, based on our analysis of prime contractor cost and schedule performance, the development of BMDS elements cost approximately $370 million more than planned during fiscal year 2004. To cover much of this cost overrun, MDA deferred work planned for fiscal year 2004, redirected funds earmarked for other programs, and requested additional funds in its fiscal year 2005 budget to cover the cost of deferred work.

In the future, MDA will likely face increased funding risks. MDA plans to request about $10 billion annually from DOD for BMDS development, procurement, and sustainment. However, DOD's acquisition programs are likely to be competing for a decreasing share of the total federal budget and MDA's programs are competing against hundreds of other DOD programs. Also, MDA continues to budget for unanticipated cost growth. For example, the Airborne Laser program plans to spend an additional $1.5 billion to develop and demonstrate a prototype aircraft. Furthermore, procurement and sustainment will demand increased funding as more missile defense components are fielded over time.

MDA policy defines a block as an integrated set of capabilities fielded during the 2-year block cycle, but we observed that MDA's fielding goals do not consistently match its cost goals. For example, Block 2004 funds are used to procure 32 Aegis Ballistic Missile Defense missiles, but of these missiles, 11 will be delivered in 2004-2005 and the remaining missiles will be delivered during 2006-2007. MDA officials intend to clarify the block policy in the near future to better align the cost and fielding goals.

Elements of Ballistic Missile Defense System

First fielded block	Future blocks
Aegis Ballistic Missile Defense	Airborne Laser
Command, Control, Battle Management, and Communications	Kinetic Energy Interceptors
Ground-based Midcourse Defense	Space Tracking and Surveillance System
Patriot	Terminal High Altitude Area Defense

Sources: MDA (data); GAO (presentation).

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Abbreviations

ABL	Airborne Laser
Aegis BMD	Aegis Ballistic Missile Defense
AI&T	Assembly, Integration, and Testing
BC/FC	Beam Control / Fire Control
BILL	Beacon Illuminator Laser
BMC2	Battle Management, Command and Control
BMC4I	Battle Management, Command, Control, Communications, Computer, and Intelligence
BMDS	Ballistic Missile Defense System

BV	Booster Validation
C2BMC	Command, Control, Battle Management, and Communications
CAP	Combined Aggregate Program
COIL	Chemical Oxygen-Iodine Laser
CONOPS	Concept of Operations
CONUS	Continental United States
CTF	Control Test Flight
DOD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
EVM	Earned Value Management
FM	Flight Mission
FT	Flight Test
FY	fiscal year
GMD	Ground-based Midcourse Defense
IBR	Integrated Baseline Review
ICBM	Intercontinental Ballistic Missile
IFICS	In-Flight Interceptor Communications System
IFT	Integrated Flight Test
IGT	Integrated Ground Test
IT	Integrated Test
KEI	Kinetic Energy Interceptors
LDO	Limited Defensive Operations
LRS&T	Long-Range Surveillance and Tracking
MEADS	Medium Extended Air Defense System
MDA	Missile Defense Agency
MRBM	Medium Range Ballistic Missile
MSE	Missile Segment Enhancement
NFIRE	Near Field Infrared Experiment
O&S	Operations and Support
OSC	Orbital Sciences Corporation
OTA	Other Transaction Agreement
PAC-3	Patriot Advanced Capability-3
PMRF	Pacific Missile Range Facility
RDT&E	Research, Development, Test, and Evaluation
SBIRS	Space-Based Infrared System
SBX	Sea-Based X-band Radar
SCF	Seeker Characterization Flight
SDACS	Solid Divert and Attitude Control System
SICO	System Integration and Checkout
SIL	System Integration Laboratory
SM	Standard Missile
SRBM	Short Range Ballistic Missile
SRR	System Requirements Review

STSS	Space Tracking and Surveillance System
TILL	Target Illuminator Laser
THAAD	Terminal High Altitude Area Defense
UEWR	Upgraded Early Warning Radar
USNORTHCOM	U.S. Northern Command
USPACOM	U.S. Pacific Command
USSTRATCOM	U.S. Strategic Command
VAFB	Vandenberg Air Force Base
WSMR	White Sands Missile Range

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Congressional Committees

Our nation's first missile defense system for protecting the United States from intercontinental ballistic missile (ICBM) attacks is expected to be activated for defensive operations in the coming months. This initial capability is the culmination of efforts on the part of the Missile Defense Agency (MDA) and other Department of Defense (DOD) components in response to the President's December 2002 directive to begin fielding an initial set of missile defense capabilities to meet the near-term ballistic missile threat to our nation. It also represents a major result of the $85 billion invested in ballistic missile defense programs since fiscal year 1985. DOD's investment in missile defense continues, as indicated by proposed budgets for the next few years. The Department estimates MDA will need $66.5 billion between fiscal years 2005 and 2011 to continue work in this area, with fiscal year 2005 appropriations of $8.8 billion accounting for 13 percent of DOD's total research and development budget.[1]

The initial capability, which DOD refers to as Limited Defensive Operations (LDO), is the first step of a national priority to develop, field, and evolve over time an overarching Ballistic Missile Defense System (BMDS). While DOD envisions a BMDS capable of protecting the United States, deployed forces, friends, and allies from ballistic missile attacks of all ranges, the LDO capability is primarily designed to provide some protection of the United States against long-range ballistic missile attacks out of Northeast Asia.

In developing the BMDS, MDA is attempting to follow an evolutionary acquisition strategy in which the development and fielding of capabilities is pursued in 2-year blocks. The configuration of a given block builds on the work completed in previous blocks. Block 2004, being deployed during the calendar years 2004-2005, is the first biennial increment of the BMDS

[1]DOD also funds missile defense activities outside of MDA. The Army requested approximately $4.5 billion for the development and procurement of its Combined Aggregate Program—consisting of Patriot and the Medium Extended Air Defense System—during fiscal years 2006 through 2011. Appendix IX provides additional information on this program.

to provide an integrated set of capabilities. LDO represents an interim capability on the path to full Block 2004 fielding.

The National Defense Authorization Act for Fiscal Year 2002 directed DOD to establish schedule, testing, performance, and cost goals for its ballistic missile defense programs.[2] As established by DOD, the goals highlight, by block, overall cost, schedule, and performance objectives for BMDS development and specify the quantities and locations of specific BMDS components[3] planned for operational use. The act also directed us to assess, at the conclusion of each of fiscal years 2002 and 2003, the extent to which MDA achieved the goals it established. We delivered an assessment covering fiscal year 2003 to Congress in April 2004.[4]

Congress has since continued to require our assessment through fiscal year 2006.[5] To fulfill this mandate, we examined the progress that MDA made in fiscal year 2004 toward its stated goals. For example, many activities completed in fiscal year 2004 by the various element programs pertain to the completion of the LDO capability, which is an integral part of the Block 2004 goals. While conducting this review, we identified issues associated with MDA's ability to fund future development and fielding of its missile defense capabilities and with MDA's application of the block approach. Our report includes these observations.

The accomplishment of MDA program goals is ultimately achieved through the efforts of individual BMDS elements, such as Ground-based Midcourse Defense and Airborne Laser. Therefore, we based our assessment on the progress made in fiscal year 2004 by those elements that are under the management of MDA and that are being developed as part of a block capability. The elements we reviewed accounted for 72 percent of MDA's fiscal year 2004 research and development budget. Details of our scope and methodology can be found in appendix X.

[2] Pub. L. No. 107-107, section 232.

[3] Functional pieces of system equipment, such as radars and interceptors, are referred to as "components."

[4] GAO, *Missile Defense: Actions Are Needed to Enhance Testing and Accountability*, GAO-04-409 (Washington, D.C.: Apr. 23, 2004).

[5] *Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005*, Pub. L. No. 108-375, section 233.

Results in Brief

By the end of fiscal year 2004, MDA carried out activities needed to field an initial missile defense capability, as planned. This included delivery and emplacement of Ground-based Midcourse Defense interceptors; upgrades of ground-based radars; enhancements to Aegis Navy ships for improved surveillance and tracking; development of command and control software for system operation; and tests to verify that components of this initial capability can communicate as part of an integrated whole. However, the performance of the system remains uncertain and unverified, because MDA has not successfully completed a flight test using operationally-representative hardware and software. Additionally, the development of system elements cost approximately $370 million more than planned during fiscal year 2004. To cover much of this cost overrun, MDA deferred work planned for fiscal year 2004, redirected funds earmarked for other programs, and requested additional funds in its fiscal year 2005 budget to cover the cost of deferred work.

Two issues have relevance for decision makers in Congress and DOD when considering future budget decisions for the missile defense program. First, although MDA has received nearly all funding requested in the past few years, the agency is expected to face increased funding risks—arising from sources both outside and within DOD—in the years ahead. MDA plans to request, on average, about $10 billion in research and development funding per year over the 2006-2011 time period to support continued development, procurement, and sustainment of hardware and software that MDA is fielding.[6] However, DOD's acquisition programs are likely to be competing for a decreasing share of the total federal budget that is allocated to discretionary (non-mandatory) spending. Also, within DOD, MDA's programs are competing against hundreds of technology development and acquisition programs for DOD's research and development budget—$70 billion in fiscal year 2005—and cost growth of existing weapon programs[7] puts even more pressure on MDA's share of research and development dollars. Additionally, funding risks can be expected from cost growth of ongoing MDA programs. For example, as part of the restructuring of MDA's Airborne Laser program, the cost to

[6] Congress authorized DOD's use of funds appropriated for MDA research, development, test, and evaluation for the fielding of ballistic missile defense capabilities. Pub. L. No. 108-136, section 222; Pub. L. No. 108-375, section 231.

[7] We found, for example, that research and development cost estimates grew $6.7 billion for the Joint Strike Fighter in calendar year 2003 and $9.2 billion for the Future Combat System in fiscal year 2004.

accomplish the objective of developing and demonstrating a prototype aircraft increased by $1.5 billion. Finally, procurement and sustainment will demand increasing levels of MDA's funding as more components are fielded over time.

Second, we observed that MDA's cost goal for a given block—which, by definition, is MDA's budget for all developmental and fielding activities associated with the block—is not aligned with the block's fielding goals. According to MDA policy, for example, interceptors identified with the Block 2004 fielding goals and fielded during calendar years 2004-2005 should be funded as part of the Block 2004 cost goal. However, we found that MDA has not been consistently matching a block's cost and fielding goals. For example, Block 2004 funds are used to procure 32 Aegis Ballistic Missile Defense missiles, but of these missiles, 11 will be delivered in 2004-2005 and the remaining missiles will be delivered during 2006-2007. Also, counter to the definition of a block as an integrated set of capabilities fielded during the 2-year block window, the Airborne Laser program will not field any capabilities during Block 2004 although Block 2004 funds are used in the program's development.

We are recommending that MDA clarify its block policy to ensure that a block's cost and fielding goals are consistently aligned. DOD concurred with our recommendation.

Background

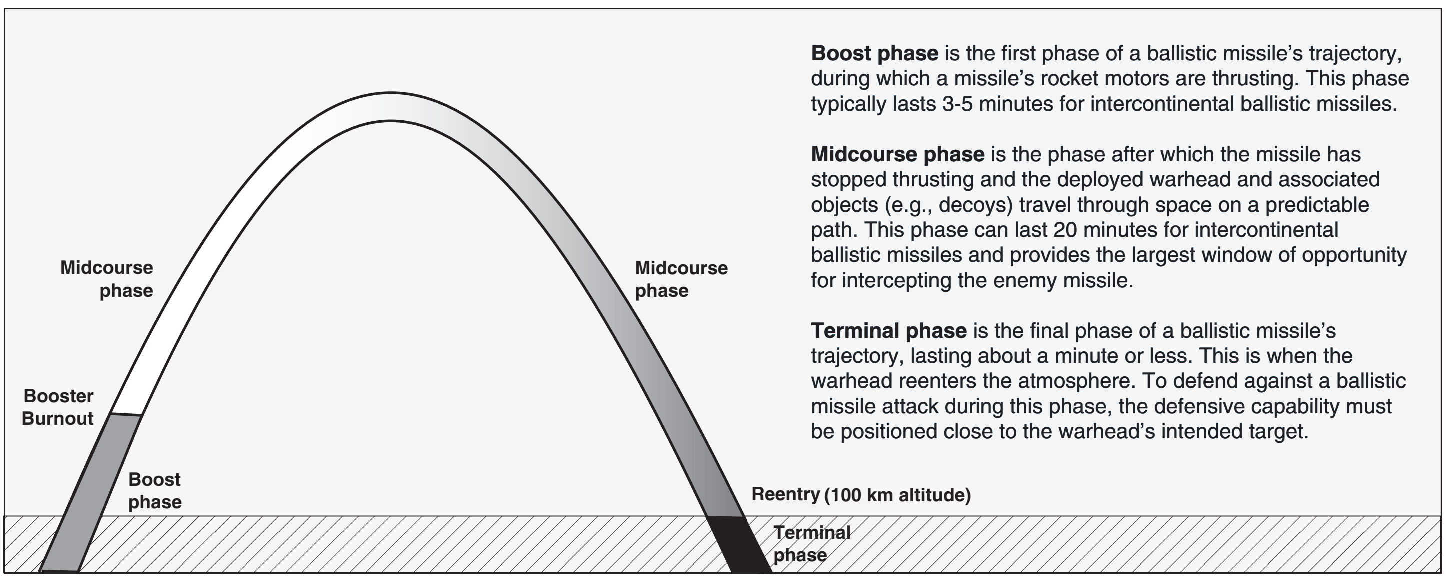
Ballistic missile defense is a challenging mission for DOD, requiring a unique combination of defensive components—space-based sensors, surveillance and tracking radars, advanced interceptors, command and control, and reliable communications—working together as an integrated system. A typical scenario to engage an ICBM is expected to unfold as follows:

- Overhead satellites detect a missile launch and alert the command authority of a possible attack.
- Upon receiving the alert, the BMDS directs its land- and sea-based radars to track the missile complex and (if so designed) to identify the warhead from decoys and associated objects.
- Based on accurate track data, an interceptor—consisting of a "kill vehicle" mounted atop a booster—is launched. The interceptor boosts itself toward the predicted intercept point and releases its kill vehicle to engage the threat.

- The kill vehicle uses its onboard sensors and divert thrusters to acquire, identify, and steer itself into the warhead. With a combined closing speed on the order of 10 kilometers per second (22,000 miles per hour), the warhead is destroyed through a "hit-to-kill" collision with the kill vehicle.

To meet this challenge, DOD intends to develop and field a ballistic missile defense system capable of defeating ballistic missiles during all phases of flight (see fig. 1).

Figure 1: Phases of a Ballistic Missile's Trajectory



Source: MDA (data); GAO (presentation).

Under the evolutionary, capabilities-based acquisition strategy being pursued by DOD, the BMDS has no fixed design or final architecture, and there are no firm requirements. According to DOD, this approach gives MDA increased flexibility to develop a system that can more readily respond to a changing threat and more easily insert new technologies for enhancing system performance.

The missile defense capability of Block 2004 is primarily one for defending the United States against ICBM attacks from Northeast Asia and the Middle East. It is built around the Ground-based Midcourse Defense (GMD) element, augmented by shipboard Aegis Ballistic Missile Defense (Aegis BMD) radars, and integrated by the Command, Control, Battle Management, and Communications (C2BMC) element. The Block 2004

BMDS also includes the Army's Patriot element for point defense of deployed U.S. forces against short- and medium-range ballistic missiles. The Block 2006 program builds directly upon Block 2004. It continues element development and funds the next increment of fielding that adds interceptors, new radars, and enhanced battle management capabilities.

MDA is also carrying out an extensive research and development effort to expand its current operational capability into future blocks. During fiscal year 2004, MDA funded the development of four other major BMDS elements—Airborne Laser (ABL), Kinetic Energy Interceptors (KEI), Space Tracking and Surveillance System (STSS), and Terminal High Altitude Area Defense (THAAD)—in addition to those elements comprising the Block 2004 defensive capability. MDA intends to integrate these elements, when ready, into future BMDS blocks. Table 1 provides a brief description of these elements, and more information about them is provided in appendixes II through VIII of this report.[8]

Table 1: BMDS Elements

Element	Missile defense role
Aegis Ballistic Missile Defense	Aegis BMD is a ship-based system designed to destroy short- and medium-range ballistic missiles during the midcourse phase of flight. Its mission is two-fold: to protect deployed U.S. forces, allies, and friends against ballistic missile attacks, and to serve as a forward-deployed BMDS sensor, especially in support of the GMD mission. MDA has plans to deliver up to 66 Aegis BMD missiles—the Standard Missile 3—and 18 ships by the end of fiscal year 2009.
Airborne Laser	ABL is an air-based system designed to destroy all classes of ballistic missiles during the boost phase of flight. ABL employs a high-energy chemical laser to rupture a missile's motor casing, causing the missile to lose thrust or flight control. MDA plans to demonstrate proof of concept in a system demonstration no earlier than 2008. The availability of a militarily useful capability is contingent on the success of the demonstration.
Command, Control, Battle Management, and Communications	C2BMC is the integrating and controlling element of the BMDS. Although it is part of the Block 2004 defensive capability, its role during this period is limited to mission planning and situational awareness—monitoring system status and missile trajectories.

[8] Table 1 lists those elements of the BMDS for which we completed a detailed review of progress achieved in fiscal year 2004. Because we were directed to assess MDA's progress in achieving its program goals and MDA does not have funding and management responsibility for the Patriot system, our review of this program—provided in appendix IX—is not as detailed. Rather, we provide information on how Patriot's eventual replacement, Medium Extended Air Defense System (MEADS), will be inserted into fielded Patriot units.

Element	Missile defense role
Ground-based Midcourse Defense	GMD is a ground-based system designed to destroy ICBMs during the midcourse phase of flight. Its mission is to protect the U.S. homeland against ballistic missile attacks from Northeast Asia and the Middle East. GMD is part of the Block 2004 defensive capability and has plans to field 18 interceptors by 2005. MDA plans to field 20 additional interceptors in Alaska by 2010.
Kinetic Energy Interceptors	KEI is a land-based element designed to destroy ICBMs during the boost and ascent phases of flight. MDA expects to demonstrate a defensive capability through flight testing during Block 2012 and expand this capability to sea basing in subsequent blocks.
Space Tracking and Surveillance System	The Block 2006 STSS element consists of a constellation of two demonstration satellites. MDA intends to use these satellites for testing missile warning and tracking capabilities. Any real operational capability of next-generation satellites, however, will not be available until the next decade.
Terminal High Altitude Area Defense	THAAD is a ground-based element 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 population centers. MDA plans to field a Block 2006/2008 unit consisting of 24 missiles in 2009.

Sources: MDA (data); GAO (presentation).

As part of MDA's planning process, MDA defines overarching program goals for the development and fielding of BMDS block configurations. The goals describe the composition of a block (components and elements under development and planned for fielding), provide the costs and schedules associated with element development and fielding, and summarize performance capabilities at the component and system levels.[9] A block's cost goal is the portion of MDA's budget dedicated to development and fielding activities associated with the block.

MDA has established Block 2004 and 2006 "Development Goals" for the continued development and testing of six BMDS elements—ABL, Aegis BMD, C2BMC, GMD, STSS, and THAAD—and stand-alone components such as forward-deployed radars.[10] These goals identify the developmental areas MDA is funding as part of the Block 2004 and 2006 programs. The associated cost goals, which are the planned budgets for these activities, are approximately $5.7 billion and $12.2 billion for Block 2004 and 2006, respectively.

[9] MDA goals are formally detailed in the agency's budget estimates and in the top-level MDA document, *Statement of Goals*.

[10] The KEI program is funded by the Block 2012 program and, accordingly, is not part of the Block 2004 and 2006 goals.

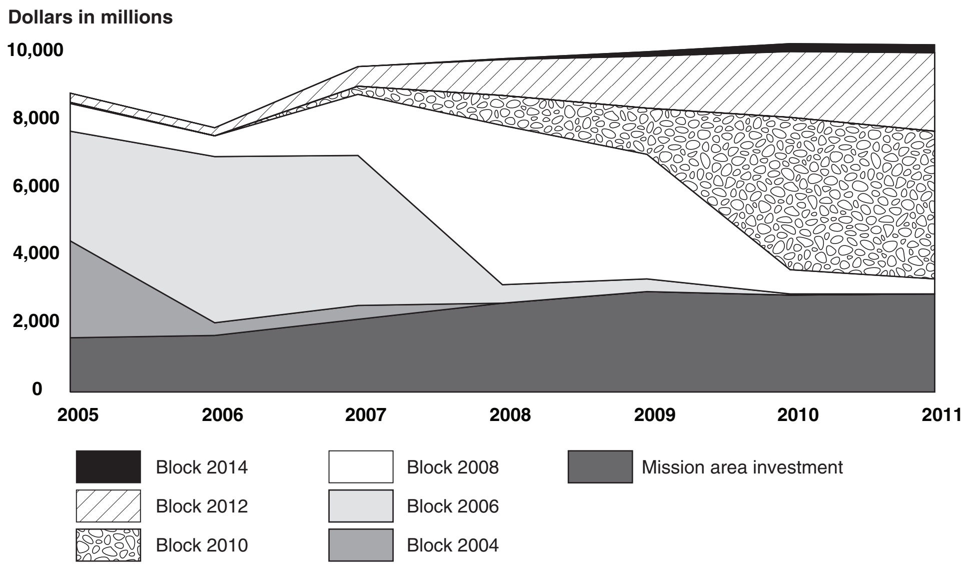
MDA also established a complementary set of goals—referred to as "Fielded Configuration" Goals[11]—in response to the President's December 2002 direction to begin fielding a limited ballistic missile defense capability. The fielding goals build directly upon the Development Goals but aim to deliver an operational missile defense capability during a given block's time frame. For example, Block 2004 goals identify the components of the BMDS available for defensive operations by the end of December 2005. MDA states that the cost goals associated with the Block 2004 and 2006 fieldings are $1.7 billion and $3.8 billion, respectively. Therefore, the total cost goals for Block 2004 and 2006 are $7.4 billion and $16.0 billion, respectively.

Figure 2 depicts MDA's total budget between fiscal years 2005 and 2011 broken out by block.[12] As illustrated, funding for a given block spans more than the 2-year period. For example, MDA estimates it will need about $12.0 billion to fund Block 2008 activities over the next 7 years through 2011.

[11] In budget documentation submitted in February 2004, MDA referred to these goals as "Operational Alert Configuration" Goals. "Fielded Configuration" is new terminology.

[12] Mission area investment noted in figure 2 represent funding of major mission areas that contribute to the development and enhancement of all blocks. For example, these investments fund system design and engineering activities, testing, advanced concept development, and other special programs.

Figure 2: Breakout of MDA Budget



Source: MDA (data); GAO (presentation).

Note: MDA's total budget for a given fiscal year is represented by the expenditures for all block activities plus mission area investments. For example, MDA's fiscal year 2005 budget of $8.806 billion is comprised of $1.605 billion for mission area investments, $2.854 billion for Block 2004 activities, $3.216 billion for Block 2006 activities, $817 million for Block 2008 activities, $48 million for Block 2010 activities, and $267 million for Block 2012 activities.

Many activities completed in fiscal year 2004 by the various element programs pertain to the completion of the LDO capability—the initial capability fielded by MDA. Although LDO is not formally listed by MDA as a Block 2004 goal, it does include the delivery of a capability on the path to meeting the fielding goals. Table 2 summarizes MDA's fielding goals.

Table 2: MDA Block 2004 Fielded Configuration Goals

BMDS element	Functionality	LDO (Sept. 30, 2004)	Block 2004 (Dec. 31, 2005)
GMD	Defend the U.S. homeland against ICBM attacks	• 5 Interceptors • Upgraded Cobra Dane radar • 1 Upgraded early warning radar (Beale) • Fire control nodes	• 20 Interceptors • Upgraded Cobra Dane radar • 2 Upgraded early warning radars (Beale, Fylingdales) • Sea-based X-band radar • Fire control nodes

BMDS element	Functionality	LDO (Sept. 30, 2004)	Block 2004 (Dec. 31, 2005)
Aegis BMD	Sea-based engagement capability against short- and medium-range ballistic missiles; early tracking of ICBMs as a BMDS sensor	• 3 Aegis destroyers (long-range surveillance and tracking only)	• Up to 9 missiles • 10 Aegis destroyers (long-range surveillance & tracking only) • 3 Aegis cruisers (engagement)
C2BMC	Integrating element of the BMDS; situational awareness; mission planning	• Software Build 4.3 • Suites (command centers) and supporting hardware at various locations	• Software Build 4.5 • Suites (command centers) and supporting hardware at various locations

Sources: MDA (data); GAO (presentation).

Note: Performance goals are not presented in this report because they are classified.

Assessment of Scheduled Activities in Fiscal Year 2004

The GMD, Aegis BMD, and C2BMC programs completed scheduled activities in fiscal year 2004 necessary to support the fielding of LDO, an integral part of Block 2004. Most notably, the GMD program completed construction activities at GMD sites, delivered and emplaced five GMD interceptors in their silos at Fort Greely, Alaska, and completed the upgrade of the Cobra Dane radar. The Aegis BMD program upgraded three destroyers for the long-range surveillance and tracking mission that supports homeland defense against ICBMs. In addition, the C2BMC program completed software development, activated control centers, and worked to integrate elements of the system.

These programs also continued developmental and fielding activities in early fiscal year 2005 to enhance LDO so that the full Block 2004 capability could be realized by the end of calendar year 2005. For example, the GMD program delivered a sixth interceptor at Fort Greely in October and two interceptors at Vandenberg Air Force Base in December, completed the upgrade of the Beale early warning radar, and initiated the upgrade of the Fylingdales early warning radar. In addition, the Aegis BMD program completed the assembly of five missiles and continued with software development in the upgrade of its cruisers and destroyers. Similarly, the C2BMC program continued with software development and testing leading to the final Block 2004 version.

Progress made toward achieving program goals relative to the fielding of the LDO and Block 2004 capabilities is summarized in tables 3 and 4, respectively. Detailed evaluations of activities completed in fiscal year 2004 by all BMDS elements are given in appendices II through VIII of this report.

Table 3: Progress toward Achieving LDO

BMDS element	Functionality	LDO (Sept. 30, 2004)	Progress assessment
GMD	Defend the U.S. homeland against ICBM attacks from Northeast Asia	• 5 Interceptors • Upgraded Cobra Dane radar • 1 Upgraded early warning radar (Beale) • Fire control nodes	The GMD program emplaced 5 interceptors at Fort Greely, Alaska, by September 2004. Many site preparation activities, including the construction of facilities and interceptor silos at Fort Greely to prepare the system for LDO, were completed. The GMD program completed the upgrade of the Cobra Dane radar on Shemya Island, Alaska. The upgrades, which consist of hardware and software improvements, enable the radar to more accurately track launched missiles for the planning of intercept engagements. The upgrade of the early warning radar at Beale Air Force Base, California, was completed in December 2004. Although radar hardware installation is complete, final software installation and testing are ongoing with completion expected in the middle of fiscal year 2005.
Aegis BMD	Early tracking of ICBMs as a BMDS sensor	• 3 Aegis destroyers (long-range surveillance and tracking only)	Aegis BMD will be used as a forward-deployed sensor to provide surveillance and early tracking of long-range ballistic missiles to support the GMD mission. This is being accomplished through the improvement of Aegis BMD software and hardware. The Aegis BMD program office completed the upgrade of 2 destroyers for this role in September 2004; a third destroyer became available in October 2004. All 3 destroyers are available for operations.
C2BMC	Integrating element of the BMDS; situational awareness; mission planning	• Software Build 4.3 • Suites (command centers) and supporting hardware at various locations	The C2BMC program office completed activities needed to ready the C2BMC element for LDO. Of significance, the LDO "build" of C2BMC, known as spiral 4.3, was delivered and C2BMC suites activated. The program also carried out a number of activities enabling BMDS integration and warfighter training.

Sources: MDA (data); GAO (presentation).

Table 4: Progress toward Achieving Block 2004 Fielded Configuration Goals\

BMDS element	Functionality	Block 2004 (Dec. 31, 2005)	Progress assessment
GMD	Defend the U.S. homeland against ICBM attacks from Northeast Asia and the Middle East	• 20 Interceptors • Upgraded Cobra Dane radar • 2 Upgraded early warning radars (Beale, Fylingdales) • Sea-based X-band radar • Fire control nodes	The GMD program continued to add interceptors to its inventory. As of December 2004, 6 interceptors are in silos at Fort Greely, Alaska, and 2 at Vandenberg Air Force Base, California. The GMD program aims to increase its inventory of interceptors for the Block 2004 defensive capability to 20 by December 2005. However, MDA designated 2 interceptors as test assets. Therefore, the Block 2004 GMD inventory will consist of 18 interceptors. The GMD program began upgrading the early warning radar at Fylingdales Airbase in England. Facility modifications are on track to be completed by the first quarter of fiscal year 2006. The GMD program office completed a variety of activities in the development of the sea-based X-band radar but assesses its planned completion by the first quarter of fiscal year 2006 as high risk.
Aegis BMD	Sea-based engagement capability against short- and medium-range ballistic missiles; early tracking of ICBMs as a BMDS sensor	• Up to 9 missiles • 10 Aegis destroyers (long-range surveillance & tracking only) • 3 Aegis cruisers (engagement)	As of December 2004, the Aegis BMD program completed assembly of 5 missiles, which are available for fielding. Program officials stated that the program expects to have available a slightly smaller inventory of missiles by December 2005 than was originally planned. The Aegis BMD program aims to increase to 10 by December 2005 the number of upgraded destroyers providing surveillance and early tracking of long-range ballistic missiles in support of the GMD mission. As of January 2005, 5 had been upgraded. The Aegis BMD program is also upgrading Aegis cruisers for the element's engagement role; that is, to defend against short- and medium-range ballistic missiles. This requires physical modification to the ships as well as software upgrades for the engagement role. As of December 2004, 1 cruiser—a ship dedicated to testing—has been upgraded. The program expects to complete the upgrade of 1 additional cruiser (rather than 2) by December 2005.
C2BMC	Integrating element of the BMDS; situational awareness; mission planning	• Software Build 4.5 • Suites (command centers) and supporting hardware at various locations	The C2BMC program office continued with activities needed to ready the C2BMC element for the full Block 2004 capability. In particular, development of the interim build, spiral 4.4, was completed in November 2004. The program office anticipates that development of the final Block 2004 build, spiral 4.5, will be completed in March 2005, after which testing will begin.

Sources: MDA (data); GAO (presentation).

DOD did not activate the LDO capability MDA developed and fielded. Although the LDO capability was expected to be placed on alert by the end of September 2004, officials from the office of the Commander of U.S. Strategic Command (USSTRATCOM) told us that September 30, 2004, was a planning date rather than a "hard date." The officials indicated that the system had not been put on alert for the following reasons:

- **Shakedown**. Since October 2004, the system has been undergoing a "shakedown"—a necessary transition phase between development and operations. During this time, the system is exercised as though an attack is under way. It enables the warfighter to become familiar with the system and, importantly, to plan for unexpected failures.

- **Training**. While initial training of operators has been completed, more is needed. For weapon systems in general, the warfighter does not have a military capability without trained operators, and training cannot begin until a weapon system is delivered (or at least far along in development).

- **Policy**. USSTRATCOM must receive an Execution Order from the Secretary of Defense before the LDO capability is declared operational. This order, which would reflect DOD policy, is to include a clear identification of command and control relationships. USSTRATCOM plans to advise the Secretary of Defense on the military utility of the system and could advise against declaring the system operational if, for example, more testing were needed to increase the command's confidence in the system's effectiveness. Also, the concept of operations (CONOPS) was not finalized, and issues such as the integration of defensive and offensive operations still had to be worked out.

USSTRATCOM officials further explained that the declaration of LDO may or may not mean the system is "on alert" for defensive operations—LDO operation is more complicated than "being on" or "being off" alert. For example, the system could be in "developmental mode" when operated by MDA for testing but capable of being transitioned to an "operational mode" for defensive operations given sufficient time.[13] As of March 2005, DOD had not announced a specific date for activating the initial missile defense capability.

[13] Additional details on system availability and readiness are classified.

Assessment of Testing in Fiscal Year 2004

MDA completed a number of ground tests and exercises in fiscal year 2004, but key flight tests using LDO-configured components were delayed. For example, MDA verified integration and connectivity between its GMD, Aegis BMD, and C2BMC elements, and the warfighter participated in several missile defense exercises (wargames) as part of their training to understand and operate the system. However, the GMD program office conducted two booster tests (non-intercept attempts) in fiscal year 2004 even though six flight tests were planned. As a result, GMD interceptors were emplaced in silos before flight testing was completed to verify that LDO hardware and software could function in an operational environment.

Significant Testing Was Completed

A summary of significant testing completed during fiscal year 2004 by each of the respective element programs is presented in table 5. More thorough discussions of element testing are given in appendices II through VIII of this report.

Table 5: Status of Element Testing—Planned and Achieved

Element	Key testing accomplished
Aegis BMD	The Aegis BMD program conducted Flight Mission 6 (FM-6) in December 2003, during which an SM-3 missile successfully intercepted a short-range ballistic missile target. In addition, the Aegis BMD element participated in non-intercept test events to assess the element's long-range tracking and surveillance (LRS&T) function—that is, using its shipboard SPY-1 radar to track long-range ballistic missiles—and to verify connectivity with the BMDS, that is, pass track data to the C2BMC and GMD elements. The program also conducted a series of ground tests focused on validating design updates to its Solid Divert and Attitude Control System (SDACS)—a collection of solid-fuel thrusters used to steer the kinetic warhead (kill vehicle) into its designated target. In response to a flight test failure in 2003, the program modified the design of this subcomponent to improve its performance and reliability during high-energy pulse operation.
ABL	The ABL program demonstrated "First Light"—the combined operation of individual laser modules to generate a single laser beam—in the first quarter of fiscal year 2005 (Nov. 2004). Although the achievement of "First Light" is a key milestone for the program, it was not intended to be an operational demonstration of a high-power laser, that is, at full power and for the length of time needed to shoot down a boosting missile. Rather, the laser's operation for a fraction of a second demonstrated successful integration of subsystems. The ABL program also completed "First Flight" in the first quarter of fiscal year 2005 (Dec. 2004). Also a key milestone for the program, "First Flight" demonstrated the flight worthiness of the demonstrator aircraft with its newly installed laser beam control system.
C2BMC	The C2BMC program conducted system-level testing of its LDO software, spiral 4.3, during fiscal year 2004 and into fiscal year 2005. Spiral 4.3 was tested in a number of venues, including Pacific Explorer III,[a] Glory Trip 185,[b] a GMD-focused System Integration and Checkout,[c] and wargames that enabled the warfighter to exercise the C2BMC in a simulated operational environment.

Element	Key testing accomplished
GMD	During fiscal year 2004, the GMD program conducted two non-intercept flight tests—one for each of its Lockheed and Orbital Sciences Corporation (OSC) boosters. Booster objectives were achieved in both flight tests, however, the mock kill vehicle failed to deploy from the Lockheed booster. The Lockheed booster test was conducted 11 months late because of problems with a propellant vendor. The OSC booster test was conducted 6 months late. GMD conducted a series of integrated ground tests in fiscal year 2004. These tests employed actual GMD-component processors integrated together in a hardware-in-the-loop facility that emulated GMD operation in a simulated environment. They also included warfighter participation to aid in the development of operational concepts. Finally, the GMD program performed a series of System Integration and Checkouts[c] of its fielded components. While these checkouts did not assess element performance, they demonstrated connectivity, functionality, and integration as part of final preparations for defensive operations.
KEI	The KEI program initiated element development in December 2003 when MDA selected Northrop Grumman as the prime contractor. At this early stage of development, no significant testing has been conducted by the program office. Because of the need to restructure the prime contract in response to reduced funding, KEI's first integrated flight test is planned for no earlier than 2010, depending on the outcome of the program's re-planning.
STSS	MDA is currently working on the first increment of STSS, which is focused on the preparation and launch of two demonstration satellites partially built under the former Space Based Infrared System Low program. MDA plans to launch these satellites in 2007. At that time, testing will be conducted to assess how well the satellites perform surveillance and tracking functions.
THAAD	The THAAD flight-test program consists of 15 flight-test events divided among Blocks 2006 and 2008. Because of delays in booster deliveries arising from the need for a new propellant vendor, the first set of flight tests have been delayed 3-5 months. The element's first test, a control test flight of the missile (non-intercept attempt), is planned to be conducted in the third quarter of fiscal year 2005, a two-quarter slip. The element's first intercept attempt, Flight Test 4, is scheduled to be conducted during the second quarter of fiscal year 2006, a two-quarter slip.

Sources: MDA (data); GAO (presentation).

[a]Pacific Explorer exercises are field exercises to demonstrate BMDS connectivity. An Aegis destroyer participates by tracking an actual missile (or a simulated target) and passes track data to the C2BMC.

[b]Glory Trips are live flight tests during which a Minuteman III missile is launched from Vandenberg Air Force Base as part of Follow-on Test and Evaluation.

[c]System Integration and Checkouts are conducted by the GMD program to verify connectivity, functionality, and integration of system components. They are not used to assess system performance.

Delays and Cancellations of GMD Flight Tests Slow Attainment of Knowledge

The GMD program conducts integrated flight tests (IFT) to realistically demonstrate element operation using actual hardware and software. MDA planned to conduct several flight tests during fiscal year 2004 to gain knowledge about the element's effectiveness and operation under real-world conditions. However, only two of six flight tests scheduled to occur in fiscal year 2004 were conducted. As noted in table 5, these were non-intercept tests of the Lockheed and OSC boosters. A second Lockheed booster test (IFT-13A) was deferred indefinitely; two intercept attempts utilizing LDO-configured hardware and software (IFT-14 and -15) were either delayed or cancelled; and, IFT-13C, the first flight test in 2 years with the potential for an intercept,[14] was delayed 9 months. When IFT-13C was conducted in December 2004, the interceptor failed to launch, which precluded the fulfillment of key test objectives associated with the LDO-configured interceptor.

IFT-13C was of particular significance because it was to have demonstrated operational aspects of the LDO capability for the first time in a flight test environment. For example:

- IFT-13C was the first flight test to utilize LDO hardware and software. Previous intercept attempts employed a surrogate booster and an earlier configuration of the kill vehicle. In particular, IFT-13C was to have launched a GMD interceptor comprised of the operational kill vehicle mated to an OSC booster.

- IFT-13C offered the opportunity to exercise Aegis BMD tracking and connectivity in a manner consistent with an actual defensive mission, that is, to demonstrate Aegis BMD's ability to serve as a fire-control radar[15] for ICBM engagements. However, because weather exceeded peacetime operational safety limits, Navy commanders withdrew Aegis BMD participation from IFT-13C; the program office concurred with the decision.

The delay of IFT-13C by 9 months demonstrates that MDA is responsibly following an event-driven test program, that is, conducting tests only when ready. IFT-13C was delayed more than once to correct technical problems with the interceptor and to upgrade the test interceptor to a configuration that matches the ones deployed. However, the event-driven approach was not carried over into fielding. Eight GMD interceptors were in their silos by the end of December 2004 before flight testing was completed to verify that LDO hardware and software could function in an operational environment. If future flight testing identifies problems with the

[14] IFT-13C was a "zero-offset flyby." Although intercepting the target was not a test objective, no action was taken to prevent an intercept.

[15] The fire control radar is the primary radar for providing the necessary targeting data to the fire control node (battle management component). In particular, data provided by the fire control radar are used to generate an interceptor flyout solution that guides the interceptor to the target.

interceptor, MDA could incur added costs to recall and update fielded assets.

Aegis BMD Conducted Limited Testing of Its Long-Range Surveillance and Tracking Capability

In anticipation of fielding for LDO, the Aegis BMD flight test program focused on long-range surveillance and tracking—that is, to operate the element as a forward-deployed BMDS sensor—in support of the GMD mission. To this end, by October 2004, the Aegis BMD program completed software development and upgraded three Aegis destroyers for this role; they are available for operations. However, the surveillance and tracking function has only been partially demonstrated. For example:

- Aegis BMD participated in Glory Trip 185, during which an Aegis destroyer successfully tracked a Minuteman III ICBM launched from Vandenberg Air Force Base. However, the test did not exercise Aegis BMD tracking and connectivity in a manner needed for an actual defensive mission, that is, as an integral part of the system during which the destroyer acts as a fire control radar. In addition, the software tested was not the version installed on fielded destroyers.

- During the Pacific Explorer II field exercise, a destroyer in the Sea of Japan successfully passed track data of a simulated target, thereby demonstrating connectivity with the BMDS. In Pacific Explorer III, an Aegis destroyer planned to track an actual missile and pass track data to the BMDS. Although the destroyer tracked the live target missile, a malfunction with the target limited the amount of data collected by the Aegis destroyer. Specifically, the target ended its flight before Aegis BMD could send the GMD element all of the information needed for engaging the target.

- Finally, delays in the GMD flight test program precluded Aegis BMD from participating in two planned integrated flight tests, IFT-13C and IFT-14, during fiscal year 2004. Without these tests, MDA has not verified that the element's long-range surveillance and tracking capability will perform as desired in an actual defensive mission.

MDA Mandated to Conduct Operationally Realistic Testing

The 2005 Defense Authorization Act, section 234, directed DOD to conduct an operationally realistic test of the BMDS by October 1, 2005, and required the Secretary of Defense, in consultation with the Director, Operational Test and Evaluation (DOT&E),[16] to prescribe appropriate test objectives. Such a test is expected to exercise the LDO and Block 2004 configuration in a more realistic manner. Officials from the office of DOT&E told us that the test would be derived from an existing flight test with objectives focused more on operational than developmental aspects.

DOT&E recently approved the operational test portion of MDA's *Integrated Master Test Plan*. The *Integrated Master Test Plan* establishes the framework for BMDS ground and flight testing through Block 2006. It is an overarching document that defines the test plans for the BMDS and its elements, identifies operational test objectives to support continuous characterization of demonstrated operational capability, and identifies associated test resources.

Assessment of System Performance in Fiscal Year 2004

MDA has conducted various ground and flight tests that provide some degree of confidence that the LDO capability—consisting of the GMD element, Aegis BMD destroyers for surveillance and tracking, and C2BMC for command and control—will operate as intended. In addition, MDA predicts that the LDO capability, although limited in inventory, will be effective[17] in providing some protection of the United States against ICBM attacks from Northeast Asia. However, the agency has not verified that the LDO capability can operate as an integrated system without range-test limitations and artificialities (for example, using surrogate components to emulate missile defense functions), and operational testers within DOD state that there is not enough data to accurately characterize system performance.

[16] DOT&E is responsible for providing independent oversight of operational test and evaluation of major defense acquisition programs to verify their operational effectiveness and suitability for combat use. The Director is the principal operational test and evaluation official within DOD and advises the Secretary of Defense and Under Secretary of Defense for Acquisition, Technology, and Logistics on operational test and evaluation. The Director also provides responsible officials with advice on developmental testing.

[17] The term "effective" means that the BMDS can destroy an ICBM with a high probability of success. The exact figures, which depend on scenario, are classified.

Assessment of LDO Effectiveness Subject to Interpretation

MDA and DOT&E differ on derived estimates of LDO effectiveness. Both offices employed similar methodologies—that is, they identified critical functions needed to carryout a BMD engagement, estimated the probability of success for each function, and combined results into a "probability chain" to calculate a total probability of success for a given scenario. However, the assessments made by MDA and DOT&E differ in that they are based on different types and sources of information.

MDA's assessment is based on the output from BMDS-level simulations using data derived from a variety of sources, including design specifications and output from high-fidelity simulations of various components (such as radars and interceptors). By employing digital simulations, estimates of system effectiveness are obtained over a wide range of conditions, scenarios, and system architectures. These simulations are anchored by data collected during flight testing so that their underlying models are reflective of real-world operation.

DOT&E generated its estimates of system effectiveness by also approximating each factor of the "probability chain," but it relied on historical data and results from recent ground and flight tests. Based on this methodology, DOT&E concluded that there is not enough test data to accurately characterize system effectiveness—that is, the estimates are too uncertain to make definitive conclusions. In commenting on MDA's methodology, DOT&E officials made the following points:

- MDA's computer-based assessments are appropriate for a developmental program, but there could be difficulty in interpreting results for operational considerations.

- A noteworthy limitation of MDA's assessment is the lack of system-level performance data. Although its models provide a good representation of the system being built, fundamentally they are not predictive of actual system performance.

The uncertainty in LDO effectiveness has a direct impact on how the warfighter operates the system. As noted by officials from USSTRATCOM, the uncertainty limits the warfighter's ability to formulate tactics and procedures in operating the system, especially with limited inventory.

In addition, knowledge of component performance can play a useful role in fielding decisions by assisting decision makers in determining whether the capability available at the time warrants the cost of fielding, operating, and sustaining the system, or whether additional investment and development to enhance the capability are needed.

Integrated Operation of LDO Capability Remains Unverified

MDA has conducted a variety of tests that provide some degree of confidence that the LDO capability will operate as intended. For example, since 1999, the GMD program has conducted eight flight tests (intercept attempts)[18] that emulated system operation against ICBM attacks. In addition, based on MDA documentation, the various functions of the BMD engagement—such as launch detection, tracking, interceptor launch, and intercept—have been demonstrated in a variety of venues, including simulations, ground tests, and flight tests. Technical indicators monitored by GMD, Aegis BMD, and C2BMC show that the elements' various components are on track to function as expected during a BMD engagement. For example, the Aegis BMD program projects that the Aegis SPY-1 radar is able to deliver adequate performance in support of the GMD mission. Furthermore, based on past flight tests, MDA states that discrimination performance of the GMD kill vehicle is adequate to meet system-level objectives relative to the Block 2004 threat.

However, collectively, these accomplishments do not verify integrated system operation of the LDO capability because of inherent limitations and artificialities. An end-to-end test of system operation—beginning with launch detection and ending with intercept confirmation—should incorporate operational test objectives such as test realism, lack of scripting, and the utilization of production-representative hardware. Although MDA has progressed in demonstrating such objectives in a ground-test setting, they have yet to be demonstrated in end-to-end flight tests. As we reported in February 2004,[19] GMD flight tests to date have demonstrated basic functionality of a representative missile defense system using surrogate and prototype components. In addition, they have shown success in intercepting a mock reentry vehicle in a developmental test environment. However, as developmental tests, they were scripted, did not use production-representative hardware and software, and

[18] GMD's December 2004 flight test, IFT-13C, and its February 2005 flight test, IFT-14, are not counted.

[19] GAO, *Missile Defense: Actions Being Taken to Address Testing Recommendations, but Updated Assessment Needed*, GAO-04-254 (Washington, D.C.: Feb. 26, 2004).

required the placement of a C-band transponder[20] on the target reentry vehicle. The transponder was essential for the execution of the flight tests—no ground radar of sufficient accuracy for guiding the interceptor to the intercept point was available.

Although MDA has conducted many tests to exercise separate functions of the BMD mission, component-level testing in preparation for LDO has been incomplete. For example, MDA conducted wargames that enabled the warfighter to exercise the C2BMC in a simulated operational environment to gain insight in and provide feedback on C2BMC capabilities. Also, GMD radars and Aegis BMD destroyers took advantage of other DOD missions[21] that enabled these elements to exercise radar and battle management operations. However, some components have not been fully tested:

- The Cobra Dane radar is located at Eareckson Air Station in Shemya, Alaska, at the western end of the Aleutian chain. Its close proximity to Russia allows it to perform its primary mission of collecting data on ICBMs and submarine-launched ballistic missiles launched into the Kamchatka impact area. In fiscal year 2004, the GMD program completed hardware installation and software upgrades to the Cobra Dane radar. To test these upgrades, Cobra Dane tracked a foreign missile launch and participated in an integrated ground test. However, the upgraded Cobra Dane radar has not participated in a flight test event as the primary fire control radar—a role it would need to fill in the event of a real threat. MDA may conduct a test during the third quarter of fiscal year 2005 using a long-range air-launched target to demonstrate the upgraded Cobra Dane under more operationally realistic conditions.

- Aegis destroyers upgraded for the long-range surveillance and tracking capability have not been exercised in a manner consistent with an actual defensive mission. That is, the Aegis BMD element has not provided track data of a target, in real time, for use in planning a BMD mission against a target ICBM. Aegis BMD will first participate in a

[20] A transponder is a receiver-transmitter that will generate a reply signal under proper interrogation. The missile defense community also refers to the transponder as the “C-band beacon.”

[21] Most notably are Glory Trips, which are live flight tests during which a Minuteman III missile is launched from Vandenberg Air Force Base as part of Follow-on Test and Evaluation.

GMD flight test in this role in fiscal year 2005.[22] Despite this concern, DOT&E officials believe that Aegis BMD can adequately perform its detection and tracking functions.

Assessment of System Cost in Fiscal Year 2004

We used contractor Cost Performance Reports in combination with Earned Value Management (EVM)[23] analysis to assess progress made by the various element prime contractors toward MDA's cost and schedule goals during fiscal year 2004. The government routinely uses such reports to independently evaluate these aspects of the prime contractors' performance. Generally, the reports detail deviations in cost and schedule relative to expectations established under the contract. Contractors refer to deviations as "variances." Positive variances are generally associated with the accomplishment of activities under cost or ahead of schedule, while negative variances are often associated with the accomplishment of activities over cost or behind schedule. Cost Performance Reports provide program mangers and others with information on a contractor's ability to perform work within estimated cost and schedule. When reports show that the contractor is encountering problems that cause cost growth, program officials can then take actions to prevent further growth.

We assessed MDA fiscal year 2004 cost performance by reviewing the cost performance of each system element, which, in turn, is based on the cost performance of its element prime contractor. We used this methodology because a large percentage of MDA's budget is allocated to prime contractors that develop the various BMDS elements. As summarized in table 6, prime contractors responsible for developing three of the seven BMDS elements we reviewed—C2BMC, KEI, and THAAD—completed their fiscal year 2004 work at or near budgeted costs. Activities cost more than budgeted for the ABL, GMD, and the STSS elements by $114 million, $220 million, and $35 million, respectively. Also, our analysis of cost and schedule performance for the entire Aegis BMD element could not be conducted, because Cost Performance Reports for the Standard Missile 3 contract were not issued until September 2004. Our detailed findings are presented in appendices II through VIII of this report.

[22] With the objective of acting as the fire control radar for an ICBM engagement, Aegis BMD planned to participate in GMD flight test IFT-14 in February 2005. The test could not be fully executed because the GMD interceptor failed to launch.

[23] The EVM system is a management tool widely used by DOD to compare the value of a prime contractor's work performed to the work's actual cost. The tool measures the contractor's actual progress against its expected progress and enables the government and contractor to estimate the program's remaining cost.

Table 6: Prime Contractor Cost and Schedule Performance in Fiscal Year 2004

Dollars in millions

BMDS element	Cost variance	Schedule variance[a]	Percent of contract completed	Comments
ABL	($114.4)	($47.6)	N/A[b]	Variances reflect cumulative prime contractor cost and schedule performance for the first half of fiscal year 2004—October 2003 through March 2004. Program officials indicated that hardware delivery delays, design problems, and integration issues were the primary drivers of the cost variances. After this time, the program was restructured and the prime contract rebaselined. Program officials directed the contractor to suspend normal contractor performance reporting between April and July 2004, during which the contractor expended $129 million. During this time, the contractor provided forecasts of expenditures to the program. The contractor resumed normal cost performance reporting in August 2004. As of September 2004, the contractor was performing work under budget but slightly behind schedule. As part of the restructuring, the prime contract's cost increased by $1.5 billion and its term extended over 3 years to accomplish the objective of developing a prototype aircraft. In total, ABL prime contract costs have increased from $1.0 billion at the time of contract award in 1996 to $3.6 billion in 2004.
Aegis BMD	3.5	(2.0)	43	The Aegis BMD element has two prime contracts: the Aegis Weapon System contract, consisting of software and hardware upgrades of existing Navy cruisers and destroyers to make them BMD capable; and the Standard Missile 3 (SM-3) contract for the development of the element's missile. Both were awarded in the second half of 2003. Variances shown are of the Aegis Weapon System contract only, which shows that the contractor completed fiscal year 2004 work under budget. The contractor who develops the SM-3 missile began reporting cost and schedule performance in the last month of fiscal year 2004; therefore, this contractor's cost and schedule performance for the year is not reported.
C2BMC[c]	(3.6)	(5.7)	100 (Part 2) 31 (Part 3)	Overall, the prime contractor is under budget. But when considering performance in fiscal year 2004 alone, the contractor performed work slightly over budget and behind schedule. The declining performance is largely attributed to issues pertaining to algorithm development and site integration.
GMD	(219.6)	(59.9)	69	Developmental issues with the GMD interceptor—booster and kill vehicle—remain the leading cause of negative cost and schedule variances. In fiscal year 2004, interceptor-related work cost $204 million more than budgeted, of which the kill vehicle accounted for 40 percent of the variance. Flight test delays also contributed to unfavorable cost and schedule performance.
KEI	0.04	(1.6)	1	The KEI prime contractor performed work in fiscal year 2004 near its budgeted costs. Program officials indicated that the slightly unfavorable schedule variance was the result of the contractor delaying activities so that it could conduct trade studies on new requirements imposed by MDA. Because of plans to restructure the KEI program—to defer the land-based capability from Block 2010 to Block 2012—the long-term performance measurement baseline[d] is no longer relevant. In August 2004, the program suspended contractor cost and schedule performance reporting until a reliable baseline to reflect the full extent of the program's restructure became available. The contractor is reporting actual costs until program restructure efforts are complete.

Dollars in millions

BMDS element	Cost variance	Schedule variance[a]	Percent of contract completed	Comments
STSS	(34.6)	(20.7)[e]	29	Prime contract cost and schedule performance eroded throughout fiscal year 2004. The erosion in cost performance was largely attributed to cost overruns by a subcontractor who had a number of quality and systems-engineering problems. Delays in software and hardware deliveries were the major causes for the unfavorable schedule variance. Despite these issues, the program office maintains that the prime contractor is expected to complete the contract early and with minimal cost overruns.
THAAD	$0.7	$8.1	61	Overall, the prime contractor is under budget and ahead of schedule. However, the contractor's favorable cost and schedule performance eroded somewhat during the second half of fiscal year 2004. The declining performance was largely driven by issues in missile development. Specifically, two explosions at a subcontractor's propellant mixing facility resulted in the need to find a new vendor.

Sources: Contractors (data); GAO (analysis).

Note: Negative variances are shown with parentheses around the dollar amounts.

[a]Schedule variance represents the value of planned work by which the prime contractor is behind schedule.

[b]As of March 2004, the program completed 88 percent of the contract under the former contract structure. However, because the prime contract was extended over 3 years, this figure is no longer accurate.

[c]C2BMC development is being carried out through a contractual vehicle known as an Other Transaction Agreement, which functions much like a prime contract. Values reflect the combined variances incurred during fiscal year 2004 by parts 2 and 3 of the C2BMC contract.

[d]A performance measurement baseline identifies and defines work tasks, designates and assigns organizational responsibilities for each work task, schedules the work tasks in accordance with established targets, and allocates budget to the scheduled work.

[e]The contractor implemented a performance measurement baseline that reflects a 6-month accelerated schedule. This means the contractor might be performing work on schedule, allowing it to complete all the work by the end of the contract, but schedule performance data would show otherwise.

Negative Cost Variances Incurred by ABL, GMD, and STSS Prime Contractors

ABL incurred a negative cost variance of $114 million during the first half of fiscal year 2004, before the program was restructured to make its cost and schedule targets more realistic. This variance stemmed primarily from two sources. First, the program encountered unanticipated complexity in manufacturing and in integrating advanced optics and laser components for the prototype system. Second, the push to rapidly develop the prototype aircraft caused the program to limit testing of subcomponents, which, in turn, generated rework and modified requirements. To address the negative variance for ABL, program officials told us that they redirected funds originally earmarked for other program efforts.

GMD incurred a negative cost variance of $220 million. The contractor originally underestimated the cost of readying the element for LDO and experienced unexpected problems requiring some rework of its kill vehicle. Additionally, in response to explosions at a subcontractor's propellant mixing facility, the program incurred cost to transition operations to a new vendor. To address its negative cost variance for GMD, MDA deferred some work planned for completion in fiscal year 2004 into fiscal year 2005, and, to cover these increased costs, requested and received additional money in its fiscal year 2005 budget. MDA also directed other programs within the agency, such as Test and Evaluation, to pick up GMD's portion of the cost of work tasks that benefited both programs. Employing established EVM analysis techniques, we estimate that the GMD contract—which ends in September 2007—will overrun its budget by between $593 million and $950 million at its completion assuming no corrective actions are taken.

The negative STSS cost variance was largely attributed to a subcontractor who had a number of quality and systems-engineering problems in developing the payload—sensors and supporting subsystems—onboard the two STSS demonstration satellites. The program office maintains that there is enough management reserve to cover the overrun at the end of the contract, assuming that the reserve is not used for other purposes before then.

Lack of Cost Performance Data for ABL, Aegis BMD, and KEI Elements Prevented Full Assessment

ABL program officials' insight of their prime contractor's cost and schedule performance between April and July 2004 was somewhat limited. During this time, program officials directed the contractor to suspend normal cost performance reporting while they restructured the ABL prime contract to make its target cost and schedule more realistic. In lieu of providing normal Cost Performance Reports, the contractor provided the program office with monthly forecast expenditure plans, detailed work activities, and the number of staff needed to complete planned tasks. The program office relied on these metrics to determine the program's status and to provide insight into the contractor's cost and schedule performance. In the 5 months since cost reporting resumed, the cost and schedule variance has been relatively stable.

We could not fully assess cost performance for the Aegis BMD program in fiscal year 2004. The prime contractor developing the SM-3 missile did not generate Cost Performance Reports until September 2004, even though the prime contract was awarded in August 2003. Program officials told us that, instead, they monitored contractor performance through monthly management and business meetings where cost performance, milestones, and future performance were reviewed. Program officials indicated that the delay in issuing Cost Performance Reports stemmed from the late establishment of the contract's performance management baseline. It was established 7 months after contract award because of the need for the program office to react to funding issues. In addition, the program suspended contractor cost and schedule performance reporting until after the Aegis BMD program office completed an integrated baseline review[24] 5 months later.

KEI program officials also had reduced insight into its prime contractor's work efforts for a portion of fiscal year 2004. After contract award in December 2003, the prime contractor began submitting Cost Performance Reports in May 2004. Program officials suspended cost performance reporting after August 2004 because of the need to restructure the prime contract in response to reduced funding. Program officials told us that the contractor will resume reporting in 2005 after a reliable baseline that reflects the full extent of the program's restructure is available.

Funding Risks Expected to Increase for Ballistic Missile Defense Program

A number of factors portend an increasing level of funding risk for the ballistic missile defense program in the years ahead. Based on DOD's Future Years Defense Plan for fiscal years 2006-2011, MDA plans to request, on average, Research, Development, Test, and Evaluation (RDT&E) funding of about $10 billion annually. This funding supports continued development, procurement, and sustainment of hardware and software that MDA is fielding.[25] However, sources outside and within DOD are expected to put pressure on MDA's share of research and development dollars.

[24] An integrated baseline review is the program manager's review of a contractor's performance measurement baseline. The review is conducted by the program manager and the manager's technical staff. It verifies the technical content of the baseline and ensures that contractor personnel understand and have been adequately trained to collect earned value management data. The review also verifies the accuracy of the related budget and schedules, ensures that risks have been properly identified, assesses the contractor's ability to implement earned value management properly, and determines if the work identified by the contractor meets the program's objective.

[25] Congress authorized DOD's use of funds appropriated for MDA research, development, test, and evaluation for the fielding of ballistic missile defense capabilities. Pub. L. No. 108-136, section 222; Pub. L. No. 108-375, section 231.

One factor for the increasing pressure is that DOD's acquisition programs such as ballistic missile defense are likely to be competing for a decreasing share of the federal budget. These programs are categorized as "discretionary spending" as opposed to "mandatory spending," such as Social Security, Medicare, and Medicaid. In fiscal year 2004, discretionary spending accounted for about 39 percent of the federal budget. The Congressional Budget Office projects that discretionary spending is likely to decrease to 36 percent of the federal budget by fiscal year 2009 and to 32 percent in by fiscal year 2014.[26]

A second factor is competing demands for funding within DOD. For example, although missile defense is seen as a national priority and has been funded nearly at requested levels in the past few years, MDA is facing budget cuts. Indeed, DOD's Program Budget Direction of December 2004 called for MDA to plan for a $5 billion reduction in funding over fiscal years 2006-2011. In addition, MDA is receiving about 13 percent of the $70 billion RDT&E budget in fiscal year 2005 but must continue to compete with hundreds of existing and planned technology development and acquisition programs for RDT&E funding. Cost growth of existing weapon programs puts additional pressure on MDA's share. We found, for example, that RDT&E cost estimates grew $6.7 billion for the Joint Strike Fighter in calendar year 2003 and $9.2 billion for the Future Combat System in fiscal year 2004.

The third factor comes from within MDA itself. The agency continues to respond to cost growth of ongoing programs to enhance the components and elements of the BMDS. As noted above, ABL, GMD, and STSS incurred a collective negative cost variance of approximately $370 million in fiscal year 2004 and, as we reported last year, MDA elements incurred a collective negative cost variance of about $380 million in fiscal year 2003.[27] Unless MDA can mitigate these cost variances, significant cost overruns could occur on these contracts in the future. Estimating cost and schedule targets of new and complex technologies can be difficult and, as demonstrated, are often underestimated. Furthermore, hardware made available for operational purposes is not being fully tested before being

[26] Congressional Budget Office, *The Budget and Economic Outlook: An Update* (Washington, D.C.: Sept. 2004).

[27] GAO, *Missile Defense: Actions Are Needed to Enhance Testing and Accountability*, GAO-04-409 (Washington, D.C.: Apr. 23, 2004).

fielded. If the need arises to correct problems identified in subsequent testing, removing and recalling this hardware could prove costly.

A fourth factor for the increasing pressure on MDA's RDT&E budget is that MDA is starting to field components of the BMDS, whose production, operation, and sustainment are also funded by RDT&E dollars. A flat RDT&E budget combined with growing fielding costs would result in a decrease in investment in research and development—MDA's primary mission. According to program documentation, MDA's budget for its fielding activities between fiscal years 2006 and 2011 includes an average of $1.76 billion per year for procuring BMDS assets and an additional $400 million per year for sustaining the fielded capability. However, the fielding costs can be expected to increase in the years to come as more components of GMD, Aegis BMD, and THAAD are integrated into the BMDS.

Operations and support (O&S) costs of fielded systems are generally significant and can be expected to be substantial for operational capabilities of the BMDS. In our 2003 report on total-ownership (life-cycle) cost,[28] we found that the cost to develop and procure a weapon system usually represents about 28 percent of the weapon system's life-cycle cost; O&S costs typically account for the remaining 72 percent of a weapon's systems total life-cycle cost. The only BMDS element thus far with a life-cycle cost estimate, the Army's Patriot-MEADS missile defense program, has comparable life-cycle cost percentages. According to the Army's Lower-Tier Project Office, the Patriot-MEADS development cost accounts for 6.4 percent, procurement accounts for 21.2 percent, and O&S costs account for 72.4 percent of the total life-cycle cost of $151 billion.

DOD officials cautioned us that estimating life-cycle costs of missile defense capabilities involves considerable uncertainty. For example, O&S costs depend on the state of readiness of the fielded system, which is difficult to predict. In addition, historical data of component reliability in the field and the cost to repair operational missile defense assets are essentially nonexistent. Furthermore, life-cycle cost estimates of standard DOD weapon systems assume O&S costs apply for long periods of time, on the order of 20 years. Components of the BMDS, however, might be in the

[28] GAO, *Best Practices: Setting Requirements Differently Could Reduce Weapon Systems' Total Ownership Costs*, GAO-03-57 (Washington, D.C.: Feb. 11, 2003).

field for shorter durations. Finally, our previous work[29] recognized that life-cycle cost estimates for revolutionary systems such as the ABL program, which utilize new technologies in unproven applications, are unknown. When fielded, operation and support efforts for ABL could be substantial because ABL will require unique support for its laser and beam-control components and ground infrastructure for chemical storage, mixing, and handling.[30]

MDA Is Not Consistently Matching Cost and Fielding Goals

In assessing the extent MDA achieved its stated goals in fiscal year 2004, we observed that MDA's cost goal for a given block is not consistently aligned with that block's fielding goals. According to MDA policy, for example, interceptors identified with the Block 2004 fielding goals and fielded during calendar years 2004-2005 should be funded as part of the Block 2004 cost goal. As originally designed, the block approach would provide MDA with the flexibility to deliver a basic capability initially and enhance it during subsequent blocks to respond to the changing threat and to insert new technologies for enhanced performance. The block approach also would provide for accountability, because MDA would identify for decision makers the promised capabilities to be delivered by the end of each block for a specified investment of funds.

In the following instances, however, we found that MDA has not been consistently matching a block's cost and fielding goals thereby obscuring the relationship between requested funding and delivered capabilities:

- Funds accounted for in the Block 2004 cost goal are being used to procure 32 Aegis BMD SM-3 missiles. Of these missiles, 11 will be delivered in 2004-2005, and the remaining missiles will be delivered during 2006-2007. Similarly, funds accounted for in the Block 2006 cost goal are being used to procure 40 missiles. Of these missiles, 7 will be delivered in 2006-2007, and the remaining delivered during 2008-2009.

[29] GAO, *Uncertainties Remain Concerning the Airborne Laser's Cost and Military Utility*, GAO-04-643R (Washington, D.C.: May 17, 2004).

[30] The ABL program manager agrees that operating costs of the ABL element are not well defined due to its technical maturity. However, as with the fielding of any new technology, the initial operating costs may be substantial. As the support concept matures, the ABL program manager expects these costs to decrease and be comparable with other Air Force high-value assets.

- The THAAD program is funding a “fire unit” as part of its Block 2006 program. Operated by the Army, it will consist of a radar, a battle management unit, 3 launchers, 24 missiles, and equipment for support, maintenance and training. Even though MDA refers to this fire unit as a Block 2006 fielding, it will not be delivered until 2009 (i.e., during Block 2008).[31]

In addition, counter to the definition of a block as an integrated set of capabilities fielded during the 2-year block window, the Airborne Laser program will not field any capabilities during Block 2004 although Block 2004 funds are used in the program’s development. Rather, the ABL program is focused on developing a prototype aircraft for use in a lethality demonstration—a flight test in which the ABL aircraft will attempt to shoot down a short-range ballistic missile. However, ABL’s funding is broken out by block—2004, 2006, and 2008—even though the program is developing a single configuration of the element that will not be integrated into the BMDS earlier than Block 2008.

Conclusion

MDA delivered much of what it planned in fiscal year 2004, and DOD is on the verge of standing up an initial capability against long-range ballistic missiles launched from Northeast Asia. Despite this success, the performance of the system remains uncertain and unverified because of recurrent test delays and failures. Also, Ground-based Midcourse Defense developmental costs continue to increase and the Airborne Laser program was restructured when it became clear that much more time and money would be needed to develop and demonstrate a prototype aircraft.

Looking to the future, decision makers in Congress and DOD face billion dollar investment decisions in allocating funds both within MDA’s RDT&E activities and between MDA and other DOD programs. In exercising their funding and oversight responsibilities, these decision makers would benefit from a consistent implementation of a block policy for which delivered capability is aligned with tax dollars received.

[31] With the submission of the fiscal year 2006 President’s Budget in February 2005, MDA implemented a new BMDS baseline approach for the THAAD program. The agency now refers to the fielding of the fire unit as a Block 2006/2008 fielding.

Recommendation for Executive Action

To assist decision makers in Congress and DOD in exercising their oversight of MDA's acquisition plans and in evaluating MDA's budget requests, we recommend that the Director, MDA, clarify and modify, as needed, its block policy to ensure that a block's cost and fielding goals are consistently aligned.

Agency Comments and Our Evaluation

DOD's comments on our draft report are reprinted in appendix I. DOD concurred with our recommendation. Acknowledging our observations, the Department noted that the policy for ballistic missile defense block definitions should provide for consistent accounting of the various features of each block. MDA is taking steps to clarify and modify the block definitions for that purpose.

We are sending copies of this report to the Secretary of Defense and to the Director, MDA. We will make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions concerning this report, please contact me at (202) 512-4841. The major contributors to this report are listed in appendix XI.

R E Levin

Robert E. Levin
Director
Acquisition and Sourcing Management

List of Congressional Committees

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

The Honorable Ted Stevens
Chairman
The Honorable Daniel K. Inouye
Ranking Minority Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Duncan Hunter
Chairman
The Honorable Ike Skelton
Ranking Minority Member
Committee on Armed Services
House of Representatives

The Honorable C. W. Bill Young
Chairman
The Honorable John P. Murtha
Ranking Minority Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Comments from the Department of Defense

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

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

MAR 0 9 2005

Mr. Robert E. Levin
Director, Acquisition and Sourcing Management
Government Accountability Office
441 G. Street, N.W.
Washington, DC 20548

Dear Mr Levin:

This is the Department of Defense (DoD) response to the Government Accountability Office (GAO) draft report, "DEFENSE ACQUISITIONS: Status of Ballistic Missile Defense Program in 2004," dated February 3, 2005, (GAO Code 120360/GAO-05-243). Our official comment is enclosed. Technical comments to this report were provided separately. Additionally, the Department is conducting a security review of the draft report and will forward the results of the review as soon as it is completed.

My point of contact for this effort is COL Dan Hughes, (703) 695-7329, daniel.hughes@osd.mil. We appreciate the opportunity to comment on the draft report.

Sincerely,

Glenn F. Lamartin
Director
Defense Systems

Enclosure:
As stated

GAO FINAL REPORT – DATED March, 2005
GAO CODE 120360/GAO-05-243

"DEFENSE ACQUISITIONS: Status of Ballistic Missile Defense Program in 2004"

RECOMMENDATION 1: To assist decision makers in the Congress and DOD in exercising their oversight of MDA's acquisition plans and in evaluating MDA's budget requests, we recommend that the Director, MDA, clarify and modify, as needed, its block policy to ensure that a block's cost and fielding goals are consistently aligned. (P. 32/GAO Final Report)

DOD RESPONSE: Concur – The Department agrees that the policy for ballistic missile defense block definitions should provide for consistent accounting of the various features of each block. MDA is taking steps to clarify and modify the block definitions for that purpose.

Appendix II Summary

Aegis Ballistic Missile Defense

Source: Missile Defense Agency

Program Description

The Aegis Ballistic Missile Defense (Aegis BMD) element is designed to protect U.S deployed forces, friends, and allies from short- and medium-range ballistic missile attacks. Additionally, its shipboard radar can serve as a forward-deployed sensor for surveillance and early tracking of long-range ballistic missiles in support of the Ground-based Midcourse Defense (GMD) mission. To provide these capabilities, the Missile Defense Agency (MDA) is upgrading existing Aegis Navy ships for the BMD mission. MDA completed an initial surveillance and tracking capability in fiscal year 2004 and plans to field an initial intercept capability in April 2005.

DOD's planned investment in the Aegis BMD program from program inception in 1996 through 2011 is approximately $10 billion. DOD expended $3.67 billion between fiscal years 1996 and 2004, Congress appropriated $1.14 billion for fiscal year 2005, and MDA is budgeting about $5.22 billion between fiscal years 2006 and 2011 for Aegis BMD development, procurement, and operations.

Fiscal Year 2004 Progress Assessment

The Aegis BMD program completed work planned for fiscal year 2004 generally on schedule and is largely on track to upgrade system software and expand missile inventory for an enhanced capability by the end of December 2005 (Block 2004). However, Aegis destroyers upgraded for the long-range surveillance and tracking (LRS&T) mission had limited opportunities to be exercised in a manner consistent with an actual defensive mission.

Schedule: In fiscal year 2004 and early 2005, the Aegis BMD program completed the upgrade of three Aegis destroyers for the LRS&T mission—all are available for operations. In addition, the program delivered five missiles, known as the Standard Missile 3 (SM-3), in the first quarter of fiscal year 2005 for the element's Block 2004 engagement capability. Because of funding constraints and ship availability, missile deliveries and ship upgrades were delayed. In particular, the program expects to have available a slightly smaller inventory of SM-3 missiles by December 2005 than was originally planned. Also, the program expected to upgrade three cruisers by the end of Block 2004, but only two will be completed by this time.

Testing: Aegis BMD flight testing conducted in fiscal year 2004 focused on the LRS&T mission, including the element's connectivity with the BMDS. Because there were limited opportunities to track actual targets using the fielded version of the LRS&T system, this capability was only partially demonstrated prior to the destroyers' fielding. The Aegis BMD program also conducted one successful intercept attempt against a short-range ballistic missile target during fiscal year 2004. Finally, design changes to the missile's divert system underwent ground testing and are planned to be tested in flight in fiscal year 2005.

Performance: The Aegis BMD program has demonstrated the capability to intercept a non-separating target through its successes in five of six flight tests. The root cause of a failure in the missile's divert system during the one unsuccessful attempt is understood, and design changes are expected to be tested in flight in fiscal year 2005. Although the program has exercised the element's LRS&T capability in a small number of flight-test events, it has not yet used the fielded version of the system software to provide real-time track data of a target for use in planning a BMD mission, as it would need to do in an actual defensive operation.

Cost: We could not fully assess cost performance for the Aegis BMD program in fiscal year 2004 based on an analysis of prime contractor Cost Performance Reports. We found that the contractor responsible for upgrading existing Aegis ships for the BMD mission completed fiscal year 2004 work $3.5 million under budget but was unable to complete $2.0 million worth of work. However, we were unable to assess cost and schedule performance of the prime contractor who develops the SM-3 missile because Cost Performance Reports were not available during fiscal year 2004.

Appendix II: Aegis Ballistic Missile Defense

Element Description

The Aegis Ballistic Missile Defense (Aegis BMD) element is a sea-based missile defense system being developed to protect deployed U.S. forces, allies, and friends from short- and medium-range ballistic missile attacks. It will also be used as a forward-deployed Ballistic Missile Defense System (BMDS) sensor, employing its shipboard SPY-1 radar, to perform surveillance and tracking of long-range ballistic missiles in support of the Ground-based Midcourse Defense (GMD) mission.

The Aegis BMD element builds upon the existing capabilities of Aegis-equipped Navy cruisers and destroyers. Planned hardware and software upgrades to these ships will enable them to carry out the missile defense mission in addition to their current role of protecting U.S. Navy ships from air, surface, and subsurface threats. The program is also developing the Standard Missile 3 (SM-3)—the system's interceptor missile, which is designed to destroy enemy warheads through hit-to-kill collisions above the atmosphere. The SM-3 is comprised of a kill vehicle[1] mounted atop a 3-stage booster.

History

In 1996, the Department of Defense (DOD) initiated the Navy Theater Wide program, the predecessor to Aegis BMD. The Navy Theater Wide system was to be a ship-based missile defense system capable of destroying short-range ballistic missiles above the atmosphere. At the time, plans called for deploying the first increment of the Navy Theater Wide system in 2010 and a final increment with an improved kill vehicle at a later, undefined date.

Developmental Phases

The Missile Defense Agency (MDA) currently manages and funds the Aegis BMD program, although the U.S. Navy has a role in its development and management. Accordingly, the Aegis BMD element is being developed under MDA's acquisition approach, which delivers system capabilities in 2-year block increments. The first increment of the Aegis BMD element, Block 2004, is expected to deliver a limited operational capability in the 2004-2005 time frame. It provides for surveillance and tracking of long-range ballistic missiles and an intercept capability (engagement role) against shorter-range ballistic missiles. The Block 2004 capability is being rolled out in three phases:

[1] The program office refers to the kill vehicle as the "kinetic warhead."

- **Initial fielding of the surveillance and tracking capability**. By October 2004, the program office upgraded three Aegis destroyers with the ability to perform the long-range surveillance and tracking (LRS&T) function as a BMDS sensor in support of the GMD mission. All three destroyers are available for operations. This capability is the element's contribution to MDA's fielding of Limited Defensive Operations (LDO), MDA's first increment of fielded capability.

- **Initial fielding of an intercept capability**. By April 2005, MDA plans to have available two cruisers, along with a combined inventory of approximately five SM-3 missiles. The cruisers are expected to be capable of performing its two BMD missions, LRS&T and the engagement of short- and medium-range ballistic missiles. This configuration could be deployed operationally if so directed in an emergency.

- **Completion of the Block 2004 element**. The program expects to increase the number of Aegis destroyers capable of providing LRS&T from 3 to 10 by the end of December 2005.[2] In addition, the program plans to deliver eight SM-3 missiles available to be deployed on upgraded cruisers available for the engagement role.[3]

Future block configurations of the Aegis BMD element build upon the Block 2004 capability. In Block 2006, MDA plans to add the capability to defeat intermediate-range ballistic missiles with limited countermeasures and to increase Aegis BMD's role as a remote sensor by upgrading radar capabilities. The Aegis BMD Block 2008 configuration will incorporate upgrades to the SPY-1 radar to improve the radar's discrimination capability and to enhance the element's command and control component so that the element can engage multiple threats simultaneously. Finally, the Aegis BMD Block 2010 and 2012 configurations are expected to incorporate missile enhancements, improve discrimination capability against advanced countermeasures, and improve planning and coordination as part of the BMDS.

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[2] Five additional destroyers will be upgraded during Block 2006, bringing the total number of upgraded destroyers to 15, which was MDA's original Block 2004 goal.

[3] MDA program goals called for the delivery of nine SM-3 missiles by the end of calendar year 2005.

Planned Accomplishments for Fiscal Year 2004

The Aegis BMD program establishes annual element-level goals by outlining specific activities the program plans to complete during a given fiscal year. In fiscal year 2004, the program focused largely on delivering the LRS&T capability for LDO and continuing with activities leading to the full Block 2004 capability. These activities can be grouped into three categories: fielding, testing, and design reviews.

- **Fielding**. The Aegis BMD program planned to install the initial version of the operational computer program and make associated hardware upgrades on three Aegis destroyers enabling them to perform the LRS&T mission. In addition, the program planned to continue its activities leading to the initial delivery of SM-3 missiles during fiscal year 2005.
- **Testing**. The Aegis BMD program office planned to conduct an intercept attempt against a short-range ballistic missile—Flight Mission 6 (FM-6)—and to participate in other events that exercise the system's LRS&T functionality and connectivity with the BMDS.
- **Design reviews**. The program planned to conduct design reviews of the final Block 2004 Aegis Weapon System software, the final Block 2004 missile configuration, and the SM-3 missile's shipboard launch system.

Assessment of Scheduled Activities

In fiscal year 2004, the Aegis BMD program completed the upgrade of three Aegis destroyers[4] for the LRS&T mission. In addition, the program was completing the final assembly of the first five SM-3 missiles for the Block 2004 engagement capability, which were delivered in early fiscal year 2005. The program is largely on track to upgrade software, expand missile inventory, and conduct flight tests to deliver an enhanced capability for Block 2004 by the end of December 2005. However, funding modifications and ship availability delayed final missile deliveries and ship upgrades. In particular, although the program expected to field nine SM-3 missiles by the end of Block 2004, only eight will be delivered by this time. Also, the program expected to upgrade three cruisers by the end of Block 2004, but only two will be completed by this time. Specific progress made in fiscal year 2004 relative to fielding, testing, and design is given in the narrative below and summarized in tables 7 to 12.

[4] The third destroyer was upgraded in October 2004.

Fielding Activities

The Aegis BMD program has plans to eventually upgrade 18 Aegis-equipped Navy ships (15 destroyers and 3 cruisers) with enhanced planning, surveillance, tracking, and engagement functions to make them capable of performing the BMD mission. These upgrades will improve the capability of the element's SPY-1 radar to discriminate a missile's warhead from decoys, enable tracking of long-range ballistic missiles as a BMDS sensor, plan engagements, and launch SM-3 missiles to engage ballistic missiles. To achieve this enhanced functionality, the Aegis BMD program office is upgrading the Aegis Weapon System on designated ships through a series of software builds and hardware upgrades, referred to as BMD 3.0E, BMD 3.0, and BMD 3.1.

Each BMD upgrade will increase the element's capability. The Aegis BMD program has successfully installed BMD 3.0E in three destroyers, which enables the ships to carry out long-range surveillance and tracking. However, the ships are not yet capable of launching missiles to engage ballistic missiles. Rather, the next software build, BMD 3.0, will be needed to provide the preliminary engagement capability for Aegis cruisers. It is expected to be approved for use in April 2005 and could be deployed operationally if so directed in an emergency. The third version of the BMD upgrade—BMD 3.1—will eventually enable the destroyers to also launch missiles, but because other hardware upgrades are needed, only Aegis cruisers will be equipped to do so by the end of Block 2004. BMD 3.1 is the last weapon system upgrade planned for the Block 2004 time frame. Table 7 summarizes the principal software development and installation activities completed in fiscal year 2004.

Table 7: Status of Aegis BMD Fiscal Year 2004 Planned Accomplishments—Fielding Activities

Activity	Description/Progress assessment
Complete and deliver long-range surveillance and tracking (LRS&T) software BMD 3.0E	The program completed BMD 3.0E development for the initial fielding of the LRS&T capability.
Install LRS&T BMD 3.0E on three Aegis destroyers	The program installed BMD 3.0E on two Aegis destroyers by September 30, 2004, and on a third Aegis destroyer in October 2004.
Begin training Aegis destroyer crews for the LRS&T mission	Crew training was completed on schedule, which included tactical operations and team certification, personnel standards, and BMD 3.0E familiarization.

Sources: MDA (data); GAO (presentation).

As software builds and hardware upgrades are completed and installed, Navy cruisers and destroyers will become available to perform their expected missions. Table 8 summarizes the availability of Aegis ships for the BMD mission in the Block 2004 time frame. Although MDA program goals specified that three cruisers would be available by the end of Block 2004 (December 2005), only two are expected to be upgraded by this time; the third is expected to be upgraded in early 2006, depending on ship availability.

Table 8: Aegis Ship Availability for the BMD Mission (Block 2004)

Ship function	September 2004	December 2004	April 2005	December 2005
Destroyers	3[b]	5[b]	9	10[c]
Capable of only LRS&T. Engagement capability will be added starting in 2006.				
Cruisers[a]	0	1	2	2
Capable of surveillance, tracking, and engagement.				
Total destroyers and cruisers available for BMD mission	**3**	**6**	**11**	**12**

Source: MDA.

[a]The total number of Aegis cruisers includes one being used as a test ship, which was scheduled to begin installation of BMD 3.0 in December 2004.

[b]The third LRS&T ship was completed in October 2004, and the fifth was completed in January 2005.

[c]15 LRS&T "equipment sets" will be available at this time, but installations may not be completed owing to the ships' operational schedules. The remaining five upgrades are planned for the Block 2006 time frame.

In fiscal year 2004, the Aegis BMD program office continued to procure SM-3 missiles for delivery in the 2004-2005 time frame. In particular, 11 "Block I" SM-3 missiles are expected to be delivered by the end of calendar year 2005, some of which will be used in flight testing. Table 9 summarizes the status of SM-3 deliveries through December 2005.

Table 9: SM-3 Missile Deliveries

	Sept. 2004 - Dec. 2004	Dec. 2004 - Apr. 2005	Apr. 2005 - Dec. 2005	Total (Dec. 2005)
SM-3 deliveries	5	1	5	**11**

Source: MDA.

Prior to September 2004, three SM-3 missiles of an earlier configuration were delivered and subsequently used in flight missions (intercept attempts), FM-4, FM-5, and FM-6. "Block I" SM-3 missiles, which are being fielded during 2004-2005, are an operational configuration that evolved from this earlier design. Fiscal year 2004 funding modifications impacted SM-3 missile integration and delivery; consequently, the Aegis BMD program expects to have available a slightly smaller inventory of SM-3 missiles by December 2005 than was originally planned.

Testing Activities

The Aegis BMD program conducts both ground and flight tests to demonstrate and validate element performance. Ground tests serve to reduce risk and, in some cases, are conducted under conditions that are difficult to replicate in flight. Flight tests verify the element's ability to engage ballistic missile targets using actual equipment, computer programs, and an operational ship with a Navy crew.

Ground Testing

Ground tests completed during fiscal year 2004 included those focused on a subcomponent of the missile's divert system—the Solid Divert and Attitude Control System (SDACS). This subcomponent is a collection of solid-fuel thrusters used to steer the kill vehicle into its designated target. When an updated SDACS design proved successful in earlier ground tests, the program flight-tested it during Flight Mission 5 (FM-5) in June 2003. However, during this test, the subassemblies supporting the energetic pulse-mode failed, causing the kill vehicle to be less maneuverable and miss its target. Program officials stated that the failure likely stemmed from a "diverter ball" in the SDACS, which acts as a valve to control pulses that allow the missile to maneuver quickly. The exercising of the high-energy pulse mode of the SDACS increased internal operating pressures, and, under the thermal stress, the protective coating of the diverter ball cracked, disabling normal SDACS operation. The root cause of this failure has been traced to a material failure under intense temperature and pressure.

In response to this failure, during fiscal year 2004, the program modified the SDACS design to improve its switching performance and reliability during high-energy pulse operation. A series of ground tests and engineering analysis is ongoing to validate the design updates. Following completion of ground tests and analysis, future flight tests are planned to demonstrate operation of the SDACS using its high-energy pulse mode.

Flight Testing

Since 1999, there have been six intercept attempts using variants of the SM-3 missile. In five of the six, the SM-3 successfully intercepted targets. In fiscal year 2004, the program conducted one of these successful intercept attempts—FM-6.[5] Additionally, the Aegis BMD element

[5] The program also conducted FM-7 in February 2005, which resulted in a successful intercept of a short-range ballistic missile target.

participated in other non-intercept test events to assess the Aegis destroyer's ability to track targets of opportunity and pass data to the BMDS. Because of the technical issues associated with the SDACS reliability that arose in FM-5, the program office delayed FM-6 from September 2003 to December 2003 and did not exercise the SDACS high-energy pulse mode as originally planned.

After the FM-6 flight mission in December 2003, Aegis BMD flight testing conducted in fiscal year 2004 focused on the LRS&T mission although there were limited opportunities to track actual targets using the fielded version of the LRS&T software, BMD 3.0E. For example, delays in the GMD flight test program prevented Aegis BMD from participating in two integrated flight tests, IFT-13C and IFT-14, during fiscal year 2004. In addition, the Aegis BMD program participated in Glory Trip 185, during which an Aegis destroyer successfully tracked a Minuteman III ICBM launched from Vandenberg Air Force Base. However, it exercised an earlier version of the LRS&T software, rather than BMD 3.0E, which is installed on fielded destroyers. Finally, in Pacific Explorer III, an Aegis destroyer planned to track an actual missile and pass track data to the BMDS. Although the destroyer tracked the live target missile, a malfunction with the target limited the amount of data collected by the Aegis destroyer. Specifically, the target ended its flight before Aegis BMD could send the GMD element enough information needed for engaging the target.

Although there were limited opportunities to track actual targets, Aegis BMD participated in other tests that verified connectivity with the BMDS. For example, in Pacific Explorer II, Glory Trip 185, Pacific Explorer III, and Pacific Explorer IV (conducted in fiscal year 2005), simulated or real ballistic missile target track data was successfully transmitted to the BMDS.

Table 10 summarizes the flight test and LRS&T activities completed in fiscal year 2004 by the Aegis BMD program.

Table 10: Aegis BMD Fiscal Year 2004 Planned Accomplishments—Flight Test and LRS&T Activities

Activity	Description/Progress assessment
Flight Mission 6 (FM-6) Occurred: Dec. 2003	An SM-3 missile successfully intercepted a short range ballistic missile (SRBM) target (SDACS used in sustain-mode only).
Participate in GMD integrated flight tests as a surveillance and tracking sensor Planned: Throughout FY2004	GMD flight tests were deferred until fiscal year 2005. IFT-13C was conducted in December 2004 and would have offered Aegis BMD the opportunity to exercise its LRS&T role. However, because of rough seas caused by severe weather that exceeded safety limits, the element did not participate. IFT-14 was conducted in February 2005, but this test failed to execute fully because the interceptor did not launch from its silo.
Pacific Explorer II Occurred: Mar. 2004	An Aegis destroyer in the Sea of Japan and an Aegis destroyer in Hawaii established full satellite communication connectivity with the BMDS across the Pacific Ocean to multiple land-based participants in Hawaii and the Continental United States. Although no actual target was launched, the ship successfully passed track data of a simulated target to exercise system connectivity.
Glory Trip 185 Occurred: June 2004	Aegis BMD successfully exercised its role as a forward-deployed sensor. During this test, an Aegis destroyer detected and tracked a Minuteman III ICBM launched from Vandenberg Air Force Base and provided track and covariance data to GMD. However, the test did not exercise Aegis BMD tracking and connectivity in a manner consistent with an actual defensive mission; that is, as an integral part of the system during which the destroyer acts as a fire control radar. In addition, the Aegis destroyer was not upgraded with the newer, LDO version of the long-range surveillance and tracking software.
Pacific Explorer III Occurred: July 2004	This event provided exposure and training to the crew of an Aegis BMD destroyer. Although the destroyer tracked the live target missile, a malfunction with the target limited the amount of data collected by the Aegis destroyer—the target's flight was terminated early.

Sources: MDA (data); GAO (presentation).

In fiscal year 2005, the program office scheduled three more Block 2004 flight tests, all of which are planned as intercept attempts. These tests aim to progressively demonstrate the element's capability against short- and medium-range unitary and separating targets, as well as demonstrate that Aegis BMD can support the BMDS as a forward-deployed sensor. FM-7 was the first flight test to use BMD 3.0 and the Block I SM-3 missile, which is the configuration of the first set of SM-3 missiles that will be made available for fielding. Table 11 provides a summary of the Block 2004 flight tests the program expects to conduct through fiscal year 2005.

Table 11: Planned Aegis BMD Fiscal Year 2005 Accomplishments—Remaining Block 2004 Flight Tests

Activity	Description
FTM 04-1 (FM-7) Date: Feb 24, 2005	FM-7 was successfully conducted. An SM-3 missile intercepted an SRBM target (SDACS used in sustain-mode only).
FTM 04-2 (FM-8) Date: 3Q FY2005[a]	FM-8 is an intercept attempt against a separating, medium-range ballistic missile (MRBM) target. The target will fly a trajectory more distant from the Aegis cruiser than in previous tests. Pending the results of ground testing, the SDACS will be tested in high-energy pulse mode.
FTM 04-3 (FM-9) Date: 4Q FY2005	FM-9 is an intercept attempt against a separating, MRBM target. The target will include additional decoys and clutter. The SDACS could be tested in high-energy pulse mode.

Sources: MDA (data); GAO (presentation).

[a]We use the notation "3Q FY2005" to mean the third quarter of fiscal year 2005 and an identical format for other time periods.

Design Reviews

The Aegis BMD program scheduled four component-level design reviews in fiscal year 2004 to evaluate the design maturity of the Aegis Weapon System software, launch system, and upgraded SM-3 missile, known as "Block IA." The program successfully completed three of these design reviews but delayed the fourth until early 2005. Table 12 summarizes the principal activities related to each review.

Table 12: Aegis BMD Fiscal Year 2004 Planned Accomplishments—Design Reviews

Activity	Description/Progress assessment
Aegis BMD 3.1 System Design Disclosure Completed Jan. 2004	The system design disclosure for the final version of Block 2004 software, BMD 3.1, was successfully completed. This review evaluated the performance of BMD 3.1 for the LRS&T mission as well as engagement scenarios with both sustain-mode and pulse-mode SDACS.
Vertical Launch System Phase I Critical Design Review Completed Feb. 2004	The critical design review of the vertical launch system phase I was successfully completed. The review examined the expected performance of the Vertical Launch System associated with BMD 3.0.
Vertical Launch System Phase II Preliminary Design Review Completed June 2004	The preliminary design review of the vertical launch system phase II was successfully completed. This review presented requirements (design specifications) and early designs for the Vertical Launch System associated with BMD 3.1.
SM-3 Block IA Critical Design Review Completed Oct. 2004	The initial critical design review of the SM-3 Block IA—the upgraded configuration of the Block I missile—was successfully completed and gave the program permission to begin missile assembly and testing. This review examined the maturity of the design and expected performance of the Block IA SM-3 missile configuration. A "close out" critical design review is planned to be conducted in April 2005.

Sources: MDA (data); GAO (presentation).

Assessment of Element Performance

We identified areas for which the Aegis BMD program has not fully demonstrated element performance and reliability. First, the program has demonstrated its intercept capability under limited conditions; second, the program has not successfully demonstrated, in a flight test, SDACS operation using its high-energy pulse mode; and third, the program has only exercised the element's LRS&T capability in a small number of flight-test events.

The Aegis BMD program demonstrated the capability to intercept a non-separating target through its successes in FM-2, FM-3, FM-4, FM-6, and FM-7. Although these tests were scripted, they are noteworthy, given the difficulty of "hit-to-kill" intercepts. Officials with the office of Director, Operational Test and Evaluation (DOT&E), pointed out that the Aegis BMD program has conducted the most operationally realistic testing of all BMDS elements, especially because they utilize an operational U.S. Navy cruiser. They recognize, however, that the targets in FM-2 and FM-3 flew trajectories that facilitated radar detection and tracking. More realistic engagement scenarios will be tested in Block 2006, for example, tests with multiple simultaneous engagements.

As we reported last year,[6] the Aegis BMD program faced challenges with ensuring the reliability of SDACS operation; the issue continues to be relevant. The root causes of the SDACS failure in FM-5 are understood and the program is implementing four design changes to correct the problem. After completing ground tests to verify these changes, the program plans to flight test the modified multi-pulse SDACS no earlier than FM-8, scheduled for the third quarter of fiscal year 2005. Even if the design changes prove to resolve the SDACS issue, program officials do not expect to implement any design changes in the first 11 Block 2004 missiles being delivered. Program officials believe that these missiles provide a credible defense against a large population of the threat even with reduced divert capability.

The program has exercised the element's LRS&T capability in a limited number of flight-test events, as noted above. Nonetheless, the Aegis BMD program predicts that the Aegis SPY-1 radar is able to deliver adequate performance in support of the BMD mission, and DOT&E officials believe that Aegis BMD can adequately perform its detection and tracking

[6] GAO, *Missile Defense: Actions Are Needed to Enhance Testing and Accountability*, GAO-04-409 (Washington, D.C.: Apr. 23, 2004).

functions. Although the Aegis destroyers have been upgraded for the LRS&T capability, they have not been exercised in a manner consistent with an actual defensive mission. That is, the Aegis BMD element has not provided track data of a target, in real time, to plan a BMD mission and launch GMD interceptors.

Assessment of Element Cost

DOD's planned investment in the Aegis BMD program from program inception in 1996 through 2011 is approximately $10 billion. As broken out in table 13, DOD expended $3.67 billion between fiscal years 1996 and 2004,[7] Congress appropriated $1.14 billion for fiscal year 2005, and MDA is budgeting about $5.22 billion between fiscal years 2006 and 2011 for Aegis BMD development, procurement, and operations. Budgeted activities in the "cooperative work" column include SM-3 component development between the United States and Japan.

Table 13: Aegis BMD Cost

Dollars in millions of then-year dollars

	Other	Block 2004	Block 2006	Block 2008	Block 2010	Cooperative work	Total
FY 1996[a] – FY 2003	$2,985	$0	$0	$0	$0	$0	**$2,985**
FY 2004 (Actuals)	0	606	24	0	0	51.8	**682**
FY 2005 (Appropriated)	0	943	122	0	0	71.3	**1,136**
FY 2006	0	101	575	135	0	24.8	**836**
FY 2007	0	15	547	354	0	52.8	**969**
FY 2008	0	0	69	637	20	112.5	**838**
FY 2009	0	0	15	546	185	131.5	**878**
FY 2010	0	0	0	205	576	129.5	**911**
FY 2011	0	0	0	44	644	100.0	**788**
FY 1996 – FY 2011	**$2,985**	**$1,665**	**$1,352**	**$1,921**	**$1,425**	**$674**	**$10,022**

Source: MDA.

Notes: Aegis BMD budget as of February 2005. Numbers may not add due to rounding.

[a]Program inception (FY 1996).

Contract Activities

In the second half of 2003, two new prime contracts for the Aegis BMD element were awarded, one for the Aegis Weapon System and one for the

[7] Includes funds expended to develop the Navy Theater Wide system.

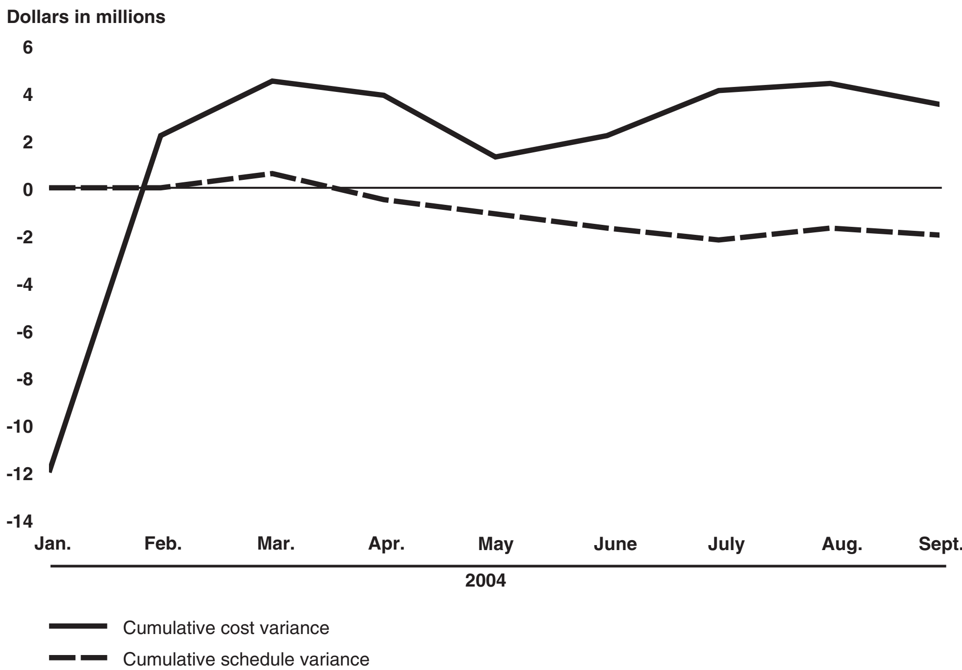
SM-3 missile. Aegis Weapon System efforts, previously part of five Navy contracts, were merged into one contract, which was awarded to Lockheed Martin in October 2003. This contract covers Block 2004 activities, including upgrades to BMD software, upgrades to the SM-3 missile launch system, and planning activities for future blocks. The two previous Navy SM-3 contracts were merged into a new contract, which was awarded to Raytheon in August 2003. It covers development and delivery of SM-3 missiles and related engineering efforts.

Prime Contractor Cost and Schedule Performance

The government routinely uses contractor Cost Performance Reports to independently evaluate a prime contractor's cost and schedule performance. Generally, the reports detail deviations in cost and schedule relative to expectations established under the contract. Contractors refer to deviations as "variances." Positive variances are generally associated with the accomplishment of activities under cost or ahead of schedule, while negative variances are often associated with the accomplishment of activities over cost or behind schedule.

We used the Cost Performance Reports to evaluate the cost and schedule performance of the Aegis Weapon System prime contractor but had insufficient data to assess the performance of the SM-3 contractor. Our analysis of the Aegis Weapon System found that the prime contractor performed at or near budgeted cost and schedule during fiscal year 2004. Specifically, since contract inception in October 2003 through September 2004, the prime contractor was $3.5 million under budget. However, it was unable to complete $2 million of work because of fluctuations in ship and testing schedules (see fig. 3).

Figure 3: Aegis BMD Fiscal Year 2004 Cost and Schedule Performance



Sources: Contractor (data); GAO (analysis).

The Defense Contract Management Agency is concerned with the delay that occurred in the implementation of the SM-3 contract's performance measurement baseline,[8] which reflects the schedule and budget for all work tasks that must be performed to meet contract objectives. Although the contract was awarded to the prime contractor, Raytheon, in August 2003, the contract's baseline was not reviewed at an Integrated Baseline Review (IBR)[9] until almost a year after contract award. Program officials indicated that the delay stemmed from the late establishment of the

[8] A performance measurement baseline identifies and defines work tasks, designates and assigns organizational responsibilities for each task, schedules the work tasks in accordance with established targets, and allocates budget to the scheduled work.

[9] An integrated baseline review is the program manager's review of a contractor's performance measurement baseline. The review is conducted by the program manager and the manager's technical staff. It verifies the technical content of the baseline and ensures that contractor personnel understand and have been adequately trained to collect earned value management data. The review also verifies the accuracy of the related budget and schedules, ensures that risks have been properly identified, assesses the contractor's ability to implement earned value management properly, and determines if the work identified by the contractor meets the program's objectives.

contract's performance management baseline, which was established 7 months after contract award because of the need for the program office to react to funding issues. Raytheon was allowed to postpone issuing Cost Performance Reports until after the Aegis BMD program office held an IBR 5 months after establishment of the baseline.

Until the completion of the Raytheon IBR, program officials monitored contractor performance through monthly management and business meetings where cost and performance data, milestones, and projections of future performance were reviewed. The program office stated that these monthly meetings provided sufficient data to monitor contractor performance. Nonetheless, without these reports, it is difficult for the program office (and other independent agencies) to monitor cost and schedule performance of the contract's various components and, therefore, to identify areas in need of corrective action. Additionally, although we are aware of past problems with SDACS performance on the SM-3 contract, we did not have any data to evaluate its impact on the contract's cost and schedule.

Appendix III Summary

Airborne Laser

Source: Missile Defense Agency

Program Description

The Airborne Laser (ABL) is being developed to shoot down enemy missiles during the boost phase of flight. Integrated onboard a Boeing 747 aircraft, ABL is designed to use a high-energy chemical laser to rupture the enemy missile's fuel or oxidizer tanks, causing the missile to lose thrust or flight control. As part of its development effort, the Missile Defense Agency (MDA) plans to demonstrate the feasibility of using the prototype ABL aircraft to shoot down a short-range ballistic missile. This event is referred to as the lethal demonstration.

DOD's planned investment in the ABL program from program inception in 1996 through 2011 is about $7.3 billion. DOD expended $2.52 billion between fiscal years 1996 and 2004, Congress appropriated $458 million for fiscal year 2005, and MDA is budgeting about $4.32 billion between fiscal years 2006 and 2011 for ABL research and development.

Fiscal Year 2004 Progress Assessment

During fiscal year 2004, MDA restructured the ABL program to focus on near-term milestones and to improve confidence in longer-term schedule and cost projections. The restructuring placed the near-term focus on two events: (1) the combined operation of individual laser modules to generate a single laser beam, known as "First Light," and (2) a flight test of the prototype aircraft with an installed laser beam control system, known as "First Flight." In light of the program's restructure, ABL completed most of its planned fiscal year 2004 activities on schedule. However, total contract costs through calendar year 2008 increased by approximately $1.5 billion, and the program's schedule was extended over 3 years.

Schedule: The program completed on schedule most of its fiscal year 2004 activities associated with the preparation for "First Light" and "First Flight." However, as a result of the recent program restructuring, the demonstration to shoot down a short-range ballistic missile—the focus of the program—was delayed from 2005 and is now scheduled to occur no earlier than 2008.

Testing: Both "First Light" and "First Flight" were achieved in early fiscal year 2005. Although the achievement of "First Light" is a key milestone for the program, it was not intended as an operational demonstration of a high-power laser, that is, at full power and for the length of time needed to shoot down a boosting missile. Rather, the laser's operation for a fraction of a second demonstrates successful integration of subsystems. "First Flight" is also a key milestone for the program. It is the first of a series of flights to demonstrate the completion of design, safety, and verification activities that are necessary to assure flight worthiness of the aircraft with the laser beam control system installed.

Performance: At this stage of ABL development—before the laser has been operated at full power or critical technologies have been demonstrated in flight tests—any assessment of effectiveness is questionable. Nonetheless, the program office monitors performance indicators to assess the element's readiness for successfully completing the lethality demonstration. One indicator in particular—atmospheric compensation, the process whereby a system of deformable mirrors and electronics is used to minimize the degradation of the laser beam as it travels through the atmosphere—is not meeting its performance objectives. Program officials told us that a recovery plan for this indicator is in place.

Cost: ABL program costs continue to grow. During the first half of fiscal year 2004, prior to the restructuring of the program, the ABL prime contractor incurred a negative cost variance of $114 million and could not complete $47 million of planned work. MDA's restructuring of the ABL program increased program cost by about $1.5 billion—the prime contract is currently valued at approximately $3.6 billion, more than three times its original value of $1.02 billion—although overall program objectives did not change.

Appendix III: Airborne Laser

Element Description

The Airborne Laser (ABL) is a missile defense system designed to shoot down enemy missiles during the boost phase of flight, the period after launch during which the missile's rocket motors are thrusting. By engaging ballistic missiles during the boost phase, ABL destroys enemy missiles early in their trajectory before warheads and countermeasures can be released. ABL plans to use a high-energy chemical laser to defeat enemy missiles by rupturing a missile's fuel or oxidizer tanks, causing the missile to lose thrust or flight control. ABL's objective is to prevent the delivery of the missile's warhead to its intended target.

ABL was initially conceived as a theater system to defeat short- and medium-range ballistic missiles. However, its role has been expanded to include the full range of ballistic missile threats, including intercontinental ballistic missiles (ICBM).[1] In addition, ABL could be used as a forward-deployed Ballistic Missile Defense System (BMDS) sensor to provide launch point, impact point, and trajectory data of enemy missiles in support of engagements by other system elements.

The ABL element consists of the following three major components integrated onboard a highly modified Boeing 747 aircraft. In addition, the element includes ground support infrastructure for storing, mixing, and handling the chemicals used in the laser.

- **High-energy chemical oxygen-iodine laser (COIL)**. The laser, which generates energy through chemical reactions, consists of six laser modules linked together to produce megawatt levels of power. Because the laser beam travels at the speed of light, ABL is expected to destroy missiles quickly, giving it a significant advantage over conventional boost-phase interceptors.

- **Beam control/fire control (BC/FC)**. The BC/FC component's primary mission is to maintain the beam's quality as it travels through the aircraft and atmosphere. Through tracking and stabilization, the BC/FC ensures that the laser's energy is focused on a targeted spot of the enemy missile.

- **Battle management/command and control (BMC2)**. The BMC2 component plans and executes the element's defensive engagements. It is being designed to work autonomously using its own sensors for launch

[1] The terms "intercontinental ballistic missile" and "long-range ballistic missile" are used interchangeably.

detection, but it could also receive early warning data from other external sensors.

History

In 1996, the Air Force initiated the ABL program to develop a defensive system that could destroy enemy missiles from a distance of several hundred kilometers. Developmental testing of the first prototype aircraft was originally planned to conclude in 2002 with an attempt to shoot down a short-range ballistic missile target.

In 2002, management authority and funding responsibility transferred from the Air Force to the Missile Defense Agency (MDA). In accordance with MDA planning, the ABL program restructured its acquisition strategy to conform to an evolutionary, capabilities-based approach.

Developmental Phases

The ABL program is focused on developing a prototype aircraft for use in a lethality demonstration—a flight test in which the ABL aircraft will attempt to shoot down a short-range ballistic missile. If this test is successful, MDA believes it will prove out the concept of using directed energy for missile defense. Although ABL's funding is broken out by block—2004, 2006, 2008, and 2010—the program is developing a single configuration of the element leading to the lethality demonstration, which will occur no earlier than 2008. A specific date for the demonstration has not been scheduled and depends on the success of ground testing. Furthermore, there is uncertainty as to when ABL will provide an initial operational capability. MDA plans to provide this capability through the development of a second aircraft, but the purchase of this aircraft is contingent upon the successful test of the prototype aircraft.

In January 2004, MDA restructured the ABL program to focus on near-term milestones and to improve confidence in longer-term schedule and cost projections. The near-term focus of the program was shifted toward two events: (1) the achievement of a key laser demonstration known as "First Light"—the first demonstration of the integration of six individual laser modules to produce a single beam of laser energy—and (2) the initial flight test of the prototype aircraft with the BC/FC installed, which is referred to as "First Flight."[2] Key provisions of the restructure call for the program office to complete the following activities during the next few years:

- Ground test and flight test the BC/FC segment independent of high-energy laser testing activities. BC/FC testing would utilize a low-power, substitute laser in place of the high-energy laser, as needed.
- Ground test the high-energy laser independent of BC/FC testing activities.
- Integrate and ground test the complete ABL weapon system (i.e., combined laser, BC/FC, and battle management segments).
- Flight test the ABL weapon system, culminating in a lethality demonstration against a boosting missile.

The lethal demonstration has been delayed by about 6 years. This event was originally scheduled to occur in 2002 and, as we reported last year,[3] was later rescheduled to be conducted in early 2005. However, as a result of the January 2004 restructuring of the program, the event is now scheduled to occur no earlier than 2008.

In its report accompanying the 2005 Defense Authorization Act, the House Armed Services Committee noted its approval of the restructured program. However, the Committee also recognized that the future of the ABL program depended upon successful completion of "First Light" and "First Flight." The Committee stated that these milestones must be completed in order for the Committee to further support the program after fiscal year 2005.

[2] "First Flight" was planned as a "passive" flight test, that is, without the use of the Track Illuminator Laser (TILL) and the Beacon Illuminator Laser (BILL). The TILL and BILL are part of the laser-beam control system used to focus the laser beam on the target and to mitigate the effects of the atmosphere on beam quality.

[3] GAO, *Missile Defense: Actions Are Needed to Enhance Testing and Accountability*, GAO-04-409 (Washington, D.C.: Apr. 23, 2004).

Fiscal Year 2004 Planned Accomplishments

The program planned to complete several activities during fiscal year 2004 commensurate with the program's restructuring. As noted above, the program shifted its near-term focus toward key demonstrations within the BC/FC and laser segments. The following activities were identified as the key milestones for the fiscal year.

- **BC/FC Segment**. Complete ground integration and testing of the BC/FC segment and begin integration of beam control segment into the ABL prototype aircraft in preparation for "First Flight."
- **Laser Segment**. Complete integration of the six laser modules in the System Integration Laboratory (SIL)—a ground-test facility located at Edwards Air Force Base, California—in preparation for "First Light."

Assessment of Scheduled Activities

In fiscal year 2004, the program completed most of its planned activities on schedule. Tables 14 and 15 summarize the progress made toward completing BC/FC and laser activities in fiscal year 2004.

Table 14: Status of ABL Fiscal Year 2004 Planned Accomplishments—BC/FC Segment

Activity	Description/Progress assessment
Complete ground integration and testing of the BC/FC	In September 2004, the program completed this activity, which is comprised of a BC/FC ground test and a test of the aircraft's flight turret. These tests were conducted in an effort to demonstrate the functionality of the full-up BC/FC and turret segments with flight hardware.
Begin integration of BC/FC segment into the ABL aircraft	In October 2004, the last major BC/FC component—the flight turret—was installed on the aircraft at Edwards Air Force Base in preparation for "First Flight."
Aircraft Readiness for Flight	In November 2004, the program verified the air-worthiness of the ABL with the BC/FC and BMC4I components installed.
Conduct "First Flight"	"First Flight" was conducted in December 2004, the first of 22 planned flight tests with the BC/FC segment. The flight test was originally planned for 2-½ hours but was terminated early due to erroneous instrument readings. These readings were corrected and a full duration flight was achieved the following week. One of its objectives was to demonstrate that all necessary design, safety, and verification activities to assure flight worthiness had been completed. "First Flight" also began the process of expanding the aircraft flight envelope—types and combinations of flight conditions—in which the ABL can operate. Finally, "First Flight" was designed to measure the environment of the BC/FC system while the aircraft is in flight.

Sources: MDA (data); GAO (presentation).

Table 15: Status of ABL Fiscal Year 2004 Planned Accomplishments—Laser Segment

Activity	Description/Progress assessment
Complete integration of the 6 laser modules in the SIL	The integration of individual modules in preparation for "First Light" was completed successfully. The completion of this activity enabled testing of the six integrated modules in the ground-test facility.
Achieve "First Light" in the SIL	"First Light" was successfully conducted in fiscal year 2005 (November 2004). "First Light" refers to the ABL ground-test event during which individual laser modules are successfully integrated and operated to generate a single laser beam.
Continue large optics fabrication and optical coating efforts	Efforts to complete studies of technologies are ongoing. Long-lead optics production is ongoing and improvements to the production process are being studied.
Continue jitter reduction and illuminator improvement	Efforts to upgrade hardware to reduce jitter—vibrations onboard the ABL aircraft that degrades the focus of the high-energy laser beam—are still ongoing. Use of advanced cooling methods to improve the power, efficiency, beam quality, and start-up time of the illuminator laser are also still ongoing.

Sources: MDA (data); GAO (presentation).

Demonstration of "First Light"

The demonstration of "First Light"—to prove that individual laser modules can be successfully integrated and operated to generate a single laser beam—was achieved on November 10, 2004, at the SIL ground facility. In general, "First Light" is an important milestone for any laser system because it demonstrates the ability to get all major laser subsystems to work together.

Although the achievement of "First Light" is a key milestone for the program, it was not intended as an operational demonstration of a high-power laser, that is, at full power and for the length of time needed to shoot down a boosting missile. Rather, the laser's operation for a fraction of a second demonstrates successful integration of subsystems. "First Light" demonstrated that the six modules are aligned optically and the flow system is functioning, but program officials noted that the operation of the laser was too short to make meaningful predictions of power and beam quality.[4] The program plans to conduct a series of tests that will gradually increase the length and power of the laser operation until full power lasing objectives are achieved.

[4] The quality of a laser beam is measured by attributes such as beam width, coherency, and sustained power.

Demonstration of "First Flight"

The achievement of "First Flight"—the first of 22 planned tests—is also a key milestone for the program. This flight test was conducted on December 3, 2004, and served as the functional check of the aircraft with its newly installed laser beam control system. This event is critical because:

- It demonstrates that all necessary design, safety, and verification activities to assure flight worthiness have been completed.
- It begins the process of expanding the aircraft flight envelope—types and combinations of flight conditions—in which the ABL can operate.
- It offers the program the opportunity to collect data on the effects of the environment on the BC/FC system while the aircraft is in flight. The data gathered during this test will be used to address jitter issues.

Although "First Flight" was conducted, the program was unable to achieve all of its intended test objectives. The test was originally planned for 2-½ hours but was terminated early due to some erroneous instrumentation readings. Program officials made several attempts to resolve the readings in flight but were unsuccessful and the aircraft was landed early. However, the instrumentation anomalies were all fixed and the program conducted a second flight test on December 9, 2004, which lasted the intended duration of 2-½ hours. The primary objective of the second test was the same as that for "First Flight"—to perform all necessary in-flight functional checks to ensure flight worthiness of the aircraft. The flight test was completed and all remaining test points not completed during "First Flight" were completed successfully.

Assessment of Element Performance

The program office monitors performance indicators to determine the program's readiness for successfully completing the lethality demonstration in 2008. Based on its assessment, 11 of 15 of these indicators point to some risk in achieving this goal. For example, one indicator—atmospheric compensation[5]—is not meeting its performance objectives. Program officials identified a shortfall in the bandwidth of the adaptive optics control system—the system of deformable mirrors and electronics that focus the laser beam on the target—as the primary cause

[5] Atmospheric compensation is the process whereby the high-energy laser beam uses a system of deformable mirrors to minimize the degradation of the laser caused by distortions in the atmosphere.

of this deficiency. Program officials told us that a recovery plan for this indicator is already in place and that the contractor is in the process of fixing the shortfall.

Another important indicator pertaining to the technology of controlling and stabilizing the high-energy laser beam so that vibration unique to the aircraft does not degrade aimpoint—a phenomenon referred to as "jitter"—was identified as a risk item by the program office early on and continues to be a program risk. Jitter control is crucial to the operation of the laser because the laser beam must be stable enough to impart sufficient energy on a fixed spot of the missile target to rupture its fuel or oxidizer tank. Because jitter is among the least mature of ABL's critical technologies, the program office is conducting ground tests and, in the future, flight tests to learn more about jitter control.

Assessment of Element Cost

DOD's planned investment in the ABL program from program inception in 1996 through 2011 is approximately $7.3 billion. As broken out in table 16, DOD expended $2.52 billion between fiscal years 1996 and 2004, Congress appropriated $458 million for fiscal year 2005, and MDA is budgeting about $4.32 billion between fiscal years 2006 and 2011 for ABL research and development.

Table 16: ABL Cost

Dollars in millions of then-year dollars

	Other	Block 2004	Block 2006	Block 2008	Block 2010	Total
FY 1996[a] – FY 2003	$2,058	$0	$0	$0	$0	**$2,058**
FY 2004 (Actuals)	0	459	0	0	0	**459**
FY 2005 (Appropriated)	0	458	0	0	0	**458**
FY 2006	0	0	465	0	0	**465**
FY 2007	0	0	630	0	0	**630**
FY 2008	0	0	0	601	0	**601**
FY 2009	0	0	0	669	0	**669**
FY 2010	0	0	0	0	792	**792**
FY 2011	0	0	0	0	1,163	**1,163**
FY 1996 – FY 2011	**$2,058**	**$917**	**$1,095**	**$1,270**	**$1,955**	**$7,295**

Source: MDA.

Note: ABL budget as of February 2005.

[a]Program inception (FY 1996).

ABL was funded as an Air Force program from 1996 through 2001 and during that time a little over $1 billion was spent. After the program was transferred to MDA in fiscal year 2002, MDA expended approximately $1 billion in fiscal years 2002 and 2003 on ABL development.

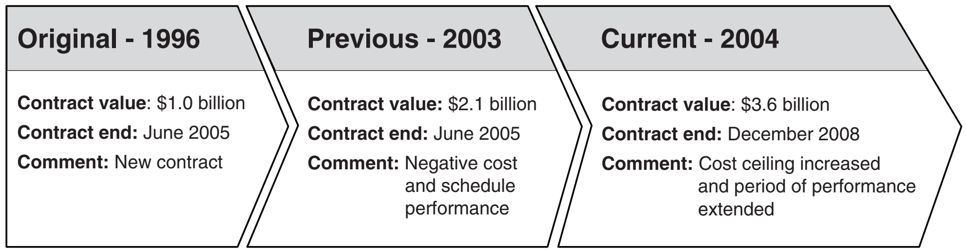
Major Contracting Activity in Fiscal Year 2004

The cost of the ABL program continues to grow. In May 2004, we reported that the prime contractor's costs for developing ABL had nearly doubled from the Air Force's original estimate.[6] In addition, the program incurred cost overruns. In fiscal year 2003 alone, the contractor overran its budget by $242 million, which resulted primarily from integration and testing issues.

The program office recognized that the contractor's unfavorable cost and schedule performance would eventually cause the contract to reach its ceiling price by May 2004. Consequently, MDA considered three alternatives to the contract: (1) continue to work toward the planned schedule, (2) develop a new schedule that scaled back planned activities, or (3) discontinue the contract. Agency officials decided to continue with the existing contract and refocus the program on near-term technical progress. In an effort to continue with the current contract, program officials reevaluated the program schedule and extended the contract period of performance, established a new estimate to complete the contract, and increased the contract cost ceiling by about $1.5 billion. Prior to the recent program restructure, the Block 2004 prime contract was valued at approximately $2.1 billion and was scheduled to end six months after the lethality demonstration in June 2005. However, as a result of the recent program changes, the lethality demonstration is now expected to occur no earlier than 2008 and the contract's period of performance was extended through December 2008. The prime contract to conduct the lethality demonstration is currently valued at approximately $3.6 billion—more than three times its original value of $1.02 billion. Figure 4 summarizes the major activity for the program's prime contract since inception.

[6] GAO, *Uncertainties Remain Concerning the Airborne Laser's Cost and Military Utility*, GAO-04-643R (Washington, D.C.: May 17, 2004).

Figure 4: ABL Block 2004 Prime Contract



Source: MDA (data); GAO (presentation).

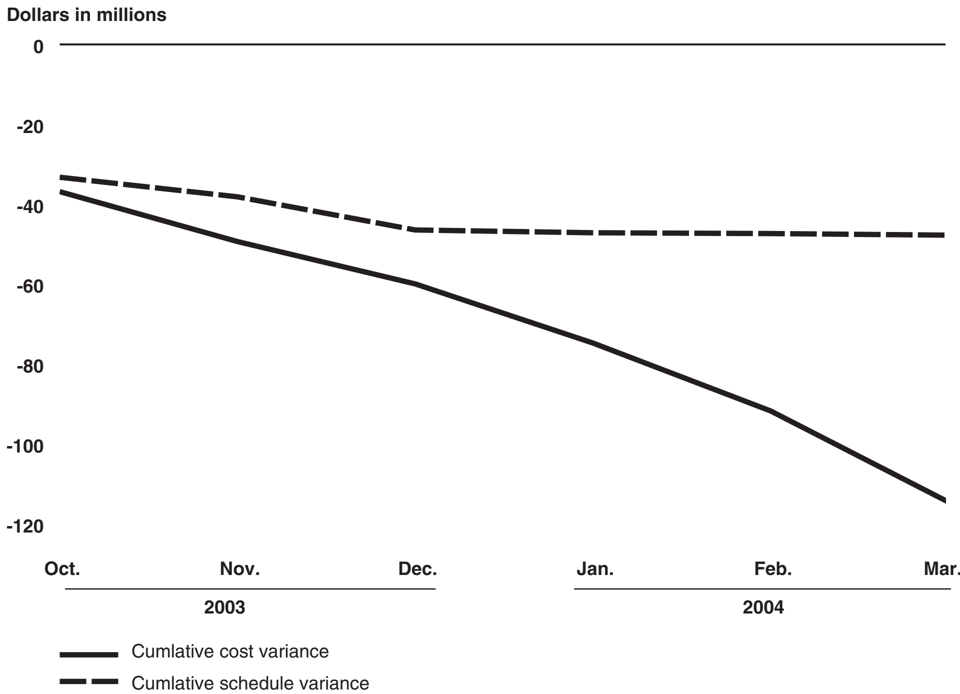
Prime Contractor Fiscal Year 2004 Cost and Schedule Performance

The government routinely uses contractor Cost Performance Reports to independently evaluate prime contractor performance relative to cost and schedule. Generally, the reports detail deviations in cost and schedule relative to expectations established under the contract. Contractors refer to deviations as “variances.” Positive variances are generally associated with the accomplishment of activities under cost or ahead of schedule, while negative variances are often associated with the accomplishment of activities over cost or behind schedule.

Our analysis of prime contractor Cost Performance Reports indicates that ABL cost and schedule performance declined during the first half of fiscal year 2004 even though the program implemented a new performance measurement baseline[7] at the beginning of the fiscal year. As illustrated in figure 5, the program incurred a negative cost variance of $114 million and a negative schedule variance of $47 million during the first 6 months of fiscal year 2004. Program officials indicated that delays in hardware delivery, design problems, and integration issues were the primary drivers of cost growth.

[7] A performance measurement baseline identifies and defines work tasks, designates and assigns organizational responsibilities for each task, schedules the work tasks in accordance with established targets, and allocates budget to the scheduled work.

Figure 5: ABL Fiscal Year 2004 Cost and Schedule Performance



Sources: Contractor (data); GAO (analysis).

Note: Insufficient data is available to perform earned value management analysis beyond March 2004. Contractor performance reporting was suspended from April 2004 through July 2004 because the program was re-planning its efforts and implementing a new performance measurement baseline.

Between April and July 2004, while the contractor was re-planning its work effort, the program was unable to fully evaluate the contractor's progress against its cost and schedule objectives. During this time, program officials directed the contractor to suspend normal cost performance reporting and redirected resources to complete the re-planning effort. Since the contractor was not required to provide program officials with full Cost Performance Reports, the program was unable to perform meaningful Earned Value Management (EVM) analysis.[8] However, in the absence of these reports, program officials took steps to ensure that some insight into the contractor's progress was maintained throughout the

[8] The EVM system is a management tool widely used by DOD to compare the value of the prime contractor's work performed to the work's actual cost. The tool measures the contractor's actual progress against its expected progress and enables the government and contractor to estimate the program's remaining cost.

re-planning effort. For example, the program measured schedule progress by comparing actual progress against the completion of detailed activities associated with “First Light” and “First Flight” and gauged the contractor’s cost performance by comparing contractor forecasted expenditures to the actual costs of the work performed.

The contractor resumed normal cost performance reporting in August 2004. As of September 2004, the contractor was performing work under budget but slightly behind schedule—the program had a positive cost variance of $6.6 million and a negative schedule variance of $1.6 million. According to Cost Performance Reports, the program experienced delays associated with the integration and checkout of the turret assembly—a subcomponent of the BC/FC system—which caused schedule slips through the end of the fiscal year. The late delivery of laser spare material and assembly parts caused additional schedule delays for the program.

Award Fee Plan Unchanged

Although the program was restructured in spring 2004 and the ABL prime contract modified to extend the contract period and increase its value, the associated award fee plan was not adjusted. Therefore, the contractor currently has no opportunity to earn any fee for successful demonstration, since the current award fee plan was tied to a successful completion of shoot down by December 2004.

Appendix IV Summary

Command, Control, Battle Management, and Communications

Source: Missile Defense Agency

Program Description

The Command, Control, Battle Management, and Communications (C2BMC) element is the integrating and controlling element of the Ballistic Missile Defense System (BMDS). It is designed to link all system elements, manage real-time battle information for the warfighter, and coordinate element operation to counter ballistic missile attacks in all phases of flight.

The C2BMC element is being developed under MDA's evolutionary acquisition approach, which delivers system capabilities in 2-year blocks beginning with Block 2004. Within each block, C2BMC software is developed incrementally through a series of software builds known as "spirals." The principal function of the Block 2004 C2BMC element is to provide situational awareness, that is, to monitor the operational status of each BMDS component and to display threat information such as missile trajectories and impact points. It also performs deliberate planning activities for developing battle plans and other operational concepts.

DOD's planned investment in the C2BMC program from program inception in 2002 through 2011 is approximately $2.2 billion. DOD expended $344 million between fiscal years 2002 and 2004, Congress appropriated $191 million for fiscal year 2005, and MDA is budgeting about $1.65 billion for C2BMC development and operations between fiscal years 2006 and 2011.

Fiscal Year 2004 Progress Assessment

The C2BMC team executed the program within budget but slightly behind schedule in fiscal year 2004. Important activities—such as the completion of software development and testing, integration activities, and operator training continued in fiscal year 2004 to ready the element for Limited Defensive Operations (LDO)—were completed.

Schedule: By the end of September 2004, the C2BMC program office completed activities needed to ready the C2BMC element for LDO. The LDO software "build" (spiral 4.3) was delivered. The program office also carried out a number of activities enabling BMDS integration and communications. Finally, C2BMC suites at U.S. Strategic Command and U.S. Northern Command were activated, and "web browsers" providing summary screens of the unfolding battle (such as trajectories of attacking missiles and launched interceptors) were installed at U.S. Pacific Command and locations in the National Capital Region.

Testing: Testing to evaluate C2BMC functionality, interoperability, and system-level integration for LDO was completed. For example, Cycle-3 testing—the third of four cycles of testing to verify that C2BMC interfaces with each BMDS element individually—was completed in August 2004. Cycle-4 testing, which is ongoing, is the final cycle of testing to verify system-level integration. During these tests, the C2BMC element participates in flight tests planned and conducted by MDA.

Performance: During testing of its software, the C2BMC program uncovered a performance issue with its "track correlation and association" algorithm in scenarios involving multiple tracks. The program monitored this issue as a high-risk item because it had the potential to impact situational awareness. In particular, threat information could be displayed differently at C2BMC suites and GMD fire control nodes, possibly causing confusion within the command structure. The problem was resolved with software fixes and the issue retired in July 2004.

Cost: Our analysis of the prime contractor's Cost Performance Reports shows that the contractor continued to carry a positive cost variance, that is, in total it completed work under budget. However, the contractor experienced a modest erosion in cost performance in fiscal year 2004. In particular, it completed fiscal year 2004 activities slightly over budget, incurring a negative cost variance of $3.6 million. The prime contractor's schedule performance was slightly, yet consistently, behind schedule for most of fiscal year 2004. In total, the contractor incurred a negative schedule variance of $5.7 million because of unanticipated technical issues.

Appendix IV: Command, Control, Battle Management, and Communications

Element Description

The Command, Control, Battle Management, and Communications (C2BMC) element is being developed as the integrating and controlling entity of the Ballistic Missile Defense System (BMDS). It is designed to provide connectivity between the various BMDS elements and to manage their operation as part of an integrated, layered missile defense system.

C2BMC has neither a sensor nor weapon. As a software system housed in command centers known as suites,[1] C2BMC provides network-centric warfare capabilities that provide the warfighter with the capability to plan and monitor the missile defense mission. The C2BMC element will track ballistic missile threats—utilizing all available sensors from the various elements—and direct weapons systems to engage the threat.

As the name indicates, the C2BMC is comprised of three major components:

- **Command and control**. The command and control component enables the warfighter to monitor the operational status of each BMDS component, display threat information, such as missile trajectory and impact point, and control defensive actions. In other words, it provides the situational awareness and planning tools to assist the command structure in formulating and implementing defensive actions.
- **Battle management**. The battle management component formulates the detailed instructions (task plans) for executing various missile defense functions, such as tracking enemy missiles, discriminating the warhead from decoys and associated objects, and directing the launch of interceptors. Once implemented, the battle manager will direct the operation of system elements and components, especially under evolving battle conditions.
- **Communications**. Leveraging existing infrastructure, the communications component manages the exchange and dissemination of information necessary for carrying out the battle management and command and control objectives.

History

The Missile Defense Agency (MDA) initiated the C2BMC program in 2002 as a new element of the BMDS. Program officials noted that initial

[1] The C2BMC element also consists of supporting hardware, such as workstations and communications equipment.

versions of C2BMC software are based on existing Air Force and GMD-developed fire control (battle management) software.

Developmental Phases

The C2BMC element is being developed under MDA's evolutionary acquisition approach, which delivers system capabilities in 2-year blocks, beginning with Block 2004. Within each block, C2BMC software is developed incrementally through a series of software builds known as "spirals." Over time, the C2BMC element will be enhanced to provide overarching control and execution of missile defense engagements with the aim of implementing layered defense through the collective use of individual BMDS elements.

The principal function of the Block 2004 C2BMC element is to provide situational awareness, that is, to monitor the operational status of each BMDS component and to display threat information such as missile trajectories and impact points. The program expects to develop this capability incrementally through spirals 4.1 – 4.5. The interim delivery, spiral 4.3, is available for Limited Defensive Operations (LDO) and is on the path to full Block 2004 functionality.

The incorporation of battle management capabilities in the C2BMC element begins with Block 2006. In the 2006-2007 time frame, the element is expected to track that ballistic missile threat throughout its entire trajectory and select the appropriate elements to engage the threat. For example, the Block 2006 C2BMC configuration would be able to generate a single, more precise track from multiple radars and to transmit it to the other elements. Together, this functionality enables each element to "see farther" than it could using its own radar system. This allows elements to launch interceptors earlier, which provides more opportunity to engage incoming ballistic missiles.

Block 2006 is also expected to make a significant improvement over Block 2004 with respect to BMDS communications. During this time, the C2BMC program office will work to establish communications to all elements of the BMDS, overcome limitations of legacy satellite communications protocols, and establish redundant communications links to enhance robustness. Such upgrades serve to improve operational availability and situational awareness.

Planned Accomplishments for Fiscal Year 2004

Planned accomplishments for the C2BMC program in fiscal year 2004 centered on completing activities to ready the element for LDO by the end of September 2004. To achieve this goal, the C2BMC element planned to complete the following specific activities:

- **Software development**. Complete the design, development, and testing of LDO C2BMC software spirals 4.1 – 4.3.
- **BMDS integration and communications**. Integrate the C2BMC element into the BMDS; install and activate global communications capabilities.
- **Make BMDS operational**. Complete and activate C2BMC suites; train operators.

Assessment of Scheduled Activities

By the end of September 2004, the C2BMC program office completed activities needed to ready the C2BMC element for LDO. The LDO "build" of C2BMC (spiral 4.3) was delivered and installed at the various suites. The program office also carried out a number of activities enabling BMDS integration and communications. Finally, C2BMC suites at U.S. Strategic Command (USSTRATCOM) and U.S. Northern Command (USNORTHCOM) were activated, and "web browsers" providing summary screens of the unfolding battle (such as trajectories of attacking missiles and launched interceptors) were installed at U.S. Pacific Command (USPACOM) and locations in the National Capital Region (such as the White House).

Status of C2BMC Software Development

Table 17 summarizes the principal development and testing activities for the first three spirals of Block 2004 C2BMC element software. Most notably, development of the LDO build, spiral 4.3, was completed in May 2004. Testing to evaluate C2BMC functionality, interoperability, and system-level integration was also completed. For example, Cycle-3 testing—the third of four cycles of testing to verify that C2BMC interfaces with each BMDS element individually—was completed in August 2004. Cycle-4 testing, the final cycle of testing to verify system-level integration, is ongoing. During these tests, the C2BMC element participates in flight tests planned and conducted by MDA.

Table 17: C2BMC Fiscal Year 2004 Accomplishments—Software Development and Testing

Software build	Activity	Completion date	Comments
Spiral 4.1	Development	Mar. 2003	All functional and performance testing was completed successfully.
	Testing	Oct. 2003	
Spiral 4.2	Development	Sept. 2003	Spiral 4.2 was tested in a number of venues, including Missile Defense Integration Exercise 04a (Mar. 2004), Integrated Missile Defense War Game 03.2 (Nov. 2003), and Pacific Explorer II (Mar. 2004).[a,b,c]
	Testing	Cycle-3: Feb. 2004	
Spiral 4.3	Development	May 2004	Spiral 4.3 is the LDO build. It was tested in Pacific Explorer III (Jul. 2004), Glory Trip 185 (June 2004), Integrated Missile Defense War Games 04.2 – 04.4 (June – Sept 2004), System Integration and Checkout 6A (Sept. 2004), and other tests.[b,c,d]
	Testing	Cycle-3: Aug. 2004 Cycle-4: Ongoing	

Sources: MDA (data); GAO (presentation).

[a]Missile Defense Integration Exercises are hardware-in-the-loop ground tests conducted to characterize the degree of integration and interoperability between BMDS elements.

[b]Integrated Missile Defense War Games are ground tests that enable the warfighter to exercise the C2BMC in a simulated operational environment. In general, the warfighter community uses them to gain insight in, and provide feedback on, C2BMC capabilities.

[c]Pacific Explorers are field exercises to demonstrate BMDS connectivity. An Aegis destroyer participates by tracking an actual missile (or a simulated target) and passes track data to the C2BMC.

[d]Glory Trips are live flight tests during which a Minuteman III missile is launched from Vandenberg Air Force Base as part of Follow-on Test and Evaluation. C2BMC objectives are geared to evaluating the element's interfacing with, and processing of track data from, forward-deployed radars.

The program office plans to complete, by the end of calendar year 2005, key activities pertaining to the development and testing of spirals 4.4 and 4.5—the final two builds of Block 2004 C2BMC element software. For example, development of spiral 4.4 was completed in November 2004 and Cycle-3 testing is expected to be completed in April 2005. In addition, the program office expects to complete development of spiral 4.5 in March 2005 and begin Cycle-3 testing in June 2005. Cycle-4 testing of spiral 4.5 is scheduled to begin during the first quarter of fiscal year 2006 with completion coinciding with the completion of Block 2004.

Status of BMDS Integration and Communications

The C2BMC program office carried out a number of activities in fiscal year 2004 related to C2BMC's role in BMDS integration and communications. For example, interface specifications between C2BMC and other elements were completed. In addition, communications software and hardware were installed at the various C2BMC sites, including USSTRATCOM, USNORTHCOM, and USPACOM. Finally, the C2BMC element participated in a number of MDA test events to verify system integration.

Status of Steps Taken to Make BMDS Operational

The C2BMC program completed a variety of activities in fiscal year 2004 to make the BMDS operational. These activities included activation of C2BMC suites at the various command sites and the training of military operators for conducting ballistic missile defense missions. Table 18 summarizes the program's efforts in making the system available for LDO.

Table 18: C2BMC Fiscal Year 2004 Planned Accomplishments—Making System Operational

Activity	Description/Progress assessment
Site Activation	C2BMC suites at USSTRATCOM and USNORTHCOM were fully activated to support defensive operations. Furthermore, so-called "web browsers" that provide situational awareness are ready to support LDO at USPACOM and three National Capital Region sites. At all sites, hardware installation, software installation, testing, and a readiness review were completed by Sept. 30, 2004.
Training	C2BMC operator training was completed at USNORTHCOM, USSTRATCOM, USPACOM, and three National Capital Region sites by Sept. 30, 2004, to support LDO. The warfighter completed a number of training courses—Joint Defense Planner Class, Situational Awareness Class, and Flag Officer Class—at all locations and participated in training events. Operator training continued through the beginning of fiscal year 2005 as part of the "shakedown" process.

Source: MDA.

Assessment of Element Performance

During testing of C2BMC software, the C2BMC program uncovered a performance issue with its "track correlation and association" algorithm in scenarios involving multiple tracks. During a portion of fiscal year 2004, the program monitored this issue as a high-risk item because it had the potential to impact situational awareness. In particular, threat information could be displayed differently at C2BMC suites and GMD fire control nodes, possibly causing confusion within the command structure.[2] The program implemented a mitigation plan to resolve this issue, including the formation of a "Blue Ribbon Panel" in June 2004 to analyze the problem. The problem was resolved with software fixes and the issue retired in July 2004.

Assessment of Element Cost

DOD's planned investment in the C2BMC program from program inception in 2002 through 2011 is approximately $2.2 billion. As broken out in table 19, DOD expended $343 million between fiscal years 2002 and 2004, Congress appropriated $191 million for fiscal year 2005, and MDA is

[2] Details of this issue are classified.

budgeting $1.65 billion for C2BMC development and operations between fiscal years 2006 and 2011.

Table 19: C2BMC Cost

Dollars in millions of then-year dollars

	Other	Block 2004	Block 2006	Block 2008	Block 2010	Core[b]	Total
FY 2002[a] – FY 2003	$179.4	$0	$0	$0	$0	$0	**$179.4**
FY 2004 (Actuals)	0	92.4	52.5	0.7	0	18.3	**163.9**
FY 2005 (Appropriated)	0	154.0	24.0	10.8	0	1.7	**190.5**
FY 2006	0	22.5	142.2	75.9	0	0	**240.6**
FY 2007	0	16.2	153.0	100.0	11.5	0	**280.7**
FY 2008	0	0	23.8	197.0	60.6	0	**281.4**
FY 2009	0	0	16.7	166.0	104.6	0	**287.3**
FY 2010	0	0	0	65.7	217.8	0	**283.5**
FY 2011	0	0	0	56.0	223.7	0	**279.7**
FY 2002 – FY 2011	**$179.4**	**$285.1**	**$412.2**	**$672.1**	**$618.2**	**$20.0**	**$2,187.0**

Source: MDA.

Note: C2BMC budget as of February 2005.

[a]Program inception (FY 2002).

[b]Core funding is part of Program Element 0603890C, “BMD Project.” Core activities involve the hiring of skilled individuals to aid in the development of the C2BMC element.

Prime Contractor Cost and Schedule Performance

C2BMC development is being carried out through a contractual vehicle known as an Other Transaction Agreement (OTA),[3] which functions much like a prime contract. MDA believes that an OTA allows the C2BMC element to take advantage of more collaborative relationships between industry, the government, Federally Funded Research and Development Centers, and University Affiliated Research Centers. OTAs generally are not subject to federal procurement laws and regulations. The OTA did implement the earned value management system used to assess the cost and schedule performance of contractors developing large weapon systems. The C2BMC Missile Defense National Team, for which Lockheed

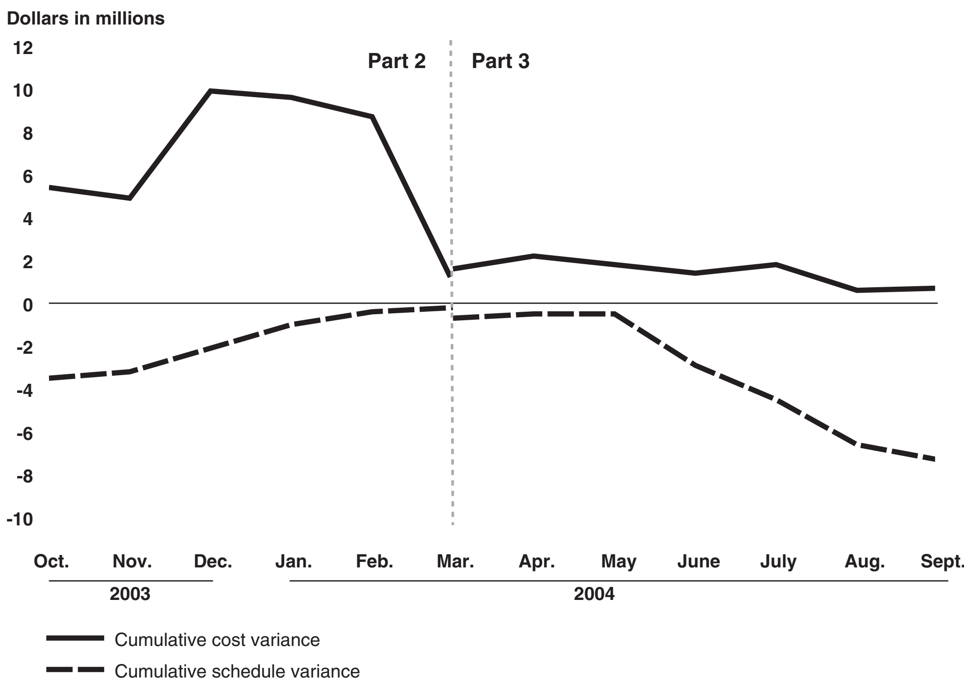
[3] An OTA refers to transactions other than contracts, grants, or cooperative agreements. OTAs are entered into under the authority of 10 U.S.C. § 2371 (2000 & Supp. II 2004) for basic, applied, and advanced research projects or under the authority of section 845 of the National Defense Authorization Act for Fiscal Year 1994 (10 U.S.C. § 2371 note) for prototype projects.

Martin Integrated System and Solutions serves as the industry lead, is developing and fielding the C2BMC element of the BMDS.

The government routinely uses contractor Cost Performance Reports to independently evaluate a prime contractor's cost and schedule performance. Generally, these reports detail deviations in cost and schedule relative to expectations established under the contract. Contractors refer to deviations as "variances." Positive variances are usually associated with the accomplishment of activities under cost or ahead of schedule, while negative variances are often associated with the accomplishment of activities over cost or behind schedule.

During fiscal year 2004, C2BMC development was performed under two parts of the existing OTA—Part 2, for which work was completed in March 2004, and Part 3, for which work began in March 2004. As illustrated in figure 6, Cost Performance Reports show that Lockheed Martin, the industry lead for the OTA, continued to carry a positive cost variance, that is, in total it completed work under budget. However, Lockheed experienced a modest erosion in cost performance in fiscal year 2004. In particular, it completed fiscal year 2004 activities slightly over budget, incurring a negative cost variance of $3.6 million on combined Part 2 and Part 3 work efforts.

Figure 6: C2BMC Fiscal Year 2004 Cost and Schedule Performance



Sources: Contractor (data); GAO (analysis).

The prime contractor's schedule performance was slightly, yet consistently, behind schedule for most of fiscal year 2004. However, beginning in May 2004, schedule performance sharply declined. In total, Lockheed incurred a negative schedule variance of $5.7 million for combined Part 2 and Part 3 work performed in fiscal year 2004.

The C2BMC program office reported the following two drivers as contributing to fiscal year 2004 cost and schedule variances.

- **Track association algorithm**. As noted in the performance section, the C2BMC program uncovered a performance issue with its "track correlation and association" algorithm during spiral testing. Resources allocated to spiral 4.4 development were used to address this problem, including the convening of a Blue Ribbon panel to analyze it. In the course of analyzing and correcting this issue, more time and money were needed for additional testing of spiral 4.3 and associated risk reduction efforts on developing an alternative algorithm.

- **Site activation**. C2BMC suites are being integrated with existing systems at USSTRATCOM, USNORTHCOM, and USPACOM. The integration efforts, particularly those aspects pertaining to information assurance, were considerably more difficult that anticipated. The result was the need for more travel by the engineering team to field, install, and troubleshoot problems at the three activation sites.

Appendix V Summary

Ground-Based Midcourse Defense

Source: Missile Defense Agency

Program Description

The Ground-based Midcourse Defense (GMD) element is a missile defense system being developed to protect the United States against limited long-range ballistic missile attacks launched from Northeast Asia and the Middle East. The first increment of this capability, Block 2004, is being developed and fielded during the 2004-2005 time frame.

By the end of September 2004, the GMD program put in place the components of a limited capability, which is known as Limited Defensive Operations (LDO). MDA plans to augment this capability with additional interceptors and radars by the end of calendar year 2005 to complete the full Block 2004 increment.

DOD's planned investment in the GMD program from program inception in 1996 through 2011 is approximately $31.6 billion. DOD expended $15.3 billion between fiscal years 1996 and 2004, Congress appropriated $3.3 billion for fiscal year 2005, and MDA is budgeting about $13.0 billion between fiscal years 2006 and 2011 for GMD development, procurement, and operations.

Fiscal Year 2004 Progress Assessment

By the end of fiscal year 2004, GMD carried out planned activities needed to field an initial missile defense capability, including, as summarized below, the emplacement of interceptors at Fort Greely, Alaska. However, delays of flight tests prevented MDA from demonstrating the operation of the integrated system in a realistic environment before placing interceptors in silos for defensive operations. The program also showed unfavorable trends in contractor cost and schedule performance in fiscal year 2004.

Schedule: The GMD program completed construction of missile silos and facilities at Fort Greely, Alaska, and Vandenberg Air Force Base, California; emplaced five GMD interceptors in their silos at Fort Greely by the end of September 2004; and completed the upgrade of the Cobra Dane radar. MDA is on track to add additional interceptors and radar capabilities throughout Block 2004, although there is some risk that the sea-based X-band radar will not be completed by the first quarter of fiscal year 2006, as planned.

Test: The GMD program office conducted two flight tests (non-intercept booster tests) in fiscal year 2004 out of six events that were planned—no intercept attempts were conducted. Accordingly, GMD interceptors were fielded before flight testing was performed to verify that LDO hardware and software could function in an operational environment. In preparation for defensive operations, the GMD program also completed a series of System Integration and Checkouts that demonstrated connectivity, functionality, and integration of its fielded components.

Performance: While ground and flight tests have demonstrated each step of the missile defense engagement sequence—detect, track, launch/engage, and intercept—collectively, these accomplishments do not verify integrated operation of the GMD capability. For example, BMDS and GMD radars have not performed their primary function as a fire control radar in a flight test event.

Cost: Our analysis of the prime contractor's Cost Performance Reports shows that the contractor overran its budgeted costs in fiscal year 2004 by $219.6 million and was unable to complete $59.9 million worth of scheduled work. Developmental issues with the interceptor's booster and kill vehicle remain the leading causes of cost overruns and schedule slips. For example, interceptor development cost $204 million more in fiscal year 2004 than the contractor budgeted. Flight test delays also contributed to unfavorable cost and schedule performance.

Appendix V: Ground-Based Midcourse Defense

Element Description

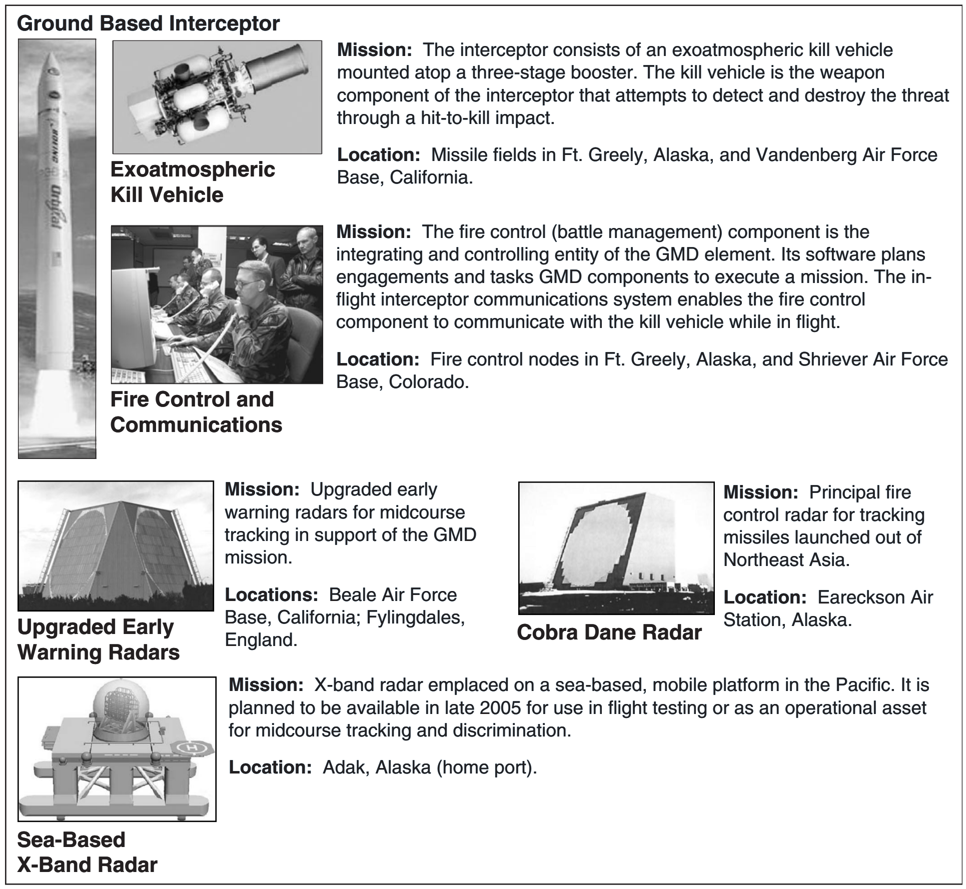
The Ground-based Midcourse Defense (GMD) element is a missile defense system designed to protect the U.S. homeland against intercontinental ballistic missile (ICBM)[1] attacks. As an integral part of the Ballistic Missile Defense System (BMDS), GMD functions to destroy long-range ballistic missiles during the midcourse phase of flight, the period after booster burnout when the warhead travels through space on a predictable path.

The GMD element relies on a broad array of components, including (1) space- and ground-based sensors to provide early warning and tracking of missile launches; (2) ground- and sea-based radars to identify and refine the tracks of threatening objects; (3) ground-based interceptors to destroy enemy missiles through "hit-to-kill" impacts outside the atmosphere; and (4) fire control and communications nodes for battle management and execution of the GMD mission. Figure 7 illustrates GMD components, current and planned, which are situated at several locations within and outside of the United States.

The program office produced, emplaced, and upgraded all GMD components needed for an initial capability by the end of September 2004 and is working to augment this initial capability with additional interceptors and radars by the end of calendar year 2005. This first block of capability—Block 2004—is estimated to provide the U.S. with protection against ICBMs launched from Northeast Asia and the Middle East.

[1] The terms "intercontinental ballistic missile" and "long range ballistic missile" are used interchangeably. They are, by definition, ballistic missiles with ranges greater than 5,500 kilometers (3,400 miles).

Figure 7: Components of the GMD Element



MDA (data); GAO (presentation).

History

The Department of Defense (DOD) established the National Missile Defense program in 1996 to develop a missile defense system capable of protecting the United States from ICBM attacks. The program was to be in a position to deploy the system by 2005, if the threat warranted. Many of the components used in the current GMD program are based directly on the research and development conducted by the National Missile Defense program.

In response to the President's December 2002 directive to field a missile defense system, the Missile Defense Agency (MDA) accelerated its developmental activities to make the GMD element operational—that is, to field a working system operated by trained warfighters. GMD remains a capabilities-based research and development program with enhanced capabilities delivered periodically in block upgrades.

Developmental Phases

GMD's development and fielding are proceeding in a series of planned 2-year blocks, which incrementally increase the element's capability by maturing the design of element components and upgrading software. Block 2004, the first increment, is being rolled out in two major phases:

- **Limited Defensive Operations (LDO)**. The GMD program completed an initial capability in September 2004, which is available for limited defensive operations. The principal components include five interceptors at Fort Greely, Alaska; GMD fire control and communications nodes for battle management and execution at Fort Greely and Schriever Air Force Base, Colorado; an upgraded Cobra Dane radar at Eareckson Air Station, Alaska; and connectivity to Aegis BMD for additional radar tracking. DOD will use this initial capability to provide the United States with protection against a limited ballistic missile attack launched from Northeast Asia. This capability was expanded by the end of calendar year 2004 with the addition of three interceptors—one at Fort Greely and two at Vandenberg Air Force Base (VAFB), California—and an upgraded early warning radar (UEWR) at Beale Air Force Base, California.
- **Block 2004 Defensive Capability**. By the end of calendar year 2005, MDA plans to augment the LDO capability by installing 10 additional interceptors at Fort Greely (for a total of 18 interceptors at Fort Greely and VAFB); deploying a sea-based X-band radar; and upgrading the early warning radar at Fylingdales, England. These enhancements are expected to provide additional protection against ICBMs launched from the Middle East.

Future block configurations of the GMD element build upon the Block 2004 capability. As part of its Block 2006 program, MDA expects to field 10 additional interceptors at Fort Greely and upgrade the early warning radar located at Thule Airbase, Greenland. MDA also plans to conduct more realistic flight tests to demonstrate performance against more complex missile threats and environments.

Planned Accomplishments for Fiscal Year 2004

The GMD element plays a central role in the Block 2004 BMDS. In general, planned accomplishments for GMD in fiscal year 2004 centered on continuing development of element components, conducting ground and flight testing, and fielding components for LDO. Specific planned accomplishments include:

- **Component Development**. The program office planned to continue development of all element components for LDO, Block 2004, and the incremental improvement of block capability.
- **Testing**. The program planned to conduct six flight tests (three booster tests, one "fly-by" test, and two intercept attempts), two integrated ground tests, and System Integration and Checkouts in preparation for LDO.
- **Fielding Initial Capability**. The program planned to complete construction of facilities and the installation of five ground-based interceptors at Fort Greely, complete upgrades of the Cobra Dane radar, and activate its fire control and communications component.

Assessment of Scheduled Activities

MDA met its fielding goals for LDO and is on track, with some schedule risk, to add additional interceptors and radar capabilities throughout Block 2004. Ground tests were conducted to ensure interoperability of element components and to verify operation and performance of component software. However, several key flight tests needed to verify the effectiveness of LDO hardware and software, originally scheduled for fiscal year 2004, were delayed into fiscal year 2005.

GMD Component Development

In fiscal year 2004, a large portion of the GMD program focused on the development of its Block 2004 components, some of which will be fielded as part of LDO. Summaries of progress made by the GMD program office during fiscal year 2004 in developing its components are given in table 20.

Table 20: Status of GMD Fiscal Year 2004 Component Development

Component	Description	Fiscal Year 2004 progress
GMD Fire Control and Communications Component	The fire control component integrates and controls the other components of the GMD element. With input from operators, the fire control software plans engagements and directs GMD components, such as its radars and interceptors, to carry out a mission to destroy enemy ballistic missiles. The in-flight interceptor communications system (IFICS), which is part of the fire control component, enables the fire control component to communicate with the kill vehicle while it is en route to engage a threat.	In fiscal year 2004, the GMD program completed software development and testing of the LDO build. MDA also completed construction of IFICS Data Terminals at Shemya and Fort Greely and activated the CONUS[a] fiber optic ring, which connects all the command, control, and communications networks of the GMD element. Additionally, connectivity to Aegis BMD and the C2BMC were completed.
Upgraded Early Warning Radars (Beale and Fylingdales)	The early warning radar is an upgraded version of existing Ultra High Frequency surveillance radars used by the Air Force for strategic warning and attack assessment. For Block 2004, the GMD program is upgrading two early warning radars—one at Beale AFB and another at Fylingdales Airbase—to enable the radars to more accurately track enemy missiles. The upgrades include improvements to both the hardware and software.	In fiscal year 2004, Beale UEWR ground support facilities and radar hardware installation were completed. Although radar hardware installation is complete, final software installation and testing are ongoing with completion expected in the middle of fiscal year 2005. MDA also began facility construction and upgrades to the early warning radar at Fylingdales, which is on track to be completed by the first quarter of fiscal year 2006.
Upgraded Cobra Dane Radar	The Cobra Dane radar, located at Eareckson Air Station on Shemya Island, Alaska, was primarily being used to collect data on ICBM test launches out of Russia. Cobra Dane's surveillance mission did not require real-time communications and data-processing capabilities; therefore, it was upgraded to be capable of performing the missile defense mission as part of the Block 2004 architecture. As an upgraded radar, Cobra Dane is expected to operate much like the upgraded early warning radar at Beale AFB. Although its hardware required minor modifications, Cobra Dane's mission software is being revised for its new application. The program plans to use existing software and develop new software to integrate Cobra Dane into the GMD architecture. It is also modifying the Cobra Dane facility to accommodate enhanced communications functions.	In fiscal year 2004, the GMD program completed hardware installation and software upgrades to the Cobra Dane radar. The radar also tracked a foreign missile launch and participated in an integrated ground test. While Cobra Dane met most of the data collection objectives in these tests, the upgraded Cobra Dane radar has not participated in a flight test event as the primary fire control radar—a role it would need to fill in the event of a real threat. MDA may perform a radar certification flight test using a long-range air-launched target during the third quarter of 2005. The primary objective of this test is to demonstrate the upgraded Cobra Dane in a more operationally realistic environment.

Component	Description	Fiscal Year 2004 progress
Sea-Based X-Band Radar	The GMD program office is managing the development of a sea-based X-band radar (SBX) to be delivered and integrated into the BMDS by the end of Block 2004. SBX will consist of an X-band radar—based on the technologies of the X-band radar prototype located at Reagan Test Site—positioned on a sea-based platform, similar to those used for offshore oil drilling. The radar is designed to track and discriminate enemy missiles with high accuracy and assess whether an intercept was successful.	During fiscal year 2004, MDA completed most platform modifications and assembly of the radar structure. Key electronic components have been completed, and all software design reviews conducted. The program office assesses the delivery of SBX by the first quarter of fiscal year 2006 as the program's only significant risk item. If complications occur in final integration, checkout, or verification, delivery could be delayed. MDA plans to exercise the SBX in flight tests beginning in fiscal year 2006.
Ground-Based Interceptor	The ground-based interceptor—the weapon component of the GMD element—consists of a kill vehicle mounted atop a three-stage booster. The booster, which is essentially an ICBM-class missile, delivers and deploys the kill vehicle into a trajectory to engage the threat. Once deployed, the kill vehicle uses its onboard guidance, navigation, and control subsystem (along with target updates from the fire control node component) to detect, track, and steer itself into the enemy warhead, destroying it above the atmosphere through a hit-to-kill collision.	In fiscal year 2004, MDA placed the first five interceptors into silos at Fort Greely; a sixth interceptor was delivered in October 2004. MDA continued to work toward building and integrating pieces of additional missiles that will be delivered throughout 2005. For example, interceptors #7 and #8 were placed into VAFB silos during December 2004, as scheduled.

Sources: MDA (data); GAO (presentation).

[a]CONUS refers to the Continental United States, i.e., the lower 48 states.

In our April 2004 report on missile defense,[2] we noted that MDA is pursuing the development of two types of boosters for the GMD interceptor, one referred to as the Lockheed BV+ booster and the other known as the Orbital Sciences Corporation (OSC) booster. We also described how problems with the development and delivery of Lockheed's BV+ booster contributed to cost growth and schedule slips for the program. For example, BV+ production was temporarily suspended because of two separate explosions at a subcontractor's propellant-mixing facility.

Despite these problems, MDA is dedicated to pursuing a dual-booster strategy. However, the problems with Lockheed's booster in fiscal year 2003 had ramifications for the program's fiscal year 2004 activities. For example, MDA planned to use BV+ boosters in alternating Block 2004 flight tests and in about half of the interceptors fielded. However, because

[2] GAO, *Missile Defense: Actions Are Needed to Enhance Testing and Accountability*, GAO-04-409 (Washington, D.C.: Apr. 23, 2004).

of BV+ development and production problems, MDA deferred BV+ participation in integrated flight tests into Block 2006, and the Block 2004 inventory of GMD interceptors will consist entirely of those utilizing OSC boosters. MDA plans to restart the manufacturing of BV+ boosters in fiscal year 2005 and to field the first BV+ booster in 2007.

GMD Testing

The GMD program conducts a variety of tests, the most visible being flight test events. For example, the program conducted booster validation (BV) flight tests to assess the operation of GMD's two booster designs. In addition, the program conducts integrated flight tests (IFT) to more realistically demonstrate the GMD element using actual hardware and software. IFTs are reflective of the environment in which the GMD element would operate for a given threat trajectory and given set of conditions.

Although MDA hoped to gain knowledge about the element's effectiveness by conducting several integrated flight tests throughout fiscal year 2004, only two of six scheduled tests—non-intercept tests of the Lockheed BV+ booster and the OSC booster—were executed. Table 21 summarizes the major GMD flight tests that MDA planned to conduct in fiscal year 2004.

Table 21: Status of Major GMD Flight Tests (Fiscal Year 2004)

Test event	Date	Description	Outcome
BV-5[a]	Original date: Feb. 20, 2003 Actual date: Jan. 9, 2004	BV+ Booster Test Objectives: • Characterize Lockheed's BV+ booster performance	All booster objectives were achieved. However, the mock kill vehicle failed to deploy.
IFT-13A	Original date: May 2003 Planned date: Deferred indefinitely	BV+ Booster Test Objectives: • Characterize booster and kill vehicle environments • Engage simulated target as part of an integrated system	The program deferred this test until BV+ production resumes.

Test event	Date	Description	Outcome
IFT-13B	Original date: July 2003 Actual date: Jan. 26, 2004	OSC Booster Test[b] Objectives: • Characterize booster and kill vehicle environments • Engage simulated target as part of an integrated system	The test was a successful demonstration of the OSC booster—all test objectives were achieved.
IFT-13C	Original date: Mar. 2004 Actual date: Dec. 14, 2004	Non-intercept attempt (zero-offset flyby)[c] with the OSC booster Configuration: • Target launch from Kodiak • Interceptor launch from Reagan Test Site • Interceptor: LDO configuration	Because the interceptor failed to launch from its silo, test objectives associated with booster and kill vehicle functioning could not be assessed. The root cause of the test failure was attributed to a timing problem with the interceptor's flight computer, which caused the interceptor to abort its launch.
IFT-14	Original date: Oct. 2003 Actual date: Feb. 14, 2005	System test (intercept attempt) with OSC booster Configuration: • Target launch from Kodiak • Interceptor launch from Reagan Test Site • Interceptor: LDO configuration	Because the interceptor failed to launch from its silo, test objectives associated with booster and kill vehicle functioning could not be assessed. The reason for the launch failure is under investigation.
FTG-04-1	Planned date: 4Q FY2005[d]	System test (intercept attempt) with OSC booster Configuration: • Target launch from Kodiak • Interceptor launch from VAFB • Interceptor: LDO configuration	TBD

Sources: MDA (data); GAO (presentation).

Note: Test schedule as of October 2004.

[a]BV-5 was the last flight test to use Lockheed's BV+ booster.

[b]Orbital Sciences Corporation builds the OSC boost vehicle. MDA accelerated the production of OSC boosters to compensate for the undelivered BV+ boosters. All of the Block 2004 interceptors use OSC boosters.

[c]A "zero-offset flyby" means that intercepting the target is not a test objective. However, no action is taken to prevent an intercept.

[d]We use the notation "4Q FY2005" to mean the fourth quarter of fiscal year 2005 and an identical format for other time periods.

IFT-13C, which was the first flight test in 2 years with the potential for an intercept,[3] was delayed several times during fiscal year 2004. Part of the delay was attributed to technical problems with the interceptor. In addition, MDA upgraded the test interceptor to a configuration that more closely matches the ones deployed. The test was conducted in December 2004, but failed to execute fully because the interceptor did not launch from its silo. IFT-13C was of particular significance, because it was to have demonstrated operational aspects of the LDO capability for the first time in a flight test environment. For example, it was to have demonstrated: (1) the operation of LDO hardware and software; (2) the operation of the kill vehicle mated with an OSC booster; and (3) "real-time" connectivity between Aegis destroyers and the C2BMC. IFT-14 was conducted in February 2005 as a repeat of IFT-13C but with the added objective to achieve an intercept. However, as in IFT-13C, it failed to execute fully because the interceptor did not launch from its silo.

MDA relies heavily on its ground test program to characterize element and system performance (especially under a broad set of conditions not testable in flight), to demonstrate interoperability, and to develop operational doctrine. MDA conducted two integrated ground tests (IGT) in fiscal year 2004, IGT-2 and IGT-4a. These tests employed actual GMD-component processors integrated together in a hardware-in-the-loop facility that emulated GMD operation in a simulated environment. They also included warfighter participation to aid in the development of operational concepts. Although the tests demonstrated that GMD components could work together, its utility in assessing element performance was limited. Officials in the office of DOT&E told us that such assessments should be anchored by flight test data so that models and simulations accurately characterize the system. Delays in the GMD flight test program precluded these tests from being adequately anchored and, therefore, limited its usefulness in assessing element performance.

The GMD program also participated in a series of System Integration and Checkouts (SICO) of its fielded components. While these checkouts do not assess element performance, they do demonstrate connectivity, functionality, integration, and configuration in preparation for defensive operations. During fiscal year 2004, MDA successfully conducted SICOs 1, 3, 5, and 6A. SICO 3 demonstrated the integration of non-LDO interceptor

[3] Technically, IFT-13C was a "zero-offset flyby." Although intercepting the target was not a test objective, no action was taken to prevent an intercept.

equipment at Fort Greely into the overall BMDS; SICO 5 confirmed that the upgraded Cobra Dane radar was properly connected to the Communications Network; and SICO 6A confirmed integration of LDO interceptor equipment at Fort Greely into the BMDS. Finally, SICO 6B was successfully conducted in the beginning of fiscal year 2005 (December 2004). It demonstrated the integration of interceptor equipment at Vandenberg into the BMDS.

Fielding Initial Capability

The GMD program completed the development, emplacement, and/or upgrade of element components planned for LDO, including ground-based interceptors, the Cobra Dane radar, the Beale UEWR (in fiscal year 2005), and the GMD fire control and communications. Most notably, five interceptors were placed in silos at Fort Greely and are available for defensive operations. GMD also completed hardware and software upgrades to the Cobra Dane and Beale radars, both of which met objectives in ground tests and tracked targets of opportunity. Fire control and communications nodes have been activated and linked to all GMD locations. Finally, facility construction at Fort Greely and other GMD sites was completed. Table 22 summarizes main accomplishments made in fiscal year 2004 for each activity.

Table 22: Status of GMD Fiscal Year 2004 Planned Accomplishments—Fielding Initial Capability

Activity	Description/Progress assessment
Ground Based Interceptor: Deliver and install 5 interceptors at Fort Greely	Five interceptors were delivered and installed at Fort Greely by September 30, 2004. Three additional interceptors were delivered (1 to Fort Greely; 2 to VAFB) by December 2004. MDA plans to have 18 interceptors available for defensive operations by the end of the first quarter of fiscal year 2006, two less than the agency's Block 2004 fielding goal. Of the 20 interceptors originally planned, two were designated as test assets.
Cobra Dane Radar: Complete upgrades, checkout, and activation	Installation and checkout of Cobra Dane's mission equipment was completed ahead of schedule. Cobra Dane software development was also completed. The radar successfully tracked a foreign missile launch but has not participated in any BMDS flight tests that demonstrate real-time tracking and communications as part of an integrated system.
Beale UEWR: Complete upgrades, checkout, and activation	All planned hardware upgrades and GMD software for LDO were completed. The Beale UEWR is now integrated with the BMDS. Although radar hardware installation is complete, final software installation and testing are ongoing with completion expected in the middle of fiscal year 2005. The upgraded radar successfully tracked a Titan missile launched out of VAFB and several satellites but has not participated in any MDA-dedicated tests like radar certification flights or integrated flight tests in its upgraded configuration. The full checkout of the upgraded software will not be verified in a flight test until fiscal year 2005.

Activity	Description/Progress assessment
GMD fire control and communications: Complete installation, checkout, and activation	GMD fire control and communications were completed on schedule to support fielding of the GMD element. The CONUS fiber optic ring and spurs to all GMD locations were activated. Satellite communication links were established and all IFICS Data Terminals were completed.
Construction: Complete construction and installation at Fort Greely and Shemya	All facilities required for alert at Fort Greely were completed, including the first missile field, Readiness and Control Building, Mechanical Electrical Building, and the on-site IFICS Data Terminals. The Missile Assembly Building and the interim power plant, although not required for LDO, were also completed.

Sources: MDA (data); GAO (presentation).

Assessment of Element Performance

GMD, the centerpiece of the BMDS Block 2004 defensive capability, has demonstrated its ability to intercept target warheads in several flight tests since 1999. Indeed, the program has achieved five successful intercepts out of eight attempts.[4] In addition, according to MDA officials, ground and flight tests have demonstrated each step of the engagement sequence—detect, track, launch/engage, and intercept—collectively, although these accomplishments do not verify integrated operation of the GMD capability.

Although GMD flight tests have demonstrated basic functionality of a representative missile defense system using surrogate and prototype components, the tests were developmental in nature and relied on artificialities to overcome test-range limitations. For example, flight tests required the placement of a C-band transponder and Global Positioning System instrumentation on the target reentry vehicle. In addition, engagement conditions were limited to low closing velocities and short interceptor fly-out ranges. Finally, the tests were scripted and did not use production-representative hardware and software.

In its push to field the first eight GMD interceptors by the end of December 2004, MDA is assuming both performance and cost risk. As noted above, the GMD program emplaced interceptors in silos before successfully conducting a flight test utilizing components with the LDO configuration. For example, the program did not demonstrate that the kill vehicle could operate with the OSC booster prior to placing it in the silo for future operational use (even though this booster puts more stress on the kill vehicle). If future flight testing identifies problems with fielded

[4] The December 2004 flight test, IFT-13C, and the February 2005 flight test, IFT-14, are not counted.

interceptors, the need for corrective actions could be costly, but confidence would increase as corrections are made and capability is understood.

Assessment of Element Cost

DOD's planned investment in the GMD program from program inception in 1996 through 2011 is approximately $31.6 billion. As broken out in table 23, DOD expended $15.3 billion between fiscal years 1996 and 2004,[5] Congress appropriated $3.3 billion for fiscal year 2005, and MDA is budgeting about $13.0 billion between fiscal years 2006 and 2011 for GMD development, procurement, and operations.

Table 23: GMD Cost

Dollars in millions of then-year dollars

	Other	Block 2004	Block 2006	Block 2008	Block 2010	Total
FY 1996[a] – FY 2003	$12,370	$0	$0	$0	$0	**$12,370**
FY 2004 (Actuals)	0	1,357	1,587	0	0	**2,944**
FY 2005 (Appropriated)	0	2,756	563	0	0	**3,319**
FY 2006	0	0	2,224	74	0	**2,298**
FY 2007	0	0	2,232	281	189	**2,702**
FY 2008	0	0	331	1,425	717	**2,473**
FY 2009	0	0	234	1,176	655	**2,065**
FY 2010	0	0	0	338	1,557	**1,895**
FY 2011	0	0	0	213	1,350	**1,563**
FY 1996 – FY 2011	**$12,370**	**$4,113**	**$7,171**	**$3,507**	**$4,468**	**$31,629**

Source: MDA.

Note: GMD budget as of February 2005.

[a]Program inception (FY 1996).

Prime Contractor Fiscal Year 2004 Cost and Schedule Performance

GMD's prime contract consumes the bulk of the program's budget. The contract originally covered Block 2004 and Block 2006 developmental activities, not the procurement and fielding of interceptors for the initial defensive capability. Therefore, the program significantly modified the contract in October 2003. The $823 million modification directed the delivery of Block 2004 interceptors 6-20. The program is expected to

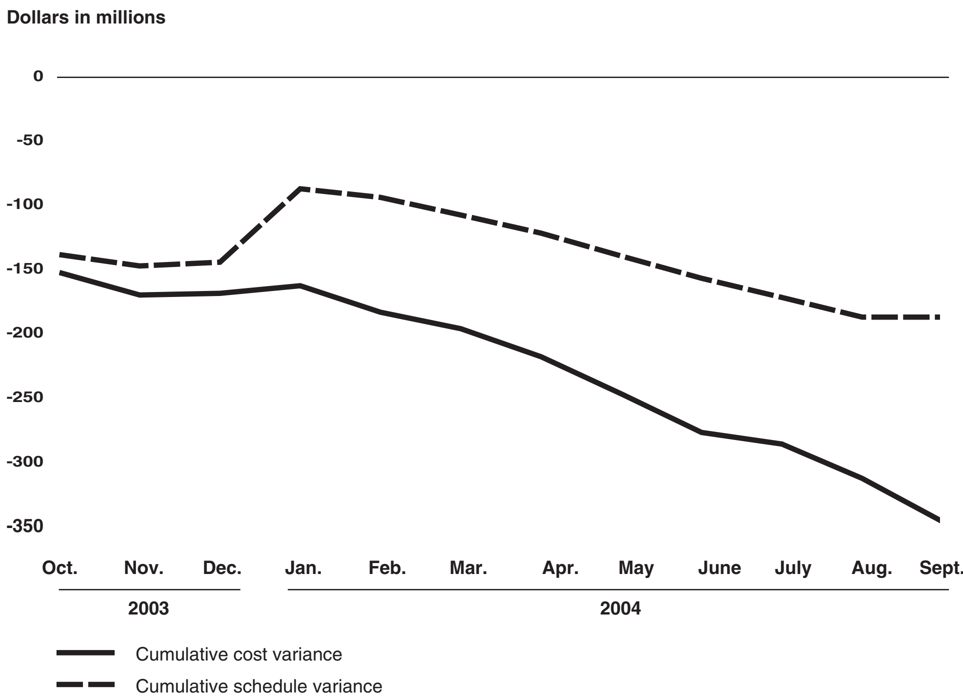
[5] Includes funds expended to develop the National Missile Defense system.

modify the contract again to procure additional interceptors. The added cost of these interceptors is already reflected in the planned GMD budget and MDA cost goals.

The government routinely uses contractor Cost Performance Reports to independently evaluate prime contractor performance relative to cost and schedule. Generally, the reports detail deviations in cost and schedule relative to expectations established under the contract. Contractors refer to deviations as “variances.” Positive variances are usually associated with the accomplishment of activities under cost or ahead of schedule, while negative variances are often associated with the accomplishment of activities over cost or behind schedule.

The GMD program showed an unfavorable trend in contractor performance in fiscal year 2004. According to our analysis, the contractor exceeded its budgeted costs during fiscal year 2004 by $219.6 million, which equates to 11.6 percent of the contract value over the fiscal year. In addition, the contractor fell behind schedule in its work plan. In fiscal year 2004, the contractor was unable to complete $59.9 million of planned work. Figure 8 shows how the contractor’s cumulative cost and schedule performance declined during fiscal year 2004.

Figure 8: GMD Fiscal Year 2004 Cost and Schedule Performance



Sources: Contractor (data); GAO (analysis).

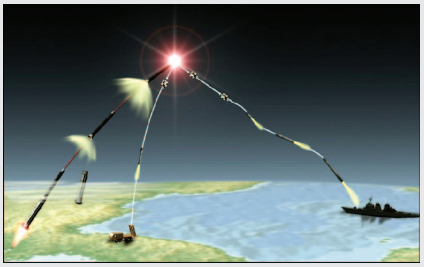
Our analysis shows that developmental issues with the interceptor continue to be the leading contributor to cost overruns and schedule slips. Interceptor-related work cost $204 million more than budgeted in fiscal year 2004, with the kill vehicle accounting for approximately 40 percent of this overrun. Delays in flight tests IFT-13C and IFT-14 also caused unfavorable cost and schedule variances.

Based on the contractor's cost and schedule performance in fiscal year 2004, we estimate that the current GMD contract—which ends in September 2007—will overrun its budget by between $593 million and $950 million. The contractor, in contrast, estimates a $200 million overrun at contract completion. However, as of the end of fiscal year 2004, the contractor had already incurred a negative cumulative cost variance of approximately $348 million. In order for the prime contractor to complete the contract within the established budget, the contractor must not incur any additional cost overruns through contract completion and recoup at least $148 million. The Defense Contract Management Agency believes that the prime contractor is optimistic in projecting that it can limit further cost growth and schedule slips. Indeed, the Defense Contract Management

Agency predicts that the contractor will continue to fall behind and be unable to recover from past cost growth and schedule slips.

Appendix VI Summary

Kinetic Energy Interceptors



Source: Missile Defense Agency

Program Description

The Kinetic Energy Interceptors (KEI) element is a new Missile Defense Agency (MDA) program in its early stage of development. The program is building on existing missile defense technology to develop an interceptor capable of destroying long-range ballistic missiles during the boost phase of flight—the period after launch when rocket motors are thrusting. KEI also provides the opportunity to engage an enemy missile in the early-ascent phase, the period after booster burnout before warheads are released. MDA expects to have available a land-based capability in the 2012-2013 time frame.

DOD's planned investment in the KEI program from program inception in 2003 through 2011 is approximately $6.0 billion. DOD expended $192 million between fiscal years 2003 and 2004, Congress appropriated $267 million for fiscal year 2005, and MDA is budgeting about $5.5 billion for KEI research and development between fiscal years 2006 and 2011.

Fiscal Year 2004 Progress Assessment

KEI program activities completed in fiscal year 2004 include the selection of Northrop Grumman as prime contractor for KEI development, associated planning activities, and experimental work geared toward collecting data of boosting missiles. Of significance, the amount appropriated by Congress for missile defense in fiscal years 2004 and 2005 did not include the amount of funding for KEI that was requested in the President's Budget. As a result, the program delayed its land-based capability from the originally planned Block 2008 time frame to Block 2012.

Schedule: In December 2003, MDA awarded Northrop Grumman a $4.6 billion prime contract to develop and test the KEI element over the next 8 years. The award follows an 8-month concept design effort between competing contractor teams, each of which was awarded $10 million contracts to design concepts for KEI.

Testing: In fiscal year 2004, the KEI program office continued with activities designed to reduce technical risks in developing the KEI interceptor. In particular, the program office is working on an experiment to collect data on boosting missiles, known as the Near Field Infrared Experiment. At this early stage of development, however, no significant testing of the land-based capability has been conducted by the program office.

Performance: Because this element is still in its infancy, data are not yet available to make a performance assessment. However, the program office identified areas of high risk that could have an impact on the element's future performance. All risks are associated with interceptor development—including motor development and plume-to-hardbody handover—stemming from the demands required of the boost phase intercept mission.

Cost: Our analysis of the prime contractor's cost performance report shows that the contractor completed planned work under budget but was slightly behind schedule in performing planned activities. Specifically, during fiscal year 2004, the contractor could not complete about $1.6 million worth of work. The program was unexpectedly tasked to complete trade studies of how to incorporate new requirements being imposed by MDA. Due to plans to restructure the KEI program, the prime contract's long-term baseline is no longer relevant; a reliable baseline will not be available until 2005.

Appendix VI: Kinetic Energy Interceptors

Element Description

The Kinetic Energy Interceptors (KEI) element is a missile defense system designed to destroy ballistic missiles during the boost phase of flight, the period after launch during which the missile's rocket motors are thrusting. KEI is also planned to engage enemy missiles in the early ascent-phase, the period after booster burnout before the missile releases warheads and countermeasures. Unlike the Airborne Laser element, which utilizes directed energy to disable boosting missiles, the KEI element launches interceptors to engage and destroy these threats through hit-to-kill collisions.

The KEI program is currently focused on developing a mobile, land-based system—to be fully demonstrated by the Block 2012 time frame—to protect the United States against long-range ballistic missile attacks.[1] The land-based system will be a deployable unit consisting of a command and control/battle management unit, mobile launchers, and interceptors. The KEI element has no sensor component, such as radars, for detecting and tracking boosting missiles. Instead, it will rely on Ballistic Missile Defense System (BMDS) sensors, such as space-based infrared sensors and forward-deployed radars, for such functions.

Concurrent with KEI development, the program is proceeding with its Near Field Infrared Experiment (NFIRE). The experiment consists of launching an experimental satellite in fiscal year 2006 to collect infrared imagery of boosting intercontinental ballistic missiles (ICBM). The data it collects will support the program's efforts in developing the software that operates the interceptor's kill vehicle, in addition to enhancing plume[2] models and boost-phase simulations.

History

In fiscal year 2003, MDA initiated the KEI program as part of its Boost Defense Segment. To select a contractor and a concept for the element, the KEI program office awarded competitive contracts to teams headed by Northrop Grumman and Lockheed Martin. Each contractor was given the flexibility to design a system that met only one broad requirement—that

[1] In our report, GAO, *Missile Defense: Actions Are Needed to Enhance Testing and Accountability*, GAO-04-409 (Washington, D.C.: Apr. 23, 2004), we stated that the land-based system would be available in the Block 2010 time frame. Because of budget cuts and a restructuring of the program, the land-based KEI capability will not be available until Block 2012.

[2] The plume is the hot exhaust gas emanating from the missile during boost phase.

the KEI element be capable of reliably intercepting missiles in their boost/ascent phases. MDA did not set cost or schedule requirements or specify how the contractors should design the system.

MDA initially requested funds for the KEI element along with other boost-phase defense elements, such as the Airborne Laser, in its Boost Defense Segment. However, in fiscal year 2004, MDA budgeted the KEI program under a new area known as BMDS Interceptors.

Developmental Phases

The KEI element is being developed under MDA's acquisition approach, which delivers system capabilities in 2-year block increments. When the KEI concept was first being pursued in fiscal year 2003—during which Northrop Grumman and Lockheed Martin were competing for the prime contract—the program planned on developing a mobile, land-based system to be available in the Block 2008 time frame and expanding it to sea-based platforms in Block 2010. However, the amount appropriated by Congress for missile defense in fiscal year 2004 did not include the amount of funding for KEI that was requested in the President's Budget. As a result, the program delayed completion of its land-based capability into Block 2010 and delayed the expansion of the sea-based capability into Block 2012.

In fiscal year 2004, the KEI program underwent a second re-plan to compensate for anticipated fiscal year 2005 funding cuts and the addition of new requirements (such as nuclear hardening) imposed by MDA. In the re-plan, the land-based capability was combined with the sea-based capability of Block 2012, both of which utilize the same interceptor.

The KEI program has undergone further restructuring, as reflected in the fiscal year 2006 President's Budget submitted in February 2005. Based on revised funding levels beyond fiscal year 2005, the program deferred the sea-based capability into Block 2014 (2014-2015 time frame), removed the international program, and initiated plans for a Space Test Bed.

The program now expects to develop KEI capabilities as follows:

- **Block 2012—land**. MDA envisions that the first-generation land based interceptors would be launched from trucks that can be driven up close to the border of the threatening nation. An initial land-based capability will be declared after the final flight test, Integrated Test 5 (IT-5), is conducted by the end of 2013.

- **Block 2014—sea**. This block increment expands KEI's land-based capabilities to include the capability to launch KEI interceptors from sea-based platforms, such as Aegis cruisers. The sea-based capability will use the same interceptor as the land-based capability.

- **Blocks 2012/2014—space test bed**. Development of the space test bed is planned to be carried out concurrently with the development of KEI's terrestrial (land and sea) capabilities. Consisting of a limited constellation of space-based interceptors, the test bed is envisioned to provide an additional layer of defense against ICBMs. MDA plans to initiate a concept design phase in fiscal year 2008 and conduct space-based intercept tests in the Block 2012/2014 time frame.

Planned Accomplishments for Fiscal Year 2004

The KEI program planned to accomplish several activities during fiscal year 2004 associated with the land-based capability, with its primary focus being the selection of a prime contractor for KEI's developmental phase. In the first quarter of fiscal year 2004, the program selected Northrop Grumman as its prime contractor and awarded the company a contract valued at $4.6 billion that covers a 98-month performance period.

The program office also planned to complete design, test, and risk reduction efforts in fiscal year 2004. However, budget reductions forced Northrop Grumman to delay several of these planned activities until fiscal year 2005. The program office originally told the contractor to plan for a $90 million budget during fiscal year 2004, but only $47 million was available. Because program funding in fiscal year 2004 was much less than requested, several design and test activities were postponed into fiscal year 2005. For example, the program's System Requirements Review (SRR)—a review during which mission objectives are documented, critical components are identified, and program planning is established—was postponed into fiscal year 2005.

Assessment of Scheduled Activities

While the program completed a number of its planned activities, overall, the KEI program progressed much more slowly than anticipated. As noted above, Northrop Grumman was forced to re-plan several scheduled activities because of reduced funding for the KEI program in fiscal years 2004 and 2005. Progress made toward achieving scheduled activities is summarized in tables 24 through 27.

A key program accomplishment in fiscal year 2004 was the selection of Northrop Grumman as the KEI prime contractor. The KEI program office employed a unique acquisition strategy in the award of the contract by making mission assurance—the successful operation of the element to perform its mission—the basis for the amount of the contractor's profit from the performance of the contract. MDA built incentives into the contract that require the prime contractor to assure mission assurance through a disciplined execution of quality processes. For example, the contractor earns an award fee only if flight tests are successful, and the percentage of the award fee earned is determined by whether the tests are conducted on schedule. The program's intention is to maximize the contractor's incentives to develop a quality product on schedule and at the originally proposed price.

Table 24: Status of KEI Fiscal Year 2004 Planned Accomplishments—Contract Award and Planning

Activity	Description/Progress assessment
Award KEI Block 2010 Development and Test Contract	In December 2003, Northrop Grumman was awarded the prime contract for KEI development. The cost-plus-award-fee contract is valued at $4.6 billion and covers a 98-month performance period (Dec. 2003 to Jan. 2012).
Conduct Integrated Baseline Review (IBR)[a]	The IBR for the Development and Test Contract was completed in March 2004. The review concluded with a decision to re-plan work given the funding constraints and to have the contractor address the cost of adding additional MDA-imposed requirements, such as anti-tampering, nuclear hardening, and insensitive munitions.[b]
Conduct Block 2010 System Requirements Review (SRR)	The SRR is being deferred until April 2005. At that time, program officials will set specific requirements for the KEI element based on detailed design trades, risk reduction tests, and performance assessments at both the element and component level.
Conduct "Continuation Review"	The fiscal year 2004 Continuation Review—a review to assess whether the program should continue—was deferred until the 4th quarter of fiscal year 2005. The program office reasoned that the value offered by such a review would be limited with only eight months of performance toward a 98-month contract.

Sources: MDA (data); GAO (presentation).

[a]An integrated baseline review is the program manager's review of a contractor's performance measurement baseline. The review is conducted by the program manager and the manager's technical staff. It verifies the technical content of the baseline and ensures that contractor personnel understand and have been adequately trained to collect earned value management data. The review also verifies the accuracy of the related budget and schedules, ensures that risks have been properly identified, assesses the contractor's ability to implement earned value management properly, and determines if the work identified by the contractor meets the program's objectives.

[b]An insensitive munition is one that will not detonate under any condition other than its intended mission to destroy a target.

Table 25: Status of KEI Fiscal Year 2004 Planned Accomplishments—Design Activities

Activity	Description/Progress assessment
Develop element simulations and models	The Kinetic Energy Interceptors Simulation was delivered by Northrop Grumman to MDA in July 2004. The simulation will be used to evaluate the end-to-end performance of the KEI element.
Develop interface requirements between KEI and C2BMC	The KEI program completed an initial draft of the KEI-to-C2BMC Interface Control Document in June 2004.
Finalize acquisition plans for sea-based test bed platform	The KEI program is investigating the use of a CG-47 class vessel to be used as a test asset so that a better understanding of the effects of the sea environment on KEI operation is gained. A survey is underway to determine the condition of the vessel and whether the vessel could accommodate a launcher.
Initiate Concept of Operations (CONOPS) development with the warfighter	The KEI program provided a draft CONOPS to the Army community for review in May 2004. Additionally, the program office commissioned the Navy to conduct a CONOPS study to determine the feasibility of integrating and operating KEI from cruisers, destroyers, and/or submarines. The Navy completed this study in August 2004.
Initiate launcher control electronic assembly development	As a result of program re-planning, this activity was deferred into fiscal year 2005.
Design and fabricate Special Test Equipment for interceptor design verification testing	As a result of program re-planning, this activity was deferred into fiscal year 2005.
Establish interceptor manufacturing process laboratory	As a result of program re-planning, this activity was deferred into fiscal year 2005.

Sources: MDA (data); GAO (presentation).

Table 26: Status of KEI Fiscal Year 2004 Planned Accomplishments—Key Test Activities

Activity	Description/Progress assessment
Initiate range planning	Northrop Grumman continues to work on facilities as well as environmental and commercial support agreements with the ranges.
Establish target requirements	The KEI program office initiated a draft Target System Requirements Document in January 2004. Working with Northrop Grumman, KEI will deliver the final version to the MDA Configuration Control Board following the SRR in April 2005.
Establish Developmental Master Test Plan	The delay in the SRR resulted in a delay in Developmental Master Test Plan delivery. Based on the current schedule, the program expects to deliver the test plan in July 2005, 90 days after the SRR.
Static booster motor firing	This activity, which would have been the first firing of booster motors for the interceptor, was deferred into fiscal year 2005.

Sources: MDA (data); GAO (presentation).

Table 27: Status of KEI Fiscal Year 2004 Planned Accomplishments—Risk Reduction Activities

Activity	Description/Progress assessment
Continue collection of boost/ascent phenomenology data	The KEI program received high-resolution data sets from several Target of Opportunity data collections during fiscal year 2004. These series of data collections provide realistic, high-resolution data sets of plumes for a variety of missile launches.
NFIRE activities	MDA directed the program to proceed with the experiment but remove the kill vehicle payload from the experiment's satellite, thereby reducing funding needs for fiscal year 2005.
Liquid Divert and Attitude Control System demonstration activities	As a result of program re-planning, this activity was deferred into fiscal year 2005.

Sources: MDA (data); GAO (presentation).

Assessment of Element Performance

At this early stage of element development, data are not available to evaluate element performance through the use of technical indicators. However, the program office identified areas of high risk[3] that may have an impact on the element's future performance. Table 28 summarizes these risks. All risks are associated with interceptor operation for the boost-phase intercept mission.

Table 28: KEI High-Risk Areas

Technology	Risk/Area of concern
Motor Development	According to program officials, there is significant risk in achieving the required booster thrust and burn time performance to meet element requirements.
Plume-to-hardbody handover[a]	The risk pertaining to plume-to-hardbody handover arises from a lack of phenomenology data. The program initially planned to utilize a 1-color infrared seeker for the kill vehicle, a plan driven by schedule constraints. However, because of program changes resulting in more time for element development, the program is proceeding with a 2-color seeker that enables the kill vehicle to better differentiate between the plume and hardbody.
Thrust Vector Control	The thrust vector control component of the booster is used to steer the interceptor during its boost phase. Program officials rated its development as a high-risk item. The risk stems from the need for highly capable steering of the boosting interceptor under stressing scenarios.
Predicted Impact Point / Divert Trades	This risk pertains to maintaining a balanced design trade to enable the kill vehicle to intercept the missile given targeting uncertainty. The design trade is between (1) predicted impact point accuracy (achieved by the KEI battle manager component) and (2) kill-vehicle divert requirements to compensate for targeting errors.

Sources: MDA (data); GAO (presentation).

[a]Plume-to-hardbody handover refers to the identification of the actual missile from among the plume of hot exhaust gas that obscures the body of the boosting missile.

[3] High risk means that the program will not meet its objectives without priority management actions and risk reduction activities.

In its July 2003 report on the boost-phase intercept mission,[4] the American Physical Society indicated that "time line" is a major challenge for boost phase defense systems. In particular, boost phase defense against ICBMs hinges (in large part) on the length of time an attacking missile is in boost phase and on the speed of the defending interceptor. Accordingly, KEI program officials recognize the time constraints of the boost phase intercept mission and the challenge in developing quicker interceptors—as is evident by the first high-risk item of table 28.

This same report also questions the feasibility of a land-based boost-phase intercept concept, especially against large nations. For example, the report states that a boost-phase intercept system employing terrestrial-based interceptors would generally be ineffective against ICBMs launched from the interiors of large countries—those having dimensions greater than 1,000 kilometers. Nonetheless, the program office contends sufficient coverage is possible given adequate numbers and stationing of KEI units. Furthermore, sea basing, which offers more options for boost phase defense, builds directly upon the investments being made in the land-based capability.

Finally, a scientific study on boost phase defense commissioned by MDA[5] focused on selected issues of high risk. Plume-to-hardbody handover was identified as high risk because of a lack of plume phenomenology data available for determining the appropriate sensor combination for the interceptor. The program office recognizes this challenge, as noted in table 28. As a result, the KEI program is proceeding with a 2-color seeker, better enabling the kill vehicle to differentiate between the plume and hardbody of a missile. In addition, the program is sponsoring NFIRE and participating in targets of opportunity to collect data of boosting missiles.

Assessment of Element Cost

DOD's planned investment in the KEI program from program inception in 2003 through 2011 is approximately $6.0 billion. As broken out in table 29, DOD expended $192 million between fiscal years 2003 and 2004, Congress appropriated $267 million for fiscal year 2005, and MDA is budgeting about

[4] *Report of the American Physical Society Study Group on Boost Phase Defense Intercept Systems for National Missile Defense* (July 2003).

[5] Battleson, Kirk, et al., Phase One Engineering Team, *Parameters Affecting Boost Phase Intercept System* (February 2002).

$5.5 billion for KEI research and development between fiscal years 2006 and 2011.

Table 29: KEI Cost

Dollars in millions of then-year dollars

	Other	Block 2010	Block 2012	Space Test Bed	Total
FY 2003[a]	$91.5	$0	$0	$0	**$91.5**
FY 2004 (Actuals)	0	100.6	0	0	**100.6**
FY 2005 (Appropriated)	0	0	267.4	0	**267.4**
FY 2006	0	0	218.7	0	**218.7**
FY 2007	0	0	420.2	0	**420.2**
FY 2008	0	0	604.6	45.0	**649.6**
FY 2009	0	0	961.1	150.0	**1,111.1**
FY 2010	0	0	1,189.3	248.0	**1,437.3**
FY 2011	0	0	1,453.5	230.0	**1,683.5**
FY 2003 – FY 2011	**$91.5**	**$100.6**	**$5,114.8**	**$673.0**	**$5,978.9**

Source: MDA.

Note: KEI budget as of February 2005.

[a]Program inception (FY 2003).

Table 29 reflects the planned funding profile of the KEI program as presented in the President's Budget for fiscal year 2006, which was submitted in February 2005. When compared with the fiscal year 2005 President's Budget—submitted last year in February 2004—KEI's current funding level is considerably less. Indeed, last year MDA budgeted $7.87 billion for KEI program activities between fiscal years 2004 and 2009. The current budget of $2.77 billion over the same time period represents a 65 percent reduction in program funding.

Prime Contractor Cost and Schedule Performance

The government routinely uses contractor Cost Performance Reports to independently evaluate prime contractor performance relative to cost and schedule. Generally, the reports detail deviations in cost and schedule relative to expectations established under the contract. Contractors refer to deviations as "variances." Positive variances are usually associated with the accomplishment of activities under cost or ahead of schedule, while negative variances are often associated with the accomplishment of activities over cost or behind schedule.

The KEI prime contractor performed work in fiscal year 2004 near its budgeted costs. From contract inception through August 2004 (which covers less than 1 percent of the contract), the contractor completed work slightly under budget but was behind schedule in performing about $1.6 million worth of planned work. Program officials indicated that the negative schedule variance was the result of the contractor delaying activities so that it could conduct trade studies on new requirements imposed by MDA. For example, the contractor has been directed to determine the cost of adding requirements for anti-tampering, nuclear hardening, and insensitive munitions.

Because of plans to restructure the KEI program, the long-term performance measurement baseline[6] is no longer relevant. Near-term work is still being performed according to plan, but the program suspended contractor cost and schedule performance reporting for current work efforts after August 2004. As a result, KEI program officials had reduced insight into its prime contractor's work efforts for a portion of fiscal year 2004. The program office told us that the contractor will resume reporting in 2005 after a reliable baseline that reflects the full extent of the program's restructure is available.

[6] A performance measurement baseline identifies and defines work tasks, designates and assigns organizational responsibilities for each task, schedules the work tasks in accordance with established targets, and allocates budget to the scheduled work.

Appendix VII Summary

Space Tracking and Surveillance System

Source: Missile Defense Agency

Program Description

The Space Tracking and Surveillance System (STSS) is being developed as a constellation of low-orbiting satellites to detect and track enemy missiles throughout all phases of flight. Funded and managed by the Missile Defense Agency (MDA), STSS replaces the Air Force's Space-Based Infrared System-Low (SBIRS-Low) program. The STSS program office is preparing to launch in 2007 two technology demonstration satellites that were partially built under the SBIRS-Low program. MDA intends to assess how well these satellites perform missile defense surveillance and tracking functions and use this information to establish capabilities and goals for next-generation STSS satellites.

DOD's planned investment in the STSS program from program inception in 2002 through 2011 is approximately $4.5 billion. DOD expended $819 million between fiscal years 2002 and 2004, Congress appropriated $305 million for fiscal year 2005, and MDA is budgeting about $3.35 billion for element development between fiscal years 2006 and 2011.

MDA's planned budget for the next 6 years through 2011 funds activities associated with the assembly and launch of the two demonstrator satellites (Block 2006), ground segment upgrades (Block 2008), and the development of an operational constellation of satellites (Block 2012).

Fiscal Year 2004 Progress Assessment

The STSS program office accomplished all but one of the principal Block 2006 activities planned for completion in fiscal year 2004 and initiated work planned for completion in fiscal year 2005. Although the prime contractor is working to an accelerated delivery schedule, quality and systems-engineering problems with a subcontractor are jeopardizing the early delivery of a satellite's payload.

Schedule: Program activities completed in fiscal year 2004 include the complex tasks of systems integration, testing, and software development. The program office completed a critical design review on time. Hardware modifications to the satellites were completed, but a heat problem resulting from the redesign of the electrical power subsystem caused a delay of three months. Software development activities were also completed, and reviews to ensure that the design for the STSS ground system could accommodate a larger constellation of satellites were conducted.

Testing: Functional tests on components of the second technology demonstration satellite were completed several months late because of minor problems with the spacecraft's computer processor and other components. Planned integration tests on the track sensor were not completed, and integration testing of an interim version of the software that controls the sensors onboard the satellites took longer than planned. Although final acceptance testing for the ground software is expected to be completed 2 months late, all software development tasks are scheduled to be completed two years before satellite launch.

Performance: Data provided by MDA indicate that two STSS performance indicators do not meet their respective requirements—one pertaining to the acquisition sensor and a second pertaining to the tracking sensor. Program officials stated that degradation in performance is within acceptable limits. The program considers the demonstration of STSS functionality more critical than verifying the effectiveness of the demonstrator satellites.

Cost: Our analysis of prime contractor Cost Performance Reports shows that the contractor completed work in fiscal year 2004 over budget by about $34.6 million. In addition, the contractor could not complete $20.7 million of scheduled work (relative to a 6-month accelerated schedule). Quality and systems-engineering problems with a subcontractor contributed to the overruns in cost and schedule.

Appendix VII: Space Tracking and Surveillance System

Element Description

The Space Tracking and Surveillance System (STSS) is being developed as a space-based sensor for the Ballistic Missile Defense System (BMDS). As envisioned by the Missile Defense Agency (MDA), the full STSS element will be comprised of a constellation of low-orbiting satellites[1] designed to detect and track enemy missiles throughout all phases of flight. Each satellite making up the program's "space segment" includes a space vehicle and a payload of two infrared sensors—the acquisition sensor to watch for the bright plumes (hot exhaust gas) of boosting missiles, and the tracking sensor to follow the missile through midcourse and reentry. The STSS element also has supporting ground infrastructure, known as the "ground segment," which includes a ground station and mission software to support the processing and communication of data from the satellites to the BMDS.

MDA is currently working on the first increment of STSS, known as Block 2006, which is focused on the preparation and launch of two technology demonstration satellites[2] partially built under the Space Based Infrared System Low (SBIRS-Low) program. MDA plans to launch these satellites in 2007, in tandem, in an effort to assess how well they perform surveillance and tracking functions. Using data collected by the satellites, MDA will determine what capabilities are needed and what goals should be set for the next generation of STSS satellites. Any real operational capability, however, would not be realized until the next decade.

History

Initiated in 1996, SBIRS-Low was the latest in a series of Department of Defense (DOD) satellite programs attempting to deliver an operational capability for detecting and tracking missiles from low-earth orbits. The program experienced cost and schedule growth and performance shortfalls. In response, DOD cancelled the accompanying demonstration program in 1999 and put the partially constructed satellite equipment into storage.

In October 2000, Congress directed the Air Force to transfer the SBIRS-Low program to the Ballistic Missile Defense Organization (MDA's predecessor). When MDA inherited SBIRS-Low, the agency decided to

[1] The satellites are expected to orbit the earth at an altitude much less than satellites in geo-synchronous orbit.

[2] The two technology demonstration satellites were part of the Flight Demonstration System.

make use of the equipment that was partially built under the SBIRS-Low technology demonstrator program. By completing the assembly of the two satellites and launching them in 2007, MDA intends to use the satellites in missile defense flight tests. At the end of 2002, the SBIRS-Low program was renamed STSS.

Developmental Phases

STSS's development is proceeding in a series of 2-year blocks, namely, Blocks 2006, 2008, and beyond. As noted above, Block 2006 involves the assembly, integration, testing, and launch of two research and development satellites in 2007. The first satellite is expected to be ready in September 2005 and the second in early fiscal year 2007. Block 2008 is primarily an upgrade of the Block 2006 ground stations, which are used to collect and analyze data from the two satellites. As technology matures and as lessons are learned from the first satellites, more capable satellites will be designed and launched in subsequent blocks.[3]

Planned Accomplishments for Fiscal Year 2004

The STSS program office intended to accomplish several activities during fiscal year 2004 related to the preparation of the two demonstration satellites for launch in 2007. Specifically, the program office planned to complete the following space- and ground-segment activities:

- **Space Segment**. The program planned to complete a design review to ensure the STSS design can support the BMDS mission; complete the reactivation of hardware components for the second satellite; modify two satellite hardware components to enhance spacecraft performance; continue to develop the payload software; and start the assembly, integration, and testing of satellite components.

- **Ground Segment**. The program planned to complete activities to ensure that the STSS element has a mature ground system design and to continue with the development of software for the ground segment of the program.

Assessment of Scheduled Activities

The STSS program office completed all but one of the principal Block 2006 activities planned for fiscal year 2004, including the complex tasks of systems integration, testing, and software development. Moreover, the

[3] Program content of Block 2010 and beyond is classified.

program office initiated work planned for completion in fiscal year 2005. The contractor has been performing to an accelerated delivery schedule, that is, attempting to complete all contracted activities six months earlier than required by the contract. However, according to the program office, quality and systems-engineering problems at the payload subcontractor are jeopardizing the early delivery. Progress made toward achieving the space- and ground-segment activities is summarized in tables 30 and 31, respectively.

Table 30: Status of STSS Fiscal Year 2004 Planned Accomplishments—Space Segment

Activity	Actual/Planned completion date	Comments
Critical Design Review	Nov. 2003 (Completed on schedule)	The STSS program office conducted a critical design review in the first quarter of fiscal year 2004. Sixteen issues were identified during the review, and all were satisfied and closed out in March 2004. According to the program office, the review was on time and the outcome was successful.
Reactivation of Satellite #2 Hardware	Oct. 2003 (Completed 5 months late)	The second satellite has been completely reactivated, which involved the contractor taking 58 hardware components out of storage and running tests on them to determine if they still worked. All but one of the components passed the appropriate functional tests. Functional tests for the final component—the spacecraft computer processor—are being deferred until the next higher-level of hardware integration. During the reactivation of this hardware, the contractor experienced minor problems with some components. Though these issues have since been resolved, they contributed to the five-month delay in the reactivation schedule. Overall, however, the components survived storage rather well, according to program officials.
Hardware Modifications • Electrical Power Subsystem • Sun Shield	 • Sept. 2003 (Completed 3 months late) • Sept. 2004 (Completed on schedule)	Performance modifications to the Sun Shield were completed as planned, but modifications to the Electrical Power Subsystem were completed three months later than expected. Although the upgrades to the power system are to result in a 200 percent improvement in on-orbit operation, the redesign was more complex than originally planned and resulted in the problem of removing excess heat produced by the power system. To resolve the heat problem, the contractor had to use $2-3 million from its management reserve to add air ducts to the spacecraft.
Payload Software • Build 2 • Closed Loop Testing of Sensor Payload Software	 • July 2004 (Completed 1 month late) • May 2005 (Ongoing)	Software builds for the space and ground segments are proceeding as planned. The program office characterized software development as being the “gem” of the program. Version 2 of the software that controls the sensors onboard the satellite was completed in mid-August 2004. Although the software team encountered problems while integrating and testing this version, the problems were resolved in time to limit the delay to one month in building the software. At the end of fiscal year 2004, the contractor had completed about half of Version 3 software for the payload data processor. A partial build of this version is undergoing integration testing and is scheduled for completion in May 2005. According to the program office, the software is on schedule to be completed two years before the satellites are launched.

Activity	Actual/Planned completion date	Comments
Assembly, Integration, and Testing (AI&T) • Track Sensor • Spacecraft #1 • Payload #1	 • Aug. 2004 (Ongoing) • July 2004 (Completed 1 month late) • Jan. 2005 (Ongoing)	The STSS program scheduled several assembly, integration, and testing activities for completion in fiscal years 2004 and 2005, which were (or expected to be) completed behind schedule. First, the program office had planned to assemble, integrate, and test the track sensor for the first satellite by the end of August 2004. Second, the program office had planned to integrate and test the spacecraft for the first payload by the end of July 2004, but did not complete the task until mid-August 2004. The objective of the tests was to demonstrate the electrical integration of the spacecraft. Third, the program office planned to start integrating and testing the payload for the first STSS space vehicle. The testing of the payload components was expected to be completed by January 2005. However, the program office reported that the schedule will be tight and will likely slip by a couple of months primarily because of quality and systems engineering problems at the payload subcontractor.

Sources: MDA (data); GAO (presentation).

Table 31: Status of STSS Fiscal Year 2004 Planned Accomplishments—Ground Segment

Activity	Actual/Planned completion date	Comments
Mature Ground System Design	Oct. 2003 (Completed 1 month late)	Reviews were conducted to ensure that the STSS program has a mature ground system design. Because of issues related to paperwork, the reviews were completed about a month later than planned. The contractor presented a detailed design for the STSS ground system at the November 2003 critical design review, and according to the program office, the proposed design is robust enough to accommodate a larger STSS constellation in the future.
Develop Ground Software	Dec. 2005	The STSS ground software development was completed in December 2005. The contractor is following a “build a little” and “test a little” approach in order to catch defects early in the process before they are costly to fix, according to program officials.

Sources: MDA (data); GAO (presentation).

Assessment of Element Performance

The Block 2006 STSS satellites will be used as technology demonstrators (rather than for operational missions) and have an in-orbit life of 18-24 months. To keep costs within budget, the program considers the demonstration of STSS functionality more critical than the demonstration of STSS effectiveness in performing the functions. MDA decided to fly these demonstration satellites before developing and producing them in larger numbers to see how components and subsystems work together as a system in a realistic environment before a greater investment of resources is made, thereby reducing program risk. As noted above, each satellite contains two infrared sensors—an acquisition sensor to detect a missile launch and a tracking sensor to track the missile through space once it has been detected. The tracking sensor would continue tracking the missile after the acquisition sensor has completed its detection function. The ability of one satellite to detect or “acquire” a missile launch and to transmit this data to its internal tracking sensor has not yet been demonstrated in space, although DOD has had successes in demonstrating some related on-orbit capabilities through experimental satellites.

Even with a focus on system functionality over effectiveness, the prime contractor continues to track 12 system level technical parameters that are critical to the performance of the sensors onboard the Block 2006 satellites. Data provided to us by MDA indicate that 2 of the 12 indicators do not meet their respective requirements. The details on these issues, including the impact on STSS performance, are classified. However, shortfalls in performance involve both sensors. The ability of the acquisition sensors to properly detect a missile launch is falling below performance margins and the accuracy of the tracking sensor is getting close to the margin. Program officials stated that the degradation in acquisition sensor performance is within allowable limits and steps are being taken to improve tracking sensor performance.

Assessment of Element Cost

DOD’s planned investment in the STSS program from program inception in 2002 through 2011 is approximately $4.5 billion.[4] As broken out in table 32, DOD expended $819 million between fiscal years 2002 and 2004, Congress appropriated $302 million for fiscal year 2005, and MDA is budgeting about $3.35 billion between fiscal years 2006 and 2011 for element development. MDA’s planned budget for the next 6 years through 2011 funds activities associated with the assembly and launch of the two demonstrator satellites (Block 2006), ground segment upgrades (Block 2008), and the development of an operational constellation of satellites (Block 2012).

[4] Prior to 2002, the SBIRS-Low program invested $686 million to develop the demonstration satellites that are now part of the STSS program.

Table 32: STSS Cost

Dollars in millions of then-year dollars

	Other	Block 2006	Block 2008	Block 2010	Block 2012	Total
FY 2002[a] – FY 2003	$544	$0	$0	$0	$0	**$544**
FY 2004 (Actuals)	0	263	0	12	0	**275**
FY 2005 (Appropriated)	0	254	0	48	0	**302**
FY 2006	0	231	0	0	1	**232**
FY 2007	0	208	45	0	167	**420**
FY 2008	0	65	29	0	440	**534**
FY 2009	0	11	24	0	579	**614**
FY 2010	0	8	14	0	737	**759**
FY 2011	0	7	14	0	773	**794**
FY 2002 – FY 2011	**$544**	**$1,046**	**$127**	**$60**	**$2,697**	**$4,474**

Source: MDA.

Note: STSS budget as of February 2005. Numbers may not add due to rounding.

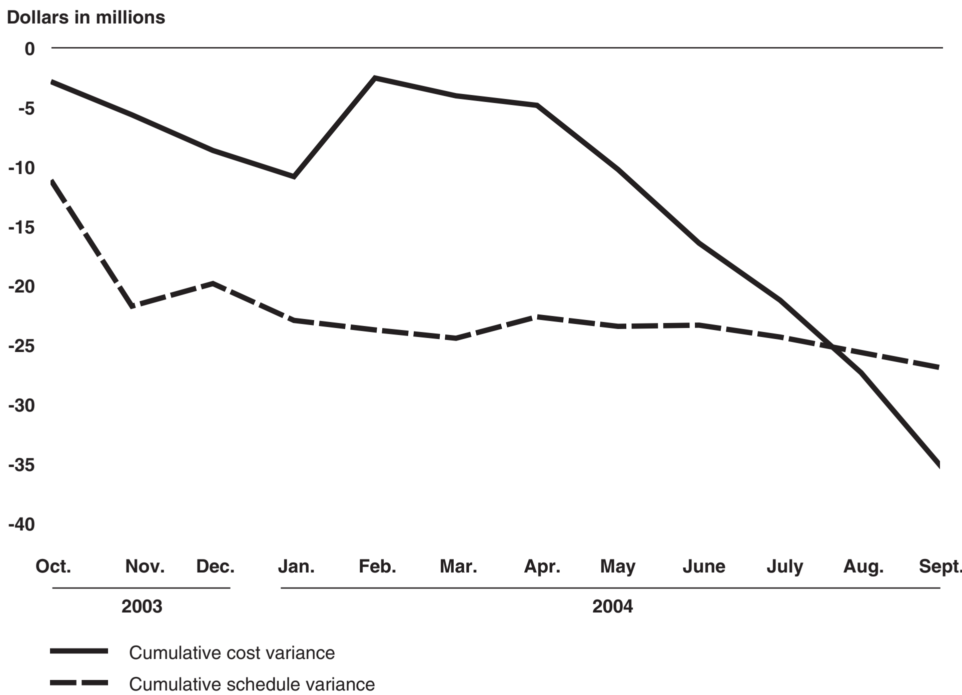
[a]Program inception (FY 2002).

Prime Contractor Cost and Schedule Performance

The government routinely uses contractor Cost Performance Reports to independently evaluate prime contractor performance relative to cost and schedule. Generally, the reports detail deviations in cost and schedule relative to expectations established under the contract. Contractors refer to deviations as “variances.” Positive variances are usually associated with the accomplishment of activities under cost or ahead of schedule, while negative variances are often associated with the accomplishment of activities over cost or behind schedule.

Figure 9 shows the STSS contractor’s cost and schedule performance during fiscal year 2004. According to Cost Performance Reports, the work completed during this time cost more than budgeted and was behind schedule relative to a 6-month accelerated schedule. Specifically, during fiscal year 2004, the work cost about $34.6 million more than expected, and the contractor could not complete approximately $20.7 million of scheduled work.

Figure 9: STSS Fiscal Year 2004 Cost and Schedule Performance



Sources: Contractor (data); GAO (analysis).

The erosion of cumulative cost variance throughout fiscal year 2004 was largely attributed to cost overruns by the payload subcontractor, whose costs comprise about one-third of the total STSS contract. During the past year, the subcontractor has had a number of quality and systems-engineering problems that contributed to overruns in cost and schedule. These problems are largely the result of unclear systems engineering procedures and the subcontractor's lack of experience with space hardware. In response to these problems, the prime contractor conducted a thorough review of the subcontractor's quality assurance program for the assembly, integration, and testing of satellite components. In addition, the subcontractor added technicians who have more experience working with space hardware and brought in systems engineers to work with the technicians. Despite these issues, the program office still expects the prime contractor to complete the contract early and with minimal cost overruns.

The cumulative schedule variance also eroded during fiscal year 2004. The delay in the delivery of the payload is the major driver of the unfavorable schedule variance. In addition to these drivers, performance upgrades to the Electrical Power Subsystem were completed three months later than planned due to a heat-removal problem. A factor complicating our analysis of schedule variance is that the contractor implemented a performance measurement baseline[5] that reflects a six-month accelerated schedule. This means the contractor might be performing work on a schedule that would allow it to complete all the work by the end of the contract, but schedule performance data would show that work was falling behind schedule.

Our assessment of fiscal year 2004 activities did not identify any evidence that the STSS program would be unable to launch the two demonstration satellites in 2007. Although the payload subcontractor experienced schedule delays and cost overruns arising from quality issues, the program office is still confident that the satellites will be delivered early. In addition, the reactivation of components from storage went better than anticipated and, accordingly, the program office reduced the risk level associated with hardware and software furnished by the government. Furthermore, the prime contractor is making progress on the parts obsolescence issue. For example, the prime contractor located most replacement parts and is assembling a database to track them.

[5] A performance measurement baseline identifies and defines work tasks, designates and assigns organizational responsibilities for each task, schedules the work tasks in accordance with established targets, and allocates budget to the scheduled work.

Appendix VIII Summary

Terminal High Altitude Area Defense

Source: Missile Defense Agency

Program Description

The Terminal High Altitude Area Defense (THAAD) element is a ground-based missile defense system designed to protect deployed military forces and civilian population centers from short- and medium-range ballistic missile attacks. THAAD engages ballistic missiles during the late-midcourse and terminal phases of flight, that is, before or after the warhead reenters the atmosphere. The THAAD program expects to field an initial capability consisting of 24 interceptors during the 2009 time frame.

DOD's planned investment in the THAAD program from program inception in 1992 through 2011 is approximately $12.3 billion. DOD expended $7.2 billion between fiscal years 1992 and 2004, Congress appropriated $760 million for fiscal year 2005, and MDA is budgeting about $4.3 billion for THAAD development and procurement between fiscal years 2006 and 2011.

Fiscal Year 2004 Progress Assessment

The bulk of fiscal year 2004 activities focused on developing and ground-testing THAAD components in preparation for the first round of flight tests in mid-fiscal year 2005. At the end of fiscal year 2004 with 61 percent of the THAAD prime contract completed, THAAD's prime contractor was under budget and ahead of schedule. However, the contractor's favorable cost and schedule performance eroded somewhat during fiscal year 2004. Our analysis indicates that problems with missile development were a major driver of the deteriorating performance.

Schedule: During fiscal year 2004, the THAAD program accomplished key activities ahead, on, or slightly behind schedule. The program conducted the missile-component design readiness review ahead of schedule, completed radar assembly on schedule, but was behind schedule on missile delivery for the element's first flight test, Flight Test 1. In addition, the program successfully conducted ground tests in preparation for the initial flight test.

Testing: Two explosions in the summer of 2003 at a subcontractor's propellant mixing facility impacted THAAD's fiscal year 2004 funding, delayed the start of flight testing, and led to a revision of the flight test program.

Performance: The program office told us that key indicators show that THAAD is on track to meet operational performance goals. However, an assessment of THAAD's effectiveness remains uncertain until the program conducts flight tests with updated hardware and software. Data from flight testing are needed to "anchor" simulations of THAAD's performance and to more confidently predict the element's effectiveness.

Cost: Our analysis of prime contractor cost performance reports shows that the contractor's favorable cost and schedule performance eroded somewhat during fiscal year 2004. The declining schedule performance was largely driven by unfavorable performance in the missile component—caused by two separate explosions at a subcontractor's propellant mixing facility—but offset by other THAAD components with favorable performance. Overall, the prime contractor is under budget and ahead of schedule.

Appendix VIII: Terminal High Altitude Area Defense

Element Description

The Terminal High Altitude Area Defense (THAAD) element[1] is being developed as a ground-based missile defense system to protect forward-deployed military forces, population centers, and civilian assets from short- and medium-range ballistic missile attacks. THAAD provides the opportunity to engage ballistic missiles—outside or inside the earth's atmosphere—not destroyed earlier in the boost or midcourse phases of flight by other elements of the Ballistic Missile Defense System (BMDS).

A THAAD unit consists of a command, control, battle management, and communications (C2/BMC) component for controlling and executing a defensive mission, truck-mounted launchers, ground-based radar, interceptor missiles, and ground support equipment. The ground-based radar is a solid-state, phased-array, X-band radar that performs search, track, discrimination, and other fire-control functions. The THAAD missile is comprised of a kill vehicle mounted atop a single-stage booster and is designed to destroy enemy warheads through hit-to-kill collisions.

History

The THAAD program entered the Program Definition and Risk Reduction phase of acquisition in 1992 but was plagued by missed intercepts in its first six attempts. As noted in our 1999 report,[2] THAAD's failures were caused by a combination of a compressed test schedule and quality control problems. The Director, Operational Test and Evaluation (DOT&E), reported in his Fiscal Year 1999 Annual Report to the Congress that the sense of urgency to deploy a prototype system resulted in an overly optimistic development schedule.

The THAAD program conducted two successful intercept attempts in 1999 after devoting substantial time to pretest activities. The program then transitioned to the product development phase[3] of acquisition, in which program activities shifted from technology development and demonstration to missile redesign and engineering. The Department of

[1] In early 2004, MDA changed the name of the THAAD element from "Theater High Altitude Area Defense" to "Terminal High Altitude Area Defense."

[2] GAO, *THAAD Restructure Addresses Problems but Limits Early Capability*, GAO/NSIAD-99-142 (Washington, D.C.: June 30, 1999).

[3] "Product development" is referred to by DOD as the "System Development and Demonstration" phase of acquisition and formerly as "Engineering and Manufacturing Development."

Defense (DOD) transferred the THAAD program from the U.S. Army to the Ballistic Missile Defense Organization (now MDA) on October 1, 2001.

Developmental Phases

The THAAD program is pursuing its goals within the MDA block approach, which incrementally increases the element's capability against the ballistic missile threat. We reported[4] last year that THAAD's development was structured around a Block 2004-2006-2008 program, with program funding aligned accordingly. However, with the submission of the fiscal year 2006 President's Budget in February 2005, MDA implemented a new BMDS baseline approach for the THAAD program. Under this new program, THAAD development is structured around a Block 2006-2008-2010 program, with funding broken out by Block 2006/2008 and Block 2010.

- **Block 2006**. Block 2006 incorporates the activities of the former Block 2004 program. The Block 2006 THAAD program is expected to demonstrate an engagement capability against short- and medium-range ballistic missiles above the atmosphere.

- **Block 2008**. By the end of Block 2008, the THAAD element will have completed additional flight tests (including attempts employing a salvo-firing doctrine), demonstrated an engagement capability inside and above the atmosphere, and be configured to accept data from other BMDS sensors for launching its interceptor missiles. THAAD's integration with the BMDS is expected to increase its defended area by more than a factor of three.

  The THAAD program includes a "fire unit" for delivery in fiscal year 2009. Operated by the Army, it will consist of a radar, a C2/BMC unit, 3 launchers, 24 missiles, and equipment for support, maintenance and training. The Army has "signed on" to receive the equipment and is planning to allocate nearly 100 soldiers for training and operations.

- **Block 2010**. The THAAD program plans to enhance the element's ability to interoperate with other elements and sensors of the BMDS. By engaging threats with external BMDS data, THAAD is expected to increase its defended area by more than a factor of ten.

[4] GAO, *Missile Defense: Actions Are Needed to Enhance Testing and Accountability*, GAO-04-409 (Washington, D.C.: Apr. 23, 2004).

Planned Accomplishments for Fiscal Year 2004

The bulk of the fiscal year 2004 activities focused on developing and ground-testing THAAD components in preparation for the first round of flight tests in mid-fiscal year 2005. We grouped activities into three categories: (1) design, (2) build, and (3) integration and test. Progress on key activities scheduled for fiscal year 2004 is discussed below.

Assessment of Scheduled Activities

During fiscal year 2004, the THAAD program accomplished key activities ahead, on, or slightly behind schedule. As examples, the program conducted the missile-component design readiness review ahead of schedule, completed radar assembly on schedule, but delivery of the missile for Flight Test 1 slipped into fiscal year 2005. Specifics regarding progress in achieving these and other key scheduled activities are summarized below in tables 33 through 35.

Table 33: Status of THAAD Fiscal Year 2004 Planned Accomplishments—Design Activities

Activity	Description/Progress assessment
Missile-component design readiness review Planned: 1Q FY2004[a] Completed: 4Q FY2003	This event was accomplished ahead of schedule. The missile component design readiness review demonstrated that the missile-component design, including internal and external interfaces, met all applicable design requirements with acceptable risk.
THAAD element design readiness review Planned: 1Q FY2004 Completed: 1Q FY2004	This event was accomplished on schedule. The stakeholders agreed during the design readiness review that they understood the THAAD system and its final integrated design, and that the design met BMDS objectives. Stakeholders included the THAAD Project Office, supporting contractors, representatives of the Army Air Defense School, and MDA.
Radar block process validation Planned: 2Q FY2004 Completed: 2Q FY2004	This event was accomplished on schedule. The radar block process validation examined the contractor's operations to determine adequacy of production planning, processes, and controls; the existence of suitable production facilities; and the radar's design stability.
C2/BMC block process validation Planned: 4Q FY2004 Completed: Under revision	The C2/BMC block process validation was delayed to address defective government-furnished C2/BMC shelters and was somewhat behind schedule at the end of fiscal year 2004. Significant progress was made toward its completion, but the remaining work is planned to carry over into fiscal year 2005. The purpose of the validation is to assess the contractor's ability to manufacture C2/BMC production representative hardware to support future fielding decisions.

Sources: MDA (data); GAO (presentation).

[a]We use the notation "1Q FY2004" to mean the first quarter of fiscal year 2004 and an identical format for other time periods.

Table 34: Status of THAAD Fiscal Year 2004 Planned Accomplishments—Build Activities

Activity	Description/Progress assessment
Radar assembly Planned: 1Q FY2004 Completed: 1Q FY2004	This event was accomplished on schedule. The radar was assembled in the first quarter of fiscal year 2004.
Missile delivery for Flight Test 1 (FT-01) Planned: 4Q FY2004 Scheduled: 2Q FY2005	Delivery of the FT-01 missile to White Sands Missile Range (WSMR)[a] was delayed to respond to a new program schedule that addresses funding shortfalls and two separate explosions at a subcontractor's propellant mixing facility. Delivery is now scheduled for the second quarter of fiscal year 2005.
WSMR activation Planned: 2Q FY2004 Completed: 2Q FY2004	This event was accomplished on schedule. All THAAD facilities at WSMR were activated by March 2004 and are preparing for FT-01.
WSMR safety qualification tests Planned: 3Q FY2004 Completed: 4Q FY2004	Although this event was completed 1 quarter behind schedule, there was no impact on FT-01's schedule.

Sources: MDA (data); GAO (presentation).

[a]WSMR is a U.S. Army missile test range in New Mexico. Because of test range limitations at WSMR, flight testing will be conducted at the Pacific Missile Range Facility, a U.S. Navy missile test range in Kauai, Hawaii, beginning with FTT-06-1 (formerly FT-05) in the fourth quarter of fiscal year 2006.

Table 35: Status of THAAD Fiscal Year 2004 Planned Accomplishments—Integration and Test Activities

Activity	Description/Progress assessment
Kill vehicle destruct test Planned: 1Q FY 2004 Completed: 1Q FY2004	This event was accomplished on schedule. Testing of the kill vehicle flight termination system met objectives.
Integrate launch and test support equipment at SIL[a] Planned: 2Q FY2004 Completed: 3Q FY2004	Because of two separate explosions at a subcontractor's propellant mixing facility in the summer of 2003, this event was accomplished about one quarter behind schedule. The launch and test support equipment completed its system checkout in June 2004. The THAAD program reports that the launch and test support equipment is on schedule to support the revised schedule of FT-01 planned for the third quarter of fiscal year 2005.

Activity	Description/Progress assessment
Kill vehicle qualification tests Planned: 4Q FY2004 Completed: 4Q FY2004	Kill vehicle qualification testing in preparation for FT-01 was completed in September 2004.

Sources: MDA (data); GAO (presentation).

[a]The System Integration Lab (SIL) refers to ground facilities at Lockheed Martin Space Systems Company, Sunnyvale, California.

THAAD Flight Test Program Delayed 3-5 Months

The THAAD flight-test program consists of 15 flight-test events divided among Blocks 2006 and 2008. Two explosions in the summer of 2003 at a subcontractor's propellant mixing facility impacted THAAD's fiscal year 2004 funding, delayed the start of flight testing, and led to revisions of the flight test plans.

The first set of flight tests have been delayed 3-5 months. The first flight test, referred to as a control test flight (CTF), is a missile-only, non-intercept test that focuses on how the missile operates under high endoatmospheric environmental conditions. The second flight test is an integrated system test with a "virtual target" to demonstrate system performance under conditions comparable to the next flight test (first flight test utilizing a real target). The third flight test is a seeker characterization flight (SCF), which ensures proper functioning of the seeker. This SCF is also a non-intercept test, but the seeker will demonstrate the ability to view a real target. The fourth flight test, FT-04, is the first intercept attempt with a configuration—target and engagement geometry—comparable to that used in flight tests conducted during the Program Definition and Risk Reduction phase of development. Table 36 summarizes the first six flight test events, including current and prior flight test dates with their objectives.

Compared to test plans of fiscal year 2004, the THAAD program deferred two test events. A second control test flight conducted at WSMR—formerly FT-02—and an intercept attempt against a threat-representative target at the Pacific Missile Range Facility (PMRF)—formerly FT-05—have been deferred to a later time.

Table 36: Planned THAAD Flight Testing

Flight test event	Date	Objectives
FT-01 (CTF) at WSMR Non-intercept flight test (missile only / no target)	Current: 3Q FY2005 Previously: 1Q FY2005	• Validate missile performance in a high-endoatmospheric flight environment • Verify missile integration with WSMR
FT-02 at WSMR Integrated system test – virtual target (New test)	Current: 4Q FY2005 Previously: N/A	• Integrated system test dry run (virtual target) • Demonstrate missile launch and control for conditions comparable to FT-03
FT-03 (SCF) at WSMR Non-intercept flight test	Current: 1Q FY2006 Previously: 3Q FY2005	• Characterize seeker in flight against a high-endoatmospheric unitary target • Verify element integration with WSMR
FT-04 at WSMR First intercept flight test	Current: 2Q FY2006 Previously: 4Q FY2005	• Demonstrate exoatmospheric discrimination and intercept of a separating target • Demonstrate lethality assessment of recovered debris
FT-05 (CTF) at WSMR Non-intercept flight test (Formerly FT-02)	Current: 2Q FY2006 Previously: 2Q FY2005	• Characterize missile performance in a low-endoatmospheric flight environment • Assesses effects of heat on seeker window • Tests performance in a high dynamic pressure fly-out
FTT-06-1 at PMRF Second intercept flight test (Formerly FT-05)	Current: 4Q FY2006 Previously: 1Q FY2006	• Demonstrate exoatmospheric aimpoint selection and intercept against a non-separating liquid-fueled target • Demonstrate integration with PMRF

Sources: MDA (data); GAO (presentation).

Note: Test schedule as of December 2004.

Assessment of Element Performance

Any assessment of THAAD's effectiveness is uncertain at this time. The program office told us that key indicators show that THAAD is on track to meet operational performance goals. However, the THAAD program has not conducted any recent flight tests and, as a result, performance indicators[5] used to gauge progress toward meeting performance objectives are based only on engineering analysis and ground testing. Until data collected during flight tests are used to “anchor” simulations of THAAD operation, the program cannot be confident that current indicators accurately predict THAAD’s performance in actual combat conditions.

Assessment of Element Cost

DOD’s planned investment in the THAAD program from program inception in 1992 through 2011 is approximately $12.3 billion. As broken out in table 37, DOD expended $7.2 billion between fiscal years 1992 and 2004, Congress appropriated $760 million for fiscal year 2005, and MDA is budgeting about $4.3 billion for THAAD development and procurement between fiscal years 2006 and 2011.

Table 37: THAAD Cost

Dollars in millions of then-year dollars

	Other	Block 2006/2008	Block 2010	Total
FY 1992[a] – FY 2003	$6,500	$0	$0	**$6,500**
FY 2004 (Actuals)	0	717.9	0	**717.9**
FY 2005 (Appropriated)	0	759.7	0	**759.7**
FY 2006	0	1,046.1	0	**1,046.1**
FY 2007	0	931.0	0	**931.0**
FY 2008	0	779.4	0	**779.4**
FY 2009	0	353.0	168.0	**521.0**
FY 2010	0	0	635.1	**635.1**
FY 2011	0	0	395.0	**395.0**
FY 1992 – FY 2011	**$6,500**	**$4,587.1**	**$1,198.1**	**$12,285.2**

Source: MDA.

Note: THAAD budget as of February 2005. MDA implemented a new BMDS baseline approach that redirected funding from Block 2004 and 2006 to Block 2006/2008.

[a]Program inception (FY 1992).

[5] The THAAD program monitors numerous performance indicators as part of its management process. For example, element effectiveness, as measured by the probability of a successful kill, is one such indicator.

Prime Contractor Fiscal Year 2004 Cost and Schedule Performance

The government routinely uses contractor Cost Performance Reports to independently evaluate the prime contractor's performance relative to cost and schedule. Generally, the reports detail deviations in cost and schedule relative to expectations established under the contract. Contractors refer to deviations as "variances." Positive variances are usually associated with the accomplishment of activities under cost or ahead of schedule, while negative variances are often associated with the accomplishment of activities over cost or behind schedule. At the end of fiscal year 2004, the THAAD prime contractor was carrying a positive cumulative cost and schedule variance of $3.9 million and $14.7, respectively.[6] That is, overall, the prime contractor was under budget and ahead of schedule.

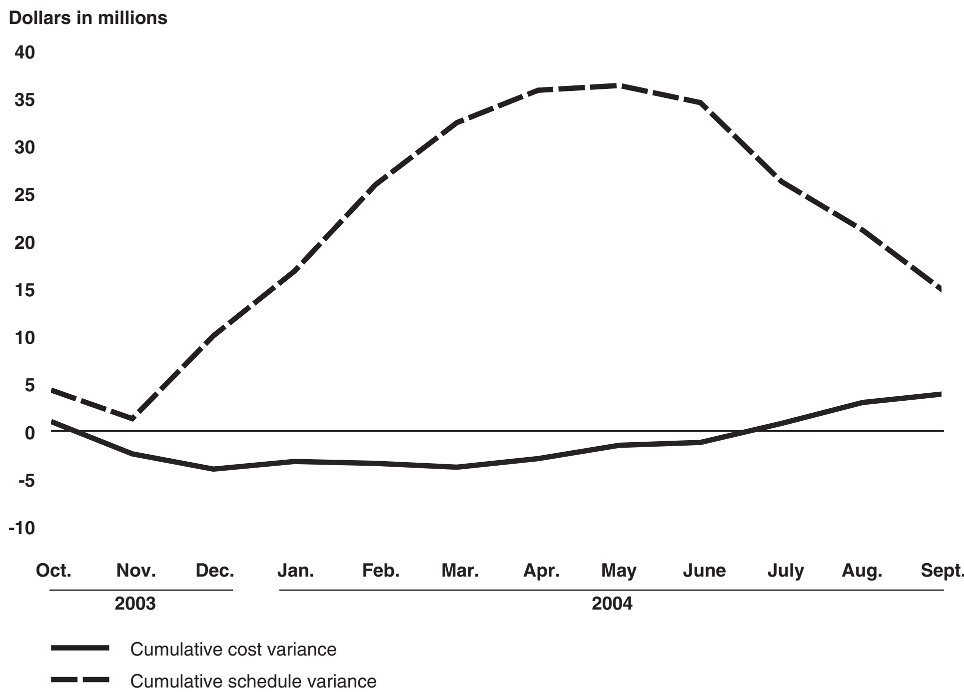
As figure 10 shows, declining cumulative schedule variance during the latter portion of fiscal year 2004 was eroding overall performance. The decline in the positive schedule variance was largely caused by problems with the missile component, which were the result of two explosions at a subcontractor's propellant mixing facility. In January 2004, these incidents and efforts to reestablish booster production caused MDA to revise THAAD's baseline.[7] The new baseline recognizes the inevitable delay to initial flight testing and all supporting tasks.[8] It also provides a new starting point for measuring the prime contractor's schedule performance. Therefore, even though the prime contractor completed $8.1 million worth above that scheduled for fiscal year 2004 (that is, incurred a positive schedule variance of $8.1 million), the variance would have been less favorable had the contractor not established a new baseline.

[6] The cost and schedule variance incurred during fiscal year 2004 was $0.673 million and $8.1 million, respectively.

[7] A performance measurement baseline identifies and defines work tasks, designates and assigns organizational responsibilities for each task, schedules the work tasks in accordance with established targets, and allocates budget to the scheduled work.

[8] The explosions caused the program to seek an alternate source. According to the program office's current risk assessment, "source replacements have the potential for delaying booster delivery during the fight test program and into production."

Figure 10: THAAD Fiscal Year 2004 Cost and Schedule Performance



Sources: Contractor (data); GAO (analysis).

The favorable cumulative cost variance incurred during fiscal year 2004 masks problems with the cost variance incurred by the missile component, which was unfavorable for the year. Major factors contributing to the missile's unfavorable cost variance include explosions at a subcontractor's facility used to mix missile propellant and the cost of efforts to reestablish booster production, as noted above; delays in activating a test facility at the Air Force Research Laboratory; and re-design efforts on a faulty valve thrust vector assembly. Favorable cost variances in other THAAD areas, such as the radar segment, offset the missile's unfavorable cost variance.

Appendix IX: Information on the Army's Missile Defense Programs

Background

The Army is responsible for funding and managing two missile defense programs. The programs—which ultimately will be fielded as a single missile defense system—include the Patriot missile defense system including its newest missile variant, the Patriot Advanced Capability-3 (PAC-3), and the Medium Extended Air Defense System (MEADS), which is currently under development. The Army intends to incrementally replace fielded Patriot components with more-capable MEADS components as they become available. The resulting system is expected to better protect deployed U.S. forces and critical assets from short- and medium-range tactical ballistic missile attacks. The Army's Lower Tier Project Office manages Patriot and MEADS development, procurement, and fielding.

Now operational with the U.S. Army, Patriot with its PAC-3 missiles is the latest evolution of the Patriot air and missile defense system. The Patriot system has four basic components: (1) ground-based radar to detect and track targets; (2) engagement control station to provide command, control, and communications; (3) launcher; and (4) interceptor missiles. Compared with earlier versions of the Patriot missile, PAC-3 provides improved performance against short- and medium-range tactical ballistic missiles, cruise missiles, and aircraft. The PAC-3 missile is in production and successfully achieved initial fielding[1] in September 2001.

MEADS is an international co-development program between the United States, Germany, and Italy with a cost share of 58, 25, and 17 percent, respectively. MEADS expands upon Patriot capability with four new components: (1) a launcher; (2) battle management, command, control, communications, computer and intelligence (BMC4I) equipment; (3) a surveillance radar; and (4) a multi-function fire control radar. MEADS is expected to offer significant improvements in tactical mobility and strategic deployability over existing Patriot units. In addition, MEADS is designed to be interoperable with other airborne and ground-based sensors and utilize a netted architecture to provide a robust, 360-degree defense against cruise missiles, unmanned-aerial-vehicles, tactical air to surface missiles, rotary-wing and fixed-wing threats, and very short and medium range theater ballistic missiles.

[1] Initial fielding, sometimes called First Unit Equipped, refers to the date a system and support elements are issued to the designated unit and specified training has been accomplished.

Combined Aggregate Program

In 2003, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved plans for combining management, development, and fielding of the Patriot and MEADS programs.[2] The approach calls for incremental fielding and early insertion of MEADS components within existing Patriot batteries rather than delivering MEADS as a single system. The Army uses the term "Combined Aggregate Program (CAP)" to refer to the transitional activities leading up to full fielding of the MEADS and replacement of Patriot components. CAP also includes an enhanced PAC-3 missile—funded 100 percent by the United States—called the Missile Segment Enhancement (MSE). The MSE missile is intended to operate at higher altitudes and longer ranges than existing PAC-3 missiles.

The plan calls for MEADS components to be inserted into Patriot battalions in three time-phased increments, as follows:

- **Increment one**. Scheduled for initial fielding in fiscal year 2009, increment one consists of the insertion of the MEADS BMC4I to begin replacing the Patriot engagement control station component and associated equipment. This increment is considered the highest acquisition priority because it (a) integrates with existing sensors to provide 360-degree coverage to counter cruise missiles, and (b) supports targeting by using data from external sensors, which is referred to as "engage on remote."

- **Increment two**. Scheduled for initial fielding in fiscal year 2011, increment two consists of the insertion of the MEADS launcher to begin replacing the Patriot launcher. This increment is expected to enhance system mobility and be capable of firing either the existing PAC-3 missile or the new MSE missile. The MSE missile is scheduled for initial fielding in 2011. It does not replace the PAC-3 missile but, rather, supplements fielded inventory.

- **Increment three**. Scheduled for initial fielding in fiscal year 2015, increment three consists of the insertion of the MEADS Ultra High Frequency surveillance radar and the X-band multifunction fire control radar to replace the Patriot C-band radars. These radars are expected to provide (a) 360-degree coverage for defense against cruise missiles and fire control to engage low-altitude, stressing targets; and

[2] *Evolution from Patriot to MEADS—Acquisition Decision Memorandum*, dated August 12, 2003.

(b) surveillance and fire control for high-value asset defense against short-range ballistic missiles.

The overall Patriot/MEADS CAP is scheduled for initial fielding in 2015 when increment three is available. MEADS production is scheduled to continue through fiscal year 2028. The 2015 fielding date, approved by the Under Secretary for Defense, represents a three-year delay from the fielding date planned in the previous MEADS program. According to a Lower Tier Project Office spokesperson, constraints in developmental funding caused the delay in initial fielding of MEADS components. Specifically, out-year Research, Development, Test and Evaluation (RDT&E) funding was insufficient to field MEADS in fiscal year 2012.

Patriot/MEADS CAP Funding

The Army's Lower Tier Project Office estimates that the life-cycle cost for the United States' portion of the Patriot/MEADS CAP program—which includes PAC-3 and MEADS-component development, procurement, and operations and support (O&S) costs—will be $150.6 billion through approximately fiscal year 2048. Of this amount:

- $109 billion (72.4 percent) is for O&S.
- $31.9 billion (21.2 percent) is for procurement.
- $9.7 billion (6.4 percent) is for RDT&E.

Operations and support costs are a large proportion of the total cost largely because of the length of time a fielded unit is supported. Although production is scheduled to end in fiscal year 2028, these newest units are expected to be in the field for another 20 years.

Table 38 summarizes the funding requested by the U.S. Army to fund development and missile procurement of the Patriot/MEADS Combined Aggregate Program over the Future Years Defense Plan (fiscal years 2006-2011). The requested funding supports the procurement of 108 PAC-3 missiles per year.

Table 38: Patriot/MEADS CAP Planned Costs

Dollars in millions of then-year dollars	RDT&E	Missile procurement
FY 2006	$288.8	$489.7
FY 2007	326.4	494.8
FY 2008	454.5	466.0
FY 2009	510.7	471.8
FY 2010	510.4	N/A
FY 2011	490.4	N/A

Source: Department of the Army.

Note: Budget as of February 2005.

Appendix X: Scope and Methodology

The accomplishment of Missile Defense Agency (MDA) program goals is ultimately achieved through the efforts of individual Ballistic Missile Defense System (BMDS) elements. Therefore, we based our assessment on the progress made in fiscal year 2004 by those seven elements that (1) are under the management of MDA and (2) are being developed as part of a block capability. The elements we reviewed accounted for 72 percent of MDA's fiscal year 2004 research and development budget. We compared each element's completed activities, test results, demonstrated performance, and prime contractor cost and schedule performance in fiscal year 2004 with those planned for the year. We also completed an abbreviated evaluation of an eighth BMDS element, the U.S. Army's Combined Aggregate Program, which consists of Patriot and the Medium Extended Air Defense System.

Many activities completed in fiscal year 2004 by the various element programs pertained to the completion of Limited Defensive Operations, which is an integral part of the Block 2004 goals. To assess progress toward schedule goals—that is, program activities including test events scheduled for completion in fiscal year 2004—we examined each element's prime contractor Cost Performance Reports, Defense Contract Management Agency's analyses of these reports (if available), quarterly reviews of element progress (known as System Element Reviews), and other agency documents to determine whether key activities were accomplished as planned. We also developed a data collection instrument, which was submitted to MDA, to gather detailed information on completed program activities, including tests, design reviews, prime contracts, and estimates of element performance.

We assessed MDA's fiscal year 2004 cost performance by separately reviewing the cost performance of each BMDS element's prime contractor. We used this methodology because MDA allocates a large percentage of its budget to fund prime contractors that develop system elements. To make these assessments, we applied established earned value management techniques to data captured in contractor Cost Performance Reports. Results were presented in graphical form to determine trends. We also used established earned value management formulas to project the likely costs of the contracts at completion.

To assess MDA's progress toward its performance goals, we analyzed data provided by MDA on the Ground-based Midcourse Defense, Aegis Ballistic Missile Defense, and Command, Control, Battle Management, and Communications elements—the elements that comprise the Block 2004 defensive capability. We supplemented this information by holding discussions with, and attending overview briefings presented by, various program office officials. Furthermore, we interviewed officials from the office of the Director, Operational Test and Evaluation, within the Department of Defense (DOD) to learn more about their assessment of the operational capability of the initial BMDS. Finally, we met with officials from U.S. Strategic Command to discuss the initial capability's military utility from the warfighter's perspective.

During our review, we observed that MDA is expected to face increasing funding risks—arising from sources both within and outside DOD—in the years ahead as MDA attempts to enhance and field its missile defense capabilities. To examine this issue further, we reviewed life-cycle cost documentation from the U.S. Army Lower Tier Project Office, our report on total ownership costs,[1] a Congressional Budget Office report,[2] and MDA documentation on the agency's plans for development and fielding.

We also observed inconsistencies in how MDA is implementing its block approach. To gain insight into this issue, we examined element-level documents and answers to a data collection instrument that we generated to extract specific information on planned deliveries of fielded assets. We also examined MDA's Statement of Goals, budget statements for fiscal years 2004 and 2005, and other documents provided by MDA, such as Missile Defense Plan II.

To ensure that MDA-generated data used in our assessment are reliable, we evaluated the agency's internal management control processes. We discussed these processes extensively with MDA upper management. In addition, we confirmed the accuracy of MDA-generated data with multiple sources within MDA and, when possible, with independent experts. To assess the validity and reliability of prime contractors' Earned Value Management systems and reports, we analyzed audit reports prepared by the Defense Contract Audit Agency. Finally, we assessed MDA's internal accounting and administrative management controls by reviewing MDA's Federal Managers' Financial Integrity Report for Fiscal Years 2003 and 2004.

[1] GAO, *Best Practices: Setting Requirements Differently Could Reduce Weapon Systems' Total Ownership Costs*, GAO-03-57 (Washington, D.C.: Feb. 11, 2003).

[2] Congressional Budget Office, *The Budget and Economic Outlook: An Update* (Washington, D.C.: Sept. 2004).

Our work was performed primarily at MDA headquarters in Arlington, Virginia. At this location, we met with officials from the Kinetic Energy Interceptors Program Office; Aegis Ballistic Missile Defense Program Office; Airborne Laser Program Office; Command, Control, Battle Management, and Communications Program Office; and Ground-based Midcourse Defense Program Office. In addition, we met with officials from the Space Tracking and Surveillance System Program Office, Los Angeles, California; Terminal High Altitude Area Defense Project Office, Huntsville, Alabama; and the U.S. Army Lower Tier Program Office, Huntsville, Alabama. We also interviewed officials from the office of the Director, Operational Test and Evaluation, Arlington, Virginia; U.S. Strategic Command, Omaha, Nebraska; and the Joint Theater Air Missile Defense Organization, Arlington, Virginia.

We conducted our review from May 2004 through February 2005 in accordance with generally accepted government auditing standards.

Appendix XI: GAO Contact and Staff Acknowledgments

GAO Contact

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